Thermally assisted motion of strongly-pinned vortices in type-II superconductors
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Abstract: Type-II superconductors are penetrated by vortices of magnetic field, each carrying a magnetic flux quantum. Vortices move under the action of an applied current, which leads to unwanted energy dissipation. Conveniently, vortex motion in real superconductors is inhibited by pinning them to crystallographic defects. Interaction of vortices with the pinning potential is described either by the framework of the collective pinning theory related to the statistical physics of elastic manifolds in quenched random media, or strong pinning theory, which is applicable in the dilute density of strong defects and allows a non-perturbative treatment. We extend the strong pinning theory to account for thermal fluctuations facilitating the vortex depinning and reducing the critical (depinning) current.

Nonergodic subdiffusion from transient interactions with heterogeneous partners
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Abstract: Transport of molecules in a cellular environment regulates many processes underlying biological functions. With the current experimental techniques, it is possible to perform single particle tracking (SPT) of long single-molecule trajectories in living cells. These experiments revealed very complex diffusion patterns, often showing anomalous subdiffusion and ergodicity breaking. We will discuss an example of such behavior, observed by recent SPT experiments in the motion of molecules in living-cell membranes [1]. These data seem to exclude conventional explanations for ergodicity breaking, based on continuous-time random walks with transient trapping. Thus the underlying microscopic mechanism for the nonergodic subdiffusion of the molecules is unclear. In this scenario, we will discuss two stochastic models that provide a description compatible with the observation of such experiments. We will first discuss models of a particle diffusing in a disordered medium, in which particles’ diffusivities vary either in time or space, reproducing the heterogeneous dynamics - characterized by frequent changes of diffusivity - revealed by the experiments [2]. Second, we will discuss a model in which a particle performs continuous Brownian motion with changes of diffusion coefficients induced by transient molecular interactions with diffusive binding partners [3].

References:

Doi-Peliti description of chemical reaction networks
Tommaso Cossetto and Massimiliano Esposito
Complex Systems and Statistical Mechanics, Physics and Materials Science Research Unit, University of Luxembourg, L-1511 Luxembourg

Abstract: We use Doi-Peliti formalism to recover many of the results recently derived for Chemical Reaction Networks (CRN). We write the general expression of the effective action for a CRN, showing that it can be recast in a suitable matrix form in case the system is linear. In the large system size limit we recover the
deterministic rate equations and we discuss the gaussian perturbations around the mean field solutions, as well as other solutions for the equation of motion of the fields. The tilting technique is then used in the effective action to study the currents. Our aim is to see the fluctuation theorems as symmetries of the tilted action. The latter will also be the direction for further developments of this work.

Andrea Falcón

**Localization transition of a random searcher driven by learning**

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³Bristol Centre for Complexity Sciences, University of Bristol, Bristol BS8 1UG, UK.

**Abstract:** We propose and solve an adaptive search model that exhibits emergent learning. The model consists of a random walk which stochastically resets to previously visited sites on a d-dimensional lattice containing one inhomogeneity, or trapping site. Due to reinforcement, this model exhibits a phase transition between diffusive behavior and stationary localized states centered around the inhomogeneity as the strength of memory, or resetting rate, is varied. The results show that similarly to living organisms non-Markovian walks are able to learn by reinforcement about their environment.

Christophe Henry

**Simulation of chain-like particles in turbulent flows**

Christophe Henry, Giorgio Krstulovic, and Jeremie Bec

Laboratoire Lagrange, Observatoire de la Côte d’Azur, CNRS, Blvd de l’Observatoire, CS 34229, 06304 Nice cedex 4, France

**Abstract:** The dynamics of complex, flexible chains of particles immersed in a fluid is studied using a fine Lagrangian tracking of articulated chains, which are described as a set of elementary particles linked together by rigid bonds. The equation of motion of each particle composing a chain contains two terms: the hydrodynamic drag force and the force due to the chain (including the effect of flexibility). This approach extends existing models applied to dumbbells or trumbbells (with 2 or 3 particles in each chain only) and allows to study highly elongated chains of many particles. Numerical results obtained in a simple extensional flow are presented and analysed with respect to the fluid properties and internal chain properties.

Pedro Monroy

**Connectivity measures in the Mediterranean sea from Lagrangian flow networks: patterns, sensitivity and robustness**

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**Abstract:** The Lagrangian Flow Network (LFN) approach to ocean transport [1] is a modeling framework in which geographical sub-areas of the sea are represented as nodes in a network and are interconnected by links representing the transport of water, substances or propagules (eggs and larvae) by currents. In this way the tools of network theory become available to address questions of fluid transport and of ecological connectivity [2,3]. Here [4] we compute for the surface of the whole Mediterranean basin four connectivity metrics derived from LFN that measure retention and exchange processes, thus providing a systematic characterization of propagule dispersal driven by the ocean circulation.

**References:**

Reza Torabi

The effect of superdiffusion on the Hopf instability in reaction-diffusion systems

Reza Torabi and Zahra Rezaei
Department of Physics, Tafresh University, Tafresh 39518 79611, Iran

Abstract: The effect of superdiffusion on the Hopf instability in reaction-diffusion systems is studied. It is shown that for a general n-component reaction-superdiffusion system, a fractional complex Ginzburg-Landau equation emerges as the amplitude equation near a Hopf instability. Numerical simulations of this equation are carried out to illustrate the effect of superdiffusion on spatio-temporal patterns.

References:

Ben Werkhoven

The consequences of surface diffusion on electrokinetic systems

Ben Werkhoven, Jeffrey Everts, Sela Samin, and René van Roij
Institute of Theoretical Physics, Utrecht University

Abstract: Usually it is assumed that adsorbed ions are “stagnant” or immobile. However, there is increasing evidence that the adsorbed ions are mobile, and conduction via a surface is necessary in order to explain observations. Therefore, we assign a (2D) diffusion constant to adsorbed ions, and show that this has important consequences to the understanding of electrokinetic systems. Firstly, the streaming electric field causes the surface charge to be inhomogeneous, which results in a new steady state with ions adsorbing on one side and desorbing on the other side of the dissolving surface. The inhomogeneous surface charge also has an impact on the zeta-potential. Consequently, the linear-response regime, where Smoluchowski equation is valid, is reduced. Lastly, an electric field normal to the surface is generated.

Carlos Granero-Belinchón

What’s the meaning of Transfer Entropy measures

Carlos Granero-Belinchon, Stephane G. Roux, and Nicolas B. Garnier
Univ Lyon, Ens de Lyon, Univ Claude Bernard, CNRS UMR 5672, Laboratoire de Physique

Abstract: Since its apparition, Transfer Entropy (Schreiber [2000]) has been broadly used in a lot of different applications belonging to a wide range of fields. Despite this fact the meaning of the measure is still not clear. In 2011, Beer and Williams questioned the signification of Transfer Entropy (Williams and Beer [2011]). From this date onwards other works are trying to advance our understanding of the meaning of Transfer Entropy (James et al. [2016], Chicharro and Panzeri [2017]). Those works present counterexamples to show that the intuitive interpretation of Transfer Entropy is not correct. We estimate the Transfer Entropy over well known synthetic systems (fractional Brownian motion, maps, GOY model) and we analyze the results trying to apprehend the signification of Transfer Entropy.

Nikola Jajcay

Information transfer across temporal scales in atmospheric dynamics

Nikola Jajcay and Milan Paluš
Institute of Computer Science, Czech Academy of Sciences, Prague, Czech Republic

Abstract: Earth climate, in general, varies on many temporal and spatial scales. In particular, air temperature exhibits recurring patterns and quasi-oscillatory phenomena with different periods. Although these oscillations are usually weak in amplitude, they might have non-negligible influence on temperature variability on shorter time- scales due to cross-scale interactions, recently observed by Paluš [1]. In this letter, we show how to discern possible cross-scale interactions and, if present, how to quantify their effect on air temperature in Europe.

Fluctuations and synchronization in networks of oscillators

Lluís Arola-Fernández

Synchronization transitions induced by topology and dynamics

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²UBICS: Universitat de Barcelona Institute of Complex Systems.

Abstract: We analyze structural transitions to synchronization in evolving complex topologies of Kuramoto oscillator, providing numerical evidence and analytical insight to a phenomena that is widely seen in nature. By constructing functionally equivalent networks and using mean field arguments, we are able to quantify the close relation between structural and dynamic perturbations in a quasi-static process, where the changes in the macroscopic response can be induced by the coupling strength and by the topology of the network.

Antonio Fernández-Peralta

Stochastic pair approximation

Antonio Fernández-Peralta¹, Adrián Carro², Raúl Toral¹, and Maxi San Miguel¹,
¹IFISC, Instituto de Física Interdisciplinar y Sistemas Complejos (CSIC-UIB), Campus Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain.
²Institute for New Economic thinking at the Oxford Martin School.

Abstract: Theoretical approaches to characterize binary-state models on complex networks have been proposed. However, most of the times, they are based on deterministic assumptions where fluctuations and finite size effects are neglected. In this work, we relax these assumptions and we generalize the previous proposed methods, taking into account the full stochastic nature of the models. Specifically, we are able to obtain analytical expressions of the stationary average density of active links and fluctuations of the magnetization $m$ for the noisy voter (Kirman) model.

Tim Herpich

Stochastic thermodynamics of coupled phase oscillators

T. Herpich, J. Thingna, and M. Esposito
Complex Systems and Statistical Mechanics, Physics and Materials Science Research Unit, University of Luxembourg, L-1511 Luxembourg, Luxembourg

Abstract: We study the (thermo-)dynamic properties of an open network of discrete and globally coupled phase oscillators under variation of the intensive bath parameter and the system size. In the continuum limit, we characterize a Hopf bifurcation leading from a desynchronized to a synchronized phase. We compare the energetics between the collective continuum dynamics and finite systems for which metastable phenomena are observed.

References:

Eduardo Henrique Filizzola Colombo

Population dynamics, growth models and ecological systems

Population dynamics in a intermittent refuge

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Departamento de Física, Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil

Abstract: Population dynamics is constrained by the environment, which needs to obey certain conditions to support population growth. We consider a standard model for the evolution of a single species population density, which includes reproduction, competition for resources, and spatial spreading, while subject to an external harmful effect. The habitat is spatially heterogeneous, there existing a refuge where the population can be protected. Temporal variability is introduced by the intermittent character of the refuge. Using analytical and numerical tools, we investigate the asymptotic behavior of the total population as a function of the size and characteristic time scales of the refuge. We obtain expressions for the minimal size required for population survival, in the slow and fast time scale limits. This scenario can apply to a wide range of scales, from a laboratory setting with bacteria to marine reserves.
Jeffrey Kelling

Aging universality classes in surface growth models
Jeffrey Kelling1, Geza Odor2, and Sibylle Gemming1

1Department of Information Services and Computing, Helmholtz-Zentrum Dresden-Rossendorf.
2Institute of Technical Physics and Materials Science, Centre for Energy Research of the Hungarian Academy of Sciences.

Abstract: Extensive dynamical simulations of a 2 dimensional driven dimer lattice gas are presented, which can be mapped to (2+1) dimensional surface growth in the Kardar-Parisi-Zhang (KPZ) or Edwards-Wilkinson universality classes. From this autocorrelation and autoresponse functions have been determined for the KPZ universality class and the underlying lattice gas. Studying the effects of different dimer lattice gas dynamics revealed strong differences in the aging behavior of the stochastic cellular automaton (SCA) and the random sequential update models. We show numerical evidence for nontrivial corrections as well as different universal scaling behaviors.

Yu Liu

Insights into resource consumption, cross-feeding, system collapse, stability and biodiversity from an artificial ecosystem
Yu Liu and David Sumpter
Department of Mathematics, Uppsala University, 75105 Uppsala, Sweden

Abstract: We develop a bottom-up model of consumer–resource interactions. We demonstrate: (i) communities self-organize so that all available resources are fully consumed; (ii) cross-feeding is a common evolutionary outcome, which evolves in a number of stages; (iii) the evolved ecosystems are often 'robust yet fragile', with keystone species required to prevent the whole system from collapsing; (iv) non-equilibrium dynamics and chaotic patterns are general properties, readily generating rich biodiversity. Establishing similar properties in an evolutionary model as simple as this suggests that these four properties are ubiquitous features of all community ecosystems.


David Navidad Maeso

Selection in dispersal-structured populations
David Navidad Maeso1,2, Marco Patriarca1, and Els Heinsalu1

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2University of Tallinn, Narva mnt 25, 101120 Tallinn, Estonia

Abstract: The dynamics of dispersal-structured populations, consisting of individuals that are characterized by different diffusion coefficients but otherwise identical, is investigated. The problem addressed corresponds to the process of natural selection. The competitive interactions among the individuals in the model are introduced by density-dependent birth and death rates. It is shown that, depending on the average value of the initial distribution of diffusivities together with the level of temporal fluctuations in the population size, distinct ranges of dispersal rates are selected in the system. Thus, either the smaller, the intermediate or the faster diffusing individuals lead the competition success.

Dekel Shapira

The lognormal-like statistics of a stochastic squeeze process
D. Shapira and D. Cohen
Department of Physics, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel

Abstract: We analyze the full statistics of a stochastic squeeze process. The models two parameters are the bare stretching rate w, and the angular diffusion coefficient D. We carry out an exact analysis to determine the drift and the diffusion coefficient of log(r), where r is the radial coordinate. The results go beyond the heuristic lognormal description that is implied by the central limit theorem. Contrary to the common "Quantum Zeno" approximation, the radial diffusion is not simply $D_r = (1/8)w^2/D$, but has a non-monotonic dependence on w/D. Furthermore, the calculation of the radial moments is dominated by the far non-Gaussian tails of the log(r) distribution.

Graziano Amati  
*Coarse-graining analysis for the strongly anharmonic FPU Model*  
Graziano Amati  
University of Luxembourg, L-1511 Luxembourg  
**Abstract:** The aim of the work is to recast the classical non-Ergodicity problem of the Fermi-Pasta-Ulam (FPU) Problem into the modern framework of coarse-graining techniques. Numerical examples are provided in order to describe the actual model employed and the related observations.

Silvia Martina  
*Spectra of random sparse matrices*  
Timothy Rogers and Isaac Pérez Castillo  
Dipartimento di Fisica e Astronomia "Galileo Galilei", Università degli Studi di Padova, Padova, Italy  
**Abstract:** There are different mathematical methods used to analyse ensembles of random matrices with a particular underlying symmetry. It's well-known that the spectral density of random matrix ensembles will converge, as the matrix dimension grows, to a precise limit. Two examples are Wigner's semi-circle law and Girko's elliptic law. The introduction of sparsity is one of the factors which complicate the mathematical analysis enormously and novel techniques are welcome for calculate the limiting spectral density. A new approach is presented to extend our knowledge of the large-scale statistical behavior of eigenvalues to random sparse matrices[1] and random non-Hermitian matrices.  

Karel Proesmans  
*The perfect spring*  
Karel Proesmans, Hans Vandebroek, and Christian Van den Broeck  
Hasselt University, B-3590 Diepenbeek, Belgium  
**Abstract:** We introduce a class of systems that can be solved exactly via transfer matrix methods. Applications include the free energy calculation for various equilibrium systems and a general criterion for perfect harmonicity, i.e., a free energy that is exactly quadratic in the external field. As an illustration, we construct a “perfect spring”, namely a polymer with non-Gaussian, exponentially distributed sub-units which nevertheless remains harmonic until it is fully stretched. This surprising discovery is confirmed by Monte Carlo and Langevin simulations.  

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**Poster abstracts second week**

**Biophysics**

Pierre Barrat-Charlaix  
*Integrating heterogeneous data in the inverse Ising problem*  
Pierre Barrat-Charlaix, Matteo Figliuzzi, and Martin Weigt  
Université Pierre et Marie Curie, 75005 Paris, France.  
**Abstract:** The inverse Ising problem has recently attracted much attention thanks to its successful applications in the statistical modeling of biological data. In the standard setting, parameters of an Ising model are inferred to reproduce statistical properties of spin configurations, either coming from a Boltzmann distribution (theoretical case), or representing biological data. In the latter case, quantitative information for a limited number of given of configurations has recently become available. In this work, we extend the usual setting of the inverse Ising problem by combining statistics from the equilibrium sample with measurements of the energy for a number of arbitrary configurations.  

Anahita Bayani  
*Spatially-dependent models of the anti-inflammatory response*  
Anahita Bayani¹, Jonathan J. Crofts¹, Nadia Chuzhanova¹, Joanne L Dunster², and Martin R Nelson⁴  
¹Department of Physics and Mathematics, Nottingham Trent University, Nottingham, UK.  
²Institute for Cardiovascular and Metabolic Research, University of Reading, Reading, UK.
Abstract: There is growing interest in inflammation due to its involvement in a wide range of medical conditions. More recent hypotheses and investigations show that inflammation is actively controlled by an anti-inflammatory process that can be modulated therapeutically. PDE models accounting for inflammatory events at the cellular level have been developed. The main focus here is on analysing the modelled systems to define specific conditions that lead to spatial patterns that are crucial to biologically characterise the models in terms of parametrisation and target strategies for inflammation resolution.

Giancarlo Croce

Unveiling the protein interaction network using the inverse Ising model

Croce Giancarlo1, Martin Weigt1, and Thomas Gueudre2
1Université Pierre et Marie Curie, 75005 Paris, France.
2Department of Applied Science, Politecnico di Torino, Torino, Italy.

Abstract: Proteins rarely act alone, conversely, most of the biochemical functions within an organism are carried out by molecular machines formed by a large number of proteins which interact in a complex way. Unveiling the protein interaction network could shed a new light on the comprehension of protein functions and pathways in biological processes. To this purpose we use a statistical mechanics approach: the proteins can be thought as binary spins which can be present (spin equals 1) or absent (spin equals 0) in a genome. The genome are then interpreted as different configuration of an Ising model with unknown couplings and fields. By analyzing the variability within a set of genomes we infer the parameters of the Ising model and use them to unveil the protein interaction network.

Marc de Gennes

Fruit fly wing morphogenesis: Role of signalling and mechanics in the formation of veins

Marc de Gennes
Francis Crick Institute, London, UK

Abstract: Between 15h and 30h after formation of the pupae, the wing of drosophila undergoes large morphological changes to eventually reach a shape that is very close to the shape of the adult wing. During this process, a subset of cells differentiate to form a very precise pattern of veins. This differentiation is the result of signalling processes, and it gives specific mechanical properties to vein cells. Both the signalling pathways involved in vein differentiations and the particular mechanics of veins cells have been described. However, it is not clear how they lead to the formation of such a well defined pattern. As a consequence the aim of my PhD is to understand the respective role of signalling and mechanics in the making of the vein pattern.

Jeyashree Krishnan

Monte Carlo simulations of an Ising model of gene-gene interaction networks

Jeyashree Krishnan1,2, Andreas Schuppert1,2, and Edoardo Di Napoli1,3
1Aachen Institute for advanced study in Computational Engineering Science (AICES), RWTH Aachen University, Germany
2Joint Research Center for Computational Biomedicine (JRC), RWTH Aachen University, Germany
3Juelich Supercomputing Center, Germany

Abstract: A major challenge that we face in complex systems is high-dimensionality. Commonly used approaches to work through this limitations in genetic networks are reductionism [1] or linear response analysis [2]. Drawing inspiration from some established concepts in statistical mechanics, here we present a Ising simulations of such networks as a toy model to understand such complex networks.

Jan Rombouts

Mathematical modeling of time delays in the Xenopus laevis cell cycle

Jan Rombouts, Alexandra Vandervelde, and Lendert Gelens
Laboratory of Dynamics in Biological Systems, KU Leuven, Belgium

Abstract: In many physical and biological systems, the response to internal and external cues is not immediate, but a time delay needs to be taken into account to accurately describe the dynamics. In this work we focus on the modeling of the early embryonic cell cycle of the frog Xenopus laevis, which is characterized by clock-like switching between DNA replication and cell division. The core mechanism responsible for these autonomous oscillations is a delayed negative feedback loop. We study a conceptual model of this cell cycle and examine the effect of discrete, distributed and state-dependent time delays on the oscillations. We clarify
the requirements for oscillatory behavior and characterize their dependence on the parameters. Our results will be combined with experiments performed by colleagues to gain new insights into the regulation of the cell cycle.

Agustín Sánchez-Cobos

**Cooperative phenomena in the mechanical behaviour of filamentous materials with molecular motors**

Agustín Sánchez-Cobos and M. Carmen Miguel
Departament de Física de la Matèria Condensada, Facultat de Física, Universitat de Barcelona Diagonal 645, E-08028 Barcelona, Spain and University of Barcelona Institute of Complex Systems (UBICS).

**Abstract:** Biological cells sense and respond to mechanical stimuli in a rather intricate manner. Indeed, cell mechanosensing involves the interplay of several cytoskeletal constituents, primarily filaments, such as actin microfilaments or microtubules, crosslinking proteins, and molecular motors. The organization of actin filaments into several spatio-temporal structures governs eukaryotic cell shape and movement. Mechanical force acting on actin structures is shared between molecular motors such as myosins and different actin crosslinkers.

Ivan Voitalov

**Link prediction in protein interaction networks using latent geometry**

I. Voitalov, R. Aldecoa, M. Kitsak, A. Ameli, A. Sharma, N. Johnson, A. Dhroso, O. Narykov, D. Korkin, and D. Krioukov

1Department of Physics, Northeastern University, Boston, MA, USA
2Harvard Medical School
3Worcester Polytechnic Institute

**Abstract:** Despite recent advances in protein interaction measurement technologies, currently available interactome networks are noisy and substantially incomplete. We offer a novel approach to identify missing protein interactions and assess their confidence level, based on the mapping of the interactome to the latent hyperbolic space. We validate the hyperbolic mapping approach through a series of systematics stability and link prediction accuracy tests and use it to identify and provide biological evidence of the predicted missing protein interactions in the Saccharomyces cerevisiae interactome.

Ilenia Apicella

**Are deep neural networks critical**

I. Apicella, S. Suweis, A. Testolin, and A. Maritan,

Dipartimento di Fisica e Astronomia "Galileo Galilei", Università degli Studi di Padova, Padova, Italy

**Abstract:** An emerging and challenging question arising in many scientific communities is why deep neural networks work so well. In this preliminary work, we want to understand if their efficiency is related to the criticality, like it is observed in many living systems [1], e.g., the brain. Models and experiments, in fact, support the hypothesis that the brain can operate near a critical point of a phase transition where some functions seem to be optimized [2].

We consider a deep neural network composed by 2 layers, trained with a MNIST dataset, using an unsupervised learning rule [3], and then we study this problem like an Ising model, dealing the neurons of the networks like as the spins and the links between them as coupling constant, introducing a fictitious temperature (like in [4]).

Shahab Bahreini Jangjoo

**Track of criticality in a top-down neural network**

Shahab Bahreini Jangjoo and Afshin Montakhab,

Shiraz University, Iran

**Abstract:** Furthermore, one of the most common behavior of the natural systems is critical behavior. This behavior is meant to reveal events that follow the power-law rule. Some of the researchers believe criticality is a significant clue to recognizing complex systems such as brain. Because of this behavior is related to neural dynamics, it would be prominent to find this treat in a top-down model which is independent of individual neuronal dynamics complications. Our findings reveal some evidences on critical behavior in the dense homogeneous associative network (dAHN) model as a top-down neural modeling. We also found
changes in excitatory and inhibitory factors in this model result in interesting behavior of the system such as subcritical behavior.

Jose Casadiego

*Model-independent inference of synaptic connectivity from spike trains*

Jose Casadiego, Dimitra Maoutsa, and Marc Timme

1Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), Göttingen 37077, Germany.

2ETH Zurich Risk Center, 8092 Zurich, Switzerland.

3Center for Advancing Electronics (CFAED), Technical University of Dresden, 01062 Dresden, Germany.

**Abstract:** Current approaches for revealing synaptic links from spike trains either (i) rely on statistical dependences, or (ii) fit a given model to data. While in the former, statistical dependencies only provide functional (and not structural) links between units, in the latter, methods may be computationally demanding (and thus constrained to small networks), and their accuracy heavily depends on the selected model. Here we develop a model-independent theory to reveal synaptic connections in networks of spiking neurons solely from spike trains.

Cristian Estarellas

*How does neural density affect dynamics?*

Cristian Estarellas and Claudio Mirasso

IFISC, Instituto de Física Interdisciplinar y Sistemas Complejos (CSIC-UIB), Campus Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain.

**Abstract:** One of the challenges in computational neuroscience is to reproduce dynamical behaviors of brain circuits using mathematical models. The solution to avoid the huge neural density of the brain is to scale the system. If the objective is to reproduce real data dynamical behaviors, the number of neurons, as well as their connectivities, in the model are key parameters. In this work he highlight the importance of the neural density in models of cortical areas. In particular, we use the Izhikevich model for three types of populations: all excitatory, all inhibitory and excitatory-inhibitory neurons. The results of our study show changes in the local an global dynamics of the population due to the neural density and the effect of the noise. A balance between the number of neurons and the connectivity probability of the network is found to keep dynamics independently of the neural density.

Loren Kocillari

*Criticality in whole-brain networks*

R. Rocha, L. Kocillari, S. Suweis, and A. Maritan

Dipartimento di Fisica e Astronomia "Galileo Galilei", Università degli Studi di Padova, Padova, Italy

**Abstract:** Human brain can be modelled as a complex network, consisting on a spatially distributed underlying structure, called connectome composed of physical connections linking different brain areas, that are functionally related among each other. New neuroimaging techniques have led to profound insights on the functional activations, especially as regarding the spatial organization of the brain during rest, where brain regions follow a typical spatio-temporal activation, called resting state networks. Based on the anatomical connections of the structural connectome, we study at the critical regime the resting state patterns. We propose an improved non-linear model based on the model of Chialvo [1], by introducing the ingredient of local flexibility.


Maria Masoliver

*Subthreshold signal encoding in coupled FitzHugh-Nagumo neurons*

Maria Masoliver and Cristina Masoller

Nonlinear Dynamics, Nonlinear Optics and Lasers (DONLL). Universitat Politècnica de Catalunya

**Abstract:** We study numerically the dynamics of two mutually coupled neurons using the well-known stochastic FitzHugh-Nagumo model. In a recent work [1] it was shown that, in a single neuron, the interplay of noise and the periodic weak (subthreshold) signal induced the emergence of relative temporal ordering in the timing of the spikes. Here, applying the symbolic method of ordinal analysis [2] to the output sequence of inter-spike intervals (ISIs), we analyze under which conditions the interplay of coupling with noise strength, period and amplitude of the external signal affects the detection of a periodic weak signal that is applied to one of the neurons.
Julius B. Kirkegaard

Random Walks and Navigation of Colonies of Microorganisms

Julius B. Kirkegaard, Ambre Bouillant, Alan O. Marron, Kyriacos C. Leptos, and Raymond E. Goldstein
Department of Applied Mathematics and Theoretical Physics, Centre for Mathematical Sciences, University of Cambridge, Cambridge, United Kingdom

Abstract: Animals are multicellular in nature but evolved from unicellular organisms. In the closest relatives of animals, the choanoflagellates, the unicellular species Salpingoeca rosetta has the ability to form colonies, resembling true multicellularity. By tracking experiments and theory we determine the random walk statistics of such swimming colonies. Introducing oxygen-gradients, we demonstrate that despite no obvious cell-cell coordination, clusters of S. rosetta cells can navigate and do so by a stochastic strategy. The optimality of this strategy is discussed on theoretical grounds.

References:

Jeroen Rodenburg

Van't Hoff's law for active suspensions

Jeroen Rodenburg1, Marjolein Dijkstra2, and René van Roij1.

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2Soft Condensed Matter Group, Debye Institute for Nanomaterials Science, Utrecht University, Prininstonplein 5, 3584 CC Utrecht, The Netherlands

Abstract: In equilibrium, the osmotic pressure of a dilute suspension, in osmotic contact with a solvent reservoir via a semipermeable membrane, is given by Van't Hoff's law. In this contribution, we extend Van't Hoff's law to a suspension of swimmers, modelled as active Brownian particles. We show that the effect of activity is to increase the osmotic pressure. Remarkably, this increase turns out to depend on the details of the swimmer-membrane interaction potential. We rationalize our findings by arguing that the swimmers interacting with the membrane influence the solvent state of the bulk suspension.


Aleix Bassolas

Scaling in the recovery of cities from special events

Aleix Bassolas, Riccardo Gallotti, Fabio Lamana, and José Javier Ramasco
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Abstract: Public transportation system must cope with increased demand in exceptional crowd gathering events such as concerts, football matches or other localized events. Here we study the emergence of delays and the collapse of a public transport network under situation of stress using a packet based model. Depending on the routing protocols used we observe a different recovery of the city. We focus on understanding the recovery times with the amount of individuals and the place of the perturbation. We find that while the local dimension of the network dominates the scaling with the number of individuals, the recovery time of a zone depends on the time that an individual needs to walk to find a a non congested stop.

Sergio Cobo

Statistical inference in social dilemmas

Sergio Cobo, Jordi Duch, Roger Guimerà, and Marta Sales-Pardo
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Abstract: Our investigation focuses on the predictability of human beings when confronted to simple decision-making scenarios, as those considered in Game Theory. The data for this study is provided by a social experiment in which participants played different types of one-on-one games. Our approach to the problem classifies both participants and games in groups. Players and games are grouped together
according to their respective similarity as observed in the data. Using this methodology, we build a predictive model. Finally we improve its predictive power by imposing the requirement that similar games should belong to the same group.

Klotilda Nikaj

*Effects of network topology on crowd behavior*

Klotilda Nikaj and Margarita Ifti

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**Abstract:** In this paper is given a specific attention to the importance of a social complex system approaching the behavior analysis by presenting an agent-based social simulation implementation of a simple and generic behavior like conformist or anticonformist to observe the effect of the topology in the evolution of the system and internal dynamic. Two different types of agents-civilians, conformist and anticonformist are arranged in a network, provided with an individual behavior, that change behavior in function of those of their neighbors, which a variety of phenomena can be studied and validated against reality. Preliminary results suggest that we have interesting differences between the implemented complex topologies of the agent network if we consider the global or the local behavior.

Eder Batista Tchawou Tchuisseu

*Dynamics Demand Control applied to the electric power grid network*

E.B. Tchawou Tchuisseu, D. Gomila, and P. Colet

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**Abstract:** A critical condition for the operation of a power grid network is that its power generators remain synchronized. Disturbances can, however, prompt desynchronization, which is a process that has been involved in large power outages. In this work we first derive the condition under which the synchronous state of a power grid is stable, and compute the basin stability to quantify the stability of a node to recover its synchronization when perturbed. We also investigate the action of the frequency controller on the improvement of the basin of stability for an elementary network of two nodes, and then we apply random fluctuations of the electrical power to study the effects of Dynamics Demand Control (DDC) on the frequency and synchrony stabilization.

Lorenzo Palmieri

*The imitation flame*

L. Palmieri¹, D. Piovani², and H.J. Jensen¹

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**Abstract:** I will present a new model for the evolution of markets and the creation of financial bubbles that is based on the Tangled Nature model for evolutionary ecology. The aim is to show to which extent the process of imitation in financial markets can lead to increasing instabilities and formation of bubbles, with a consequent crash of the economy. In the model, each agent can adopt a strategy that determines how it interacts with other agents and with the global market, i.e. a strategy that is visible by each agent and that changes over time. Consequently, the system displays two kinds of transitions:

1) The first kind is represented by endogenous transitions, which are part of the internal dynamics that drives the system to more stable configurations through the creation of quasi-equilibrium states.

2) The second kind is represented by exogenous transitions, which are caused by the interactions between the agents in the system and the global market, that changes independently of the internal dynamics.

Interestingly, one can show that lowering the level of competition between companies that adopt the same strategy (i.e. increasing the level of imitation in the system) leads to a reduction in the number of endogenous transitions. However, the fact that the system appears to be more stable is just smoke and mirrors, since this apparent robustness just conceals an increased vulnerability to external changes, that will affect the magnitude of exogenous transitions and lead to financial crises.

Sabin Roman

*Mathematical modelling of societal growth and collapse*

Sabin Roman¹, Seth Bullock², Erika Palmer³, Markus Brede¹
Abstract: The poster will present a summary of my PhD results regarding societal dynamics of Easter Island and coupled societies [1], the Maya civilisation and emergence of network structures reflecting social inequality [2].

References:

Somaye Sheykhali
Predicting the group formation and evolution process in signed networks based on balance theory
Somaye Sheykhali¹, Amir Hossein Shirazi², and GholamReza Jafari²
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Abstract: Based on the classical theory of structural balance, relations between people on social networks is a combination of positive (friendly) and negative (antagonistic) interactions which undergo evolution in the path that leads to one of the final balanced states known as “Paradise” and “bipolar”. However, some parameters resist real networks from reaching the final balanced states. One of these factors is the relations that individuals tend to retain, regardless of the tensions it may cause and its overall costs. In this research, we study the effects of such links both configuration and also the number of them on the balanced or unbalanced final states. In addition, using Balance theory and the number of two-stars on each link (the pair of edges that form a triangle with the link), one can calculate the probability of each link to flip. In this way, we can predict the final state of the network.

Gemma Rosell-Tarragó
Dynamics coupling in centrality measures and transition to global excellent achievement
Gemma Rosell-Tarragó and Albert Díaz-Guilera,
ClabB (Complexity lab Barcelona) and UBICS (Universtat de Barcelona Institute of Complex Systems)

Abstract: An increasing number of studies from the field of psychology and pedagogy is defending the decisive role of interactions in the complex nature of humans, but especially children, development processes such as language acquisition, play and social interaction, emotions and conflicts, friendship formation among others. We develop and analyse a dynamic agent-based model of achievement and connect the role of both dynamic parameters as well as topology and centrality measures in order to identify and determine phase transitions between different regions: from lowest values to global excellent achievement stable state.

Adams Vallejos
Statistical model with a \( \kappa \)-deformed distribution.
A. Vallejos, H.F. Astudillo, and F. Borotto.
Universidad de Concepción, Chile.

Abstract: A multiple-agent based closed economic system is simulated to study the money distribution in it as a product of the introduction of family trading terms in binary commercial transactions. We pose an inhomogeneity hypothesis in the trading term, from which the system evolves into a \( \kappa \)-deformed Gamma-like solution [1], based on the deformed exponential and logarithm functions introduced by Kaniadakis [2]. Expressions for some inequality measures are also reported.

References: