Universitat de Barcelona

# UBICS Institute of Complex Systems

## Annual Report

## 2020


UBICS

Institute of Complex Systems

Universitat de Barcelona

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# UBICS Institute of Complex Systems
# Annual Report
# 2020

# FOREWORD

The Institute of Complex Systems (UBICS), created in 2016, is an interdisciplinary research institute of the Universitat de Barcelona that currently hosts more than 60 senior and young researchers.

At the UBICS, physicists, mathematicians, neurologists, psychologists, historians, linguists and computer scientists work together to advance research in a broad range of disciplines. The UBICS research covers from the most basic aspects of complex systems to applications of new knowledge at the interface between matter, life and social sciences.

The Institute also aims to integrate young researchers with a diversity of profiles with the goal to encourage their training in this multidisciplinary challenging environment.

In this annual report, we present both a global picture of the research conducted at the Institute and the results of the scientific effort in terms of publications, funds, and activities.

*Albert Díaz Guilera*
*Director*

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# INSTITUTE STRUCTURE

# 1 INSTITUTE STRUCTURE

## Organization chart


## Executive Board

Díaz Guilera, Albert
→ *Director*

Soriano Fradera, Jordi
→ *Secretary*

Casademunt Viader, Jaume

Miguel López, M. del Carmen

Serrano Moral, Maria Ángeles

Taulé Delor, Maria

## Council

Casademunt Viader, Jaume

De Frutos Manzanares, Laia

Díaz Guilera, Albert

Massip Bonet, Maria Àngels

Miguel López, M. del Carmen

Montalà Flaquer, Marc

Muñoz Andirkó, Alejandro

Ortín Rull, Jordi

Palassini, Matteo

Pérez Vicente, Conrado Juan

Revilla Calvo, Víctor

Serrano Moral, Maria Ángeles

Soriano  Fradera, Jordi

Taulé Delor, Maria

Tierno, Pietro

Teller Amado, Sara

## Advisory Board

Byrne,  David S.
→ *Durham University, UK*

Cugliandolo, Leticia
→ *Université Pierre et Marie Curie - Paris VI*

Joanny, Jean Francois
→ *ESPCI, École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris*

Manrubia, Susanna
→ *Spanish National Centre for Biotechnology (CSIC)*

Vespignani, Alessandro
→ *MOBS Lab - Laboratory for the Modeling of Biological and Socio-technical Systems*

## Research Groups

### GRUP DE FÍSICA NO-LINEAL (2017SGR-1061)

*http://www.ecm.ub.es/nonlinphys/english/index.html*

| | |
|---|---|
| Casademunt Viader, Jaume | Física de la Matèria Condensada |
| Fernandez de las Nieves, Alberto | Física de la Matèria Condensada |
| Ibañes Miguez, Marta | Física de la Matèria Condensada |
| Ortín Rull, Jordi | Física de la Matèria Condensada |
| Planet Latorre, Ramon | Física de la Matèria Condensada |
| Sancho, José Maria | Física de la Matèria Condensada |
| Soriano Fradera, Jordi | Física de la Matèria Condensada |
| Tierno, Pietro | Física de la Matèria Condensada |

### GRUP DE FÍSICA DE BIOMOLÈCULES I SISTEMES PETITS (2017SGR-1614)

*http://www.ffn.ub.es/ritort/index.html*

| | |
|---|---|
| Palassini, Matteo | Física de la Matèria Condensada |

### GRUP DE FÍSICA ESTADÍSTICA (2017SGR-884)

*http://www.ffn.ub.edu/statphysgroup*

| | |
|---|---|
| Levis Sotomayor, Demian | Física de la Matèria Condensada |
| Miguel López, Maria del Carmen | Física de la Matèria Condensada |
| Pagonabarraga Mora, Ignasi | Física de la Matèria Condensada |
| Reguera López, David | Física de la Matèria Condensada |

### COMPLEXITY LAB BARCELONA (CLabB) (2017SGR-1064)

*http://www.clabb.eu*

| | |
|---|---|
| Boguñà Espinal, Marian | Física de la Matèria Condensada |
| Bonhoure, Isabelle | Física de la Matèria Condensada |
| Cozzo, Emanuele | Física de la Matèria Condensada |
| Díaz Guilera, Albert | Física de la Matèria Condensada |
| Masoliver García, Jaume | Física de la Matèria Condensada |
| Montero Torralbo, Miquel | Física de la Matèria Condensada |
| Perelló Palou, Josep | Física de la Matèria Condensada |
| Pérez Vicente, Conrado Juan | Física de la Matèria Condensada |
| Peter, Franziska | Física de la Matèria Condensada |
| Prignano, Luce | Física de la Matèria Condensada |
| Serrano Moral, Maria Ángeles | Física de la Matèria Condensada |

### MATERIALS: TRANSICIONS DE FASE I SISTEMES MULTIESCALA (2017SGR-0598)

*http://www.ub.edu/web/ub/ca/recerca_innovacio/recerca_a_la_UB/grups/fitxa/M/MATEFASE/index.html?*

| | |
|---|---|
| Vives Santa-Eulalia, Eduard | Física de la Matèria Condensada |

### GRUP DE COMPLEXITAT, COMUNICACIÓ I SOCIOLINGÜÍSTICA (2017SGR175)

*http://www.sociocomplexitat.ub.edu*

| | |
|---|---|
| Bastardas i Boada, Albert | Filologia Catalana i Lingüística General |

### GRUP D'ESTUDI DE LA VARIACIÓ (2017SGR-94)

*http://www.ub.edu/GEV*

| | |
|---|---|
| Massip Bonet, Àngels | Filologia Catalana i Lingüística General |

### CENTRE PER A L'ESTUDI DE LA INTERDEPENDÈNCIA PROVINCIAL A L'ANTIGUITAT CLÀSSICA (CEIPAC) (2017SGR-512)

*http://ceipac.ub.edu*

| | |
|---|---|
| Garcia Sanchez, Manel | Història i Arqueologia |
| Remesal Rodríguez, José | Història i Arqueologia |
| Revilla Calvo, Víctor | Història i Arqueologia |
| Aguilera Martin, Antonio | Història i Arqueologia |
| Pons Pujol, Luís | Història i Arqueologia |

### PSICOLOGIA QUANTITATIVA (2017SGR-269)

*http://www.ub.edu/gteaap*

| | |
|---|---|
| Guàrdia Olmos, Joan (1/2) | Psicologia Social i Quantitativa |
| Peró Cebollero, Maribel (1/2) | Psicologia Social i Quantitativa |

### SISTEMES COMPLEXOS I ESPORT (2017SGR-1637)

*http://www.inefc.cat/inefc/AppPHP/main.php?id_pagina=183*

| | |
|---|---|
| Balagué Serré, Natàlia | INEFC- Educació Física |
| Mateu Serra, Mercè | INEFC- Educació Física |

### CENTRE DE LLENGUATGE I COMPUTACIÓ (CLIC) (2017SGR-341)

*http://clic.ub.edu*

| | |
|---|---|
| Boeckx, Cedric | Filologia Catalana i Lingüística General |
| Martí Antonín, Maria Antònia | Filologia Catalana i Lingüística General |
| Rodríguez Santiago, Inmaculada | Matemàtiques i Informàtica |
| Salamó Llorente, Maria | Matemàtiques i Informàtica |
| Taulé Delor, Maria | Filologia Catalana i Lingüística General |

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# UBICS IN FIGURES

# 2 UBICS IN FIGURES

## UBICS

**45** Senior Researchers

**21** Early Stage Researchers

**10** External Members

**1** Services and Administration Personnel

## ICREA

Catalan Institution For Research And Advanced Studies

**3** Research Professors

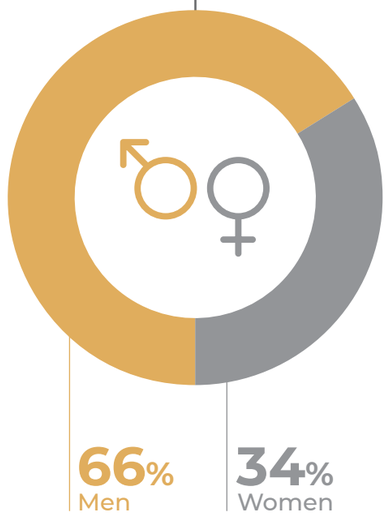
**3** Academia Professors

## ERC

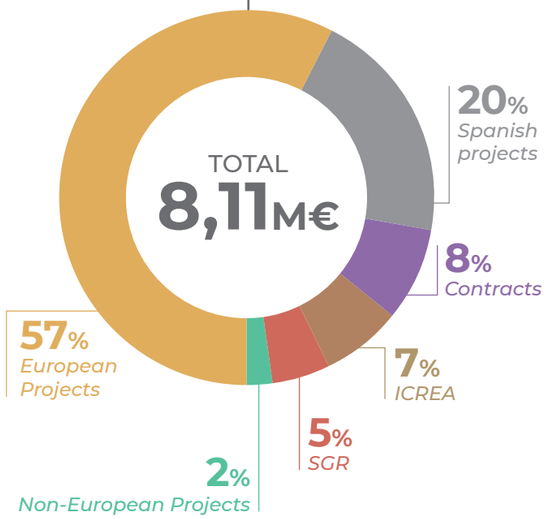
European Research Council

**1** Consolidator Grant

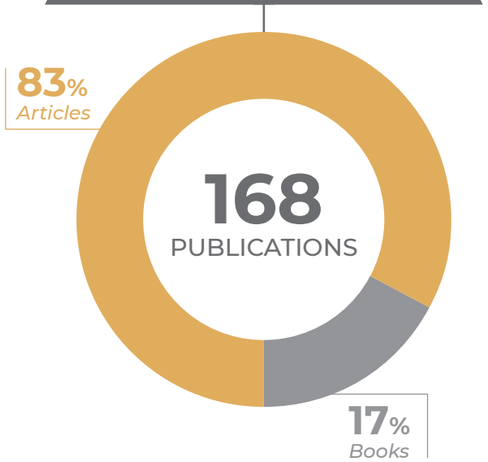
## GENDER



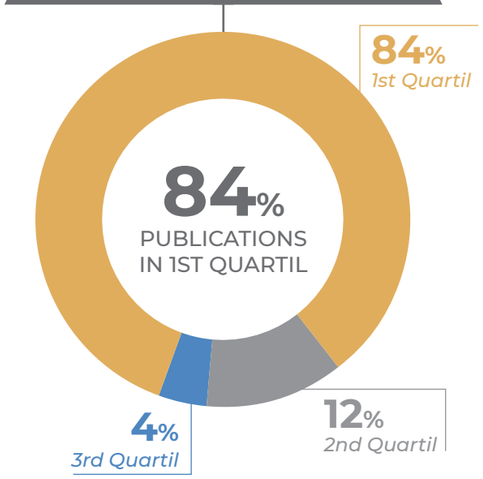

## FUNDING




## PUBLICATIONS




## ARTICLES




## Where to find us

Martí i Franquès, 1, 08028 Barcelona | e-mail: ubics@ub.edu | web: ubics.ub.edu | twitter: @UB_ICS

### Campuses

| Mundet Campus | Barcelona Knowledge Campus | Humanities Campus |
|---|---|---|
| Passeig de la Vall d'Hebron, 171<br>08035 Barcelona | Baldiri Reixac, 2<br>08028 Barcelona | Gran Via Corts Catalanes, 585<br>08007 Barcelona |

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# UBICS STAFF

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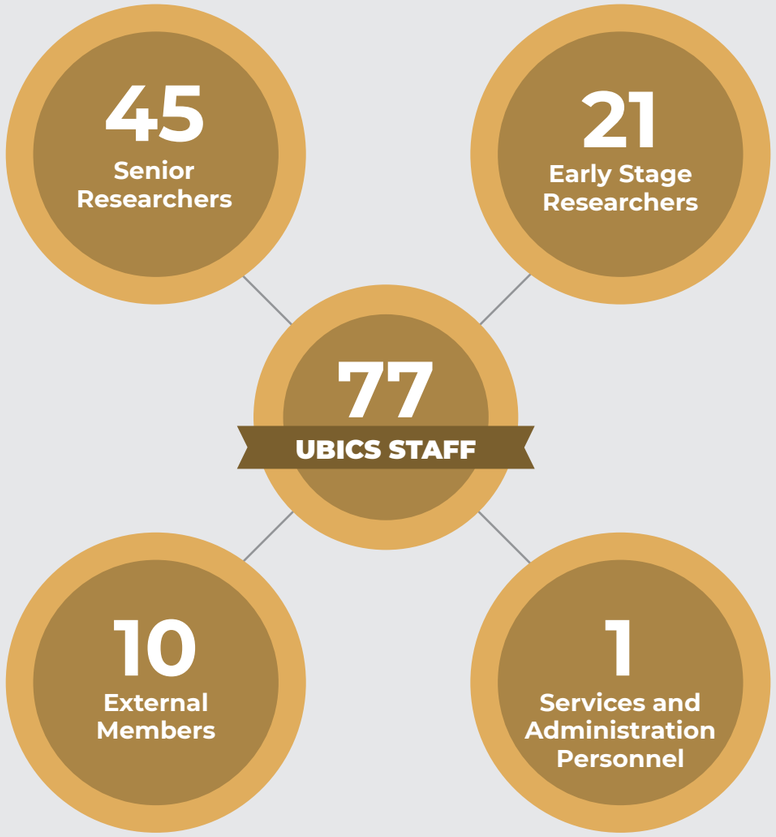


## 45 SENIOR RESEARCHERS

- **Aguilera Martin, Antonio**
  *Departament d'Història i Arqueologia*
- **Almagro Blanco, Pedro**
  *Departament Física de la Matèria Condensada*
- **Bastardas Boada, Albert**
  *Departament Filologia Catalana i Lingüística General*
- **Boeckx, Cedric**
  *Departament Filologia Catalana i Lingüística General*
- **Boguñà Espinal, Marian**
  *Departament Física de la Matèria Condensada*
- **Borrego Iglesias, Carlos**
  *Departament de Matemàtiques i Informàtica*
- **Casademunt Viader, Jaume**
  *Departament Física de la Matèria Condensada*
- **Cozzo, Emmanuelle**
  *Departament Física de la Matèria Condensada*
- **Díaz Guilera, Albert**
  *Departament Física de la Matèria Condensada*
- **Hernández Gonzalez, Jerónimo**
  *Departament de Matemàtiques i Informàtica*
- **Farrús Cabeceran, Mireia**
  *Departament de Filologia Catalana i Lingüística General*
- **Fernández Nieves, Alberto**
  *Departament de la Física de la Matèria Condensada*
- **Guàrdia Olmos, Joan**
  *Departament Psicologia Social i Psicologia Quantitativa*
- **Hernández Hernández, Raúl Josué**
  Departament de Física de la Materia Condensada
- **Ibañes Míguez, Marta**
  *Departament Física de la Matèria Condensada*
- **Levis Sotomayor, Demian Francisco**
  *Departament Física de la Matèria Condensada*
- **Lozano Pérez, Sergio**
  *Departament d'Història Econòmica, Institucions, Política i Economia Mundial*
- **Malvestio, Irene**
  *Departament de Física de la Matèria Condensada*
- **Martí i Antonín, M. Antònia**
  *Departament Filologia Catalana i Lingüística General*
- **Masoliver García, Jaume**
  *Departament Física de la Matèria Condensada*
- **Massip Bonet, Maria Àngels**
  *Departament Filologia Catalana i Lingüística General*
- **Miguel López, M. Del Carmen**
  *Departament Física de la Matèria Condensada*
- **Montero Torralbo, Miquel**
  *Departament Física de la Matèria Condensada*
- **Ortín Rull, Jordi**
  *Departament Física de la Matèria Condensada*
- **Pagonabarraga Mora, Ignacio**
  *Departament Física de la Matèria Condensada*
- **Palassini, Matteo**
  *Departament Física de la Matèria Condensada*
- **Perelló Palou, Josep**
  *Departament Física de la Matèria Condensada*
- **Pérez Vicente, Conrado Juan**
  *Departament Física de la Matèria Condensada*
- **Peró Cebollero, Maribel**
  *Departament Psicologia Social i Psicologia Quantitativa*
- **Peter, Franziska**
  Departament de Física de la Matèria Condensada
- **Planet Latorre, Ramon**
  *Departament Física de la Matèria Condensada*
- **Pons Pujol, Luis**
  *Departament Història i Arqueologia*
- **Puertas Prats, Eloi**
  *Departament de Matemàtiques i Informàtica*
- **Reguera López, David**
  *Departament Física de la Matèria Condensada*
- **Remesal Rodríguez, José**
  *Departament Història i Arqueologia*
- **Revilla Calvo, Víctor**
  *Departament Història i Arqueologia*

## SENIOR RESEARCHERS

- **Rodríguez Santiago, Inmaculada**
  *Departament Matemàtiques i Informàtica*
- **Salamó Llorente, Maria**
  *Departament Matemàtiques i Informàtica*
- **Sancho Herrero, José María**
  *Departament Física de la Matèria Condensada*
- **Serrano Moral, Maria Ángeles**
  *Departament Física de la Matèria Condensada*
- **Soriano Fradera, Jordi**
  *Departament Física de la Matèria Condensada*
- **Taulé Delor, Maria**
  *Departament Filologia Catalana i Lingüística General*
- **Tierno, Pietro**
  *Departament Física de la Matèria Condensada*
- **Vives Santa-Eulalia, Eduard**
  *Departament Física de la Matèria Condensada*
- **Zheng, Muhua**
  *Departament de la Física de la Matèria Condensada*

## 21 EARLY STAGE RESEARCHERS

- **Cañete Masse, Cristina**
  *Departament Psicologia Social i Psicologia Quantitativa*
- **Cigarini, Anna**
  *Departament Física de la Matèria Condensada*
- **De Frutos Manzanares, Laia**
  *Departament d'Història i Arqueologia*
- **Farràs Permanyer, Laia**
  *Departament de Psicologia Social i Psicologia Quantitativa*
- **Fernandez Lopez, Clara**
  *Departament de Física de la Matèria Condensada*
- **Ferri Condeminas, Irene**
  *Departament Física de la Matèria Condensada*
- **Gómez Robledo, Maria Aide**
  *Departament d'Història i Arqueologia*
- **Larroya Paixà, Ferran**
  *Departament de Física de la Matèria Condensada*
- **Mercadal Melia, Josep**
  *Departament de Física de la Matèria Condensada*
- **Montalà Flaquer, Marc**
  *Departament Psicologia Social i Psicologia Quantitativa*
- **Moriano Palacios, Juan**
  *Departament de Filologia Catalana i Lingüística General*
- **Muñoz Andirkó, Alejandro**
  *Departament Filologia Catalana i Lingüística General*
- **Ortiz Castillo, Elisenda**
  *Departament Física de la Matèria Condensada*
- **Ostinato, Mattia**
  *Departament de la Matèria Condensada*
- **Palacin Copado, Carlos**
  *Departament d'Història i Arqueologia*
- **Rodríguez Gallo, Carolina**
  *Departament Física de la Matèria Condensada*
- **Rosell Tarragó, Gemma**
  Departament Física de la Matèria Condensada
- **Sánchez Cobos, Agustín**
  *Departament Física de la Matèria Condensada*
- **Theofanopoulou, Constantina**
  *Departament Filologia Catalana i Lingüística General*
- **Tiago Martins, Pedro**
  *Departament Filologia Catalana i Lingüística General*
- **Van der Kolk, Jasper**
  Departament de la Matèria Condensada
- **Venelin Orlinov, Kovatchev**
  *Departament Filologia Catalana i Lingüística General*

## 10 EXTERNAL MEMBERS

- **Balaguer, Natàlia**
  *INEFC - Institut Nacional d'Educació Física de Catalunya*
- **Baldeon, Johan Paul**
  *Departament Matemàtiques i Informàtica*
- **Bermúdez Lorenzo, Juan Manuel**
  *URJC- Departamento de Ciencias de la Educación, Lenguaje, Cultura y Artes*
- **Bonhoure, Isabelle**
  *FBG - Fundació Bosch i Gimpera*
- **Corvera Poiré, Eugenia**
  *UNAM - Universidad Nacional Autónoma de México*
- **González Vázquez, Mateo**
  *Departament d'Història i Arqueologia*
- **Martin Oliveres, Antoni**
  *Departament d'Història i Arqueologia*
- **Pérez González, Jordi**
  *UdG- Departament d'Història i Història de l'art*
- **Prignano , Luce**
  *FBG - Fundació Bosch i Gimpera*
- **Vázquez, Pablo**
  *FBG - Fundació Bosch i Gimpera*

## 1 SERVICES AND ADMINISTRATION PERSONNEL

- **Teller Amado, Sara**

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# RESEARCH LINES

# 4 RESEARCH LINES

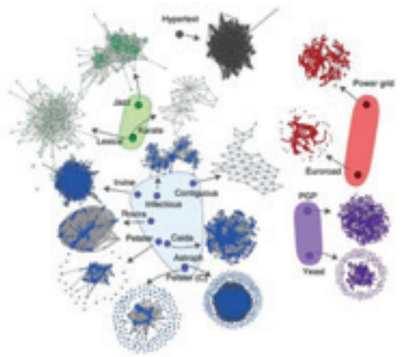
## Foundations

**An important number of the Institute's researchers are carrying out their own research on the identification and description of the general principles and key mechanisms that govern complex systems. This includes, on the one hand, the study of theoretical aspects within the framework of network science and the modeling of the basic agents that make up a system and the study of emerging behaviors through their interactions. On the other hand, the analysis of many complex systems often involves processing a large amount of information, which requires the continuous development of tools in the context of so-called "Big Data", with clear applications in the context of the Institute. Finally, a large number of complex systems are intrinsically dynamic, that is, they evolve over time. Problems ranging from fluid dynamics and plasticity in neural networks and metabolic networks to the dynamics of social networks, all require the development of common tools. This is a fundamental aspect that focuses the research activities carried out by the members of the Institute. Not to mention the field of Statistical Physics, from which most of the physics researchers at the Institute come, which still has fundamental problems to be solved.**

### Statistical Physics

Statistical Physics techniques are at the basis of our approach to the study of complex systems. Statistical Physics uses the methods of probability theory and statistics to bridge the gap between the microscopic properties of individual atoms and molecules and the macroscopic or bulk properties of materials.

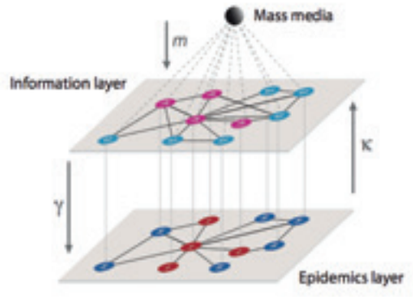
At the Institute, statistical physicists generalize the applicability of this discipline by studying other types of microscopic elements




that interact to give place to collective macroscopic phenomena. Apart from the philosophical approach, some specific techniques that we have adapted for the study of complex systems are statistical models of anomalous diffusion and transport, models for the study of phase transitions and criticality --such as the Ising model--, and renormalization group theory.

### Networks

Network Science focuses on the study of interactions as graph representations of complex systems. Complex networks display patterns of connection that are neither purely regular nor totally random, and are common to many real systems in differents domains. These non-trivial topological features, combined with dynamical processes and evolutionary changes, explain many of the emergent phenomena observed in complex systems.




Researchers at the Institute are working on the development of theoretical and computational tools and methodologies for the study of complex networks, and on their application to the construction of predictive models for physical, biological, and social phenomena. Among the Network Science topics studied at UBICS are network geometry, multilayer networks and dynamical processes, and our research also extends to a wide range of real complex systems, including the molecular networks of interactions in cells, the brain, online and offline social networks, the Internet, and international trade webs.


## Dynamical Systems

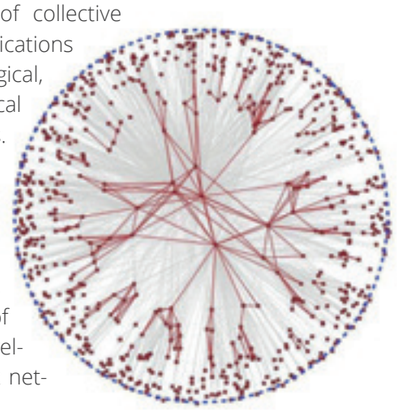
Complex systems are inherently dynamic and both properties and processes change over time. Dynamical systems theory provides a mathematical framework for treating time dependence in complex systems, typically involving continuous time and stochastic or random events. Apart from time dependence in geometrical space, it is common to deal with extended versions for systems with discrete elements. This serves, for instance, to study dynamical processes in networks.

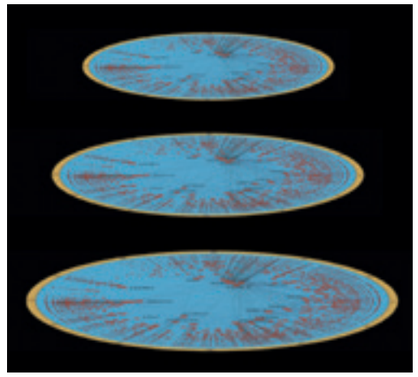
Among the different dynamical processes, the phenomenon of synchronization has received a lot of attention, becoming one of the paradigmatic examples of the emergence of collective properties with applications in physical, biological, chemical, technological and social systems. UBICS researchers have devoted great efforts to understanding synchronization phenomena, taking advantage of the most recent developments in complex network science.

## Data Science

The study of real complex systems requires the curation, structuring, filtering, analysis, and visualization of large amounts of empirical and experimental data. The main goal is to extract knowledge from data by combining a data-driven approach, based on different statistical, data mining, and machine learning techniques, with analytic and computational methodologies that allow us to construct and simulate meaningful models with predictive power.

Applications have been developed at the Institute to be applied in fields ranging from language structure to social networks and urban mobility. Concretely, UBICS researchers have proposed a Collaborative Conversational Recommender framework, in which a synchronous and online 3D interface for multiple consumers integrates with a recommender system. Our work has also focused on game-based learning tools for both teachers and students. In the case of teachers, mechanisms for the design of educational games have been proposed. Moreover, related to social awareness (i.e., energy awareness), there are implementations of several gamified solutions that incorporate virtual agents to motivate and educate children in energy issues. These virtual agents communicate with users in natural language.







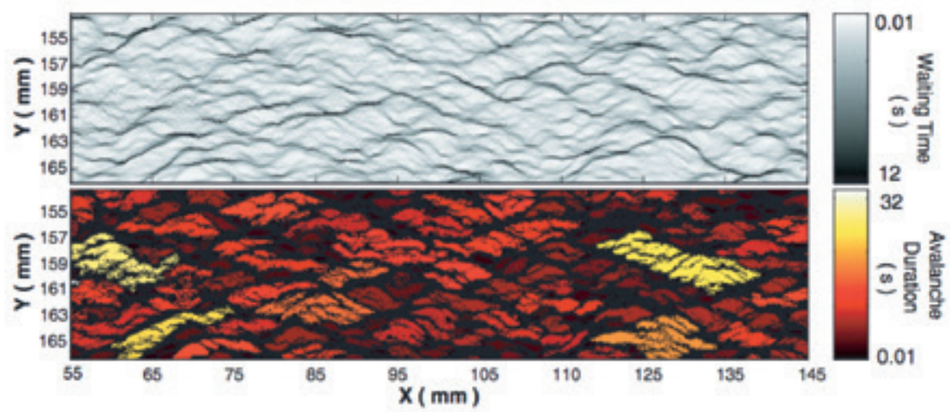
# Science Of Matter

**Condensed matter systems exhibiting phase transitions and criticality are probably the very first examples of complex systems. In such situations, the system's response to external changes is not a simple superposition of the response of its constituents but rather an emerging collective property. Understanding it through the use of techniques from the fields of statistical and nonlinear physics increases its predictability and allows for the design of new and useful tailored materials. Indeed, a broad variety of physical and chemical systems and processes can be described as complex systems, and their degree of complexity demands the adaptation or the extension of currently existing tools to new situations.**

**An important field of research within the science of complex matter focuses on soft matter materials, which include colloids, polymers and gels, complex fluids, and biological materials. What these systems have in common is that they are easily deformed by external forces and that their behavior is governed by weak interactions at energy scales comparable to thermal energy. While research on soft matter has traditionally been focused on synthetic materials, rapid developments in molecular biology have provided evidence that soft interactions and fluctuation phenomena also play a vital role in biology. Soft materials display complex spatiotemporal responses and special physical properties, including high deformability and complex rheology, which makes them very attractive for technological applications, in particular, in the food and cosmetics industries. Regarding complex materials, it is also worth emphasizing the interest of the research community in developing intelligent materials, i.e. materials that are able to adapt their properties or structure according to specific needs or to environmental changes (in some cases mimicking natural materials and processes), and thus have a huge technological and industrial impact.**

## Soft Matter

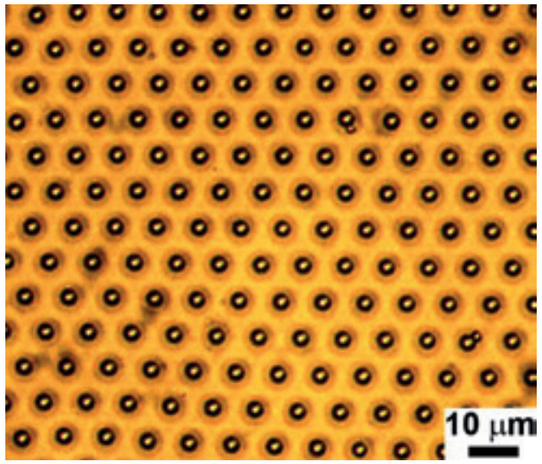
Among the extensive variety of soft matter materials, colloidal systems, i.e. fluid suspensions of micron-sized polymer spheres, are particularly interesting, not only for their ubiquitous nature (colloids are present in creams, foams, smoke, paints, etc..), but also because they provide a rich playground for basic Condensed Matter Physics. Colloidal particles display Brownian motion, size in the visible wavelength and dynamics in experimentally accessible time frames. Yet interactions in colloidal systems can be easily tailored in strength and range via the application of rela-



tively small external fields. These striking features make colloids excellent models for the study of behavior and dynamics in dissipative systems with intrinsic noise, i.e. systems broadly distributed in many physical, chemical and biological disciplines.

UBICS researchers have recently discovered a new scenario for a first-order phase transition that occurs via a complete inversion of the system energy landscape. This phenomenon was termed the "landscape inversion phase transition" (LIPT) and was observed by applying an external magnetic field to an assembly of paramagnetic colloids two dimensionally confined above a stripe patterned magnetic substrate. Another recent breakthrough in the optical manipulation of colloidal microspheres demonstrated the possibility of confining a cluster of particles into a circular assembly, and rotating the outer particle corona via laser tweezing. This colloidal model system was used as a microscopic clutch to investigate the transmission of torque through soft materials at the nanoscale. Another line of UBICS research focuses on understanding how curved colloidal crystalline shells can adapt their shape and resist failure. This is of fundamental importance because these structures are at the forefront of the drive to fabricate new functionalized self-assembled materials. Some biological structures, such as virus capsids, also represent nearly-ideal examples of spherical crystallography. Studies by UBICS researchers highlight the fundamental role played by geometrically necessary crystal defects, such as the pentagons in a soccer ball, in controlling mechanical stability and plastic deformation of these colloidal shells.

## Complex flows and complex fluids




Complex fluids are seemingly homogeneous at macroscopic scale, but they are disordered at the microscopic scale and possess structure at intermediate scales. As a result their deformation and flow response to external solicitations is usually very different from that of conventional liquids and solids. Examples of complex fluids include polymeric melts or solutions, glasses, gels and foams. Complex fluids are ubiquitous in industry (e.g. in food and cosmetics) and in living organisms (e.g. blood and mucus).

Researchers at UBICS study hydrodynamic flows in complex scenarios that involve both Newtonian and complex fluids, and either bulk or interfacial instabilities such as vortex ring formation and viscous fingering. Combining experimental work, statistical analysis and theoretical modeling, they also explore the morphological and dynamic properties of two-phase displacements in disordered media, in which scale-invariance, non-Gaussian velocity fluctuations, avalanches, and intermittency can be observed. Current lines of research include the study of (i) the origin of instabilities (vortex ring formation and elastic turbulence) in the oscillatory pipe flow of non-Newtonian fluids, and (ii) the basic mechanism behind hysteresis in drainage/imbibition displacements in laboratory models of single pores.



## Active Matter

Condensed matter systems composed of self-propelled units operating far from thermodynamic equilibrium belong to the realm of active matter. Such active "particles" possess internal degrees of freedom that allow them to self-propel by extracting energy from their environment and dissipating it to move in a preferred direction. Interaction between these elements originates patterns of self-organization and characteristic flows similar to those found in natural flocking systems. Flocking is very frequent in nature. Indeed, the phenomenon can be observed at a broad range of length scales, from mammal herds and fish schools to bacteria colonies and cellular migrations. These systems give rise to new fundamental questions and the possibility of synthesizing new types of smart materials, for example, those based on assemblies of filamentous proteins and molecular motors.
Researchers at UBICS are investigating how biological cells sense and respond to mechanical stimuli, which involves the interplay of several cytoskeletal constituents: primarily filaments, such as actin microfilaments or microtubules, crosslinking proteins, and molecular motors. The transport of various types of cargoes in cells is, for example, based on molecular motors moving along the cytoskeleton. Often, these motors work in teams rather than as isolated molecules. Our studies attempt to understand the effects of elastic coupling on (i) the dynamics of motor complexes (small number of motors), and (ii) the mechanical stability of actin assemblies. Another line of research investigates the propulsion of colloidal systems at the micro/nanoscale. It has recently been demonstrated that elongated DNA-linked paramagnetic colloids subjected to external precessing fields are capable to propel in a controlled way in viscous fluids. Future investigations will focus on determining interactions among micro-swimmers and the role played by hydrodynamic interactions, and on implementing optical forces to test swimmers' performance and their constrained motion into microscopic pores or microfluidic networks. As stated before, flocking is a phenomenon by which a general class of self-propelled entities, using limited environmental information and simple rules, organize themselves into an ordered state of motion. In some cases, interactions among moving entities are quite heterogeneous, and this feature has an important impact on collective motion. The presence of heterogeneous social interactions, naturally represented in terms of social networks, has been, for instance, observed in mammals and fish. UBICS researchers are also investigating the effects of such a broad class of interactions among group members, as well as behavioral contagion, on flocking dynamics.

## Smart Materials

The design of new useful tailored materials benefits from its fundamental understanding using techniques from statistical and nonlinear physics. In many cases an efficient design implies the control of the amount of disorder as well as the use of multiscale modelling approaches from the nanoscale to large thermodynamic scales.

Our research focuses on the study of functional materials for sensors and actuators, super-elastic materials, shape memory alloys, ferrocaloric materials for efficient refrigeration, as well as the problem of critical failure of materials under compression (up to geophysical scales)

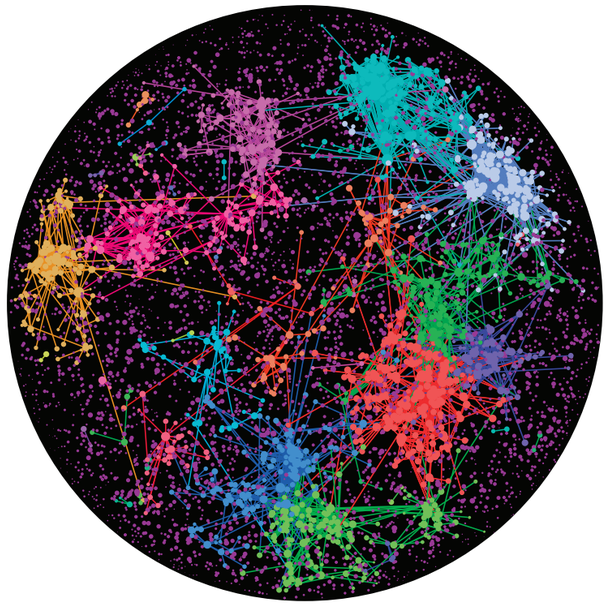
# Life Sciences

**Biological systems, both for their intrinsic wealth and because of their importance, have received special attention from the complex systems viewpoint. Much of the Institute's research activity is geared towards solving a large variety of problems in the biological context, and at diverse spatial and temporal scales. Investigations cover experimental, computational and theoretical approaches. Research areas include the study of fundamental molecular mechanisms, genomics and proteomics, the generation of forces and the mechanics of cells and tissues, morphogenesis and development, systems biology at the cellular level, and neuroscience. For the latter, the Institute houses its own laboratories. Additionally, the associated studies carried out at the level of microorganisms and tissues exhibit, thanks to their fundamental perspective, a clear connection with the research conducted in active matter, an area that is also central to the Institute.**

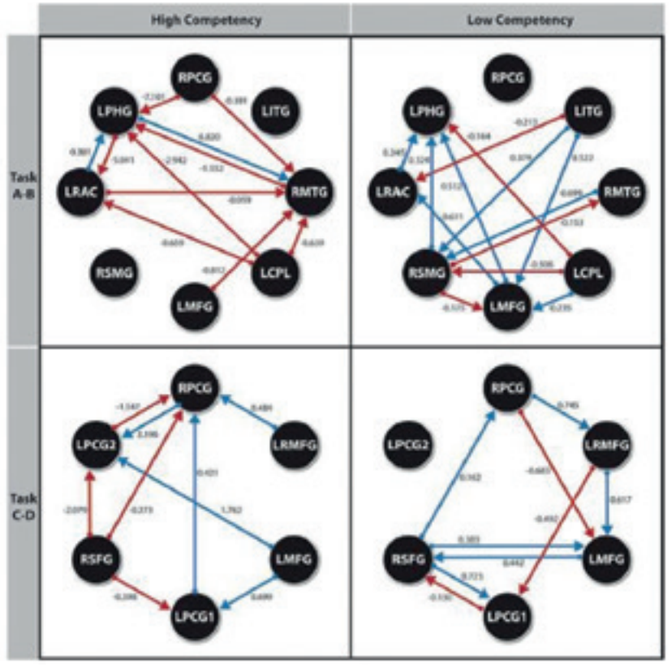
## Molecular Biophysics

The advent of nanotechnologies in recent decades has made it possible to probe and measure biological systems down to the molecular scale. This has given rise to a more physical approach to traditional molecular biology, and, in particular, to attempts to solve the longstanding puzzles of biological building blocks and their behavior. This includes, for instance, the structure of proteins as a result of their folding dynamics, and the performance of molecular machines such as motor proteins.

In this context, the Institute is developing a first important line of research in single-molecule physics in an effort to understand the structural properties of relevant biomolecules through mechanical measurements of single molecules. A second line of research addresses the collective effects of molecular motors, i.e. cooperation among motor proteins to perform complex tasks, including the development of efficient strategies in intracellular transport and collective force generation. The latter is a problem that is directly relevant to medical applications, such as in neurodegenerative diseases.



## Cell and Multicellular Biology



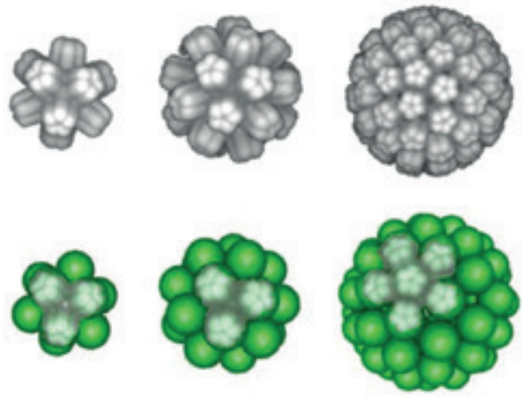

The biological cell is the basic unit of life, and constitutes in itself a remarkably complex system that combines thousands of chemical reactions by thousands of molecular species, all happening at the same time with fascinating harmony within an extremely crowded and noisy environment. The current access to quantitative data enabled by modern technologies has revealed the cell to be a whole new universe for physical inquiry and quantitative modeling, posing a formidable challenge for interdisciplinary science.

In this context, the research at the Institute aims at understanding the physical mechanisms of self-organization that can integrate such a variety of processes at very different scales. The problem is highly complex given the formidable information processing required to orchestrate cellular mechanisms in response to external stimuli; or to accomplish a variety of tasks required for survival, from metabolism to cell division. Research also focuses on different aspects of the physics within cells, with an emphasis on collective effects and emerging phenomena. Among the aspects that are more amenable to physical modeling under study, we can highlight those referring to force generation and cell mechanics, which are crucial for instance to cell motility and cell division, and to the processes associated with membrane dynamics. At a higher level of organization, the Institute also studies collective phenomena of cells in tissues. Here our emphasis is on mechanical aspects and includes the study of collective cell migration of epithelial cells, an area that is relevant to a variety of problems related to wound healing, cell regeneration, and, ultimately, to the understanding of cancer. Our goal is to extract the generic physical principles that govern the complex network mechanical and biochemical interactions underlying these systems. At the multicellular level, our ultimate goal is to achieve an integration of mechanics and information in development; that is, to understand the organization of physical forces and biological regulation in the context of embryogenesis, organogenesis and beyond.

### Systems Biology

Systems Biology is a growing research field that aims at characterizing and understanding living organisms from the interaction among their building blocks, for instance the gene-gene interactions that dictate the animal body plan.

The research performed at UBICS within the field of Systems Biology uses mathematical and computational models of these blocks and interactions, and integrates methodologies from fields like dynamical systems and complex networks. This research includes important collaborations with wet laboratories and uses reported public data. The derived models, tools and approaches are applied to the comprehension of several aspects relating to living systems. A first aspect aims at the understanding of the patterning and growth processes that underlie the development of multicellular organisms. Such studies range from the embryonic animal development of vertebrates to plant growth. A second aspect focuses on the relationship between the large-scale architecture of the biological networks of interactions at different levels and their functionality.



### Neuroscience

Living neuronal networks, in particular the human brain, are considered to be among the most complex systems in nature. The quest to understand them has caught the attention of different research groups at the Institute, who are exploring them through a rich repertoire of experimental, computational and theoretical tools.

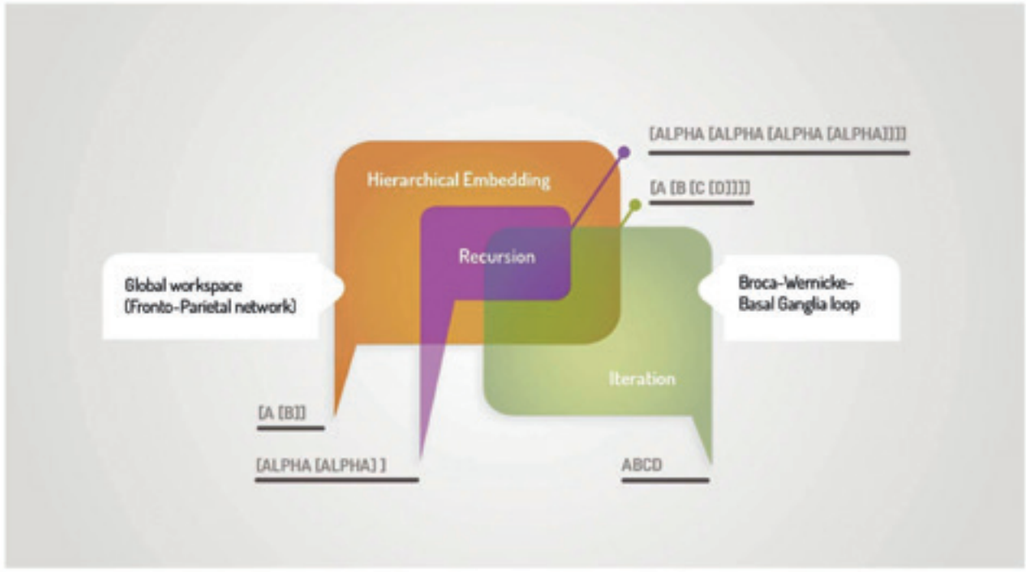
Two major lines of action shape neuroscience research, centered at either the scale of the brain or at the scale of mesoscopic neuronal circuits. At the scale of the brain, researchers study statistical models for the complex representation of the behavior of brain signal recordings in Functional Magnetic Resonance Imaging (fMRI) paradigms. Statistical, computational and mathematical models are generated with the aim of understanding the features of functional and effective connectivity maps between brain regions. These models provide a framework not only for systematic analysis, but also to diagnose and understand brain pathologies such as Mild Cognitive Impairment, Major Depressive Disorder, or simply aging. At the mesoscale, our research focuses on the emergence of collective phenomena in neuronal circuits. Neuronal cultures derived from either rat primary cells or human induced pluripotent stem cells are used as the main experimental platforms, and laboratory data is combined with theoretical modeling and numerical simulations. The investigation of complex phenomena in cultures include the ability of neuronal circuits to exhibit spontaneous activity patterns, synchronization mechanisms, and the capacity of these circuits to manifest an exquisite robustness in combination with broad flexibility. Given the relation between neuronal networks and connectivity, research also covers the modeling of neurological disorders in vitro and in silico, in particular in Huntington's, Parkinson's and Alzheimer's disease.

## Social Sciences

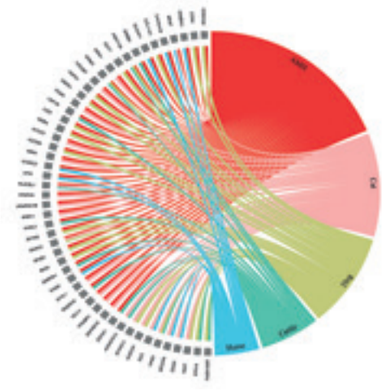
**Applications in the social sciences range from aspects at the individual level to the study of large scale sociopolitical and economic structures, including those of the past. One of the applications that we can already consider as traditional in complex system science is economy and finance. But the activities of the institute aim to open up other fields of applicability. For example, concepts such as coordination dynamics and other characteristics of networks are being applied to the study of behaviors related to sports, both individually and at team level. Similarly, we are also working on issues related to the biological nature of human language ability, its development at the individual level, its emergence in species, and its implementation at the brain level. In the same way, the complex perspectives we are adopting illuminate more thoroughly the dynamics of the sociocomunicative and sociopolitical factors influencing language use, evolutionary change and maintenance and replacement phenomena.**

### Psychology and behaviour

Social dilemmas and game theory provide tools and strategies for measuring and quantifying an individual's social traits based on their actions when these individuals confront their own benefit with another's interest or with the collective interest. These dilemmas therefore make it possible to analyze, for example, the levels of cooperation, trust, reciprocity and sense of collectivity that arise when participants in these types of experiments play together and interact with each other generally through a digital interface capable of gathering the data related to their decisions. The research carried out along these lines combines experimental performance with empirical analysis either through basic statistics or sophisticated clustering algorithms and with the provision of new models to better interpret what is been observed in the experiments.



At UBICS, researchers work together with many actors to build tailored-made research collectives to address concerns and issues grounded mostly in urban contexts by means of citizen science participatory strategies and methodologies. Our methodologies are based on community processes and provides a large set of social dilemmas and dyadic games for the understanding of specific behavioural traits in social interactions. By means of citizen science strategies, our experimental setup was placed in the wild with situated, public and participatory experiments involving citizens at different levels. We have been working in several neighborhoods, applying this methodology to study the mechanisms behind collective climate actions to provide innovative tools for schools to increase student's motivation or to better understand mental health care in community ecosystem.



## Economy and finance

Stock markets exhibit several universal statistical stylized facts and patterns that can be studied and modelled thanks to the large data sets available. Relevant issues can therefore be studied to obtain a better understanding of stock price movements and a better description of risk. Physics, complex systems science and their way of looking at natural phenomena have all contributed in a multidisciplinary way to this field, which, since the early 1990s, has been labelled econophysics.

UBICS researchers apply stochastic processes and other tools from the field of statistical physics to model volatility, to understand the statistics of extreme times such as first-passage time, to interpret emerging prices with agent based models and even to identify the relevant information that triggers the actions of individual traders. Other topics that have been studied recently include the economics of climate change and game theory.

## Linguistics

Linguistics is a diverse field of research, and several different disciplines within it relate to the notion of complex systems. The study of language can be used to access information about human behaviour, the human brain and its processes, and about social and cultural structures on a larger scale. The field of linguistics further generates some very concrete applications, mostly related to technology and human-machine interactions, as well as clinical applications.

The work done by the linguistics department of our university within the Institute for Complex Systems is focused on three very distinct lines of research. The research group for biolinguistics studies the neurobiological foundations of the human capacity for language, as well as human-specific cognition at a more general level. To do so it employs a combination of theoretical, computational and genetic methods. Some of the main lines of investigation within the group are studying phenomena like the Neandertal genome, vocal learning in songbirds and its relationship to the human capacity for language, and the molecular processes that are involved in memory formation. In the line of Sociolinguistics and Linguistic Variation, the focus is on the application of theories of complexity to the comprehension of social, communicative-cognitive and linguistic phenomena. Finally, concerning Computational Linguistics, we focus on the detection of the linguistic features that allow us to identify communicative attitudes, opinion (polarity), irony, emotions and socio-political stance in oral and written texts, especially those produced on social media. There is also interest in the development of language technology resources, which are the base of natural language processing applications (information extraction, question-answering, recommendation systems, machine translation, etc.).

## History

The trade system of the Roman Empire is one of the first recognized networks of interaction and interdependence between the Mediterranean basin and northern Europe and is generally considered to be the first complex European trade network. In the last fifty years, many theories and hypotheses about the organization of the Roman Empire trade system have been proposed but, due to the lack of source material, these theories continue to be speculative.

Among the best archaeological semantic markers available for the Roman Empire are amphorae and their associated epigraphy. Amphorae provide information on geographical origin, transported products, economic transactions and the social positions and relationships between people involved in trade.

At UBICS, researchers model the dynamics of the amphorae trade system during the Roman Empire using geospatial and social network techniques in order to better understand the evolutionary trends of the trading network. The research undertaken is an example of a truly interdisciplinary perspective on trade network studies.

5

# FUNDING

# 5 FUNDING

## European Projects

- ***Custom architecturally defined 3D stem cell derived functional human neural networks for transformative progress in neuroscience and medicine (MESO_BRAIN)***
  **Period: 01/09/2016 to 28/02/2020**
  Investigator: **Soriano Fradera, Jordi**

- ***Transport of soft matter at the nanoscale (NANOTRANS)***
  **Period: 01/03/2016 to 29/02/2020**
  Investigator: **Pagonabarraga Mora, Ignacio**

- ***An e-infrastructure for software, training and consultancy in simultion and modelling (E-CAM)***
  **Period: 01/10/2015 to 39/07/2020**
  Investigator: **Pagonabarraga Mora, Ignacio**

- ***Towards novel nano-scale technologies based on phoretic flow effects (nanophlow)***
  **Period: 01/02/2018 to 31/01/2021**
  investigator: **Pagonabarraga Mora, Ignacio**

- ***Advanced Research Infrastructure for Archaeological Data Networking in Europe - plus (ARIADNEplus)***
  **Data: 01/01/2019 to 31/12/2022**
  Investigator: **Remesal Rodriguez, Jose**

- ***Charge transport in nanochannels (ELNANO)***
  **Data: 01/10/2019 to 30/09/2022**
  Investigator: **Pagonabarraga Mora, Ignacio**

- ***Co-designing Citizen Social Science for Collective Action (CoAct)***
  **Data: 01/01/2020 to 31/12/2022**
  Investigator: **Perello Palou, Josep**

- ***ENgineering FrustratiOn in aRtificial Colloidal icEs: degeneracy, exotic lattices and 3D states (ENFORCE)***
  **Data: 01/01/2020 to 31/12/2024**
  Investigator: **Tierno, Pietro**

- ***Simulating Roman Economies. Studying the Roman Economy through computational network modelling and archaeological big data (SIMREC)***
  **Data: 01/05/2019 to 31/01/2020**
  Investigator: **Díaz Guilera, Albert**

- ***Territories as Responsive and Accountable Networks of S3 through new Forms of Open and Responsible decision-Making (TRANSFORM)***
  **Data: 01/01/2020 to 31/12/2022**
  Investigator: **Perello Palou, Josep**

## Other International Projects

- ***El papel del cerebelo en la evolución del lenguaje*** Agency: BBVA Fundation
  **Period: 30/09/2020- 29/01/2022**
  Investigator: **Boeckx, Cedric**

- ***Mapping big data systems: rembedding large complex network in dimensional hidden metric spaces*** Agency: BBVA Fundation
  **Period: 15/06/2018 to 14/06/2020**
  Investigator: **Serrano Moral, Maria Ángeles**

- ***Modulation of Tau seeding and pathology in tauopathies by BBB-nanocarriers, epitope selective vaccination and ectoPrP Tau receptor bodies (STOPTauPATHOL)*** Agency: La Caixa Fundation
  **Period: 15/09/2019 to 14/09/2022**
  Investigador: **Soriano Fradera, Jordi**

## Spanish Government Funded Research Projects

- *Conversión de energía a escalas pequeñas: explotando el carácter de no equilibrio de la materia activa*
  Period: 26/11/2019 to 25/11/2022
  Investigator: **Levis Sotomayor, Demian Francisco**

- *Desinformación y agresividad en Social Media: Analizando el lenguaje*
  Period: 01/01/2019 to 31/12/2021
  Investigator: **Taule Delor, Maria**

- *Diatopía y cambio lingüístico. Scripta y proyección dialectal*
  Period: 30/12/2016 to 29/12/2020
  Investigator: **Massip Bonet, Maria Àngels**

- *Estructura y dinámica de suspensiones coloidales: El papel de la rigidez de las partículas*
  Period: 01/01/2019 to 31/12/2021
  Investigator: **Fernandez De Las Nieves, Alberto**

- *Estudio de dinámicas no lineales en redes complejas multicapa bajo incertidumbre estructural*
  Period: 01/01/2019 to 31/12/2021
  Investigator: **Díaz Guilera, Albert**

- *Fenómenos colectivos en materia blanda, tejidos celulares y redes neuronales*
  Period: 01/06/2020 to 31/05/2023
  Investigator: **Casadamunt Viader, Jaume**

- *Física no lineal y estocástica de las interacciones reguladoras de procesos biológicos*
  Period: 01/01/2019 to 31/12/2021
  Investigator: **Ibañes Miguez, Marta**

- *Indicadores estadísticos para el estudio de redes de conectividad cerebral en registros de resonancia magnética funcional (FMRI) y su aplicación para el diagnóstico del deterioro cognitivo*
  Period: 01/01/2019 to 31/12/2022
  Investigator: **Guàrdia Olmos, Joan**

- *Materiales con respuesta activa para refrigeración limpia y eficiente*
  Period: 30/12/2016 to 29/12/2020
  Investigator: **Vives Santa-Eulalia, Eduard**

- *Relaciones interprovinciales en el Imperio Romano. Producción y comercio de alimentos hispanos (Provinciae Baetica et Tarraconensis)*
  Period: 01/01/2018 to 31/12/2020
  Investigator: **Revilla Calvo, Victor**

- *Componiendo el lenguaje en la Evolución - Orden temporal e integración de subcomponentes del lenguaje*
  Period: 01/06/2020 to 31/05/2023
  Investigator: **Boeckx, Cedric**

- *Efectos de similaridad, heterogeneidad e interdependencia en el comportamiento colectivo de sistemas complejos artificiales y naturales II*
  Period: 01/06/2020 to 31/05/2023
  Investigator: **Miguel Lopez, Maria Del Carmen**

- *Un nuevo enfoque para el escalada de flujo multifásico, deformación mecánica y transporte hidrodinámico en medios permeables: nuevos experimentos y análisis de datos*
  Period: 01/06/2020 to 31/05/2023
  Investigator: **Ortín Rull, Jordi**

- *Física estadística para ciudades: modelos estocásticos y experimentos públicos*
  Period: 01/06/2020 to 31/05/2023
  Investigator: **Perelló Palou, Josep**

- *Dinàmiques socioeconòmiques del món rural romà: formes d'hàbitat i cultura material al litoral central català*
  Period: 01/01/2018 to 31/12/2021
  Investigator: **Revilla Calvo, Victor**
  Departament de Cultura de la Generalitat de Catalunya

## Spanish Government Funded Networks Of Excelence

- *Ingeniería de la frustración en hielos coloidales artificiales: degeneración y redes exóticas*
  Period: 01/12/2018 to 30/11/2019
  Principal investigator: **Tierno, Pietro**

## AGAUR-SGR Consolidated Groups

- *Complexity Lab Barcelona (CLabB)*
  2017SGR1064
  Period: 01/01/2017 to 31/12/2020
  Investigator: **Perelló Palou, Josep**

- *Grup de complexitat, comunicació i sociolingüística*
  2017SGR175
  Period: 01/01/2017 to 31/12/2020
  Investigator: **Bastardas Boadas, Albert**

- *Centre per a l'Estudi de la Interdependència provincial a l'Antiguitat Clàssica (CEIPAC)*
  2017SGR512
  Period: 01/01/2017 to 31/12/2020
  Investigator: **Revilla Calvo, Víctor**

- *Física no-lineal*
  2017SGR1061
  Period: 01/01/2017 to 31/12/2020
  Investigator: **Ortín Rull, Jordi**

- *Psicologia Quantitativa*
  2017SGR269
  Period: 01/01/2017 to 31/12/2020
  Investigator: **Guàrdia Olmos, Joan**

- *Centre de Llenguatge i Computació (CLIC)*
  2017SGR341
  Period: 01/01/2017 to 31/12/2020
  Investigator: **Taulé Delor, Maria**

- *Vertically aligned nanowires via soft colloidal lithography for solar cell applications.*
  Period: 01/02/2020- 31/01/2023
  Investigator: **Fernandez de las Nieves, Alberto**

- *Pattern Formation and Collective Behavior in Living Matter.*
  Period: 01/02/2020- 31/01/2022
  Investigator: **Reguera Lopez, David**

## Contracts With Public And Private Entities

6

# PUBLICATIONS

# 6 PUBLICATIONS


*Word cloud of all publications of UBICS members*

## ARTICLES

Research line : **FOUNDATIONS**

- ***A robust solution to variational importance sampling of minimum variance***
  **Hernández-González, J. & Cerquides, J.**
  Entropy, vol. 22, no 12, p. 1405, pp. 1-19
  DOI: https://doi.org/10.3390/e22121405

- ***Optimising data diffusion while reducing local resources consumption in opportunistic mobile crowdsensing***
  **Hernández-Orallo, E., Borrego, C., Manzoni, P., Marquez-Barja, J.M., Cano, J.C. & Calafate, C.T.**
  Pervasive and Mobile Computing, vol. 67, p. 101201
  DOI: https://doi.org/10.1016/j.pmcj.2020.101201

- ***Precision as a measure of predictability of missing links in real networks***
  **García-Pérez, G., Aliakbarisani, R., Ghasemi, A. & Serrano, M.Á.**
  Physical Review E, vol. 101, no 5, p. 052318
  DOI: https://doi.org/10.1103/PhysRevE.101.052318

- ***Forwarding in opportunistic information-centric networks: an optimal stopping approach***
  **Borrego, C., Amadeo, M., Molinaro, A., Mendes, P., Sofia, R.C., Magaia, N. & Borrell, J.**
  IEEE Communications Magazine, vol. 58, no 5, p. 56-61., no. 9112743
  DOI: https://doi.org/10.1109/MCOM.001.1900774

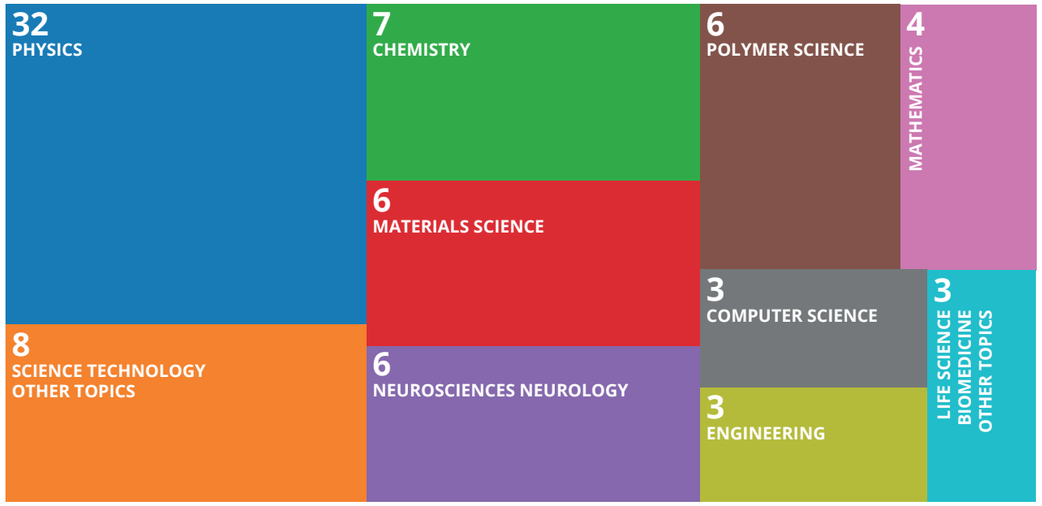
- ***Random walk with hyperbolic probabilities***
  **Montero, M.**
  Journal of Statistical Mechanics: Theory and Experiment, vol. 2020, no 1, p. 013203
  DOI: https://doi.org/10.1088/1742-5468/ab535b

- ***Comparing spatial networks: a one-size-fits-all efficiency-driven approach***
  **Morer, I., Cardillo, A., Díaz-Guilera, A., Prignano, L. & Lozano, S.**
  Physical Review E, vol. 101, no 4, p. 042301
  DOI: https://doi.org/10.1103/PhysRevE.101.042301

- ***A software-defined networking approach for congestion control in opportunistic networking***
  **De Toro, M. & Borrego, C.**
  International Conference on Information Networking, no. 9016597, pp. 354-359
  DOI: https://doi.org/10.1109/ICOIN48656.2020.9016597

- ***Two-dimensional telegraphic processes and their fractional generalizations***
  **Masoliver, J. & Lindenberg, K.**
  Physical Review E, vol. 101, art.1, no. 012137
  DOI: https://doi.org/10.1103/PHYSREVE.101.012137

*Publications in Web of Science (WoS) according to "Research areas"*




- *Functionability in complex networks: leading nodes for the transition from structural to functional networks through remote asynchronization*
  **Rosell-Tarragó, G. & Díaz-Guilera, A.**
  Chaos, vol. 30, no 1, p. 013105.
  DOI: https://doi.org/10.1063/1.5099621

- *Enhancing sentient embodied conversational agents with machine learning*
  **Tellols, D., Lopez-Sanchez, M., Rodríguez, I., Almajano, P. & Puig, A.**
  Pattern Recognition Letters, vol. 129, p. 317-323.
  DOI: https://doi.org/10.1016/j.patrec.2019.11.035

- *A privacy-preserving routing protocol using mix networks in opportunistic networks*
  **Chen, D., Borrego, C. & Navarro-Arribas, G.**
  Electronics (Switzerland), vol. 9, no 11, p. 1754. , pp. 1-15.
  DOI: https://doi.org/10.3390/electronics9111754

- *Network temporality can promote and suppress information spreading*
  **Xue, X., Pan, L., Zheng, M. & Wang, W.**
  Chaos, vol. 30, no 11, p. 113136., no. 0027758, .
  DOI: https://doi.org/10.1063/5.0027758

- *Epidemic spreading under infection-reduced-recovery*
  **Zhang, X., Ruan, Z., Zheng, M., Barzel, B. & Boccaletti, S.**
  Chaos, Solitons and Fractals, vol. 140, p. 110130.
  DOI: https://doi.org/10.1016/j.chaos.2020.110130

- *Erratum: equivalence between non-markovian and markovian dynamics in epidemic spreading processes*
  **Starnini, M., Gleeson, J.P. & Bogunã, M.**
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- *Small worlds and clustering in spatial networks*
  **Boguñá, M.; Krioukov, D.; Almagro, P. & Serrano, M.Á**
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- *Applications in security and evasions in machine learning: a survey*
  **Sagar, R., Jhaveri, R. & Borrego, C.**
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- *Effects of two channels on explosive information spreading*
  **Wu, J., Zheng, M., Xu, K. & Gu, C.**
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- *Geometric detection of hierarchical backbones in real networks*
  **Ortiz, E; Garcia-Perez, G & Serrano, MA**
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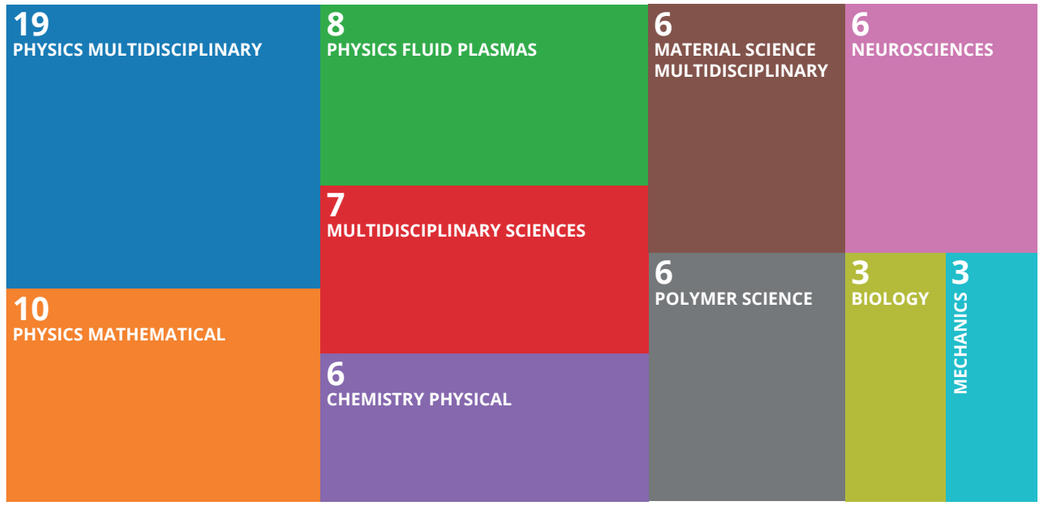
*Publications in WoS according to "Web of Science categories"*




Research line : **LIFE SCIENCES**

- *Geometric renormalization unravels self-similarity of the multiscale human connectome*
  **Zheng, M., Allard, A., Hagmann, P., Alemán-Gómez, Y. & Ángeles Serrano, M.**
  PNAS, vol. 117, no 33, p. 20244-20253
  DOI: https://doi.org/10.1073/PNAS.1922248117

- *Grafted human pluripotent stem cell-derived cortical neurons integrate into adult human cortical neural circuitry*
  **Grønning Hansen, M., Laterza, C., Palma-Tortosa, S., Kvist, G., Monni, E., Tsupykov, O., Tornero, D., Uoshima, N., Soriano, J., Bengzon, J., Martino, G., Skibo, G., Lindvall, O. & Kokaia, Z.**
  Stem Cells Translational Medicine, vol. 9, no 11, p. 1365-1377
  DOI: https://doi.org/10.1002/sctm.20-0134

- *Landau theory for cellular patterns driven by lateral inhibition interaction*
  **Sancho, J.M. & Ibañes, M.**
  Physical Review E, vol. 102, no 3, p. 032404
  DOI: https://doi.org/10.1103/PhysRevE.102.032404

- *Impact of physical obstacles on the structural and effective connectivity of in silico neuronal circuits*
  **Ludl, A. & Soriano, J.**
  Frontiers in Computational Neuroscience, vol. 14, p. 77
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- *Human pluripotent stem cell-derived neurons are functionally mature in vitro and integrate into the mouse striatum following transplantation*
  **Comella-Bolla, A., Orlandi, J.G., Miguez, A., Straccia, M., García-Bravo, M., Bombau, G., Galofré, M., Sanders, P., Carrere, J., Segovia, J.C., Blasi, J., Allen, N.D., Alberch, J., Soriano, J. & Canals, J.M.**
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- *Deficits in coordinated neuronal activity and network topology are striatal hallmarks in huntington's disease*
  **Fernández-García, S., Orlandi, J.G., García-Díaz Barriga, G.A., Rodríguez, M.J., Masana, M., Soriano, J. & Alberch, J.**
  BMC Biology, vol. 18, p. 1-16., no. 58
  DOI: https://doi.org/10.1186/s12915-020-00794-4

- *Modern human changes in regulatory regions implicated in cortical development*
  **Moriano, J. & Boeckx, C.**
  BMC Genomics, vol. 21, p. 1-10., no. 304
  DOI: https://doi.org/10.1186/s12864-020-6706-x

- *Development of two-photon polymerised scaffolds for optical interrogation and neurite guidance of human ipsc-derived cortical neuronal networks*
  **Crowe, J.A., El-Tamer, A., Nagel, D., Koroleva, A.V., Madrid-Wolff, J., Olarte, O.E., Sokolovsky, S., Estevez-Priego, E., Ludl, A.,**

**Soriano, J., Loza-Alvarez, P., Chichkov, B.N., Hill, E.J., Parri, H.R. & Rafailov, E.U.**
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- ***Shape selection and mis-assembly in viral capsid formation by elastic frustration***
**Mendoza, C.I. & Reguera, D.**
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- ***Resting-state functional connectivity dynamics in healthy aging: an approach through network change point detection***
**Mancho-Fora, N., Montalà-Flaquer, M., Farràs-Permanyer, L., Bartrés-Faz, D., Vaqué-Alcázar, L., Peró-Cebollero & M., Guàrdia-Olmos, J.**
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- ***Navigable maps of structural brain networks across species***
**Allard, A. & Serrano, M.Á.**
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- ***Spontaneous functional recovery after focal damage in neuronal cultures***
**Teller, S., Estévez-Priego, E., Granell, C., Tornero, D., Andilla, J., Olarte, O.E., Loza-Alvarez, P., Arenas, A. & Soriano, J.**
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- ***Using fmri to assess brain activity in people with down syndrome: a systematic review***
**Carbó-Carreté, M., Cañete-Massé, C., Peró-Cebollero, M. & Guàrdia-Olmos, J.**
Frontiers in Human Neuroscience, vol.14, no. 147
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- ***Glutamate receptors in domestication and modern human evolution***
**O'Rourke, T. & Boeckx, C.**
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- ***Neuronal spatial arrangement shapes effective connectivity traits of in vitro cortical networks***
**Tibau, E., Ludl, A.-A., Rudiger, S., Orlandi, J.G. & Soriano, J.**
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- ***Resting-state functional dynamic connectivity and healthy aging: a sliding-window network analysis [conectividad dinámica funcional en situación de reposo y envejecimiento sano: análisis de redes mediante ventanas móviles]***
**Mancho-Fora, N., Montalà-Flaquer, M., Farràs-Permanyer, L., Bartrés-Faz, D., Vaqué-Alcázar, L., Peró-Cebollero, M. & Guàrdia-Olmos, J.**
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- ***The effect of second-generation antidepressant treatment on the memory of patients with major depressive disorder: a meta-analysis study with structural equation models***
**Gudayol-Ferré, E., Duarte-Rosas, P., Peró-Cebollero, M. & Guàrdia-Olmos, J.**
Journal of clinical psychopharmacology, vol. 40, no 1, p. 54-62
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- ***Functional interactions in patients with hemianopia: a graph theory-based connectivity study of resting fmri signal***
**Pedersini, C.A., Guardia-Olmos, J., Montala-Flaquer, M., Cardobi, N., Sanchez-Lopez, J., Parisi, G., Savazzi, S. & Marzi, C.A.**
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- ***Functional strengthening through synaptic scaling upon connectivity disruption in neuronal cultures***
**Estevez-Priego, E; Teller, S; Granell, C; Arenas, A & Soriano, J**
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- ***Motility and morphodynamics of confined cells***
**Lavi, I., Meunier, N., Voituriez, R. & Casademunt, J.**
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Research line : **SCIENCE MATTER**

- ***Motility-induced microphase and macrophase separation in a two-dimensional active brownian particle system***
**Caporusso, C.B., Digregorio, P., Levis, D., Cugliandolo, L.F. & Gonnella, G.**
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- ***Suppression of acoustic emission during superelastic tensile cycling of polycrystalline ni50.4ti49.6***
**Nataf, G.F., Romanini, M., Vives, E., Žužek, B., Planes, A., Tušek, J. & Moya, X.**
Physical Review Materials, vol. 4, no 9, p. 093604
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- ***Universal scaling of active nematic turbulence***
**Alert, R., Joanny, J.-F. & Casademunt, J.**
Nature Physics, vol. 16, no 6, p. 682-688
DOI: https://doi.org/10.1038/s41567-020-0854-4

- ***Curvature corrections remove the inconsistencies of binary classical nucleation theory***
**Aasen, A., Reguera, D. & Wilhelmsen, Ø.**
Physical Review Letters, vol. 124, no 4, p. 045701
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- ***Controlled generation of vapor/liquid slug flows by local boiling in microgravity***
**Bitlloch, P., Ruiz, X., Ramírez-Piscina, L. & Casademunt, J.**
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- ***Unraveling the hidden complexity of quasideterministic ratchets: random walks, graphs, and circle maps***
**Blanch-Mercader, C., Orlandi, J.G. & Casademunt, J.**
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DOI: https://doi.org/10.1103/PhysRevE.101.012203

- ***Field synchronized bidirectional current in confined driven colloids***
**Meng, F.; Ortiz-Ambriz, A.; Massana-Cid, H.; Vilfan, A.; Golestanian, R. & Tierno, P.**
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- ***Concurrent tracking of strain and noise bursts at ferroelastic phase fronts***
**Blaysat, B.; Balandraud, X.; Grédiac, M.; Vives, E.; Barrera, N. & Zanzotto, G.**
Communications Materials, vol. 1, no 1, p. 1-7
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- ***Dynamics and clogging of colloidal monolayers magnetically driven through a heterogeneous landscape***
**Leyva, S.G., Stoop, R.L., Tierno, P. & Pagonabarraga, I.**
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DOI: https://doi.org/10.1039/d0sm00904k

- ***Rheology of capillary foams***
**Okesanjo, O., Tennenbaum, M., Fernandez-Nieves, A., Meredith & J.C., Behrens, S.H.**
Soft Matter, vol. 16, no 29, p. 6725-6732
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- ***Kinetics of active water/ethanol janus droplets***
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Soft Matter, vol. 16, no 29, p. 6803-6811
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- ***Propulsion and energetics of a minimal magnetic microswimmer***
**Calero, C., García-Torres, J., Ortiz-Ambriz, A., Sagués, F., Pagonabarraga, I. & Tierno, P.**
Soft Matter, vol. 16, no 28, p. 6673-6682
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- *Activity effects on the nonlinear mechanical properties of fire-ant aggregations*
**Tennenbaum & M., Fernandez-Nieves, A.**
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- *Stokes layers in oscillatory flows of viscoelastic fluids: viscoelastic layers in oscillatory flows*
**Ortín, J.**
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- *Complexation of pluronic l62 (eo6)-(po34)-(eo6)/aerosol-ot (sodium bis(2-ethylhexyl) sulfosuccinate) in aqueous solutions investigated by small angle neutron scattering*
**Zhou, B., Fernandez-Nieves, A., Chen, W.-R., Kim, & T.-H., Do, C.**
Physical Chemistry Chemical Physics, vol. 22, no 22, p. 12524-12531
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- *Topology restricts quasidegeneracy in sheared square colloidal ice*
**Oğuz, E.C., Ortiz-Ambriz, A., Shem-Tov, H., Babià-Soler, E., Tierno, P. & Shokef, Y.**
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- *Dynamic response of a compressible binary fluid mixture*
**Lombard, J., Pagonabarraga, I. & Corvera Poiré, E.**
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- *Spontaneous polarization and locomotion of an active particle with surface-mobile enzymes*
**De Corato, M., Pagonabarraga, I., Abdelmohsen, L.K.E.A., Sánchez, S. & Arroyo, M.**
Physical Review Fluids, vol. 5, no 12, p. 122001
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- *Modification of lipid membrane compressibility induced by an electric field*
**Prathyusha, K.R., Pagonabarraga, I. & Kumar, P.B.S.**
Physical Review E, vol. 102, no 6, p. 062413.
DOI: https://doi.org/10.1103/PhysRevE.102.062413

- *The origin of hysteresis and memory of two-phase flow in disordered media*
**Holtzman, R., Dentz, M., Planet, R. & Ortín, J.**
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- *Dynamical modes of sheared confined microscale matter*
**Gerloff, S., Ortiz-Ambriz, A., Tierno, P. & Klapp, S.H.L.**
Soft Matter, vol. 16, no 41, p. 9423-9435
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- *Behavior and mechanics of dense microgel suspensions*
**Nikolov, S.V., Fernandez-Nieves, A. & Alexeev, A.**
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- *Unravelling the role of phoretic and hydrodynamic interactions in active colloidal suspensions*
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- *Self-assembly of microscopic rods due to depletion interaction*
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- *Unfolding the prospects of computational (bio) materials modeling*
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Journal of Chemical Physics, vol. 153, no 10, p. 100901
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- *Coherence-enhanced diffusion filtering applied to partially-ordered fluids*
**Ellis, P.W., Nambisan, J. & Fernandez-Nieves, A.**
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- *Tracking the dynamics of power sources and sinks during the martensitic transformation of a cu-al-ni single crystal*
**Ianniciello, L., Romanini, M., Mañosa, L., Planes, A., Engelbrecht, K. & Vives, E.**
Applied Physics Letters, vol. 116, no 18, p. 183901
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- *Polarized epifluorescence microscopy and the imaging of nematic liquid crystals in highly curved geometries*
**Ellis, P.W., Klaneček, S. & Fernandez-Nieves, A.**
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DOI: https://doi.org/10.1103/PhysRevE.101.052703

- *Electrophoretic origin of long-range repulsion of colloids near water/nafion interfaces*
**Esplandiu, M.J., Reguera, D. & Fraxedas, J.**
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- *Capillary jumps of fluid-fluid fronts across an elementary constriction in a model open fracture*
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- *Reverse janssen effect in narrow granular columns*
**Mahajan, S., Tennenbaum, M., Pathak, S.N., Baxter, D., Fan, X., Padilla, P., Anderson, C., Fernandez-Nieves, A. & Pica Ciamarra, M.**
Physical Review Letters, vol. 124, no 12, p. 128002
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- *Self-propulsion of active colloids via ion release: theory and experiments*
**De Corato, M., Arqué, X., Patinõ, T., Arroyo, M., Sánchez, S. & Pagonabarraga, I.**
Physical Review Letters, vol. 124, no 10, p. 108001
DOI: https://doi.org/10.1103/PhysRevLett.124.108001

- *Collective directional locking of colloidal monolayers on a periodic substrate*
**Stoop, R.L., Straube, A.V., Johansen, T.H. & Tierno, P.**
Physical Review Letters, vol. 124, no 5, p. 058002.
DOI: https://doi.org/10.1103/PhysRevLett.124.058002

- *Emergent collective colloidal currents generated via exchange dynamics in a broken dimer state*
**Massana-Cid, H., Ortiz-Ambriz, A., Vilfan, A. & Tierno, P.**
Science Advances, vol. 6, no 10, p. eaaz2257
DOI: https://doi.org/10.1126/sciadv.aaz2257

- *Block copolymer-nanorod co-assembly in thin films: effects of rod-rod interaction and confinement*
**Diaz, J., Pinna, M., Zvelindovsky, A.V., Pagonabarraga, I. & Shenhar, R.**
Macromolecules, vol. 53, no 8, p. 3234-3249
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- *Ontology-based semantic interoperability on the virtual materials marketplace*
**Horsch, M.T., Chiacchiera, S., Seaton, M.A., Todorov, I.T., Kunze, R., Summer, G., Fiseni, A., Andreon, B., Di Minico, A.S., Kaiser, E.B., Kanagalingam, G., Stephan, S., Sindelka, K., Lisal, M., Branas, J.D., Pagonabarraga, I., Chiricotto, M., Elliott, J.D., Carbone, P., Toti, D., Mogni, G., Goldbeck, G., Bruning, H., Schiffels, P. & Cavalcanti, W.L.**
CEUR Workshop Proceedings, 2721, pp. 134-138.
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- *Cooperation and competition of viscoelastic fluids and elastomeric microtubes subject to pulsatile forcing*
**Torres Rojas, A.M. & Corvera Poiré, E.**
Physical Review Fluids, vol. 5, no. 6, p.063303
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- *Collective motion of chiral brownian particles controlled by a circularly-polarized laser beam*
  **Hernández, R.J., Sevilla, F.J., Mazzulla, A., Pagliusi, P., Pellizzi, N. & Cipparrone, G.**
  Soft Matter, vol. 16, no 33, p. 7704-7714
  DOI: https://doi.org/10.1039/c9sm02404b

- *Capillary-based microfluidics—coflow, flow-focusing, electro-coflow, drops, jets, and instabilities*
  **Guerrero, J., Chang, Y.-W., Fragkopoulos, A.A. & Fernandez-Nieves, A.**
  Small, vol. 16, no. 9, p.1904344
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- *Flocking-enhanced social contagion*
  **Levis, D.; Diaz-Guilera, A.; Pagonabarraga, I. & Starnini, M.**
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Research line : **SOCIAL SCIENCES**

- *A story-writing based study on the acquisition of aspect in spanish by mandarin chinese learners*
  **Sun, Y., Rodríguez, L.D. & Taulé, M.**
  Revista Española de Lingüística Aplicada, vol. 33, no 2, p. 588-617
  DOI: https://doi.org/10.1075/resla.18031.sun

- *Quantifying human engagement into playful activities*
  **Reguera, D., Colomer-de-Simón, P., Encinas, I., Sort, M., Wedekind, J. & Boguñá, M.**
  Scientific Reports, vol. 10, no 1, p. 1-7
  DOI: https://doi.org/10.1038/s41598-020-60742-8

- *Gender-based pairings influence cooperative expectations and behaviours*
  **Cigarini, A., Vicens, J. & Perelló, J.**
  Scientific Reports, vol. 10, no 1, p. 1-10., no. 1041
  DOI: https://doi.org/10.1038/s41598-020-57749-6

- *Evolutionary dynamics do not motivate a single-mutant theory of human language*
  **de Boer, B., Thompson, B., Ravignani, A. & Boeckx, C.**
  Scientific Reports, vol. 10, no 1, p. 1-9
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- *Benchmarking seeding strategies for spreading processes in social networks: an interplay between influencers, topologies and sizes*
  **Montes, F., Jaramillo, A.M., Meisel, J.D., Diaz-Guilera, A., Valdivia, J.A., Sarmiento, O.L. & Zarama, R.**
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- *Relationship between quality of life and the complexity of default mode network in resting state functional magnetic resonance image in down syndrome*
  **Carbó-Carreté, M., Cañete-Massé, C., Figueroa-Jiménez, M.D., Peró-Cebollero, M. & Guàrdia-Olmos, J.**
  International Journal of Environmental Research and Public Health, vol. 17, no 19, p. 7127, pp. 1-14
  DOI: https://doi.org/10.3390/ijerph17197127

- *Mismis: misinformation and miscommunication in social media: aggregating information and analysing language [mismis: desinformación y agresividad en los medios de comunicación social: agregando información y analizando el lenguaje]*
  **Rosso, P., Casacuberta, F., Gonzalo, J., Plaza, L., Carrillo, J., Amigó, E., Verdejo, M.F., Taulé, M., Salamó, M. & Martí, M.A.**
  Procesamiento de Lenguaje Natural, vol. 65, p. 101-104
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- *A multilevel analytical framework for studying cultural evolution in prehistoric hunter–gatherer societies*
  **Romano, V., Lozano, S. & Fernández-López de Pablo, J.**
  Biological Reviews, vol. 95, no 4, p. 1020-1035
  DOI: https://doi.org/10.1111/brv.12599

- *A cognitively inspired clustering approach for critique-based recommenders*
  **Contreras, D. & Salamó, M.**
  Cognitive Computation, vol. 12, no 2, p. 428-441
  DOI: https://doi.org/10.1007/s12559-018-9586-5

- *The use of the past tense aspect in spanish by study at-home and study-abroad chinese learners in semi-guided writing tasks*
  **Sun, Y., Díaz, L. & Taulé, M.**
  Circulo de Linguistica Aplicada a la Comunicacion, num. 81, p. 301-318
  DOI: https://doi.org/10.5209/CLAC.67944

- *Focus of negation: its identification in spanish*
  **Taulé, M., Nofre, M., González, M. & Martí, M.A.**
  Natural Language Engineering, p. 1-22
  DOI: https://doi.org/10.1017/S1351324920000388

- *Eliminate the effect of severity of the personal outcomes scale: linear regression in persons with intellectual disability [eliminar el efecto de la severidad en la escala de resultados personales: uso de la regresión lineal en personas con discapacidad intelectual]*
  **Carbó-Carreté, M., Cañete-Massé, C., Peró-Cebollero & M., Guàrdia-Olmos, J.**
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  Congreso Internacional Las villas romanas bajoimperiales de Hispania,Palencia, 209-216

- ***Nuevos sellos anfóricos hallados en bregenz. Revilla calvo, v., Aguilera martín, a., Pons pujol, ll., García sánchez, m. (Eds.) Ex baetica romam. Homenaje a josé remesal rodríguez***
  **Bermúdez, J.M.**
  Col·lecció Homenatges. Universitat de Barcelona, Barcelona, p. 647-654
  ISBN: 978-84-9768-410-7

- ***Depredadores romanos. En busca del oro. Revilla calvo, v., Aguilera martín, a., Pons pujol, ll., García sánchez, m. (Eds.) Ex baetica romam. Homenaje a josé remesal rodríguez***
  **Pérez, J.**
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  ISBN: 978-84-9768-410-7

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# PHD THESES

# 7 PHD THESES

- *el comercio de productos hispanos en el norte de italia (s. I-III d.c.) / il commercio di derrate iberiche verso l'italia settentrionale (s. I-III d.c.)*
  Author: Joan Rodríguez Segura
  Director: Lluís Pons Pujol & Alfredo Buonopane

- *Gli spazi verdi delle domus con peristilo di ercolano*
  Author: Chiara Romano
  Director: Lluís Pons & Irene Mañas

- *Dynamics and effective connectivity in bi- and three-dimensional neuronal cultures: from self-organization to engineering*
  Author: Estefanía Estévez Priego
  Director: Jordi Soriano & Daniel Tornero

- *Competition and response: from active matter to electrolytes under confinement*
  Author: Sara Dal Cengio
  Director: Ignacio Pagonabarraga

- *Paraphrasing, textual entailment and semantic similarity above the word level*
  Author: Venelin Kovatchev
  Director: Maria Salamó & Maria Antonia Martí

- *Statistical modelling of avalanche observables: criticality and universality*
  Author: Víctor Navas Portella
  Director: Alvaro Corral & Eduard Vives

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# UBICS ACTIVITIES

# 8 UBICS ACTIVITIES

## UBICS Webinars

This year we performed two series of webinars titled "Complex Systems and COVID-19" focused on the COVID-19. These webinars were organized by UBICS and complexitat.cat and were addressed to people interested in this field.


- **Tackling Complexity: Foundations And Applications**

Speaker: **Manlio De Domenico**
Comune Lab, Fondazione Bruno Kessler
11.06.2020 | 16.00 H

Complex systems consists of units whose interactions at a microscopic scale lead to the spontaneous emergence of collective behavior and other unexpected phenomena at the meso- and macroscale. In this seminar I will introduce some basic concepts and tools of complexity science without relying on technicalities. In the second part of the seminar I will briefly discuss the relevance of big data for the analysis of complex systems and, more specifically, of socio-technical systems, spanning from the rise of collective attention to one of the most relevant phenomena observed during the COVID-19 pandemic: the infodemic related to coronavirus.

YouTube https://www.youtube.com/watch?v=UFuq4IyIDbM

- **Data Science To Fight Against Covid-19**

Speaker: **Nuria Oliver**, Data-Pop Alliance & Ellis
18.06.2020 | 16.00 H

In my talk, I will describe the work that we have done within the Commission on AI and COVID-19 for the President of the Valencian Region. As commissioner, I have led a multi-disciplinary team of 20+ scientists who have volunteered since March 2020. We have been working on 4 large areas: (1) human mobility modeling; (2) computational epidemiological models (both metapopulation and individual models); (3) predictive models; (4) citizen surveys (https://covid19impactsurvey.org).
I will describe the results that we have produced in each of these areas and will share the lessons learned in this very special initiative of collaboration between the civil society at large (through the survey), the scientific community (through the Expert Group) and a public administration (through the Commissioner at the Presidency level).

YouTube https://www.youtube.com/watch?v=0C7PoVf2QNY&list=PLf7A47_ENtnLkXJ8QPspRIT5a0zz-1nPd&index=6&t=0s

- **Why Some Patients Develop A Severe Syndrome While Other Remain Asymptomatic? Early-Warning Signals Associated With The Phase Transition From Health To Disease**

Speaker: **Santiago F. Elena**
Institute For Integrative Systems Biology, Csic
25.06.2020 | 16.00 H

One of the most outstanding observations during COVID-19 pandemics is that some patients have an asymptomatic infection while others suffer severe symptoms, some of them becoming fatal. Is there any relation between the global gene expression state of patients and they propensity to suffer an asymptomatic infection? Is it possible to identify which genes, or groups of them within a regulation network, may serve as markers to predict the clinical fate of a patient before the presence of any symptom? In this seminar I will introduce the fundamentals of the theory of Dynamical Biomarkers of Networks (DBN), illustrating their application to the analysis of transcriptomic data during disease progression in a pathosystem model.

YouTube https://www.youtube.com/watch?v=IMY08wJQn-dU&list=PLf7A47_ENtnLkXJ8QPspRIT5a0zz-1nPd&index=3

- **Epidemics And Mobility**

Speaker: **Alex Arenas**, Deim, Universitat Rovira I Virgili
02.07.2020 | 16.00 H

Reaction–Diffusion Processes Have Been Widely Used To Study Epidemics In Networked Metapopulations. In The Context Of Epidemics, Reaction Processes Are Understood As Contagions Within Each Subpopulation (Patch), While Diffusion Represents The Mobility Of Individuals Between Patches. Recently, The Characteristics Of Human Mobility, Such As Its Recurrent Nature, Have Been Proven Crucial To Understand The Phase Transition To Endemic Epidemic States. Here, We Present A Framework Able To Cope With The Elementary Epidemic Processes, The Spatial Distribution Of Populations And The Commuting Mobility Patterns. We Will Show After, How This Framework Has Been Adapted To Describe The Covid-19 Pandemic.

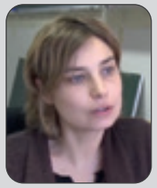
YouTube https://www.youtube.com/watch?v=54NoVIRdKo0&t=739s

- **Fractional Diffusion On The Human Proteome As An Alternative Explanation To The Multi-Organ Damage Of Sars Cov-2**

Speaker: **Prof. Ernesto Estrada**
Iuma, Universidad De Zaragoza
16.07.2020 | 16.00 H

Sars Cov-2 Is The New Coronavirus Causing The Pandemic Known As Covid-19. This Respiratory Disease Is Characterized By Multi-Organ And Systemic Damages In Patients. The Abundance Of Ace2 On Human Organs Has Been Claimed As Responsible For Such Multi-Organ Spread Of The Virus Damages. However, Once On Circulation The Virus Could Spread To Practically Every Organ In The Human Body As Ace2 Is Ubiquitous On Endothelia And Smooth Muscle Cells Of Virtually All Organs. Contrastingly, Sars Cov-2 Only Damages Selectively A Few Organs. Here, We Develop The Hypothesis That The Effects Of The Sars Cov-2 Virus Can Be Spread Through The Human Protein-Protein Interaction (Ppi) Network In A Subdiffusive Way. We Then Elaborate A Time-Fractional Diffusion Model On Networks Which Allow Us To Study This Phenomenon. Starting The Diffusion From The Sars Cov-2 Spike Protein To The Human Ppi Network We Show Here That The Pertubations Can Spread Across The Whole Network In Very Few Steps. Consequently, We Discover A Few Potential Routes Of Propagation Of These Perturbations From Proteins Mainly Expressed In The Lungs To Proteins Mainly Expressed In Other Different Tissues, Such As The Heart, Cerebral Cortex, Thymus, Lymph Node, Testis, Prostate, Liver, Small Intestine, Duodenum, Kidney, Among Others Already Reported As Damaged By Covid-19.

YouTube
https://www.youtube.com/watch?v=53tEodkCv0c&list=PLf7A47_ENtnLkXJ8QPspRIT5a0zz-1nPd&index=5



- **Dynamics Of T-Cell Memory Formation And Reactivation After Covid-19**

Speaker: **Aleksandra Walczak**
Ens, Paris
26.11.2020 | 15.30 H

The Immune Repertoire Responds To A Wide Variety Of Pathogenic Threats. Immune Repertoire Sequencing Experiments Give Us Insight Into The Composition Of These Repertoires. Since The Functioning Of The Repertoire Relies On Statistical Properties, Statistical Analysis Is Needed To Identify Responding Clones. Using Such Methods I Will Describe The Repertoire Level Response To The Sars-Cov-2, Among Other Perturbations. More Generally, I Will Show How Immune Repertoires Provide A Unique Fingerprint Reflecting The Immune History Of Individuals, With Potential Applications In Precision Medicine.

YouTube
https://www.youtube.com/watch?v=ffa6dnkoKd0&list=PLf7A47_ENtnLkXJ8QPspRIT5a0zz-1nPd&index=6



- **The Economic Impact Of The Covid-19 Pandemic: A Non-Equilibrium Network Model**

Speaker: **Maria Del Rio-Chanona**
Institute For New Economic Thinking And Mathematical Institute, University Of Oxford
17.12.2020 | 15.30 H

We Develop A Non-Equilibrium Production Network Model For Predicting The Economic Impact Of The Covid-19 Pandemic. In The First Part Of This Work, We Made Quantitative Predictions Of First-Order Supply And Demand Shocks For The U.s. Economy Associated With The Covid-19 Pandemic At The Level Of Individual Occupations And Industries. To Analyze The Supply Shock, We Classify Industries As Essential Or Non-Essential And Construct A Remote Labor Index, Which Measures The Ability Of Different Occupations To Work From Home. Demand Shocks Are Based On A Study Of The Likely Effect Of A Severe Influenza Epidemic Developed By The Us Congressional Budget Office. Compared To The Pre-Covid Period, These Shocks Would Threaten Around 20 % Of The Us Economy's Gdp, Jeopardise 23 % Of Jobs And Reduce Total Wage Income By 16 %. We Then Design An Economic Model To Address The Unique Features Of The Covid-19 Pandemic. Our Model Also Includes A Production Function That Distinguishes Between Critical And Non-Critical Inputs, Inventory Dynamics, And Feedback Between Unemployment And Consumption. We Demonstrate That Economic Outcomes Are Very Sensitive To The Choice Of The Production Function, Show How Supply Constraints Cause Strong Network Effects, And Find Some Counter-Intuitive Effects, Such As That Reopening Only A Few Industries Can Actually Lower Aggregate Output. Our Results Suggest That There May Be A Reasonable Compromise That Yields A Relatively Small Increase In R0 And Delivers A Substantial Boost In Economic Output. This Corresponds To A Situation In Which All Non-Consumer Facing Industries Reopen, Schools Are Open Only For Workers Who Need Childcare, And Everyone Who Can Work From Home Continues To Work From Home.

YouTube
https://www.youtube.com/watch?v=lNaQQGDBRA8&list=PLf7A47_ENtnLkXJ8QPspRIT5a0zz-1nPd&index=7

- **Reducing The Stress On Intensive Care By Optimally Load Balancing Patients In The Era Of Covid-19**

Speaker: **Lucas Lacasa**
Reader In Applied Mathematics, Queen Mary University Of London
14.01.2021 | 15.30 H

As The Number Of Cases Of Covid-19 Continues To Grow, Local Health Services Across Different Countries Are At Risk Of Being Overwhelmed With Patients Requiring Intensive Care. At The Same Time, Surges And Demand Are Not Homogeneous Across A Country, As Different Regions See Incidence Grow Or Decline In An Asynchronous Way. This Enables The Possibility Of Balancing Demand By Sharing Patients. In This Talk I Will Describe A Proposal That We Put Forward In Late March 2020 During The First Wave Of Covid-19, Which Computes Quasi-Optimal Re-Routing Strategies To Either Transfer Patients Requiring Intensive Care Units (Icu) Or Ventilators, Constrained By Feasibility Of Transfer. The Method Is General And Applicable Regionally Or At A National Level. I Will Give The Details Of The Method And Showcase It With Realistic Data From The United Kingdom And Spain. Depending On Different Icu Demand Profiles, Up To 1000 Patients (Per Algorithm Step) Which Would Otherwise Not Receive Care Could Be Re-Allocated Without The Needs Of Increasing Capacity Of The Hospitals. I Will Also Briefly Discuss Our Experience In Going From The Scientific Idea To The Operationalised Platform.

YouTube
https://www.youtube.com/watch?v=8L5hoTNPhMM&list=PLf7A47_ENtnLkXJ8QPspRIT5a0zz-1nPd&index=8

## UBICS Activities


- **International Day Of Women And Girls In Science**

On February 11th 2020, the UBICS celebrated the International Day of Women and Girls in Science. In coordination with other institutes of the University of Barcelona, a short open event called *"Dones en la recerca científica"* was organized at the lecture hall Fontseré (Physics and Chemistry faculties). This event aimed at promoting the scientific career in young female degree students by showing examples of present-day female scientists, who exposed their experience in the path towards science and debated gender topics involved in academia.

**PROGRAM**

**15.00-16.00 h**

Seminar by **Dra. Roberta Sinatra** (Assistant professor, ITU Copenhagen)

Title: **Quantifying the biases of scientific success**


Abstract: Performance, also referred to as quality of fitness, represents the objective achievements of an individual, like the winning record of an athlete or the body of work of a scientist. In contrast, success, also referred to as impact, popularity, or visibility, is a collective phenomenon, indicating a community's reaction to an individual's performance. Why is the difference between performance and success important? Because in many areas of human activity, we often rely on success to measure performance - especially in science, where citations and visibility are constantly used to gauge quality, to assign recognition, and to allocate resources. Yet, success is strongly susceptible to effects that have NOTHING to do with performance, like gender or reputation. In this talk, we study success and impact in science, and ask: What is the role of luck in achieving high impact? What is the effect of gender and reputation on success? Can we model the different career evolution of male and female scientists? Based on the premise that success is a collective phenomenon, we use the tools of network science, data science, and computational social science to provide quantitative answers to these questions.

**16.00-17.00 h**

Open discussion led by **Dra. Roberta Sinatra** (Assistant professor, ITU Copenhagen), **Dra. Joaquina Álvarez Marrón** (CSIC-Jaume Almera) and **Dra. Núria Salan Ballesteros** (UPC).



- **Minicurs De Xarxes Complexes**

Along February-March 2020, UBICS organized a course entitled "Minicurs de Xarxes Complexes" focused on introducing the field of complex networks. The course was mainly addressed to students of the last year of the Physics degree or that were carrying out a Master, although it was also opened to doctorate students. The course was divided in four sessions of two hours each. Every session was given by a UBICS scientist, covering from basic concepts to applications in neuroscience and social networks. Around 60 participants attended the course. Their positive feedback at the end of the course evinced the interest for complex networks and their importance in multidisciplinary science.

**PROGRAM**

**Introducció a les Xarxes Complexes. Exemples. Models bàsics**
12.02 | 13.30-15.00 h
Lecturer: **Maria Àngels Serrano**

**Fonaments teòrics. Teoria de Xarxes Complexes**
19.02 | 13.30-15.00 h
Lecturer: **Marián Boguñá**

**Aspectes computacionals. Repositoris de Dades. Python**
26.02 | 13.30-15.00 h
Lecturer: **Albert Diaz-Guilera**

**Aplicacions amb dades experimentals. Interpretació. Gephi**
4.03 | 13.30-15.00 h
Lecturer: **Jordi Soriano**

- **Vi Festa De La Ciència**


On May 8th 2020, three research groups of UBICS participated in the *"VI Festa de la Ciència"*, which had to be celebrated online due to the COVID-19 pandemic. Researchers shared videos illustrating their investigations in a popular terms and shared different resources, available at the UBICS website. The Science Party takes place every year and its main objective is to present the research that is carried out at UB, and in amusing and educative way.

The most important contributions to the event were the following. (i) UBICS itself presented the video *"Descobrint els sistemes complexos"* to introduce the project Complexifica, an initiative for high-quality dissemination and outreach. In the webpage of Complexifica one can find different applets and videos that explain attractive Complex Systems models. (ii) The Institute of Physical Education (INEFC) group presented a platform for students called SUMA (Synthetic Understanding through Movement Analogies, https://suma.edu.mk), devoted to explain how Nature works in a comprehensive way. And (iii), the CEIPAC group of History announced their EPNet Project (Production and Distribution of Food during the Roman Empire: Economic and Political Dynamics). In this project historians, mathematicians, physicists and computer scientists work together in order to prove hypothesis, to investigate ancient Roman social relations and to quantify food spread networks.

In addition, on July 27th a virtual workshop was given by Dr. Jordi Perez, a CEIPAC and UBICS member, better explaining the EPNet Project. In particular, he showed how economics and social classical history can be reconstructed from ancient Roman amphorae.

All the conducted activities along the science party can be revisited here:
http://www.ub.edu/Laubdivulga/Festacienciaub/Festacienciavi/Sistemes_complexos.html

**Some other important activities of UBICS along 2020 had to be cancelled because of the COVID-19 pandemic, most notably the UBICS Day and the XV Fira d'Empreses.**

## UBICS Outreach

• **Complexifica Project**

UBICS offers diverse resources to better understand science trough the Complex Systems perspective, with a general channel for dissemination at the website ubics.ub.edu/divulgacio.php. However, one of the most innovative resources is what we call *"Complexifica"* http://ubics.ub.edu/complexifica/index.html, where important statistical physics ideas are described in detail. The Ising or the Shelling models, among others, are explained through videos and interactive applets.
Additionally, and along 2020, the student Marc Guarch developed new applets to explain epidemic models (based on the SIR Model) in order to better understand the spread of a virus over a population, a very interesting idea in the context of the COVID-19 pandemic. These applets are accompanied by illustrative videos developed by Irene Ferri, a UBICS student, and quizzes created by Sara Teller, our research manager.

The *"Complexifica"* initiative was launched to support the increasing number of students that want to know more about key theoretical concepts in Complex Systems.

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# ACTIVITIES OF UBICS MEMBERS

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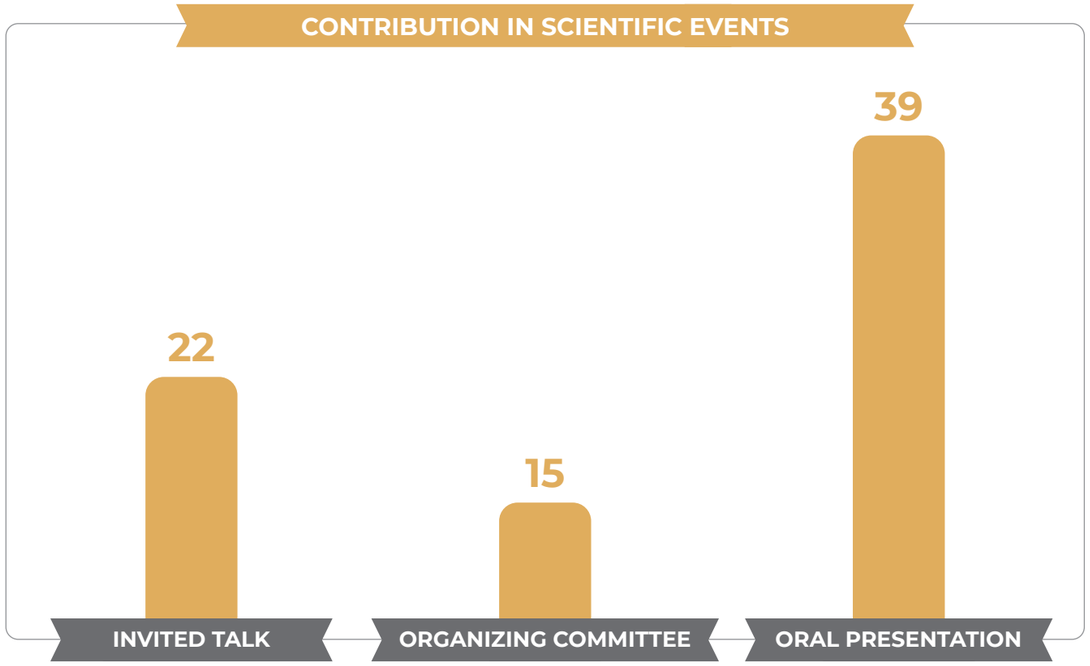


- **The Physics of Collective Cell Migration**
  Princeton (USA)
  **Casademunt, J.**
  *Hydrodynamic approach to spreading epithelia. active wetting and fingering*

- **NANOTRANS Barcelona Meeting**
  Barcelona (SPAIN)
  **Tierno, P.**
  *Emergent collective colloidal currents generated via exchange dynamics in a broken dimer state*

- **ECSA - European Citizen Science Association 2020**
  Trieste (ITALY)
  **Cigarini, A.; Perelló, J.; Gresle, A.; de la Torre, L.; Pinazo, M.; Ribera, M.**
  *Measuring impact in participatory research: an open, multidimensional and multi-actors online evaluation platform*

- **10th International Conference on the Mesolithic in Europe (MESO'2020)**
  Toulouse (FRANCE)
  **Cucart-Mora, C.; Romano, V., Lozano, S., Gómez-Puche, M. Fernández-López de Pablo, J.**
  *Ornaments as a proxy for reconstructing social networks in iberian mesolithic hunter-gatherers*

- **XXXVI Congreso Internacional de la Sociedad Española del Procesamiento del Lenguaje Natural (SEPLN 2020)**
  Virtual Conference (INTERNATIONAL)
  **Rosso, P.; Casacuberta, F.; Gonzalo, J.; Plaza,L.; Carrillo, J.; Amigó, E.; Verdejo, M.F.; Taulé, M.; Salamó, M.; Martí, M.A.**
  *MISMIS: misinformation and miscommunication in social media: aggregating information and analysing language*

- **European Association of Archaeologists (EAA) 2020 Virtual Annual Meeting**
  Virtual Conference (INTERNATIONAL)
  **Cucart-Mora, C.; Romano, V.; Lozano, S.; Gómez, M.; Fernández-López de Pablo, J.**
  *Reconstructing mesolithic social networks from the iberian peninsula using ornaments*

- **1st TIR-FOR SYMPOSIUM. From territory studies to digital cartography**
  Virtual Conference (INTERNATIONAL)
  **Martin Oliveras, Antoni; Revilla, Víctor; Stubert, Lisa; Vogel, Sebastian**
  *Geospatial-economic studies and archaeological data analysis applied to ancient viticultural landscapes. the case of laetanian roman wine, hispania citerior tarraconensis*

- **Annus Nefastus, Misfortunes, Changes and Opportunities in the Roman World Congress**
  Virtual Conference (INTERNATIONAL)
  **Pons Pujol, Ll.**
  *La masacre de la población de volubilis (40/41 d.c.) durante la conquista de mauritania*

- **III International Congress. Mediterranean Cities. Mobility and displacement of people**
  Barcelona (SPAIN)
  **Revilla, V.**
  *Mobilitat i identitats personals a hispania: la ciutat com a espai d'interacció en un imperi mediterrani*

- **Annus Nefastus, Misfortunes, Changes and Opportunities in the Roman World Congress**
  Virtual Conference (INTERNATIONAL)
  **Remesal, J.**
  *La consolidación económica de un imperio*

- **Arqueología Española en Italia**
  Virtual Conference (NATIONAL)
  **Remesal, J.**
  *Monte Testaccio: 30 años de la misión española en Roma*

- **XVII Foro internacional sobre la Evaluación de la Calidad de la Investigación y de la Educación Superior (FECIES)**
  Virtual Conference (NATIONAL)
  **Remesal, J.; Perez, J.**
  *Humanidades tradigitales. Nuevos enfoques, viejas cuestiones. Herramientas para la elaboración de investigacionescientíficas*

- **XVII Foro internacional sobre la Evaluación de la Calidad de la Investigación y de la Educación Superior (FECIES)**
  Virtual Conference (NATIONAL)
  **Remesal, J.**
  *Ciencia y Techné. El cambio de paradigma*

- **Toletum – XI. Workshop - Antike Digital**
  Virtual Conference (NATIONAL)
  **Remesal, J.**
  *Ciencia y Techné. El cambio de paradigma*

- **ArcheoFOSS. Open software, hardware, processes, data and formats in archaeological reseaech. International Conference. XIV**
  Virtual Conference (INTERNATIONAL)
  **Remesal, J.; Pérez, J.; Bermúdez, J.M**
  *Roman open data: computational tool to analyze the roman empire trading system*

- **Vía de la Plata**
  Zamora (SPAIN)
  **Remesal, J.**
  *Que seas más feliz que Augusto y mejor que Trajano*

- **VTILITAS QVAERIT FRVCTVM**
  Virtual Conference (NATIONAL)
  **Remesal, J.**
  *La producción y comercialización del aceite en las campiñas hispanorromanas*

- **XVII Foro internacional sobre la Evaluación de la Calidad de la Investigación y de la Educación Superior (FECIES)**
  Virtual Conference (NATIONAL)
  **Pérez, J. ; Aguilera, A.**
  *Un caso de innovación docente en la asignatura de Epigrafía en la Enseñanza Universitaria: la base de datos del CEIPAC*

- **III International Congress. Mediterranean Cities. Mobility and displacement of people Barcelona**
  Barcelona (SPAIN)
  **Revilla, V.**
  *Movilidad geográfica e identidad personal en las ciudades de Hispania*

- **1st TIR-FOR SYMPOSIUM. From territory studies to digital cartography**
  Virtual Conference (INTERNATIONAL)
  **Martin, A.; Revilla, V.; Stubert, L.; Vogel, S.**
  *Geospatial-economic studies and archaeological data analysis applied to ancient viticultural landscapes. The case of laetanian roman wine, hispania citerior tarraconensis*

- **XVII Foro internacional sobre la evaluación de la calidad de la investigación y de la educación superior (FECIES)**
  Virtual Conference (NATIONAL)
  **Pérez, J.; Revilla, V.; Pons, LL**
  *Guía para una correcta visibilidad curricular en el ámbito académico de las Humanidades Digitales. Estrategias para optimizar las labores de gestión del/de la historiador/a*

- **Vtilitas qvaerit frvctvm**
  Virtual Conference (NATIONAL)
  **Revilla, V.**
  *Denominaciones de origen romanas: la producción y el comercio de los vinos de hispania*

- **Interspeech**
  Virtual Conference (INTERNATIONAL)
  **Külebi, B.; Öktem, A.; Peiró-Lilja, A.; Pascual, S.; Farrús, M.**
  *Catotron - a neural text-to-speech system in catalan*

- **Interspeech**
  Virtual Conference (INTERNATIONAL)
  **Peiró-Lilja, A.; Farrús, M.**
  *Naturalness enhancement with linguisti information in end-to-end tts using unsupervised parallel encoding*

- **IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)**
  Virtual Conference (INTERNATIONAL)
  **Cámbara, G.; Luque, J.; Farrús, M.**
  *Detection of speech events and speaker characteristics through photo-plethysmographic signal neural processing*

- **International conference on Motile active matter**
  Virtual Conference (INTERNATIONAL)
  **Pagonabarraga, I.**
  *Mechanisms controlling self-propulsion and collective response of active diffusiophoretic colloids*

- **73rd Annual Meeting of the APS Division of Fluid Dynamics (APS DFD 2020)**
  Virtual Conference (INTERNATIONAL)
  **Pagonabarraga, I.**
  *Collective self-propulsion in active and passive apolar colloidal mixtures*

- **Workshop on transport of soft matter at the nanoscale**
  Manresa (SPAIN)
  **Pagonabarraga, I.**
  *Dynamic interactions in active suspensions*

- **Frontiers in computational methods for active matter**
  Lausanne (SWITZERLAND)
  **Pagonabarraga, I.**
  *Activity induced phase transitions: from mips to chiral self-sorting*

- **CECAM Webinar series: The importance of being H.P.C. Earnest**
  Virtual Conference (INTERNATIONAL)
  **Pagonabarraga, I.**
  *E-cam: addressing modelling challenges in multiple scales in the hpc leading edge*

- **ReaxPro Online Conference**
  Virtual Conference (INTERNATIONAL)
  **Pagonabarraga, I.**
  *Emerging collective behavior in block-copolymer nanocomposites*

- **Barcelona Mathematical Days 2020. Complex Systems and Networks**
  Virtual Conference (INTERNATIONAL)
  **M. Boguñá**
  *Non-markovian dynamics in sis epidemic models*

- **ECSA CONFERENCE 2020**
  Virtual Conference (INTERNATIONAL)
  **Bonhoure, I; Cigarini, A; Vicens, J; Perelló, J.**
  *Citizen science with and for public libraries: from librarians capacitation to research co-creation, an analysis of two barcelona region-based projects.*

- **Transparència i crisi climàtica després del COVID19**
  Virtual Conference (NATIONAL)
  **Perelló, J.**
  *Ciència ciutadana*

- **6th International conference on computational social science**
  Virtual Conference (INTERNATIONAL)
  **Arenas, A.; Borge-holthoefer, J.; Perelló, J.; Gutiérrez-Roig, M.**
  *Mapping individual behavior in financial markets: synchronization and anticipation*

- **Final symposium and MC meeting 2020 cost-action citizen science to promote creativity, scientific literacy, and innovation throughout europe**
  Virtual Conference (INTERNATIONAL)
  **Perelló, J.; Samson, R.**
  *Overarching cross-working group synthesis and overarching measures*

- **CCS 2020- Conference on Complex Systems 2020**
  Virtual Conference (INTERNATIONAL)
  **Perelló, J.; Montero, M.; Masoliver, J.; Farmer, D.; Geneakoplos, J.**
  *Statistics and stochastic interest rate models for climate change mitigation*

- **CCS2020 - Conference on complex systems 2020**
  Virtual Conference (INTERNATIONAL)
  **Peter, F.; Chen, G.; Arkady P.**
  *Fluctuations in system of coupled oscillators induce micro-correlations*

- **Knowledge for change: a decade of citizen science (2020-2030) in support of the SDGs**
  Virtual Conference (INTERNATIONAL)
  **Perelló, J.**
  *enhancing social dimensions in citizen science: sdgs and social tipping points*

- **CCS2020 - Conference on complex systems 2020. satellite workshop: "Citizen social science & complex systems science: coping social issues with active citizen participation"**
  Virtual Conference (INTERNATIONAL)
  **Larroya, F.; Perelló, J.**
  *Data and main statistical features for pedestrian mobility through a citizen science project*

- **Knowledge for change: a decade of citizen science (2020-2030) in support of the SDGs**
  Virtual Conference (INTERNATIONAL)
  **Arza, V.; Perelló, J.**
  *Co-defining digital platforms to provide actionable insights along sdgs: mental health care provision and environmental justice*

- **Knowledge for change: a decade of citizen science (2020-2030) in support of the SDGs**
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  **Peter, F.; Perelló, J.**
  *The co-creation of a chatbot for improving mental health care*

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  **Cigarini, A.; Bonhoure, I.; González-Virós, I.; Perelló, J.**
  *Building a participatory network for research on social support in mental health: cooperation, mission-oriented research and actionable insights*

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  **Gresle, A.-S.; Santoro, V.; Cigarini, A.; de la Torre, L.; Jimeno, I.; Dempere, H.; Ribera, M.; Puertas, E.; Perelló, J.; Pinazo, M.J.**
  *An innovative online tool to self-evaluate and compare participatory research projects*

- **Probability seminars, school of mathematics research**
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  **Serrano, M. A.**
  *Geometric renormalization unravels the multiscale structure of complex networks*

- **9th RIEC international symposium on brain functions and brain computer**
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  **Montalá, M.; Estévez-Priego, E.; Faci-Lázaro, S.; Gómez-Gardeñe, J.; Ludl, A.-A.; Soriano, J.**
  *Tuning the richness of spontaneous activity patterns in neuronal cultures through engineering*

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  **Soriano, J.**
  *High throughput calcium imaging*

- **Micromechanics, statistics and hazards of mechanical failure**
  Virtual conference (international)
  **Vives, E.**
  *Failure of porous materials under compression: two universality classes?*

- **13th international conference of education, research and innovation**
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  **Blasco-Martel, Y.; El Bachiri, N.; Lozano, S.**
  *Development of an indicator to measure sot skills' perception*

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  *Spatiotemporal organization of correlated local activity within global avalanches in slowly driven interfaces*

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  **Fernandez-Nieves, A.**
  *Force chains in fire-ant columns: Jannsen's experiment with active matter*

- **DPG spring meeting, Dresden. Symposyum of 'Dynamics and statistical physics' section**
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  **Casademunt, J.**
  *A hydrodynamic approach to collective cell migration in epithelial tissues*

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  **Planet, R.; López, J.M.; Santucci, S.; Ortín, J.**
  *Spatiotemporal organization of correlated local activity within global avalanches in slowly driven interfaces*

- **EPS condensed matter division 2020 (CMD2020GEFES)**
  Virtual Conference (INTERNATIONAL)
  **Mendoza, C.I.; Reguera, D.**
  *Triggering mis-assembly in viral capsid formation by elastic frustration*

- **XVII encuentro inter-bienal del grupo especializado de termodinámica (GET) de las reales sociedades españolas de física y química (RSEF y RSEQ)**
  Lanzarote (SPAIN)
  **Reguera, D.**
  *¿Hasta qué punto entendemos los fenómenos de nucleación?*

- **Socinfo2020**
  Virtual Conference (INTERNATIONAL)
  **Cozzo. E.; Díez-Hermoso, M.; Díaz-Guilera, A.; Prignano, L.**
  *Organic and false amplifier networks in online social media*

- **NetSci 2020**
  Virtual Conference (INTERNATIONAL)
  **Cozzo. E.; Díez-Hermoso, M.; Díaz-Guilera, A.; Prignano, L.**
  *Organic and false amplifier networks in online social media*

- **Social Networks and Cultural Evolution in Prehistoric Hunter-Gatherers. PALEODEM project webinar series.**
  Virtual Conference (INTERNATIONAL)
  **Lozano, S.; Romano, V.**
  *When prehistoric archaeology meets network science: testing demography-dependent models of cultural change*

- **XI Conferencia internacional de computación e informática del norte de Chile**
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  **Salamó, M.**
  *Inside and outside the recommender systems: fundamental components*

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