**IFISC**: Institute for Cross-Disciplinary Physics and Complex Systems

Joint Research Institute of CSIC and UIB created in June 2007 building upon the former Cross-Disciplinary Physics Department of IMEDEA (1995)
IFISC: Institute for Cross-Disciplinary Physics and Complex Systems

Joint Research Institute of CSIC and UIB created in June 2007 building upon the former Cross-Disciplinary Physics Department of IMEDEA (1995)

Mission: Cross-Disciplinary and Strategic research from the perspective of physicists

Cross-Disciplinary: Transfer of knowledge, concepts and methods across the borders among established fields and colonization of frontier spaces.

Strategic: Focus on fields of strong potential for the future and emerging topics beyond the traditional physics of the XXth century. Avoid incremental research and the basic-applied dichotomy

Responsible Research and Innovation

IFISC ASSESSMENT Strategic Plan CSIC 2010-13

“IFISC is unique in the Spanish context and also has internationally a very strong standing. It challenges the world best centres and it is a major actor of emergence of complex science.”
Human Resources 2013

**CSIC staff:** 3 Research Prof.
1 Senior Researcher
3 Tenured Scientists

**UIB staff:** 4 Full Prof. (3 in 2014)
5 Prof.

**Total permanent researchers:** 16 (15 in 2014)

**Associated researchers:** 1 (FNRS)

**Postdoctoral Research Associates:** 18 (1 RyC, 2 JAE-CSIC, 1 Marie Curie, 10 Project contracts, 2 UIB lecturers, 1 UIB contract, 1 Japanese Gov. Fellowship)

International level: Spanish 7/18, EU 8/18

**PhD fellows/contracts:** 24 (4 Spanish FPI, 3 Balear Government, 4 JAE-CSIC, 9 Project contracts, 2 foreign fellowships, 1 UIB fellowship, 1 UIB Assistant)

International level: Foreign 10/24
Mobility: UIB students 7/24

**Long term visitors:** 8

67 scientists from 14 different nationalities

**Support personnel:** 8
IFISC Research Lines

COMPLEX SYSTEMS:
STATISTICAL AND NONLINEAR PHYSICS

- TRANSPORT AND INFORMATION IN QUANTUM SYSTEMS
- NONLINEAR PHOTONICS
- NONLINEAR DYNAMICS IN FLUIDS
- BIOCOMPLEXITY
- DYNAMICS AND COLLECTIVE PHENOMENA OF SOCIAL SYSTEMS

Associated Unit: UIB Group on Human Cognition and Evolution

http://ifisc.uib-csic.es
### IFISC RESEARCH LINES

**Coherence and Integration**

**Interaction and Bridges**

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| 2) Transport and Information in Quantum Systems |
| X | X | X | X | X | X | X |

| 3) Nonlinear Photonics |
| X | X | X | X | X | X |

| 4) Nonlinear Dynamics in Fluids. |
| X | X | X |

| 5) Biocomplexity |
| X | X | X | X | X | X | X | X |

| 6) Dynamics and Collective Phenomena of Social Systems. |
| X | X | X | X | X | X | X | X |

http://ifisc.uib-csic.es
Our seminars are webcast live

http://ifisc.uib-csic.es/live.php
Publications

http://ifisc.uib-csic.es/publications/

High impact 2007-2013:
1 Rev. Mod. Phys,
2 Science, 7 PNAS,
2 Nature Comm.

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<th>JOURNALS WITH LARGEST NUMBER OF PUBLICATIONS</th>
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<td>Non-Physics Journals (excluding IEEE Journals)</td>
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Contributions outside traditional basic physics (2008-13): 82


Grand total budget of active projects in 2013: 3,486,719 €
Budget of EC-funded active projects in 2013: 63,63 % of total

Normalization: 15 tenured scientists, 1 experimentalist
Spanish National Science Plan (MINECO)

**FISICOS** (Consolider-C): Física Interdisciplinar de Sistemas Complejos, (2007-13), 1,318,900 €. PI: M. San Miguel

**TIQS**: Transport and Information in Quantum Systems (2012-14). PI. Ll. Serra

**MODASS**: Modelización y análisis de sistemas sociales: Evolución estructura, correlaciones temporales y propagación de opiniones (2012-14). PI. V.M. Eguíluz


**TRIPHOP**: Towards brain-inspired efficient photonic information processing (2013-15). PI. I. Fischer

**TOTAL MINECO FUNDING GRANTED IN 2012-13: 1.228.450 €**
IFISC Main Projects (2012-13)

**EUROPEAN COMMISSION FP7**

**PHOCUS:** Towards a Photonic liquid state machine based on delayed coupled systems (2010-12). [FP7-ICT-2009-C-240763]. IFISC Budget: 635,489€ PI. I. Fischer/C. Mirasso

**LINC:** Learning about Interacting Networks in Climate (2012-15) [PITIN-GA-2011-289447]. IFISC Budget: 502,162€ PI. E. Hernández-García

**Complex World:** Analysis of air transportation using complex networks, EC-SESAR-Eurocontrol (2011-15). IFISC Budget: 120,000 € PI. M. San Miguel

**EUNOIA:** Evolutio User-centric Networks for Intraurban Accessibility.(2012-14) [FP7-ICT-2011-8-318367] IFISC Budget: 493,762€. Coordinator and PI. M. San Miguel/P. Colet

**LASAGNE:** Multi-Layer Spatiotemporal Generalized Networks.(2012-15) [FP7-ICT-2011-8-318132]. IFISC Budget: 310.194 €. PI. M. San Miguel/E. Hernández-García


**TREE:** Data-driven modelling of network-wide extension of the Tree of REactionary delays in ECAC área (2013-16) (EC-EUROCONTROL) IFISC Budget: 270,000€. PI. J. Ramasco

**Grand total budget of FP7 active projects in 2013:** 1,969,343€
Representative publications 2013

Dissipative soliton excitability induced by spatial inhomogeneities and drift
*Phys. Rev. Lett.* 110, 064103

**Temporal Networks: Slowing Down Diffusion by Long Lasting Interactions**
*Phys. Rev. Lett.* 111, 188701

Scattering Theory of Nonlinear Thermoelectric Transport
*Physical Review Letters* 110, 026804

Discording Power of Quantum Evolutions
*Physical Review Letters* 110, 010501
Representative publications 2013

Complex Photonics: Dynamics and applications of delay-coupled semiconductors lasers
Reviews of Modern Physics 85, 421-470

- Neuro-inspired all-optical information processing at Gigabyte/s data rates
  Nature Communications 4, 1364

- Lagrangian transport in a microtidal coastal area: the Bay of Palma, Mallorca Island, Spain
  Nonlinear Processes in Geophysics 20, 921-933
**Representative publications 2013**

**Optimal search of resources by sharing information: Mongolian gazelles as a case study**
*Physical Review Letters 110, 248106*

**Dynamics of brain networks in the aesthetic appreciation**
*Proceedings of the National Academy of Sciences 110, 10454-10461*

**Conflict and Cooperation: Wars on editing Wikipedia articles**

**Systemic delay propagation in the US airport network**
*Scientific Reports 3, 1159*
Focus: Voter Model Works for US Elections

Published April 18, 2014 | Physics 7, 40 (2014) | DOI: 10.1103/Physics.7.40

A computer simulation of individual voter behavior matches statistical measures of data from 30 years of US presidential elections. A computer simulation of voters influencing one another over time can reproduce stable statistical patterns from US presidential elections, according to a report in Physical Review Letters. The model uses population and commuting data for every US county and assumes that voters may change their political preferences based on interactions with others at home or at work. The type of model the researchers used has not been directly compared with election data before, and the researchers believe similar models could elucidate how political and cultural opinions move through a population or remain stable over time.

Democrat share. Initial condition 2000

Data

Model
IFISC WORKSHOPS (2012-13)

IFISC WORKSHOPS

INTERNATIONAL CONFERENCE ON DELAYED COMPLEX SYSTEMS
June 4-8, 2012

SEARCH AND STOCHASTIC PHENOMENA IN COMPLEX PHYSICAL AND BIOLOGICAL SYSTEMS
May 28-June 1, 2012

FISES 12
XVIII CONGRESO FISICA ESTADISTICA
October 18-20, 2012

EXPLORATORY WORKSHOPS

FORUM ON THEORY AND MECHANISMS OF SOCIAL INTERACTION FOR THE BIG DATA ERA
May 6-8 2013
Son Bernadinet

WORKSHOP ON URBAN DEVELOPMENT AND GLOBAL SYSTEMS SCIENCE
Brussels, 13-14 Feb 2013

IFISC SUMMER SCHOOLS

THIRD SUMMER SCHOOL ON STATISTICAL PHYSICS OF COMPLEX AND SMALL SYSTEMS
September 2-13, 2013

LINC FIRST SCHOOL:
LEARNING ABOUT INTERACTING NETWORKS IN CLIMATE
September 10-12, 2012

http://ifisc.uib-csic.es
Master’s Degree in Physics of Complex Systems

Welcome

The Master in Physics of Complex Systems is an official degree offered by the University of the Balearic Islands (UIB) in collaboration with the Spanish National Research Council (CSIC). It is organized and taught by IFISC, the Institute for Cross-Disciplinary Physics and Complex Systems, a joint UIB-CSIC research center in Palma de Mallorca, Spain.

Surf@IFISC program

IV Summer school

UNESCO UniTwin Complex Systems Digital Campus
http://unitwin-cs.org/index.html

Shared PhD program of excellence in Physics of UIB

http://ifisc.uib-CSIC.es
Press releases

Opening Science

Explorant les Fronteres entre els Sabers VI
“Nuevas formas de divulgar la ciencia”
CaixaForum, May 2013

@IFISC_mallorca
http://www.facebook.com/ifisc
http://ifisc.uib-csic.es
Complex systems are characterized by emergent and collective phenomena of many interacting units. Fundamental understanding of these systems comes from Statistical Physics together with the Theory of Dynamical Systems, which includes the study of chaos and the effect of fluctuations and random events on systems evolution.

Phenomena under consideration include synchronization, phase transitions, nonequilibrium instabilities, spatio-temporal pattern formation, or dynamics and evolution of complex networks.

Research projects:

- **INTENSE@COSYP**
  Complex Systems Physics: Information, Technology, Society and Ecology. PI. M. San Miguel

- **LASAGNE**
  Multi-Layer Spatiotemporal Generalized Networks
  PI. M. San Miguel

- **LINC**
  Learning about Interacting Networks in Climate
  PI. E. Hernández-García

http://ifisc.uib-csic.es
PA 2014-17 Objectives

- **Main objective:**
  Understanding emergent phenomena in complex systems using the framework of nonlinear and statistical physics and dynamical systems.

**Specific objectives:**
- Study of micro-macro connections
- Network inference and detection of causality in large data-sets
- Investigation of non-local interactions, memory, delay, noise and heterogeneity in complex systems
- Generic approaches to complex networks and master equations, including fluctuation relations

**Research projects:**

**-INTENSE@COSYP**

**-LASAGNE**
Multi-Layer Spatiotemporal Generalized Networks
Pl. M. San Miguel

**-LINC**
Learning about Interacting Networks in Climate
Pl. E. Hernández-García
High Throughput Computing (HTC)

History:
- 2000: 21 cores
- 2004: totally renewed, 36 cores
- 2006: updated to 48 cores
- 2007: totally renewed, 120 cores
- 2009: updated to 230 cores
- 2012: totally renewed

48 diskless computing nodes:
- two hexa-core E5-2630 per node
- 32 or 64 GB RAM per node
- Grand Total: 576 cores, 2Tb RAM
- Users do not access directly to the cluster. Transparent access.
- SoGE (queue system) distributes load among nodes

Node of Grid-CSIC, es-NGI and EGI

Cluster IDataplex with 544 computational cores
- 64 nodes dx360M2 two quad-core Xeon L5520.
- 16 GB Ram per node.
- 4 nodes for disk access.
- dual Gbit ethernet connection.

Storage: 96 TB

Data Handling, Data Mining, Information Extraction, Application Development
TRANSPORT AND INFORMATION IN QUANTUM SYSTEMS

Studies of quantum properties of transport through nanostructures and quantum information theory. Subjects of interest include: mesoscopic systems, spintronics, thermoelectrics, quantum correlations, classical-quantum transition, quantum phenomena in out of equilibrium systems, complex quantum phenomena.

Research projects:

- **TIQS**
  Transport and Information in Quantum Systems.
  PI. Ll. Serra

Quantum Spin liquids

Rosa López  David Sánchez  Llorens Serra  Roberta Zambrini
PA 2014-17 Objectives

- **Main objective:** Study of quantum properties of transport in nanostructures and advancing understanding of quantum complex systems.

**Specific objectives:**
- Complex quantum phenomena in mesoscopic, spintronic, thermoelectric, optical and out of equilibrium systems.
  Quantum synchronization
- Superconductivity and Majorana physics
- Classical-quantum transition and quantum correlations. Quantum probes of complex systems.

**Research projects:**

- **TIQS**
  Transport and Information in Quantum Systems.
  PI. Ll. Serra
Nonlinear phenomena, dynamical instabilities and synchronization in photonic systems. Performing experiments on and modelling of modern photonic sources, network motifs and networks of coupled photonic elements, fundamental questions, as well as novel applications to communication and photonic information processing schemes are being explored.

**TRIPHOP:** Towards brain-inspired efficient photonic information processing.

PI: I. Fischer
**PA 2014-17 Objectives**

- **Main objective:** To explore fundamental phenomena and applications of nonlinear photonic systems, by experiment and modeling.

**Specific objectives:**
- Investigation of nonlinear phenomena, dynamical instabilities and synchronization in photonic systems, including delay effects and network motifs
- Applications of delay-coupled laser systems: encrypted communication, random bit generation, all-optical information processing, neuro-inspired machine learning
- Investigation and utilization of spatio-temporal dynamics of broad area lasers and laser arrays

**Research projects:**

**TRIPHOP**
Towards brain-inspired efficient photonic information processing.
PI. I. Fischer
NONLINEAR DYNAMICS IN FLUIDS

Stirring and mixing in fluid flow, Lagrangian transport in the ocean and the atmosphere, dynamics of planktonic populations and Coherent Structures.

Research projects:

- **ESCOLA**
  Lagrangian Coherent Structures in the Ocean Dynamics
  PI. C. López

- **LINC**
  Learning about Interacting Networks in Climate
  PI. E. Hernández-García
**IFISC Research Lines**

**NONLINEAR DYNAMICS IN FLUIDS**

*Emilio Hernández*  
*Cristóbal López*  
*Tomàs Sintes*

**PA 2014-17 Objectives**

- **Main objective:** Study basic processes in fluid flow for which nonlinear dynamics has shown to be useful, such as stirring, mixing, biological reactivity, or turbulence

**Specific objectives:**
- Identification of two- and three-dimensional Lagrangian Coherent Structures in model systems, oceanic and atmospheric data
- Analysis of the impact of flow on plankton productivity and in marine biogeochemical process
- Influence of transport in the functioning of the Earth system and climate


**Research projects:**

- **ESCOLA**  
  Lagrangian Coherent Structures in the Ocean Dynamics  
  PI. C. López

- **LINC**  
  Learning about Interacting Networks in Climate  
  PI. E. Hernández-García
Study of biological systems under the prism of Complex Systems science, i.e. from the tenet that important observed behavior stems from emergent interactions among constituents.

Nonlinear dynamics and emergent phenomena in biological systems, in particular information processing in neuronal systems, complex structures, networks and collective phenomena in ecology.

-INTENSE@COSYP

Complex Systems Physics:
Information, Technology, Society and Ecology.
**Main objective:** Study of biological systems under the prism of Complex Systems science, i.e. from the tenet that important observed behavior stems from emergent interactions among constituents.

**Specific objectives:**
- Study of information processing in the brain: encoding-maintenance and decoding of information, robustness and reliability, transient behavior and attractors
- Analyze synchronization in sensory processing: network topologies and conduction delays
- Understand the interplay of mobility and ecological interactions in population dynamics
- Modeling of vegetation spatial patterns, clonal, and biological diversity

**-INTENSE@COSYP**
DYNAMICS AND COLLECTIVE PHENOMENA OF SOCIAL SYSTEMS

Concepts, tools and models aiming at identifying generic mechanisms underlying collective phenomena in these systems are developed with the use of Game Theory, Statistical Physics, Agent Based Models and Complex Networks Theory. Opinion formation, Cooperation, cultural conflicts and problems of social consensus are examples of phenomena under study. Present focus is on data driven research on socio-technical systems.

**PA 2014-17 Objectives**

- **Main objective:** Identification and modeling of generic mechanisms underlying collective phenomena in social and socio-technical systems

**Specific objectives:**

- Study of multilayer and dynamical complex social networks
- Understand information aggregation, trust, emotions, meaning, consensus and popularity in social systems
- Data analysis and modeling of delay propagation in the air transport network
- Study of energy efficiency and power-grid operation policies based on social networks
- Analyzing urban mobility from geolocalized online data

**Research projects:**

- **MODASS**
  Modelización y análisis de sistemas sociales. Pl. V. M. Eguíluz

- **EUNOIA**
  Evolutive User-centric networks for Intraurban Accessibility
  Pl. M. San Miguel

- **INSIGHT**
  Innovative Policy Modelling and Governance Tools for Sustainable Post Crisis Urban Development
  Pl. J. Ramasco

- **Complex World**
  Analysis of air transportation using complex networks
  Pl. M. San Miguel

- **TREE**
  Data-driven modelling of network-wide extension of the Tree of REactionary delays in ECAC área
  Pl. J. Ramasco