
IFISC*
Instituto de Física
Interdisciplinar
y Sistemas Complejos
*CONNECTING SCIENCE
UNDERSTANDING COMPLEXITY
ifisc.uib-csic.es

STAFF

62 Full time Scientists [+10 visitors]

- **36** PhD
- **26** Predocs

- **16** Permanents
- **1** Associated
- **19** Postdocs

18 Nationalities

RESEARCH LINES

Complex Systems. Statistical and Nonlinear Physics

- Quantum Complexity
- Nonlinear Photonics
- Fluid Dynamics
- Biocomplexity
- Social Systems

IFISC

(Institute for Cross-Disciplinary Physics and Complex Systems)

IFISC is a joint research institute of the Universitat de les Illes Balears (UIB) and the Consejo Superior de Investigaciones Científicas (CSIC) created in 2007. Its mission is to develop Cross-Disciplinary and Strategic Research in complex systems following the established scientific approach of physicists.

By Cross-Disciplinary Research we mean the transfer of knowledge, concepts and methods to create bridges among traditional disciplines. By Strategic Research we mean focusing on advanced studies in emerging strategic fields with a strong potential impact, avoiding the "basic-applied" polarization.

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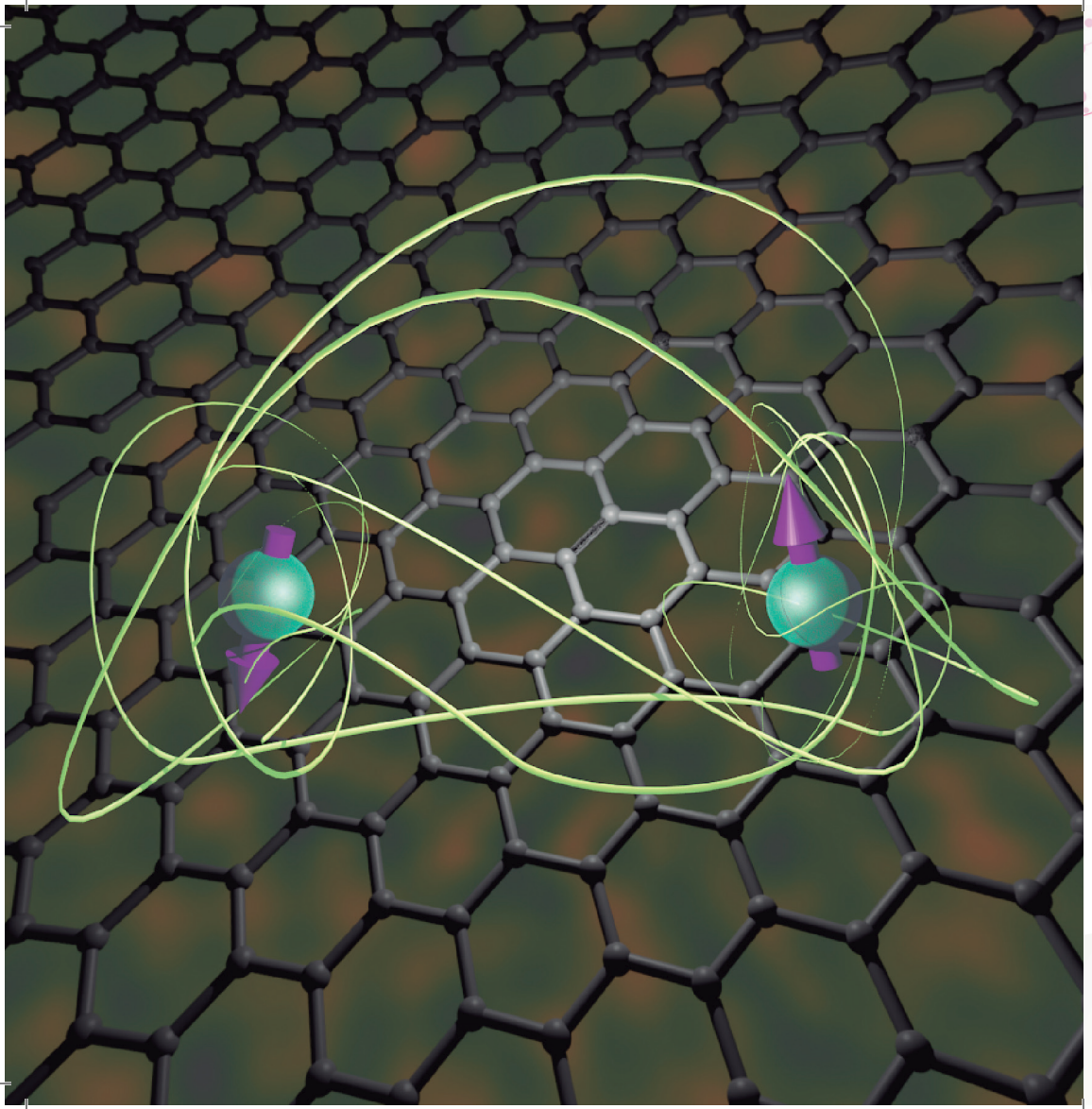
COMPLEX SYSTEMS. STATISTICAL AND NONLINEAR PHYSICS

Complex systems are characterized by emergent and collective phenomena of many interacting units. Fundamental understanding of these systems and the Micro-Macro paradigm, comes from Statistical Physics together with Computational Methods, Quantum Mechanics, Information Theory, Complex Networks, Big Data analysis and the Theory of Dynamical Systems, which includes the study of nonlinear dynamics, chaos and the effect of fluctuations and random events on system's evolution.

This research line of exploratory nature is the backbone of IFISC: We develop new concepts and methods for the study of Complex Systems, and we analyze generic phenomena such as synchronization, phase transitions, nonequilibrium instabilities, spatiotemporal pattern formation, and the dynamics and evolution of complex networks.



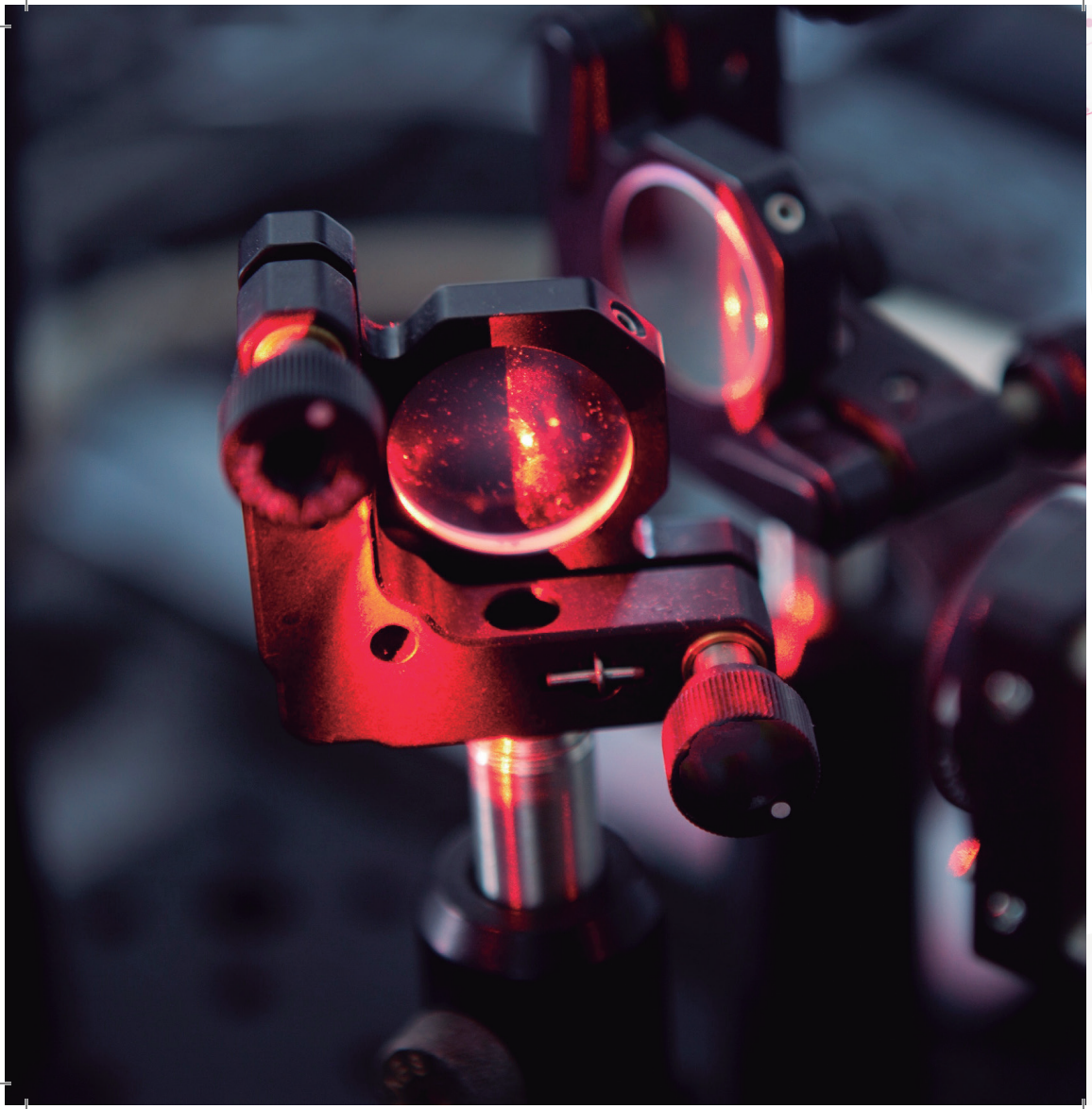
01
QUANTUM COMPLEXITY

TRANSPORT AND INFORMATION IN QUANTUM SYSTEMS

Understanding of Quantum Complex Phenomena plays a key role in the development of Quantum Technologies identified as one of the most strategic areas for future research and innovation.

In this research line, we are devoted to questions related to quantum transport for charge(nanoelectronics), spin (spintronics), energy (thermoelectrics) and information (quantum correlations), with a particular focus on nanostructures.

Moreover, we investigate decoherence effects in complex environments, explore quantum probing, and emergent phenomena such as synchronization, with a focus on quantum correlations and thermodynamics and their impact on information processing.

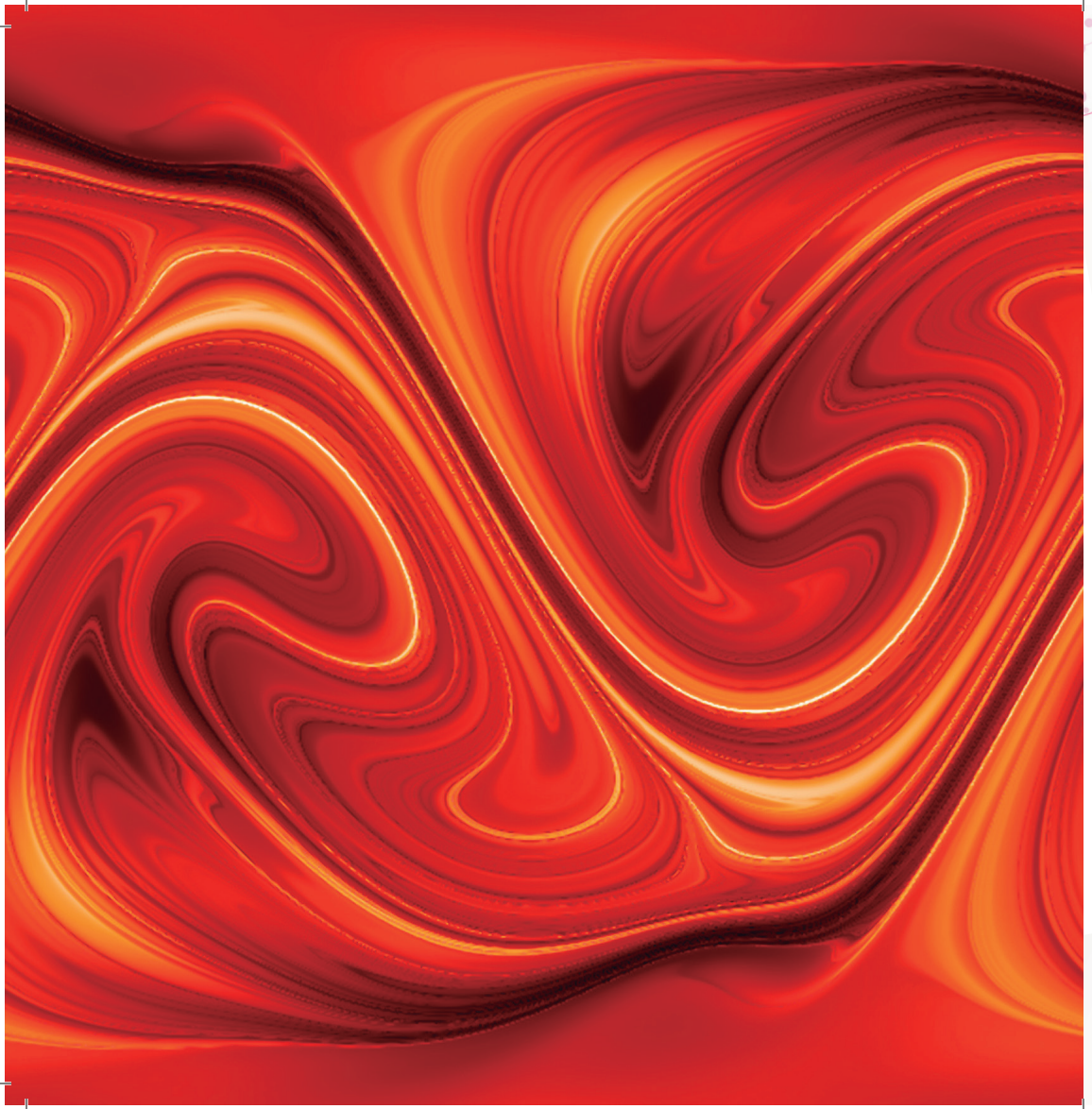


02
NONLINEAR PHOTONICS

NONLINEAR PHOTONICS

Within this line of research, we explore complex phenomena in photonics, filling the gap between Modern Photonic Sources and Functional Complex Systems. Our Nonlinear Photonics Lab, working alongside a strong theoretical team, aims to gain an in-depth understanding of complex phenomena and to provide novel solutions from communication to information processing, transferring knowledge to the Information and Communication Technologies (ICT) domain.

We study nonlinear and spatio-temporal emission properties of semiconductor lasers, implement optical complex networks based on lasers, advance characterization techniques, and demonstrate the utility of optical complexity for information technologies including encryption and ultra-fast neuro-inspired photonic information processing.

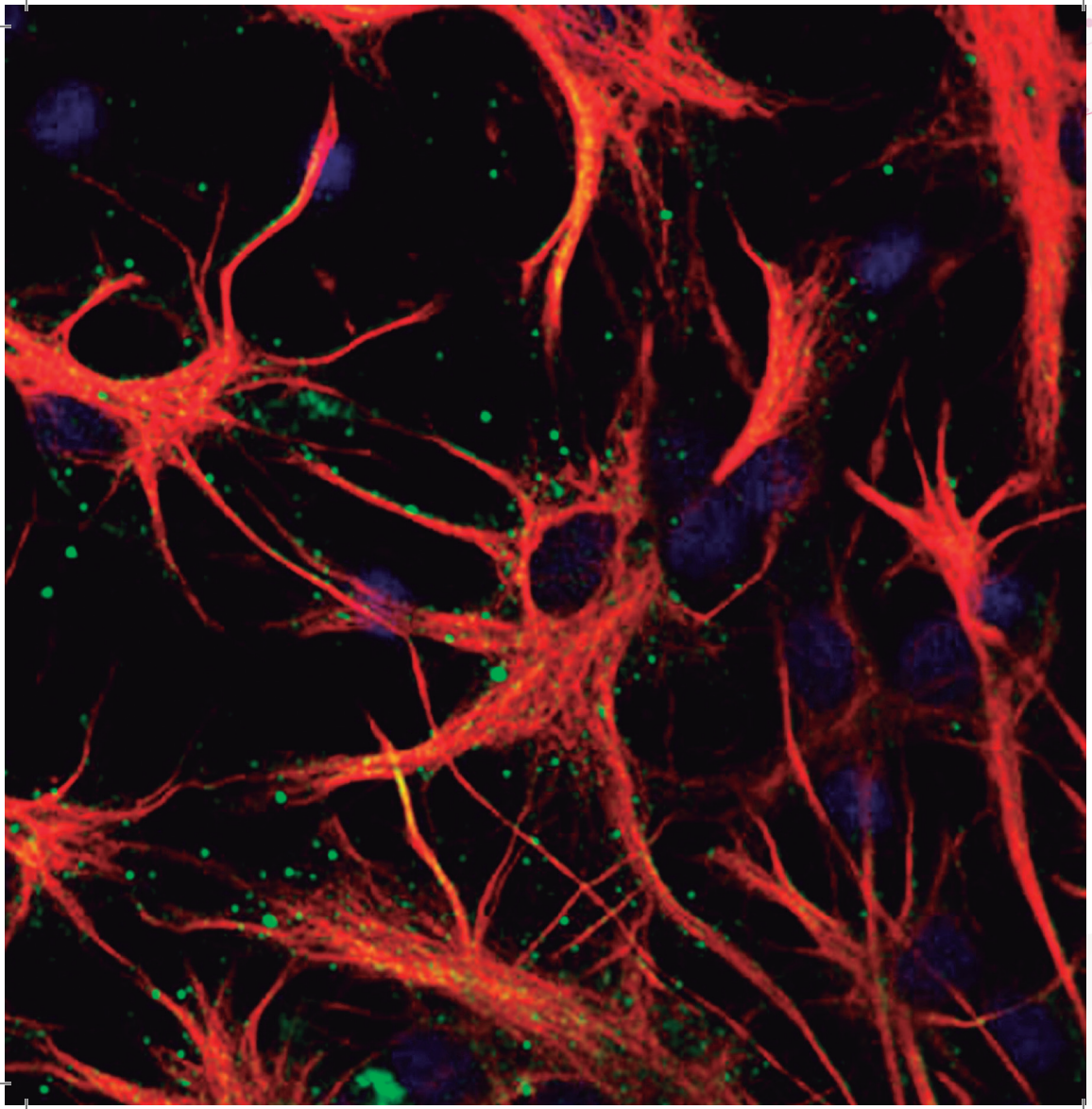


03
FLUID DYNAMICS

NONLINEAR DYNAMICS IN FLUIDS

Fluid flows occur in a huge range of scales, from blood capillaries to atmospheric weather systems. The way in which substances are transported has large impacts, e.g., on how pollutants arrive to distant locations, plankton meets the nutrients, or into the whole heat balance involved in the Earth climate.

At IFISC we develop techniques useful to characterize transport in fluids, quantify stretching, mixing, and connectivity between parts of a fluid. We apply them to geophysical settings, mostly in the ocean. We develop tools to identify barriers to the transport of oxygen and nutrients, evaluate the ecological implications of larval transport, or track the origins of water vapor masses transported by atmospheric winds.



BIOCOMPLEXITY

Living systems are the paradigm of complex systems, with nonlinear interactions occurring at all spatial and temporal scales, from molecules and genes to the planetary scales defining the global biosphere.

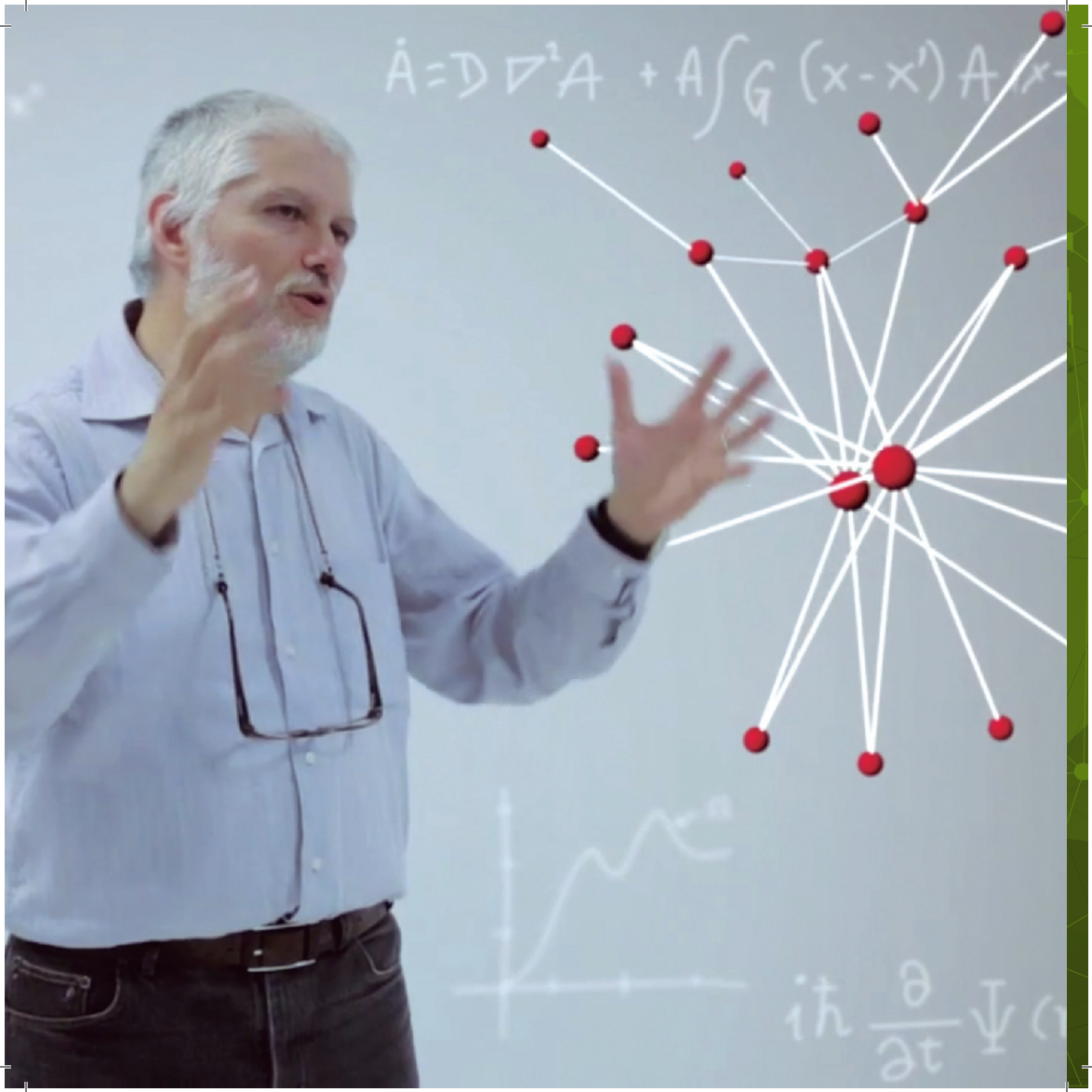
One of the focus of our research is the ecological level where we consider modes of organisms' mobility and their interplay with food search, disease propagation, spatial patterning, and also with the basic ecological interactions such as competition, predation, or mutualism. Another focal issue in our studies is understanding brain function, which requires approaches at scales that range from individual neurons to the whole brain. At the neuronal level, we concentrate on aspects of synchronization between interacting neuronal populations and study how information flows. With the help of statistical measures, we analyze experimental data and compare the results with neuronal models.

05
SOCIAL SYSTEMS

COLLECTIVE PHENOMENA IN SOCIAL AND SOCIO-TECHNICAL SYSTEMS

Social systems are prominent examples of Complex Systems, emergent phenomena, and the Micro-Macro paradigm. Today's main societal changes and challenges arise from the feedback loop that entangles society with Information and Communication Technologies (ICT) as a prototypical socio-technical system.

In this line of research we develop new concepts, tools and models aiming at identifying generic mechanisms underlying collective phenomena in these systems. We do this in the framework of Computational Social Sciences with the use of Game Theory, Statistical Physics, Agent Based Models, Complex Networks Theory, and Big Data analysis. We study phenomena such as opinion formation, cooperation, cultural conflicts, language competition and social learning. Moreover, we focus on ICT data-driven research on socio-technical systems, addressing problems of human mobility, transportation, tourism, city science, epidemics, and energy consumption.


$\dot{A} = D \nabla^2 A + A \int G (x - x') A$
$i\hbar \frac{\partial}{\partial t} \Psi$

MASTER IN PHYSICS OF COMPLEX SYSTEMS

Built upon the strong leadership of IFISC in the study of Complex Systems, we offer a master's program covering both fundamental aspects (networks, nonlinear dynamics, statistical and quantum physics, data analysis, etc.) and applications in physics and engineering, earth, life and social sciences, together with training in the needed theoretical, experimental and computational tools.

The Master in Physics of Complex Systems is an official degree by the Universitat de les Illes Balears in collaboration with the Consejo Superior de Investigaciones Científicas. The Master is taught in English. Mobility grants are offered.

More information: ifisc.uib-csic.es/master.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DISSEMINATION & OUTREACH

At IFISC we feel responsible for ensuring an active dialogue with the general public. We regularly organize various outreach activities that include:

- Press releases highlighting the main scientific achievements of IFISC.
- A seminar program streamed online and available on our You Tube channel: youtube.com/user/IFISCseminars.
- Conferences and exhibitions with the aim of bringing science closer to the general public.
- Participation in Science fairs and the Spanish Science week.
- Open-day sessions for secondary and university students as well as for the general public.
- School talks at different levels.

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