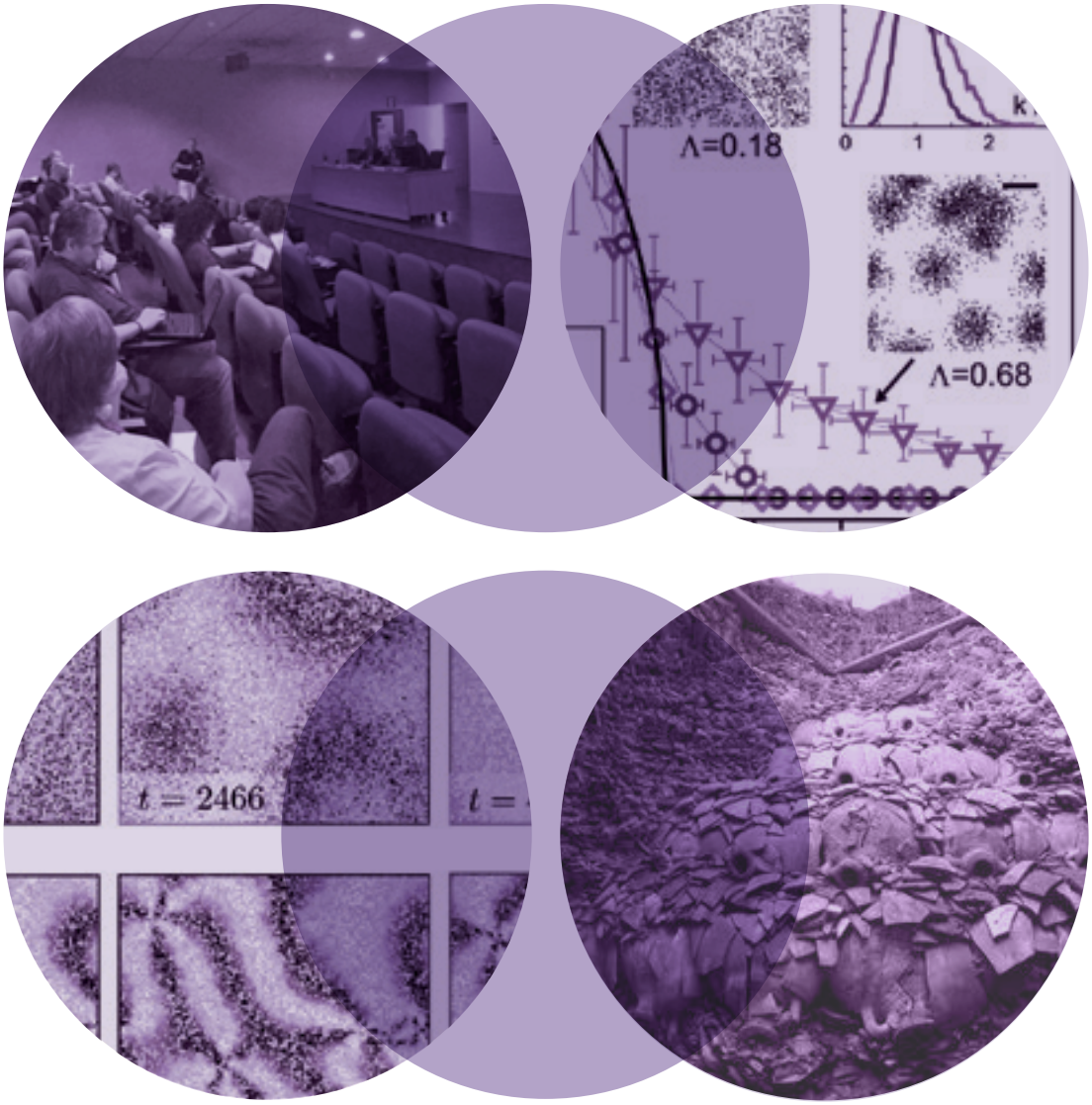
Universitat de Barcelona

UBICS Institute of Complex Systems

Annual Report

2021



UBICS

Institute of Complex Systems

Universitat de Barcelona

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UBICS Institute of Complex Systems
Annual Report
2021

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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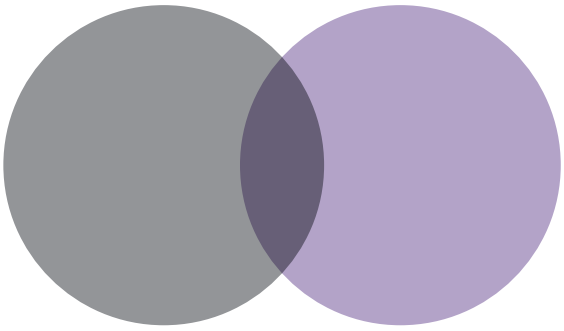

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INSTITUTE STRUCTURE

1 INSTITUTE STRUCTURE

Organization chart

Executive Board

Díaz Guilera, Albert
→ *Director*

Soriano Fradera, Jordi
→ *Secretary*

Farrús Cabeceran, Mireia

Ibañes Miguez, Marta

Levis Sotomayor, Demian

Perelló Palou, Josep

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Lozano Pérez, Sergio

Miguel Lopez, Maria Del Carmen

Moriano Palacios, Juan Andrés

Perello Palou, Josep

Pi i Jaumà, Irina

Salamo Llorente, Maria

Serrano Moral, Maria Angeles

Soriano Fradera, Jordi

Taulé Delor, Maria

van der Kolk, Jasper

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→ *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
Dediu, Dan	Departament Filologia Catalana i Lingüística General
Farrús Cabeceran, Mireia	Departament Filologia Catalana i Lingüística General

ECONOMIC HISTORY AND DEVELOPMENT (INDUSTRY, BUSINESS AND SUSTAINABILITY) (2017SGR1466)

Lozano Pérez, Sergio	Departament d'Història Econòmica, Institucions, Política i Economia Mundial

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UBICS IN FIGURES

2 UBICS IN FIGURES

UBICS

47 Senior Researchers

26 Early Stage Researchers

12 External Members

1 Services and Administration Personnel

ICREA

Catalan Institution For Research And Advanced Studies

4 Research Professors

4 Academia Professors

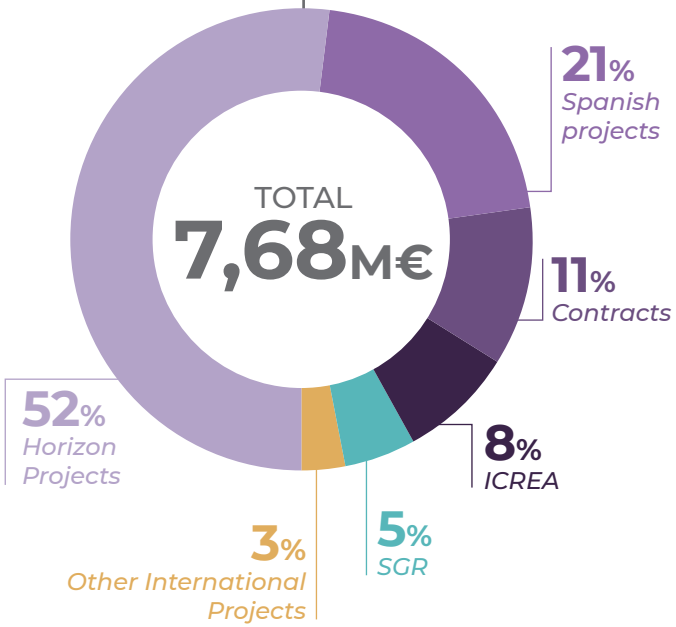
ERC

European Research Council

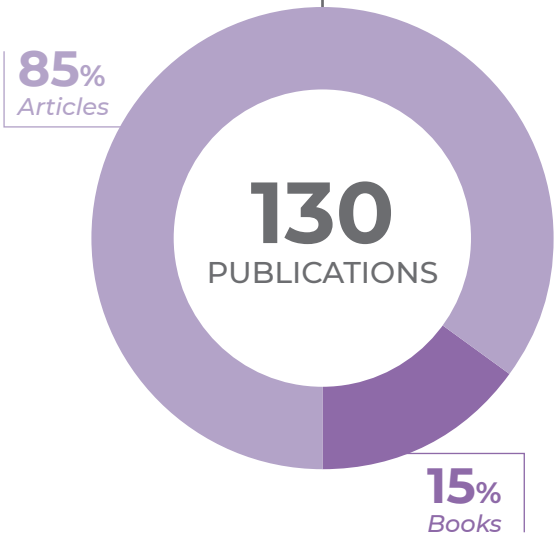
1 Consolidator Grant

GENDER

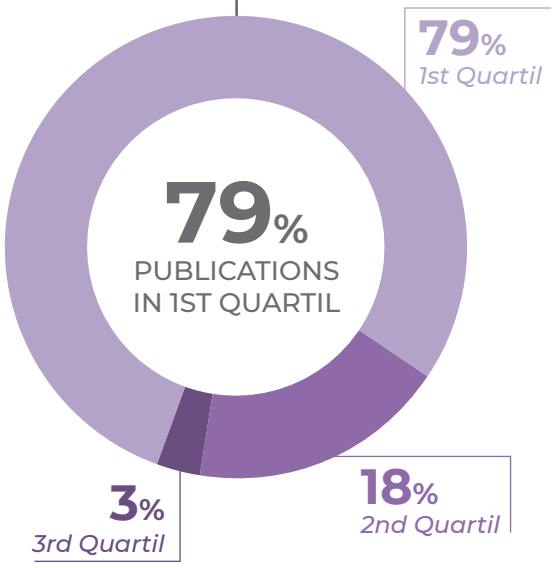
FUNDING



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 08035 Barcelona	Baldiri Reixac, 2 08028 Barcelona	Gran Via Corts Catalanes, 585 08007 Barcelona

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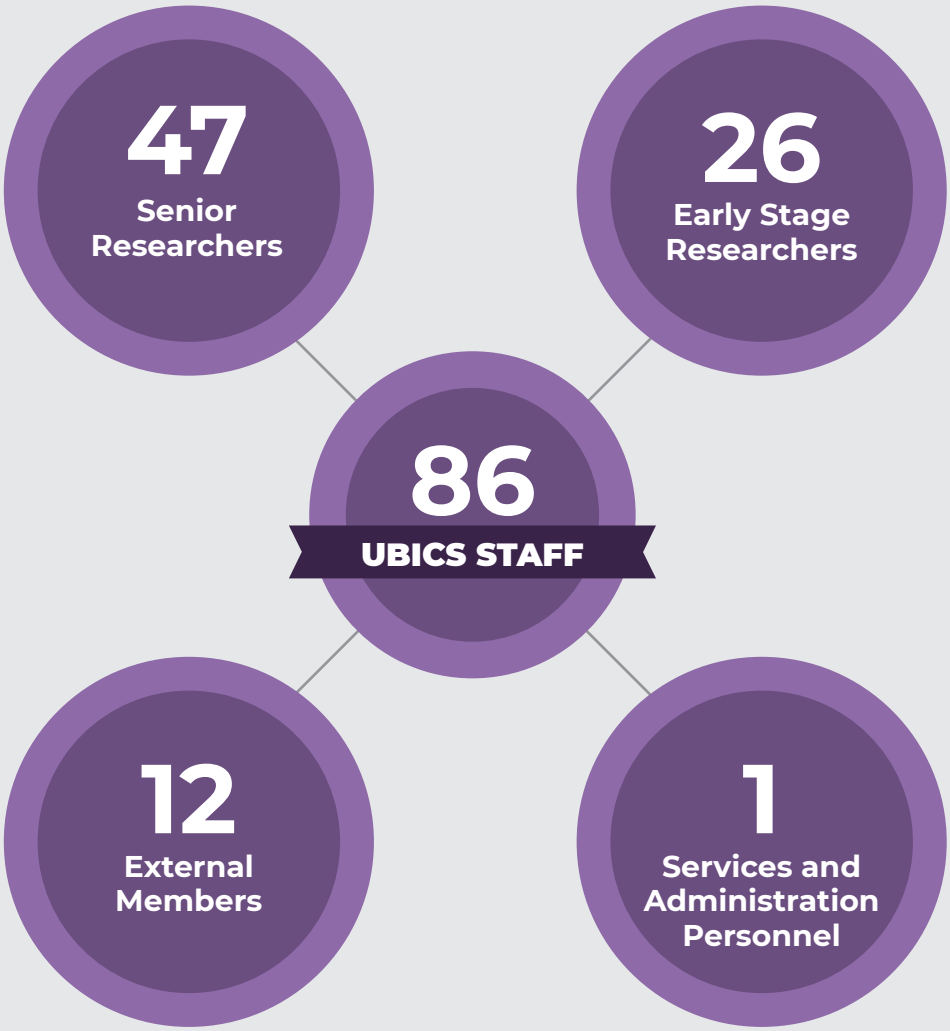
UBICS STAFF

3 UBICS STAFF



47 SENIOR RESEARCHERS

- **Aguilera Martin, Antonio**
  Departament d'Història i Arqueologia
- **Bastardas Boada, Albert**
  Departament Filologia Catalana i Lingüística General
- **Boeckx, Cedric**
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- **Boguñà Espinal, Marian**
  Departament Física de la Matèria Condensada
- **Casademunt Viader, Jaume**
  Departament Física de la Matèria Condensada
- **Cozzo, Emmanuelle**
  Departament Física de la Matèria Condensada
- **Dediu, Dan**
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- **Díaz Guilera, Albert**
  Departament Física de la Matèria Condensada
- **Hernández Gonzalez, Jerónimo**
  Departament de Matemàtiques i Informàtica
- **Farràs Permanyer, Laia**
  Departament de Psicologia Social i Psicologia Quantitativa
- **Farrús Cabeceran, Mireia**
  Departament Filologia Catalana i Lingüística General
- **Fernández Nieves, Alberto**
  Departament de la Física de la Matèria Condensada
- **Gallardo-Pujol, David**
  Facultat de Psicologia
- **Guàrdia Olmos, Joan**
  Departament Psicologia Social i Psicologia Quantitativa
- **Ibañes Míguez, Marta**
  Departament Física de la Matèria Condensada
- **Lavi, Ido**
  Departament de 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
- **Martí i Antonín, M. Antònia**
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- **Masoliver García, Jaume**
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- **Massip Bonet, Maria Àngels**
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- **Miguel López, M. Del Carmen**
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- **Montero Torralbo, Miquel**
  Departament Física de la Matèria Condensada
- **Ortín Rull, Jordi**
  Departament Física de la Matèria Condensada
- **Pagonabarraga Mora, Ignacio**
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- **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**
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- **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

SENIOR RESEARCHERS

- **Reguera López, David**
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- **Remesal Rodríguez, José**
  Departament Història i Arqueologia
- **Revilla Calvo, Víctor**
  Departament Història i Arqueologia
- **Rodríguez Santiago, Inmaculada**
  Departament Matemàtiques i Informàtica
- **Garcia Sanchez, Manuel**
  Departament d'Història i Arqueologia
- **Ortiz Ambriz, Antonio**
  Departament de Física de la Matèria Condensada
- **Prignano, Luce**
  FBG - Fundació Bosch i Gimpera
- **Salamó Llorente, Maria**
  Departament Matemàtiques i Informàtica
- **Sancho Herrero, José María**
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- **Serrano Moral, Maria Ángeles**
  Departament Física de la Matèria Condensada
- **Soriano Fradera, Jordi**
  Departament Física de la Matèria Condensada
- **Taulé Delor, Maria**
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- **Tierno, Pietro**
  Departament Física de la Matèria Condensada
- **Vives Santa-Eulalia, Eduard**
  Departament Física de la Matèria Condensada

26 EARLY STAGE RESEARCHERS

- **Casajús Saiz, Sergio**
  Departament Física de la Matèria Condensada
- **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
- **Fernandez Lopez, Clara**
  Departament de Física de la Matèria Condensada
- **Ferri Condeminas, Irene**
  Departament Física de la Matèria Condensada
- **Gómez Robledo, Maria Aide**
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- **Granados Leyva, Sergio**
  Departament Física de la Matèria Condensada
- **Jankowski, Robert**
  Departament Física de la Matèria Condensada
- **Larroya Paixà, Ferran**
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- **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
- **Ariza Casanoba, Alejandro**
  Departament Filologia Catalana i Lingüística General
- **Ortiz Castillo, Elisenda**
  Departament Física de la Matèria Condensada
- **Ostinato, Mattia**
  Departament de la Matèria Condensada

EARLY STAGE RESEARCHERS

- **Palacin Copado, Carlos**
  Departament d'Història i Arqueologia
- **Pi i Jaumà, Irina**
  Departament Física de la Matèria Condensada
- **Rodríguez Gallo, Carolina**
  Departament Física de la Matèria Condensada
- **Rojo González, Javier**
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- **Rosell Tarragó, Gemma**
  Departament Física de la Matèria Condensada
- **Sadurní Parera, Marc**
  Departament de Física de la Matèria Condensada
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- **Termens, Joan**
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- **Van der Kolk, Jasper**
  Departament de la Matèria Condensada
- **Zaida Chavero, Lara**
  Departament Física de la Matèria Condensada

12 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
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  History and Archaeology, University of Trier
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  Departament d'Història i Arqueologia
- **Moros Diaz, Juan Alonso**
  Departament d'História i Arqueologia
- **Pérez González, Jordi**
  UdG- Departament d'Història i Història de l'art
- **Tiago Martins, Pedro**
  Departament Filologia Catalana i Lingüística General
- **Vázquez, Pablo**
  FBG - Fundació Bosch i Gimpera

1 SERVICES AND ADMINISTRATION PERSONNEL

- **Teller Amado, Sara**

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RESEARCH LINES

4 RESEARCH LINES

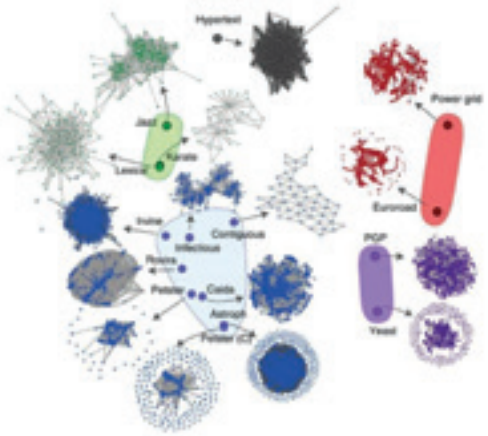
Foundations

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

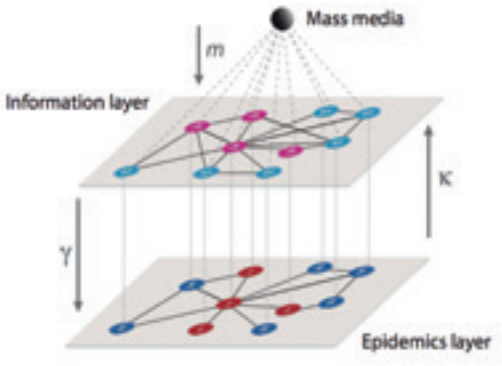
Statistical Physics techniques are at the basis of our approach to the study of complex systems. Statistical Physics uses the methods of probability theory and statistics to bridge the gap between the microscopic properties of individual atoms and molecules and the macroscopic or bulk properties of materials.

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

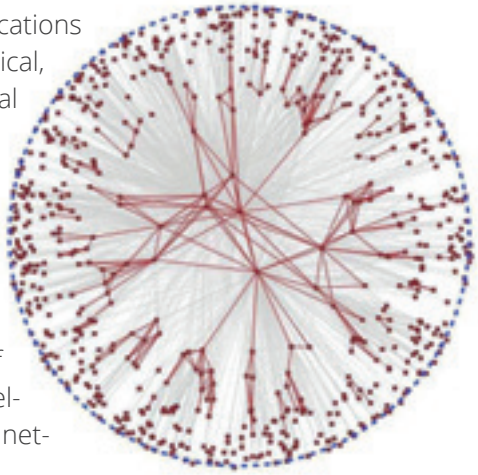
Complex systems are inherently dynamic and both properties and processes change over time. Dynamical systems theory provides a mathematical framework for treating time dependence in complex systems, typically involving continuous time and stochastic or random events. Apart from time dependence in geometrical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

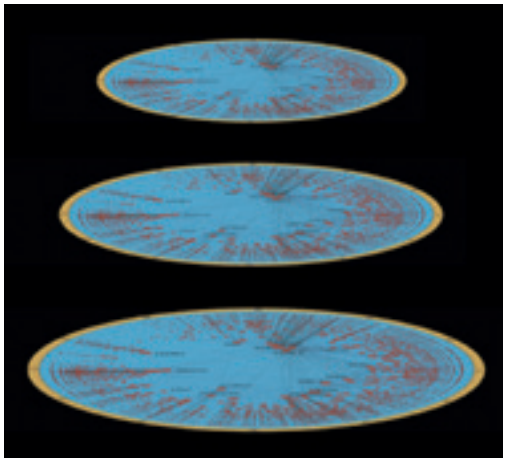
Among the different dynamical processes, the phenomenon of synchronization has received a lot of attention, becoming one of the paradigmatic examples of the emergence of collective properties with applications in physical, biological, chemical, technological and social systems. UBICS researchers have 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.





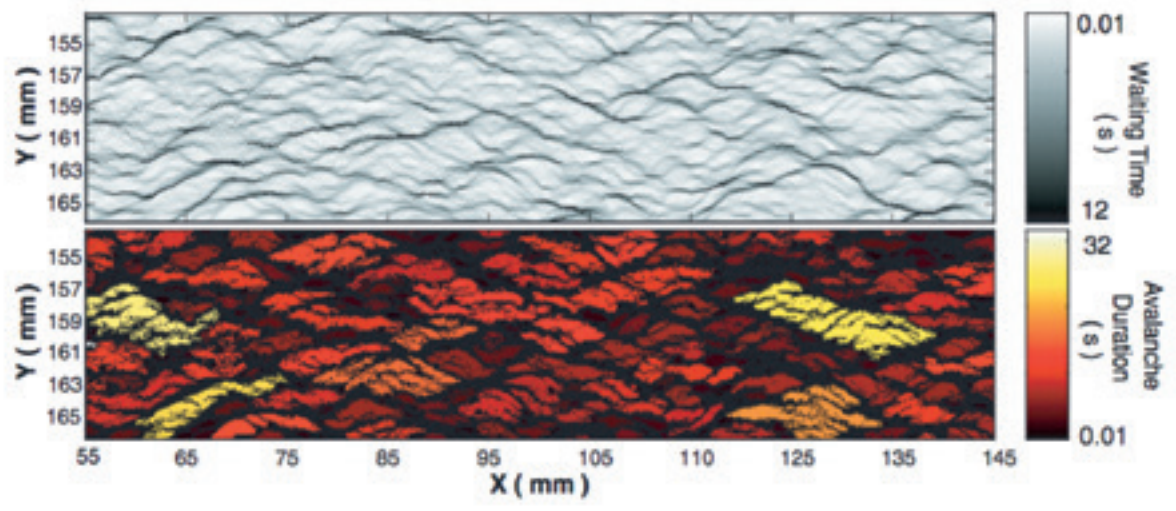
Science Of Matter

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

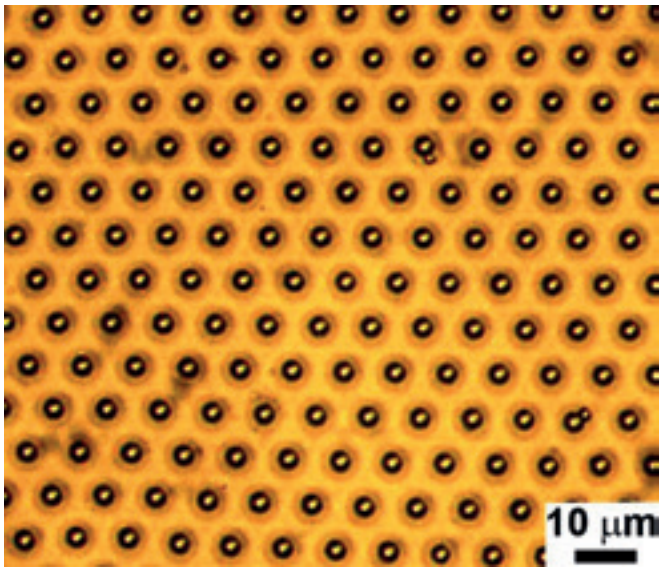
Among the extensive variety of soft matter materials, colloidal systems, i.e. fluid suspensions of micron-sized polymer spheres, are particularly interesting, not only for their ubiquitous nature (colloids are present in creams, foams, smoke, paints, etc..), but also because they provide a rich playground 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)

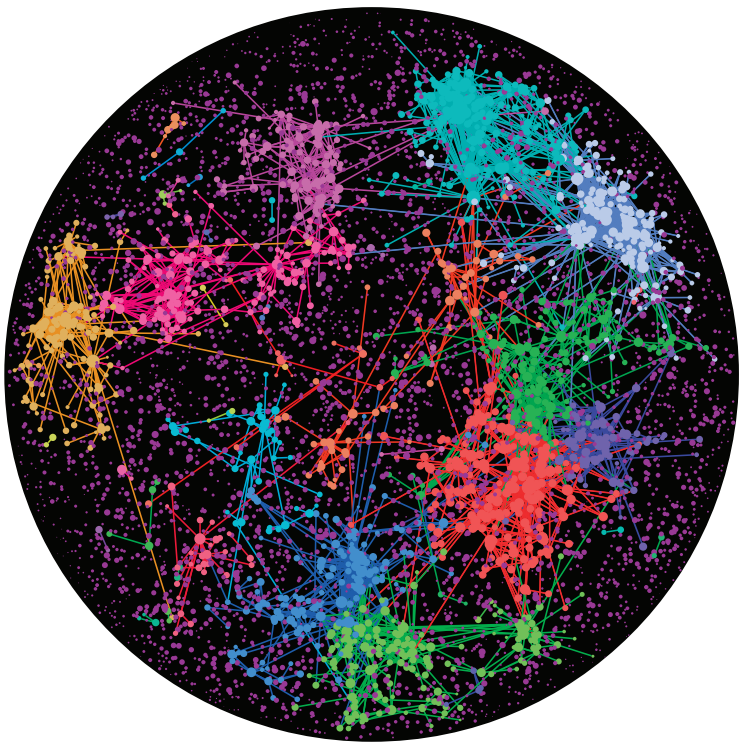
Life Sciences

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.

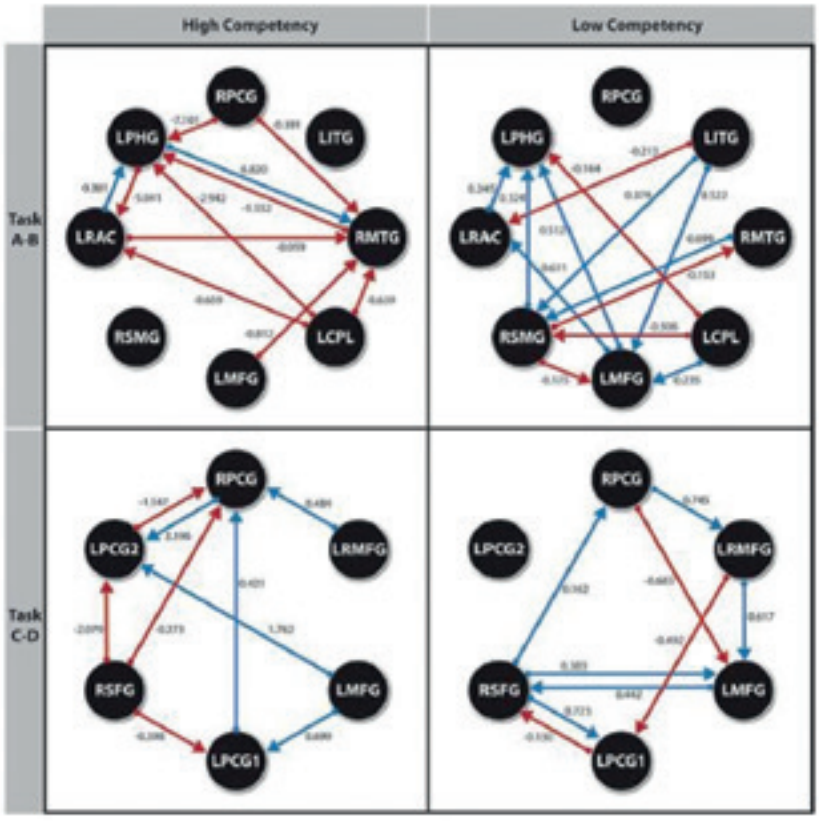
Molecular Biophysics

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



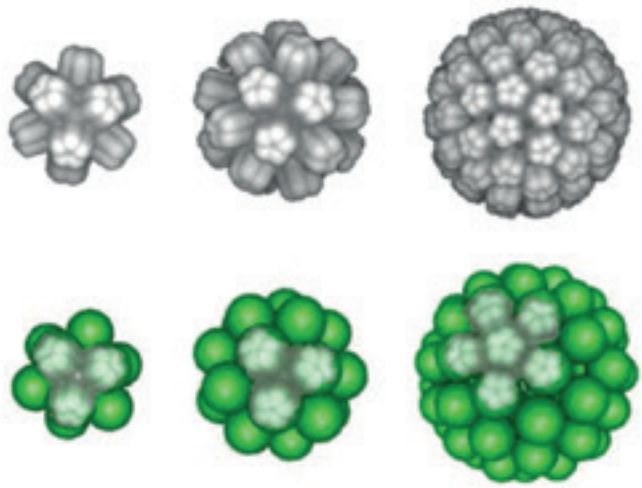
The biological cell is the basic unit of life, and constitutes in itself a remarkably complex system that combines thousands of chemical reactions by thousands of molecular species, all happening at the same time with fascinating harmony within an extremely crowded and noisy environment. The current 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.

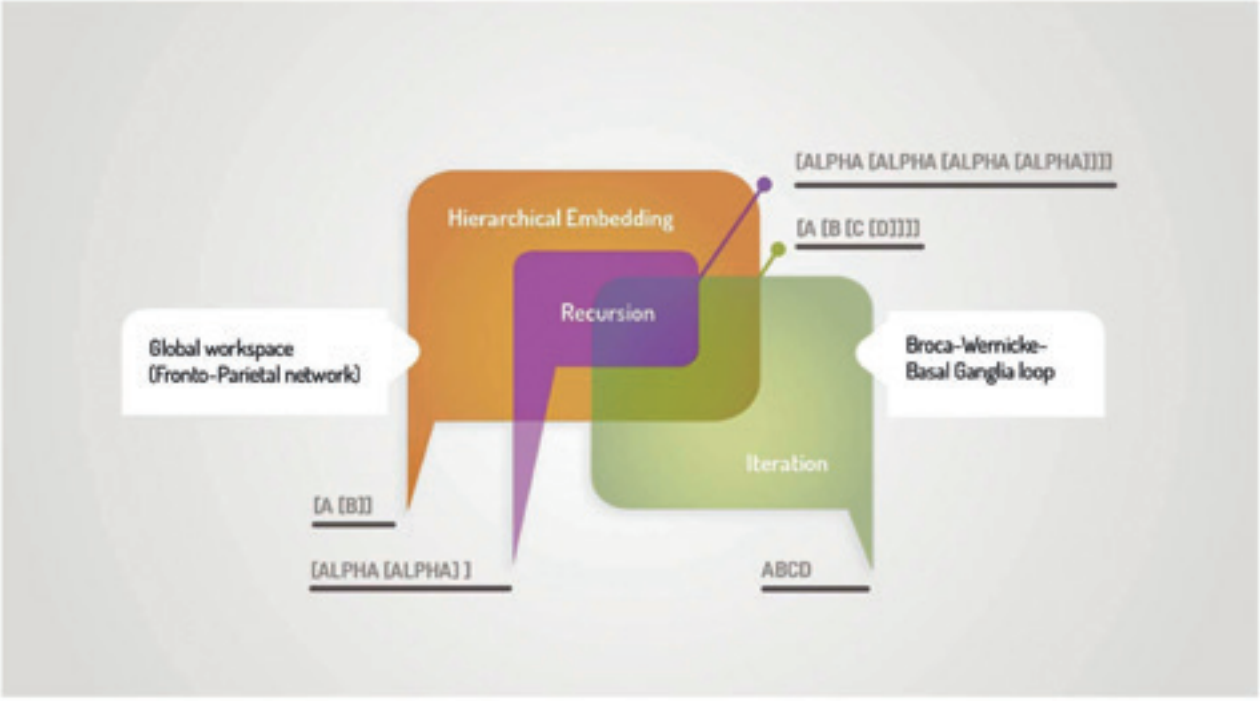
Two major lines of action shape neuroscience research, centered at either the scale of the brain or at the scale of mesoscopic neuronal circuits. At the scale of the brain, researchers study statistical models for the complex representation of the behavior of brain signal recordings in Functional Magnetic 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

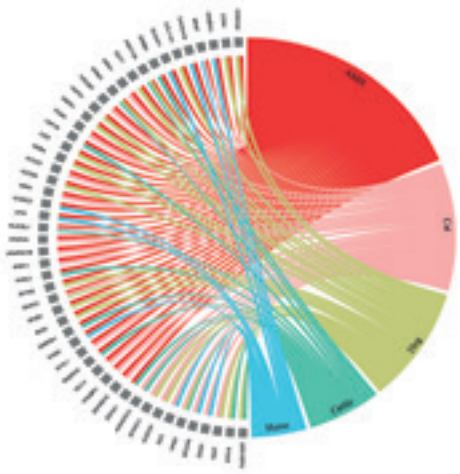
Applications in the social sciences range from aspects at the individual level to the study of large scale sociopolitical and economic structures, including those of the past. One of the applications that we can already consider as traditional in complex system science is economy and finance. But the 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 phenome-

na. 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

Horizon Projects

- ***An e-infrastructure for software, training and consultancy in simultion and modelling (E-CAM)***
  Period: 01/10/2015 to 30/07/2020
  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

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

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

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

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

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

- ***Neuronal networks from Cortical human iPSCs for Machine Learning Processing (NEU-ChiP)***
  Period: 01/09/2021 to 31/08/2024
  Investigator: Soriano Fradera, Jordi

Other International Projects

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

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

- ***STERHEOTYPES: STudying European Racial Hoaxes and sterEOTYPES***
  Investigator: Taulé Delor, Maria
  Agency: VolkswagenStiftung (Fundación Volkswagen)

Spanish Government Funded Research Projects

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

- ***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

- ***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

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

- ***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

- ***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

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

- ***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: modeles estocásticos y experimentos públicos***
  Period: 01/06/2020 to 31/05/2023
  Investigator: Perelló Palou, Josep

- ***IA explicable para desinformación y detección de conspiración durante infodemias (XAI-DisInfodemics)***
  Period: 01/12/2021 to 30/11/2024
  Investigator: Taule Delor, Maria

- ***Materiales calóricos y multicalóricos avanzados para una refrigeración limpia y eficiente***
  Period: 01/09/2021 to 31/08/2025
  Investigator: Vives Santa-Eulalia, Eduard

- ***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

- ***LIKE-BCN: sociaL accessIble, and walKablE Barcelona***
  Period: 09/12/2021 to 08/06/2023
  Investigator: Lozano Perez, Sergio
  21S09383-001

AGAUR-SGR Consolidated Groups

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

- *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 30/09/2021
  Investigator: **Ortín Rull, Jordi**

- *CLiC - Centre de LLenguatge i computació*
  2017SGR341
  Period: 01/01/2017 to 30/09/2021
  Investigator: **Taulé Delor, Maria**

- *Psicologia Quantitativa*
  2017SGR269
  Period: 01/01/2017 to 30/09/2021
  Investigator: **Guàrdia Olmos, Joan**

- *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**

- *LIKE-BCN: sociaL accessIble, and walKablE Barcelona*
  21S09383-001
  Period: 09/12/2021 - 08/06/2023
  Investigador: **Lozano Perez, Sergio**

Contracts With Public And Private Entities

18

CONTRACTS

FOR A TOTAL AMOUNT OF

871.356,22 €

6

PUBLICATIONS

6 PUBLICATIONS

Word cloud of all publications of UBICS members

ARTICLES

Research line : **COMPLEX NETWORS, DS & AI**

- ***Modeling partial lockdowns in multiplex networks using partition strategies***
  Plazas A., Malvestio I., Starnini M., Díaz-Guilera A.
  Applied Network Science 6 (2021)
  https://doi.org/10.1007/s41109-021-00366-7

- ***An intelligent framework for end-to-end rockfall detection***
  Zoumpekas T., Puig A., Salamó M., Garcia-Sellés D., Blanco Nuñez L., Guinau M.
  International Journal of Intelligent Systems 36 (2021) 6471-6502
  https://doi.org/10.1002/int.22557

- ***We Are Not the Same Either Playing: A Proposal for Adaptive Gamification***
  Rodríguez I., Puig A., Rodríguez A.
  Frontiers in Artificial Intelligence and Applications 339 (2021) 185-194
  https://doi.org/10.3233/FAIA210133

- ***Quasi-symmetries in complex networks: A dynamical model approach***
  Rosell-Tarragó G., Díaz-Guilera A.
  Journal of Complex Networks 9 (2021) 1-37
  https://doi.org/10.1093/comnet/cnab025

- ***Scaling up real networks by geometric branching growth***
  Zheng M., García-Pérez G., Boguñá M., Serrano M.Á.
  Proceedings of the National Academy of Sciences of the United States of America 118 (2021)
  https://doi.org/10.1073/pnas.2018994118

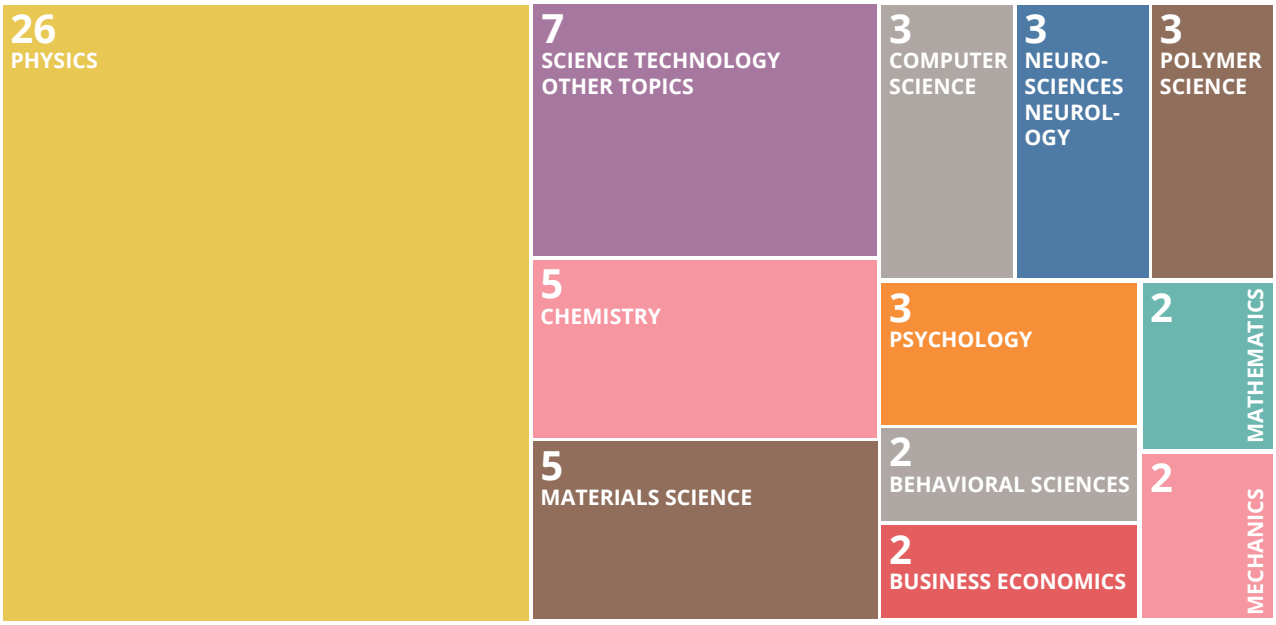
- ***Network geometry***
  Boguñá M., Bonamassa I., De Domenico M., Havlin S., Krioukov D., Serrano M.Á.
  Nature Reviews Physics 3 (2021) 114-135
  https://doi.org/10.1038/s42254-020-00264-4

- ***Jump-diffusion models for valuing the future: Discounting under extreme situations***
  Masoliver J., Montero M., Perelló J.
  Mathematics 9 (2021)
  https://doi.org/10.3390/math9141589

- ***Optimal cost tuning of frustration: Achieving desired states in the Kuramoto-Sakaguchi model***
  Rosell-Tarragó G., Diáz-Guilera A.
  Physical Review E 103 (2021)
  https://doi.org/10.1103/PhysRevE.103.012216

- ***Random walks with invariant loop probabilities: Stereographic random walks***
  Montero M.
  Entropy 23 (2021)
  https://doi.org/10.3390/e23060729

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



- ***Telegraphic transport processes and their fractional generalization: A review and some extensions***
  Masoliver J.
  Entropy 23 (2021)
  https://doi.org/10.3390/e23030364

- ***Maximum Likelihood Estimation of Power-Law Exponents for Testing Universality in Complex Systems***
  Navas-Portella V., González Á., Serra I., Vives E., Corral Á.
  SEMA SIMAI Springer Series 11 (2021) 65-89
  https://doi.org/10.1007/978-3-030-64272-3_5

- ***Perturbation of the normalized Laplacian matrix for the prediction of missing links in real networks***
  Aliakbarisani, R., Ghasemi, A., & Serrano, M. Á.
  IEEE Transactions on Network Science and Engineering, (2021)
  https://doi.org/10.1109/TNSE.2021.3137862

- ***A Semi-Deterministic Random Walk with Resetting.***
  Villarroel, J., Montero, M., & Vega, J. A.
  Entropy, 23(7), 825, (2021)
  https://doi.org/10.3390/e23070825

- ***Integrating collaboration and leadership in conversational group recommender systems***
  Contreras, D., Salamó, M., & Boratto, L.
  ACM Transactions on Information Systems (TOIS), 39(4), 1-32.ç, (2021)
  https://doi.org/10.1145/3462759

- ***Children building and having fun while they learn geometry.***
  Puig, A., Rodríguez, I., Baldeón, J., & Múria, S.
  Computer Applications in Engineering Education (2021)
  https://doi.org/10.1002/cae.22484

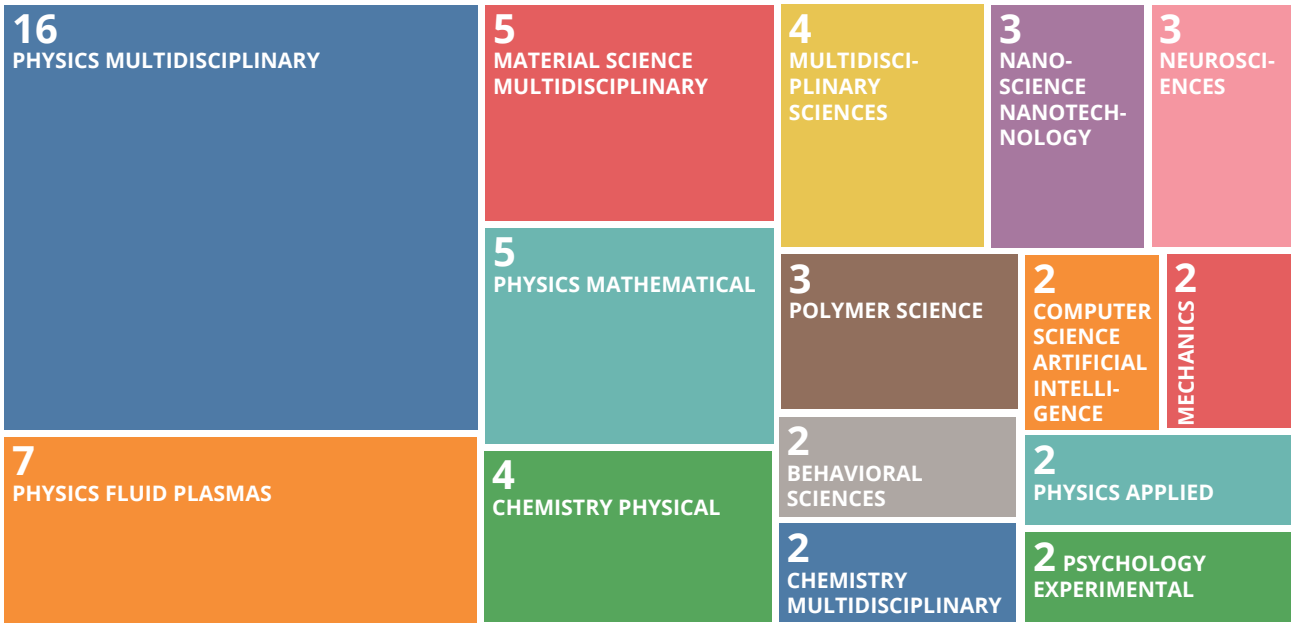
- ***Enabling cross-continent provider fairness in educational recommender systems.***
  Gómez, E., Zhang, C. S., Boratto, L., Salamó, M., & Ramos, G.
  Future Generation Computer Systems, 127, 435-447, (2022).
  https://doi.org/10.1016/j.future.2021.08.025

- ***Provider fairness across continents in collaborative recommender systems.***
  Gómez, E., Boratto, L., & Salamó, M.
  Information Processing & Management, 59(1), 102719, (2022).
  https://doi.org/10.1016/j.ipm.2021.102719

Research line : **PHYSICS OF MATTER**

- ***Collective motion of run-And-Tumble repulsive and attractive particles in one-dimensional systems***
  Gutiérrez C.M.B., Vanhille-Campos C., Alarcón F., Pagonabarraga I., Brito R., Valeriani C.
  Soft Matter 17 (2021) 10479-10491
  https://doi.org/10.1039/d1sm01006a

Publications in WoS according to "Web of Science categories"



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  Perelló, J.; Klimczuk, A.; Land-Zandstra, A.; Vohland, K.; Wagenknecht, K.; Narraway, C.; Lemmens, R.; Ponti, M.
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- *We Are Not the Same Either Playing: A Proposal for Adaptive Gamification Pages 185 - 194 DOI*
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  Artificial Intelligence Research and Development, 339, 185-194 , IOSPRESS
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- *The Shortest Path to Network Geometry*
  M. Ángeles Serrano; Marián Boguñá
  Cambridge University Press

7

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

- *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 Antònia Martí

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

- *Memory-induced complex contagion in spreading phenomena on networks*
  Author: Xavier Roderic Hoffmann
  Director: Marian Boguñá Espinal

8

UBICS ACTIVITIES

8 UBICS ACTIVITIES

UBICS Activities

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

On February 11th 2021, the UBICS celebrated the International Day of Women and Girls in Science, and in coordination with other institutes of the University of Barcelona. This year the event was composed by different online activities that included the presentation of a documentary, a talk and discussions:

Program

7, 8 and 9 February

"Picture a Scientist". A documentary film directed by **Sharon Shattuck** and **Ian Cheney**, produced by Rocofilms.

11 February

15.00 h ***"Modelització de la COVID19 des d'una perspectiva de sistemes complexos"*** by **Dra. Clara Granell (Univ. Rovira i Virgili)**

15.45 h Open discussion ***"Accions per visibilitzar el treball de les dones científiques"***

This event was organized by some Faculties (Ciències de la Terra, Biologia, Química, Física) and research institutes (IBBUB, IN²UB, ICCUB, IQTCUB, IdRA, UBICS i Geomodels). Also, the Vicerrectorat d'Igualtat i Gènere collaborated in the activities.

Finally, many of the UBICS female students participated that day by creating a video explaining in an appealing way their research. These videos were published on different UBICS social channels.

- **XV Fira d'Empreses**

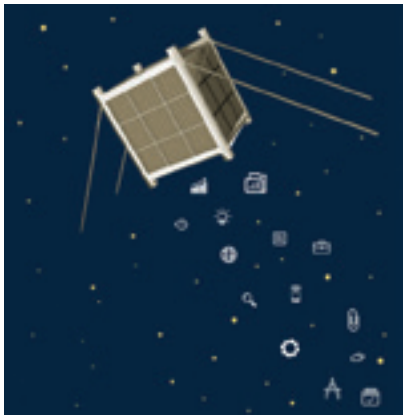
On April 28th 2021, UBICS participated in the Fira d'Empreses Virtual de Ciències i Engenieries. This year we built a virtual stand in the online platform *Taalentfy*. This event represented a favorable opportunity for the students to get in contact with private business sectors and with research institutes related to their studies.
Many students came to request information, which shows the increasing interest for Complex Systems topics and their related career opportunities among students. Thanks to this event, two students collaborated with UBICS in the preparation of laboratory sessions in one of the courses of the recently created Master in Physics of Complex Systems and Biophysics.

- **VII Festa De La Ciència**

On May 26th 2021, three research groups of UBICS participated in the **"VII Festa de la Ciència"**, which had to be celebrated online due to the COVID-19 pandemic. Researchers shared videos illustrating their investigations in popular terms and shared different resources, available here.
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 UBICS contributions to the event were the following: (i) UBICS itself presented the video "Descobrint els sistemes complexos" to show 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. This year we presented the SIR model, an epidemiologic model that simulates how an infectious agent can affect a population (e.g. COVID-19); (ii) the Neuroscience group presented a video explaining why neuronal cultures are an interesting tool for physicists and biologists to understand normal and diseased brain functioning; and finally (iii), the CEIPAC group of History announced some results of the EPNet Project (Production and Distribution of Food during the Roman Empire: Economic and Political Dynamics). In particular, the group 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:
www.ub.edu/laubdivulga/festacienciaub/festacienciaVII/index.html



- **1st Session of the UB Institutes:**
  "The exploration (and exploitation) of space"

On 26th June 2021 UBICS participated in the 1st Session of the UB Institutes: "The exploration (and exploitation) of space". The aim of the meeting was to tackle the topic of space from a cross-sectional perspective using the research carried out at the different research institutes of the UB. The event, which was live-streamed on UBtv, started with a roundtable on the Newspace Strategy of Catalonia, launched by the Catalan Government. Next, several researchers gave presentations, in a series of brief talks, on the exploration and exploitation of space, as well as the science that derives from it.

- **UBICS Day 2021: interdisciplinary research to face challenges in sustainable development**

On 6th September 2021, UBICS celebrated its annual UBICS Day 2021, with talks by the Institute researchers and networking activities. This year the UBICS Day was centered on sustainable development challenges. Place: Aula Magna, Edifici Històric (Carrer d'Aribau, 2, 08011 Barcelona)

Program
09.30h-09.45h Opening

09.45h-10.00h Welcome
Dra. Montserrat Puig Llobet, Vicerectora d'Igualtat i Gènere

10.00h-11.00h Talks
M. Farrús *Challenges in Speech Technologies*
R. Planet *Continuously sheared granular matter reproduces in detail seismicity laws*
D. Levis *Biomimetic Active Matter, a new frontier in Satistical Physics*

11.00h-11.30h Coffee Break

11.30h-12.30h Talks
M. Peró *fMRI as a biomarker: the brain, a complex machine. Is it true that only works in a 10% of its possibilities?*
A. Fernández-Nieves *Physical aspects of fire-ant collectives*
S. Lozano *Exploring past economic interactions: Network externalities in the 19th century*

12.30h-13.30h Poster session

13.30h-15.00h Lunch

15.00h-16.00h Talks
J. Hernández *Using Probabilistic Graphical Models for learning in label-ambiguous scenarios*
D. Reguera *Non-equilibrium phenomena at small scales: from nanomotors to viral self-assembly*
J. Pérez *The Future of the Past. An update to Ancient History Studies toolbox*

16.00h-17.00h Thematic discussions
Discussion 1 (oriented to senior researchers): *"Open Science"*
Speakers: **I. Labastida** (open science manager)
Discussion 2 (oriented to early-career researchers): *"What is beyond a PhD?"*
Speakers: **Mireia Marti & Albert Díaz-Guilera**
Chairpersons: **A. Diaz-Guilera & J. Soriano**

17.00h-18.00h Thematic discussions
Discussion 1 (oriented to senior researchers): *"Horizon Europe: overview"*
Speakers: **Armando J. Palomar** (international research assessor)
Discussion 2 (oriented to early-career researchers): *"Data Management"*
Speakers: **I. Labastida** (open science manager)
Chairpersons: **A. Diaz-Guilera & J. Soriano**

20.30h-22.30h Dinner (Moritz)

- **UBICS Board Games Day**

On 16th December 2021, UBICS organized a board games day for PhD, TFM and TFG students from UBICS, to get to know them better and gather in a social event before Christmas holidays, while learning about complex networks. First, Dr. Jordi Soriano introduced some concepts of complex systems related to renowned board games such as Carcassone or Catan. Later, students played these games in little groups.

UBICS Courses

- **Introductory course to Matlab**

Along February-March 2021, UBICS organized a course entitled "Introducció al Matlab". The course was given by Dr. Jordi Soriano and it was focused on introducing the essential programming tools to visualize and manage experimental data obtained from the lab. This course was essentially addressed to biologist and neuroscientist PhD students.

- **Minicurs: Introducció a la Intel·ligència Artificial (aplicat als sistemes complexos)**

Along February-March 2021, UBICS organized an online course entitled "Minicurs de Introducció a la Intel·ligència Artificial" focused on introducing the field of complex machine learning and artificial intelligence (AI). 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 five sessions of 1h30min each. Almost every session was given by a UBICS member, covering from basic concepts to applications in complex systems. About 200 participants attended the course. Their positive feedback at the end of the course evinced the interest for AI & data science and their importance in multidisciplinary science.

Program

Introducció a la Intel·ligència Artificial: algoritmes de cerca
Day: **23 february (13.30h-15.00h)**
Lecturer: **Mario Gutiérrez**

Introducció al aprenentatge automàtic
Day: **25 febreruary (13.30h-15.00h)**
Lecturer: **Maria Salamó**

Introducció al Deep Learning: Casos pràctics en Visió per Computador
Day: **4 march (13.30h-15.00h)** Lecturer: **Eloi Puertas**

Aprenentatge automàtic per al processament del llenguatge natural
Day: **11 march (13.30h-15.00h)** Lecturer: **Mireia Farrús**

Aplicacions avançades (del machine learning a sistemes complexos)
Day: **25 march (13.30h-15.00h)** Lecturer: **Pedro Almagro**

- **Introductory course in Version Control with Git**

On 23th September 2021 UBICS organized an Introductory course in Version Control with Git. Git has become the primary version control system for programming code. This beginners course was given by Dra. Franziska Peter. The course essentially motivated the usage of distributed version control and explained the basic principles in an informal way.

UBICS Outreach

Our dissemination activities are focused on awakening the interest of complex systems among students, teachers, researchers and the general public. Many of our scientists are involved in disseminating every year their research work in popular science journals, events addressed to high school students, popular science events, ...
Apart from the high number of activities performed by the researchers individually, the UBICS has worked another year in its own outreach program, which includes:

- **Website and Complexifica Project**

UBICS offers resources to understand science through the Complex Systems perspective, with a general channel for dissemination at the website ubics.ub.edu/divulgacio.php. In this channel, in addition to innovative websites explaining complex system science, there is dissemination material created by UBICS members, such as presentations, booklets, dissemination pills created by UBICS grantees explaining their research. Also, one can find in other channels of the UBICS website the dissemination of the Institute articles published in high impact journals.
One of the most innovative resources for high-quality dissemination and outreach, particularly addressed to high school and college students is the site http://ubics.ub.edu/complexifica/, where important statistical physics ideas are described in detail. The Ising and epidemic models, among others, are explained through videos, interactive applets and quizzes.

- **Outreach events**

As one see in the above UBICS Activities section, every year the Institute participates in different outreach events. One of the most successful is the Science Party organized by the University of Barcelona, which presents the research carried out at UB in an educative way. We also contribute to the activities of the International Day of Women and Girls in Science, on February 11th every year, and in the European Researchers Night.

- **Social Media**

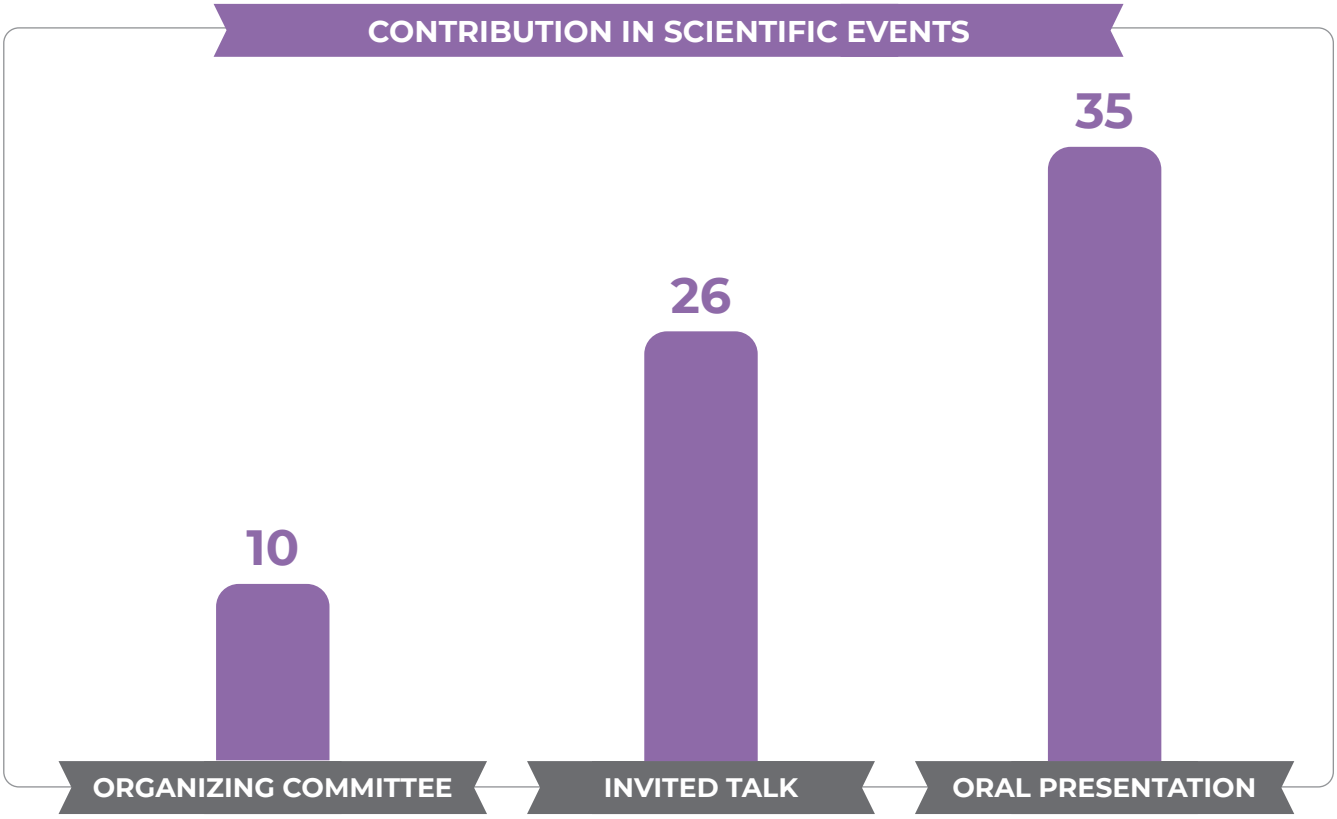
On 2021 UBICS created more content exclusively for social media to show the research carried out by the Institute to students and general public. The most interesting outreach content generated by UBICS members is disseminated visually on Instagram. UBICS has a profile also in Twitter, mainly used to announce the research achievements and activities. In addition, audiovisual projects mainly developed by predoctoral trainees are always uploaded at the Vimeo and Youtube UBICS accounts.

9

ACTIVITIES OF UBICS MEMBERS

9 ACTIVITIES OF UBICS MEMBERS

CONTRIBUTION IN SCIENTIFIC EVENTS



- **Mobile eHealth Platform for Home Monitoring of Bipolar Disorder**
  CZECH REPUBLIC
  Codina-Filbà, J.; Escalera, S.; Escudero, J.; Antens, C.; Buch-Cardona, P.; Farrús, M.
  International Conference on Multimedia Modeling, MMM

- **Iberspeech**
  SPAIN
  - **Kocour, M.; Cámbara, G.; Luque, J.; Bonet, D.; Farrús, M.; Karafiát, M.; Veselý, K.; Ĉernocký, J.**
    BCN2BRNO: ASR System Fusion for Albayzin 2020 Speech to Text Challenge
  - **Bonet, D.; Cámbara, G.; López, F.; Gómez, P.; Segura, C.; Farrús, M.; Luque, J.**
    Speech enhancement for wake-up-word detection in voice assistants

- **Interspeech**
  CZECH REPUBLIC
  Codina-Filbà, J.; Cámbara, G.; Peiró-Lilja, A.; Grivolla, J.; Carlini, R.; Farrús, M.
  The INGENIOUS multilingual operations app

- **JNNFM Online-seminar-series 2021**
  UNITED KINGDOM
  Ortín, J.
  Stokes layers in oscillatory flows of viscoelastic fluids

- **British Aphasiology Society (BAS) International Biennial Conference**
  UNITED KINGDOM
  Cistola, G.; Farrús, M.; van der Meulen, I.
  Identifying an adaptable aphasia-friendly text-to-speech system for Spanish patients with acquired reading impairments

- **LAC2020+1. Landscape Archaeology Conference. Virtually together**
  SPAIN
  Martín i Oliveras, A,; Revilla Calvo, 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

- **WSCG 2021 International Conference on Computer Graphics, Visualization and Computer Vision**
  CZECH REPUBLIC
  Kavaz, E.; Puig, A.; Rodríguez, I.; Taulé, M.; Nofre, M.
  Data visualization for supporting linguists in the analysis of toxic messages

- **From speech technology to big dataphonetics and phonology: a win-win paradigm. Workshop of Phonetics and Phonology in Europe Conference**
  SPAIN
  - **Cámbara, G.; Peiró-Lilja, A.; Farrús, M.; Luque, J.**
    English accent accuracyanalysis in a state-of-the-art automatic speech recognition system
  - **Farrús, M.; Elvira-García, W.; Garrido-Almiñana, J.**
    On the need of standard assessment metrics for automatic speech rate computation tools

- **Networks 2021: A joint Sunbelt and NetSci Conference**
  USA
  Lozano, S; Romano, V; Gómez-Puche, M; Cucart-Mora, C; Fernández-López de Pablo, J.
  Long-term interplay between social structure and cultural change: The diffusion of trapeze-based industries during the Iberian Late Mesolithic (c 8800-8200 BP)

- **43rd European Conference on IR Research (ECIR 2021)**
  ITALY
  Gómez, E.; Boratto, L.; Salamó, M.
  Disparate impact in Item Recommendation: A case of Geographic Imbalance

- **44th International ACM SIGIR Conference on Research and Development in Information Retrieval (SIGIR 2021)**
  CANADA
  Gómez, E.; Shui Zhang, C.; Boratto, L.; Salamó, M.; Marras, M.
  The Winner Takes it All: Geographic Imbalance and Provider (Un) fairness in Educational Recommender Systems

- **IberLEF 2021: 3rd Workshop on Iberian Languages Evaluation Forum, SEPLN 2021 Conference and CEDI 2021**
  SPAIN
  Taulé, M.; Ariza, A.; Nofre, M.; Amigó, E.; Rosso, P.
  Overview of the DETOXIS Task at IberLEF-2021: DEtection of TOXicity in comments In Spanish.

- **Wine growing & Winemaking in the Roman World. An International conference in honour of J.-P. Brun, Rome, Academia Belgica, British School at Rome, Koninklijk Nederlands Instituut Rome**
  ITALY
  Martín i Oliveras, A.; Revilla Calvo, V.
  Quantifying the Roman viticulture supply chain

- **COMMUNAL ART - RECONCEPTUALISING METRICAL EPIGRAPHY NETWORK European Union's Horizon 2020 research and innovation programme under the Marie Skalodowska-Curie grant agreement No 954689. / Workshop Objects of the Past - Presentation and Museology**
  SPAIN
  García Sánchez, M.; Giralt Soler, S.
  Epigraphia 3D: Latin epigraphy of Hispania for everybody

- **2nd International Conference in Experiences in Active Learning in Higher Education (ICEALHE)**
  SPAIN
  Lozano, S.; El Bachiri, N.; Blasco-Martel, Y.
  Does flipped-classroom affect students' perceived self-learning ability and responsibility?

- **I WORKSHOP VIRTUAL. Análise da paisagem romana: estudos de caso, métodos e perspectivas**
  PORTUGAL
  Martín, A.; Revilla, V.; Stubert, L.; Vogel, S.
  Geospatia-economic studies and archaeological data analysis applied to ancient viticultural landscapes. The caso of Hispania Citerior Tarraconensis

- **XII Conferencia Internacional de Computación e Informática del Norte de Chile**
  CHILE
  Rodríguez, I.
  Sistemas de interfaces inteligentes

- **SKM21 - 'DPG Spring meetiing' cancelled in 2020, held online in 2021. Symposium 'Spain as Guest of Honor' representing Spain's research in Condensed Matter Physics**
  GERMANY
  Casademunt, J.
  Hydrodynamics of collective cell migration in epithelial tissues

- **15th International Conference on Free Boundary Problems, Berlin (online).**
  GERMANY
  Casademunt, J.
  Symmetry-breaking and motility of cells and tissues

- **BARCSYN**
  SPAIN
  Montalà-Flaquer, M.; Ide, K.; Fernández-López, C.; Yamamoto, H.; Hirano-Iwata, A.; Soriano, J.
  Tuning synchrony in living neuronal networks through neuroengineering

- **Dynamics Days (online)**
  FRANCE
  Montalà-Flaquer, M.; Ide, K.; Fernández-López, C.; Yamamoto, H.; Hirano-Iwata, A.; Soriano, J.
  Tuning the richness of dynamical patterns in living neuronal networks through neuroengineering

- **European Association of Archaeologists (EAA) 2020 Virtual Annual Meeting**
  HUNGARY
  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

- **EFP-PSGB Conference**
  UNITED KINGDOM
  Romano, V.; Lozano, S.; Cucart-Mora, C.; Gómez Puche, M.; Fernández López de Pablo, J.
  Modelling Prehistoric Hunter-Gatherer Networks for the Study of Cultural Evolution

- **COMPLENET 2021**
  UNITED KINGDOM
  Ferri, I.; Palassini, M.; Pérez-Vicente, C.; Diaz-Guilera, A.
  Three states magnetic opinion model on different topologies

- **WINS Satellite at Networks 2021**
  SPAIN
  Ferri, I.; Palassini, M.; Pérez-Vicente, C.; Diaz-Guilera, A.
  Three states magnetic opinion model on different topologies

- **CCS2021**
  FRANCE
  Ferri, I.; Cozzo, E.; Diaz-Guilera, A.; Prignano, L.
  A bounded confidence model of emotionally aroused integrate and fire oscillators.

- **From Networks to Neural Networks in Finance**
  ITALY
  Diaz-Guilera, A.
  Complex networks foundations

- **Graphs in Artificial Intelligence and Neural Networks (GAIN)**
  GERMANY
  Boguñá, M.
  Network geometry

- **EMMC Webinar series "Translation and how it will evolve in Open Translation Environments and the EU Materials Modelling Marketplaces**
  AUSTRIA
  Pagonabarraga, I.
  Translation in VIMMP

- **Summer School ' ITN Active Matter: Initial training in numerical methods'**
  PORTUGAL
  Pagonabarraga, I.
  Lattice Boltzmann for simple and active fluids

- **The future of meetings Workshop**
  AUSTRIA
  Pagonabarraga, I.
  CECAM, a European center for simulation and modeling going virtual

- **Twenty-First symposium on thermophysical properties**
  USA
  Pagonabarraga, I.
  Active matter: Emergent behavior and statistical description of Intrinsically out of equi- librium systems

- **11th Liquid Matter Conference**
  CZECH REPUBLIC
  Pagonabarraga, I.
  Chemically Sensitive Colloids: Mechanisms Controlling Activity, Self-Propulsion and Collective Response

- **SIMAI 2020+2021**
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  E-CAM: A path to extreme-scale computing for industry and academia

- **Summer School ' ITN Active Matter: Initial training in theoretical methods'**
  UNITED KINGDOM
  Pagonabarraga, I.
  Simple active models

- **SIG CMMS Virtual Researchers Forum**
  KENIA
  Pagonabarraga, I.
  CECAM: A European center for molecular computational science

- **"The anomalous diffusion challenge workshop", ICFO Ballaterra (Spain)**
  SPAIN
  Massana-Cid, H.; Ortiz-Ambriz, A.; Tierno, P.
  Emergent colloidal current due to exchange dynamics in a broken dimer phase

- **International conference "Vortex 2021"**
  SPAIN
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- **International conference "Magnetic Soft Matter"**
  LATVIA
  Rodriguez Gallo, C.; Ortiz-ambriz, A.; Tierno, P.
  Topological boundary constraints in artificial colloidal ice

- **III Congreso Internacional de Filosofia de la Salud Pública**
  SPAIN
  Perelló, J.
  Hacia una ciencia ciudadana social

- **Mapping the Air in Venice**
  ITALY
  Perelló, J.; Ripoll, A.
  xAir workshop: mapping with analogic tools.

- **12th International Conference on Porous Media (Interpore)**
  USA
  Holtzman, R., Dentz, M., Planet, R., Ortín, J.
  Energy dissipated through Haines jumps in disordered media

- **International Symposium "Molecular Anthropology of Language: Results and Prospects", NCCR Evolving Language, University of Zürich**
  SWITZERLAND
  Dediu, D.
  Culture, environment and genes interact in complex ways to "nudge" language change and influence linguistic diversity

- **Workshop on Active Matter**
  USA
  Fernandez-Nieves, A.
  Correlations between active-nematic defects

- **11th Liquid Matter Conference**
  CZECH REPUBLIC
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  Active-nematic defects: Their correlations and arrangement

- **Probing Out-of-Equlibrium Soft Matter**
  SWITZERLAND
  Fernandez-Nieves, A.
  Physics of fire ants

- **21th Symposium on Thermophysical Properties**
  USA
  Esplandiu, M.J.; Reguera, D.
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- **World Hospital Congress**
  SPAIN
  E. Andrés, E. Reixach, M. Sans, N. García, A. Hervás, N. Sánchez, M. Farrús, J. Codina.
  COPD and Voice: Transforming Healthcare through Natural Language Processing (NLP). IHF Barcelona 2021 - 44th

- **European Physiology day. "A multi-faceted approach for supporting network physiology" Symposium.**
  TURKEY
  Balagué, N.
  Complex systems for Exercise Physiology. 2021, Federation of European Physiology Societies.

- **Congress of Complex Systems in Sport**
  GERMANY
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- **Workshop La intervención de Roma en las comunidades indígenas**
  SPAIN
  Revilla, V.
  La primera fase de urbanización del litoral nororiental de Hispania Citerior (siglos II-I a.C.): la diversidad de modelos y su materialización

- **X Congreso Geológico de España**
  SPAIN
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  Identificación y clasificación de desprendimientos de roca con LIDAR y machine learning en Montserrat y Castellfollit de la Roca (Cataluña)

- **UBICS DAY 2021**
  Lozano, S.; Badia-MIró, M.
  Exploring past economic interactions: Network externalities in the 19th century

- **Agrupaciones civicas, intracívicas y no cívicas en Hispania Citerior altoimperial**
  Revilla, V.
  Dinámicas urbanas e identidades cívicas en el conventus Tarraconensis

- **Congrés Nacional d'Educació Ambiental**
  SPAIN
  Perelló, J.; Cebrián, G.; Ramon Revilla, A.
  De la recerca a l'acció transformadora

- **I Encuentro Nacional de Ciencia ciudadana, Ciencias sociales y Humanidades**
  SPAIN
  Perelló, J.
  Hacia una ciencia ciudadana social: transdisciplinariedad, personas coinvestigadoras y acción colectiva

- **Jornadas UBICS 2021**
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  Fernandez-Nieves, A.
  Physical aspecs of fire-ant collectives

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