XI Workshop GISC, February 7th

Sala de Grados, Facultad de Ciencias Físicas, Universidad Complutense de Madrid.
All the info is also on the web: https://sites.google.com/site/giscworkshopxi/

Program

10:00	Susanna Manrubia	*Early warning signals and hysteresis in epochal evolution induced by environmental stochasticity*
10:30	Pablo Catalán	*toyLIFE: a toy Universe for gaining insight into biological evolution*
11:00	Coffee Break ☕	
11:30	Esteban Moro	*Using Friends as Sensors to Detect Global-Scale Contagious Outbreaks*
12:00	Svetozar Nesic	*Thin Liquid Films vs Stochastic Thin Liquid Films*
12:30	Alvaro Rodríguez Rivas	*Observation of a tricritical wedge filling transition in the 3D Ising model by Monte Carlo simulations*
13:00	Lunch ☕	
14:30	Antonio Rodríguez	*Electron pairing in periodic potentials under an external electric field*
15:00	Pablo Rodríguez	*Repulsive Casimir Effect Between Chern Insulators*
15:30	Mario Amado	*Quantum point contact ballistic Josephson junctions: A building block for the detection of Majorana fermions*
16:00	Coffee break ☕	
16:30	Édgar Roldán	*Thermodynamics of symmetry breaking*
17:00	Armando Relaño	*Irreversibility without dissipation in isolated quantum systems*
17:30	Concluding remarks and Closing 0ㅠ	

Location X

Facultad de Ciencias Físicas is located at +40° 27' 4.29", -3° 43' 34.45" (40.451193,-3.726235) or Plaza de Ciencias, s/n. Universidad Complutense de Madrid.

<M> You can reach it by Metro and a 10 minute walk from either Ciudad Universitaria o Metropolitano stations.
EMT Buses 82, G, F and U stop at Plaza de Ciencias.

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Sala de Grados is on the first floor. Take the first corridor to the right, then first door on the left.

Wi-Fi connection))

If you have a working **Eduroam** connection at your institution, it should work at the Physics building out of the box. If you do not, or have problems connecting, try this:

1. Connect to **UCM-CONGRESO** wireless network and type in the network password "**congresos2011**" (without the quotes) and connect.
2. Open a browser and try to open whatever URL, ex. www.google.es
3. A form should appear. Insert Username: gisc@congreso.ucm.es and a new password "**workshop**"
4. After some seconds, you should be redirected to your chosen URL and be able to browse the net.

Coffee

Coffee will be served in **Sala de Profesores**, just at the end of the corridor from Sala de Grados.

Lunch

We will have lunch in the self-service downstairs. There will be some tables at our disposal. Price is 4.70 euros for the menu (1st and 2nd course, dessert, drink not included). You may also have just a first, or a second course and dessert for a reduced price.

Dinner

Dinner will be at Casa Mono, C/Tutor, 37. We have a reservation at 20:30 and will consist in an agreed menu for 35€ including drinks, which is posted at Workshop's web. www.casamonomadrid.com

Certificate.

If you would like a certificate to acknowledge your participation as *Speaker* (for justification of travel expenses, for example), please ask the organizer in advance (ldinis@fis.ucm.es).

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Abstracts

Susanna.Manrubia.CAB

Early warning signals and hysteresis in epochal evolution induced by environmental stochasticity

Complex dynamical systems may experience critical transitions where their dynamical behaviour or internal structure changes suddenly. In evolutionary dynamics, punctuated equilibria and epochal evolution might be instances of such a phenomenon. We use model fitness landscapes with epistasis and multiple peaks to show that population dynamics shows flickering under small stochastic environmental changes. This behaviour alerts of the existence of tipping points, where sudden transitions occur. Transitions at the genomic level appear as a generic phenomenon in constant and slowly driven landscapes affected by even slight stochasticity, and are preceded by early-warning signals. As the transition is approached, the time to reach mutation-selection equilibrium dramatically increases, leading to the appearance of hysteresis in the composition of the population. Several indicators are at reach with current technologies to anticipate epochal evolution, which can suppress adaptation if environmental changes are sufficiently faster than the typical adaptation time.

Pablo.Catalán.UC3M

toyLIFE: a toy Universe for gaining insight into biological evolution

The existence of neutral mutations has been known since the middle of the 20th century. With the recent access to genome sequences, however, the relevance of neutrality has become more patent. Many models have attempted to study the effects of this neutrality on evolution. Usually, these models assume that every organism has a genotype and an associated phenotype. If an organism mutates, it changes into another genotype, but not necessarily into another phenotype. Genotypes that are associated to the same phenotype are said to be in the same neutral network. If a genotype can suffer many mutations without changing its phenotype, it is said to be robust. Models that study these phenomena define various kinds of “genotypes” - RNA, proteins, gene regulatory networks (GRNs) – and a corresponding “phenotype” – secondary structure in the case of RNA and proteins, and gene expression patterns, in the case of networks. Then, various properties of these neutral networks are studied. However, there are many levels of degeneracy that contribute to neutrality and are not taken into account in these models. Besides, it is difficult to define mutations on “genotypes” such as gene networks: if mutations affect the DNA, how are these changes translated into gene network structure? To solve these problems, we have developed a toy model that includes several levels of organization in order to study the effect of degeneracy on mutational robustness.

We present here toyLIFE, a new framework designed to study the evolution of organisms at various levels of organization. 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.

Esteban.Moro.UC3M

Using Friends as Sensors to Detect Global-Scale Contagious Outbreaks

Recent research has focused on the monitoring of global-scale online data for improved detection of epidemics, mood patterns, movements in the stock market, political revolutions, box-office revenues, consumer behaviour and many other important phenomena. However, privacy considerations and the sheer scale of data available online are quickly making global monitoring infeasible, and existing methods do not take full advantage of local network structure to identify key nodes for monitoring. Here, we develop a model of the contagious spread of information in a global-scale, publicly-articulated social network and show that a simple method can yield not just early detection, but advance warning of contagious outbreaks. In this method, we randomly choose a small fraction of nodes in the network and then we randomly choose a "friend" of each node to include in a group for local monitoring. Using six months of data from most of the full Twittersphere, we show that this friend group is

more central in the network and it helps us to detect viral outbreaks of the use of novel hashtags about 7 days earlier than we could with an equal-sized randomly chosen group. Moreover, the method actually works better than expected due to network structure alone because highly central actors are both more active and exhibit increased diversity in the information they transmit to others. These results suggest that local monitoring is not just more efficient, it is more effective, and it is possible that other contagious processes in global-scale networks may be similarly monitored.

Svetozar.Nesic.UC3M

Thin Liquid Films vs Stochastic Thin Liquid Films

It has been shown [1] that, in the regime controlled by surface tension, the spreading dynamics of a thin viscous fluid droplet changes significantly when it is subjected to thermal fluctuations. Technically, this has been accomplished through the incorporation of appropriate stochastic terms [1] into the standard lubrication equation [2,3]. In practice, it leads to a modification of the classic Tanners law for spreading, with implications for Micro and Nanofluidic systems [4]. We have recently found a new law of spreading for the same kind of systems, but in the gravity-dominated regime. Moreover, in the deteministic case a finite contact angle is formed when a van der Waals attractive force is introduced to the system and we show that there is a slight change in contact angle when thermal fluctuations are taken into account.

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Alvaro.Rodríguez.US

Observation of a tricritical wedge filling transition in the 3D Ising model by Monte Carlo simulations

We report the observation of a tricritical filling transition by Monte Carlo simulations of a modified double wedge 3D Ising model [1,2]. This model is based on applying surface antisymmetric fields H_S acting on the walls of the upper and lower wedge, thereby each one favoring different bulk phases under coexistence conditions. The introduction of a new linear magnetic field h_l acting alone on the spins of the upper and lower corners of the double wedge, weakens the contribution to the free energy associated to the linear tension in those areas, increasing the effective interfacial potential at the system and driving the filling transition first-order. The obtained probability distribution function of the magnetization (PDFs) for different sizes of the system, show an excellent agreement with the theoretical prediction by the phenomenological theory developed by our group [3–6] to solve analytically the critical filling transition. For $h_l = H_S$ we reproduce the reported results for the critical filling [6]. For $h_l \approx 0$ the magnetization PDFs converges as system size grows to the predicted tricritical distribution. If $h_l \approx -0.5$ the observed results are consistent with a first-order transition scenario. These results agree with the phenomenology predicted by our theory, showing that the line tension associated with the wedge becomes a relevant field of the system in the sense of the renormalization group.

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Antonio.Rodríguez.UPM

Electron pairing in periodic potentials under an external electric field

We study the semiclassical dynamics of interacting electrons in a biased crystal lattice. A complex dynamical scenario emerges from the interplay between the Coulomb and the external electric fields. When the electrons are far apart, the Coulomb potential may be small compared to the external potential and the electrons oscillate with effective Bloch frequencies, determined by the local electric field. In the opposite case, nearby electrons either separate or form a bound pair, depending on the initial energy compared to the band width. The pair due to the Coulomb field is stable even in the absence of the external field.

Pablo.Rodríguez.LPTMS

Repulsive Casimir Effect Between Chern Insulators

We theoretically predict that the Casimir force in vacuum between two Chern insulator plates can be repulsive (attractive) at long distances whenever the sign of the Chern numbers characterizing the two plates are opposite (equal) and can be further tuned to attraction by electrostatic doping. We calculate and take into account the full optical response of the plates and argue that such repulsion is a general phenomena for these systems as it relies on the quantized zero frequency Hall conductivity. At the end, we discuss the possibility of measuring repulsion in the lab with recently discovered Chern insulators, as thin films of Cr-doped (Bi,Sb)2 Te3 and theorically predicted ones.

Mario.Amado.NEST

Quantum point contact ballistic Josephson junctions: A building block for the detection of Majorana fermions

The possibility to realize finely-tunable ballistic Josephson nano-junctions (JJs) in a high-mobility two-dimensional electron gas (2DEG) would open novel research avenues for the investigation of Majorana Fermions[1]. So far the majorities of the experimental studies have focused on systems based on InAs[2,3] and InSb[4] nanowires, which are not ballistic. 2DEG InAs-based heterostructures, on the other hand, would allow the fabrication of sub-micrometric ballistic JJs in which, contrary to nanowires, the geometry could be tailored at will. In this contribution we present our ongoing efforts[5,6] towards the creation of this novel class of hybrid ballistic nano devices as building blocks for the detection and exploitation of Majorana excitations.

We focus in particular on two geometries: In a quantum point contact ballistic JJ the continuous modification of the magneto-electrical Josephson interference pattern is achieved by depleting the weak link using etched side gates and an external perpendicular magnetic field[5]. For wide junctions the supercurrent presents a Fraunhofer-like interference pattern whereas by shrinking electrostatically the normal region the periodicity evolves continuously to a monotonic decay. We can, therefore, explore for the first time both the wide- and narrow-junction limits within the same JJ in comparison with previous works where only one of the two limits were obtained[7]. In the case of a quantum ring-based ballistic JJ the exploitation of its geometry would give us the possibility to generate a controllable π-junction that might be used for the investigation of this elusive quasiparticle.

References

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Édgar.Roldán.ICFO

Thermodynamics of symmetry breaking

A symmetry breaking (SB) involves an abrupt change in the set of microstates that a system can explore. This change has unavoidable thermodynamic implications. According to Boltzmann's microscopic interpretation of entropy, a shrinkage of the set of compatible states implies a decrease of entropy, which eventually needs to be compensated by dissipation of heat and consequently requires work. Examples are the compression of a gas and the erasure of information. On the other hand, in a spontaneous SB, the available phase space volume changes without the need for work, yielding an apparent decrease of entropy. Here we show that this decrease of entropy is a key ingredient in the Szilard engine and Landauer's principle and report on a direct measurement of the entropy change along SB transitions in a Brownian particle. The SB is induced by a bistable potential created with two optical traps. The experiment confirms theoretical results based on fluctuation theorems, allows us to reproduce the Szilard engine extracting energy from a single thermal bath, and shows that the signature of a SB in the energetics is measurable, providing new methods to detect, for example, the coexistence of metastable states in macromolecules.

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Armando.Relaño.UCM

Irreversibility without dissipation in isolated quantum systems

Equilibrium states in isolated quantum systems can be more complex than the usual statistical behavior. In system close to integrability, equilibrium states keep large amounts of memory about the initial condition in a set of extra commuting constants; in systems with a global discrete symmetry, the equilibrium state can depend on the degree of symmetry-breaking of the initial condition. We use this last kind of systems to show that there exist cyclic processes in which the energy is totally recovered, but some information about the initial state is irreversibly lost. So, this extra information has to be included in a proper definition of the entropy for this kind of systems.