IFISC

UNIT OF EXCELLENCE MARÍA DE MAEZTU

AGENCIA ESTATAL DE INVESTIGACIÓN

Connecting Science,

Understanding Complexity .

IFISC: Institute for Cross-Disciplinary Physics and Complex Systems

Joint Research Institute of CSIC and UIB

Exploring emergent phenomena

in the physical, technical, biological and social world.

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 in Complex Systems following the established scientific approach of physicists.

Cross-Disciplinary: Transfer of knowledge, concepts and methods to create bridges among traditional disciplines

Strategic: Focusing on advanced studies in emerging strategic fields with a strong potential impact, beyond the traditional physics of the XXth century. Avoid incremental research and the basic-applied polarization

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."

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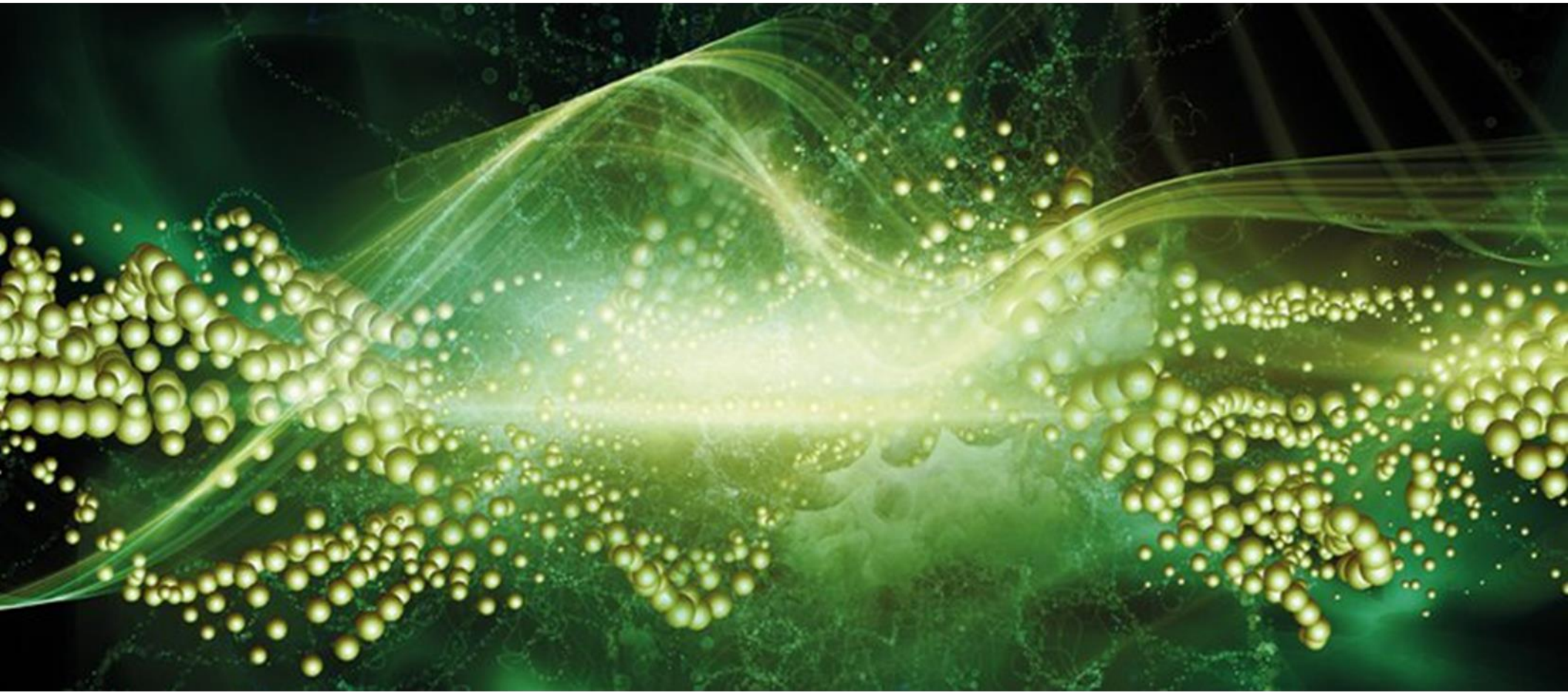
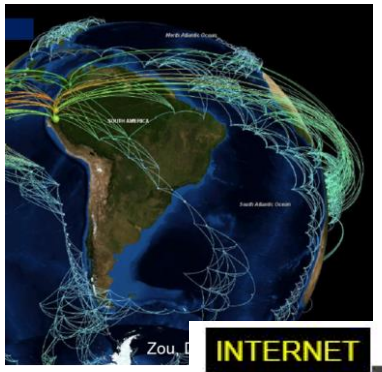
Connecting Science, Understanding Complexity

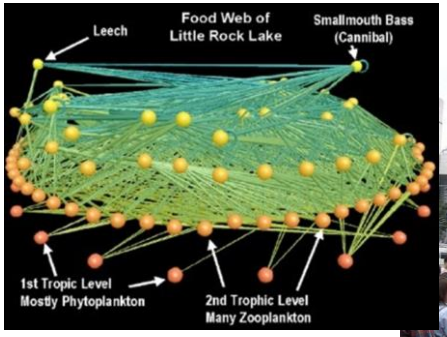


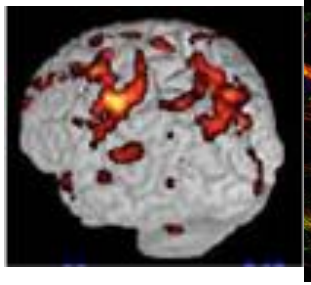
Exploring emergent phenomena in the physical, technical, biological and social world

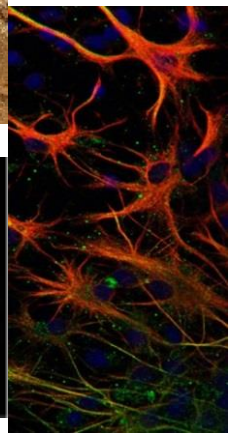
Complex Systems Society:

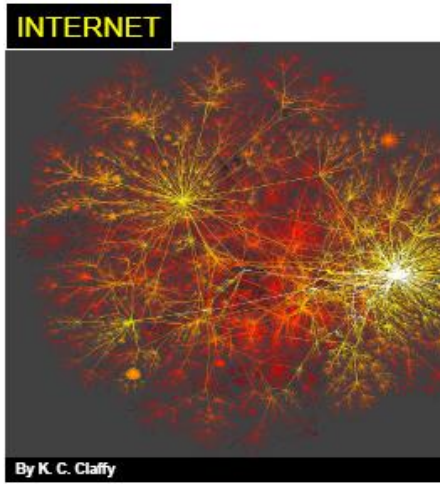
Complex systems are systems where the collective behavior of their parts entails emergence of properties that can hardly, if not at all, be infered from properties of the parts. Examples of complex systems include ant-hills, ants themselves, human economies, climate, nervous systems, cells and living things, including human beings, as well as modern energy or telecommunication infrastructures.

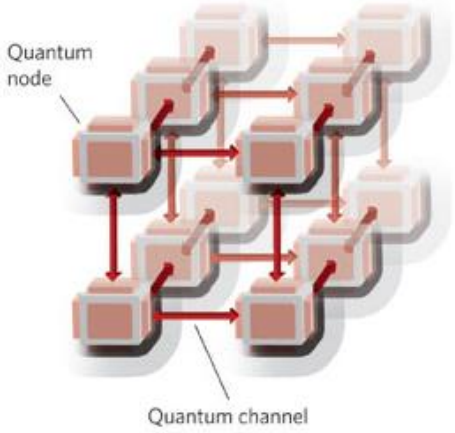


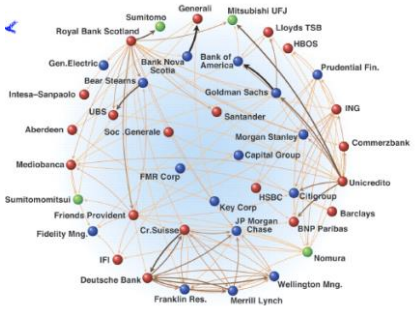












Human Resources 2018

CSIC staff: 3 Research Prof.

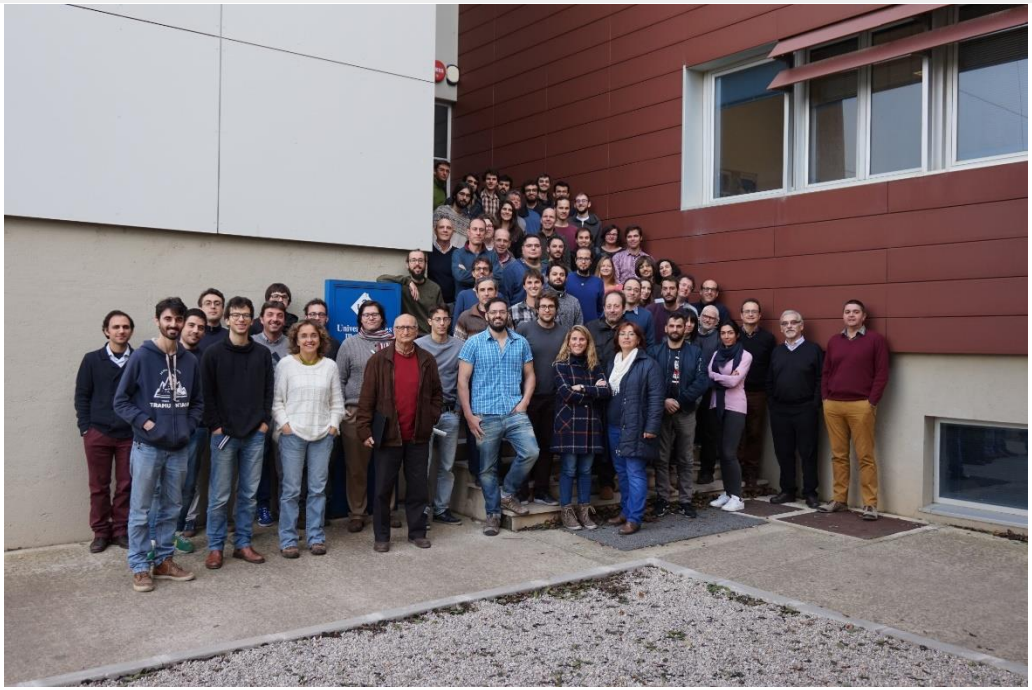
1 Senior Researcher

5 Tenured Scientists

UIB staff: 4 Full Prof.

4 Prof.

Total permanent researchers: 17



Postdoctoral Research Associates: 16 (2 RyC,1 Marie Curie, 2 Balear Government, 1 UIB lecturer, 10 project contracts)

International level: Spanish 6/17, EU 7/17, Rest of the world: 3/17

PhD contracts: 24 (6 Spanish FPI + FPU, 4 Balear Government, 9 Project contracts, Other: 5)

International level: Foreign 9/23 Mobility: UIB grad students 7/23

Long term visitors + associated: 13

Support personnel: 8

70 scientists 18 different nationalities

NEW CSIC staff:

Dr. Sandro Meloni, (June 2018)

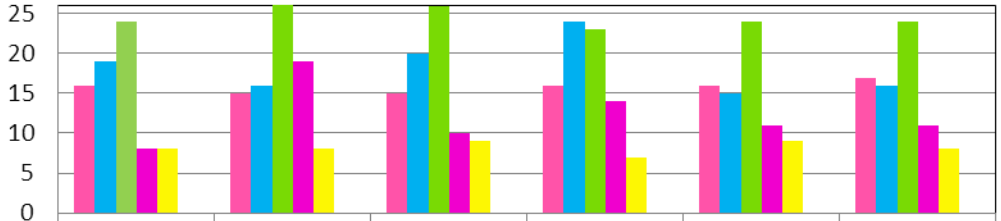
PhD University Roma Tre, 2010
Ramon y Cajal fellow, BIFI, Zaragoza
Junior Scientific Award 2017 Complex Systems Society

Dr. Tobias Galla, (July 2019)

MSc Muenster, Germany, 2000
Phd Oxford 2004
Reader, School of Physics, Manchester

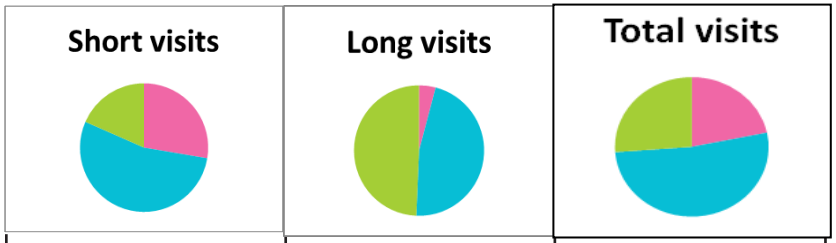
Human Resources

PERSONNEL IFISC 2013-2018



	2013	2014	2015	2016	2017	2018
PERMANENT STAFF	16	15	15	16	16	17
POSTDOCTORAL AND ASSOCIATED	19	16	20	24	15	16
PhD STUDENTS	24	27	26	23	24	24
LONG TERM VISITORS	8	19	10	14	11	11
SUPORT PERSONNEL	8	8	9	7	9	8
TOTAL	75	85	80	84	75	76

VISITORS 2012-18



	Short visits	Long visits	Total visits
Spain	60	3	63
Europe	117	34	151
Rest of the world	40	36	76
Total	217	73	290

	Total	Male	Female
Permanent staff	17	1	2
Associated staff	2	2	0
Postdoctoral fellows	16	15	1
PhD students	24	19	5
Long-term visitors	11	7	4
Suport personnel	8	5	3
Total	78	63	15

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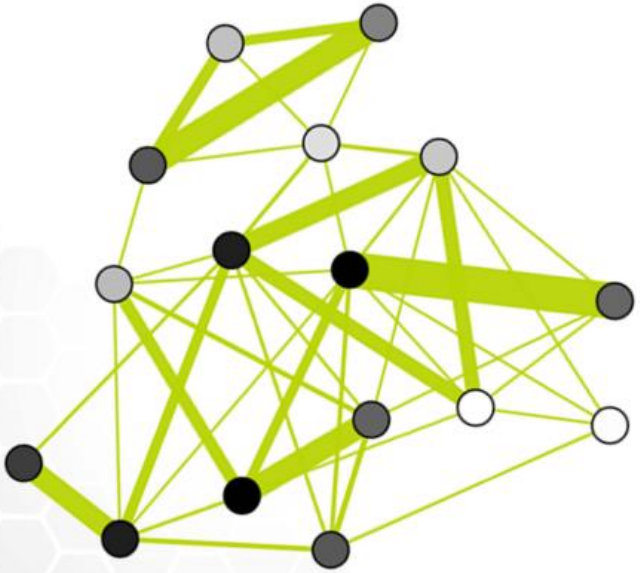
UNIT OF EXCELLENCE MARÍA DE MAEZTU

10 YEARS CONNECTING SCIENCE, UNDERSTANDING COMPLEXITY

2007

2017

Internal synergies:
Network of joint publications 2007-17 among IFISC senior scientists



Talent attraction: scientists from 38 different nationalities

Italy	31	Iran	5	China	2
Germany	18	Poland	5	Estonia	2
Argentina	12	Korea	3	Japan	2
France	11	UK	3	Mexico	2
USA	9	Greece	3	Portugal	2
Belgium	7	Hungary	3	Ukraine	2
Brazil	7	Russia	3	15 other	
Venezuela	6	Cameroon	2	countries	1

10 YEARS IFISC

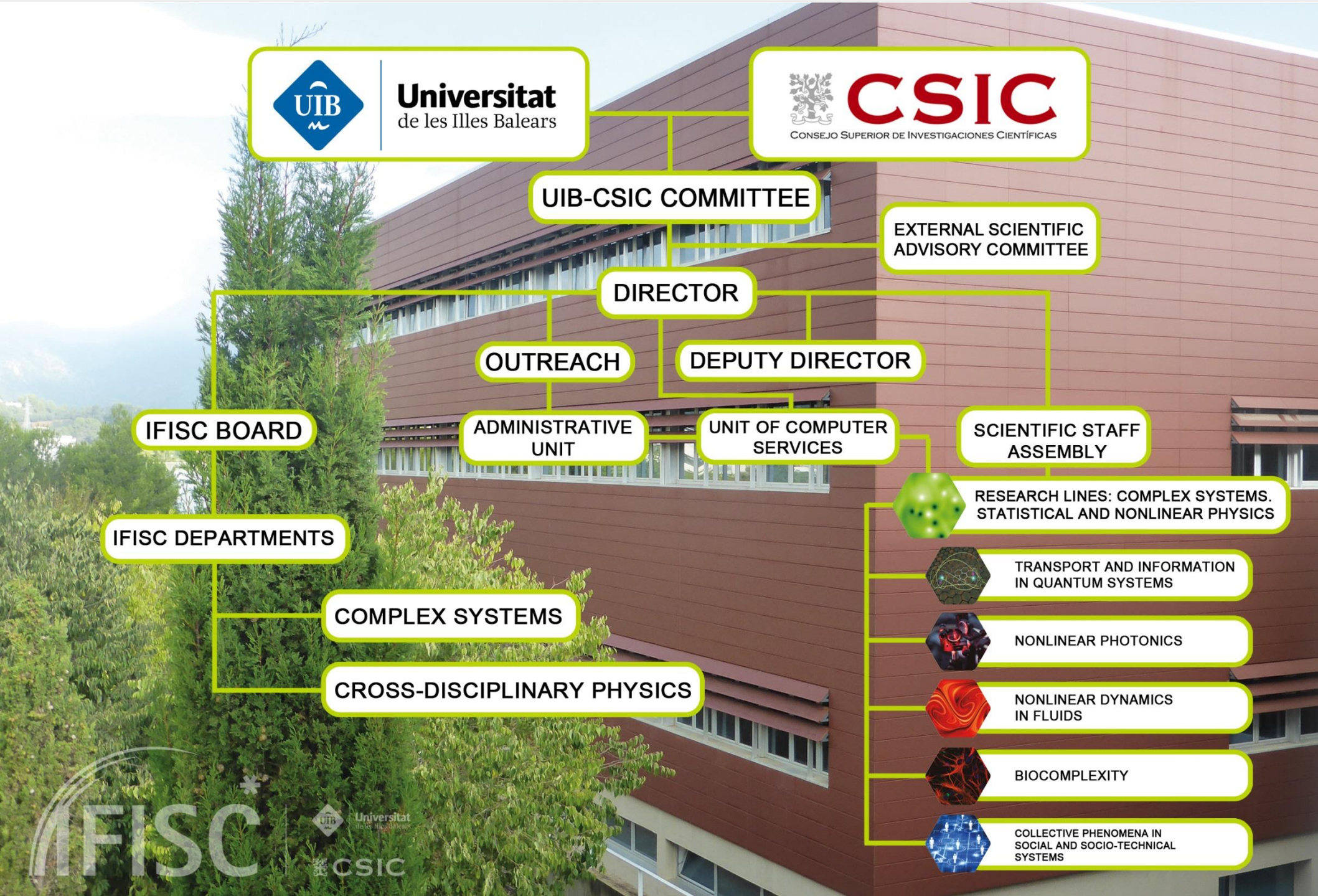
Universitat de les Illes Balears

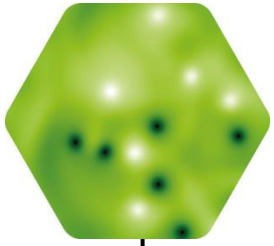
CSIC

IFISC

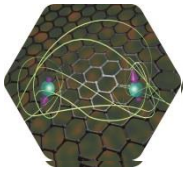
UNIT OF EXCELLENCE MARÍA DE MAEZTU

IFISC STRUCTURE CHART



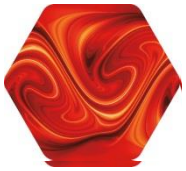


COMPLEX SYSTEMS: STATISTICAL AND NONLINEAR PHYSICS

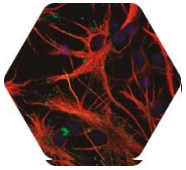


TRANSPORT AND INFORMATION IN QUANTUM SYSTEMS

NONLINEAR PHOTONICS



NONLINEAR DYNAMICS IN FLUIDS



BIOCOMPLEXITY

COLLECTIVE PHENOMENA IN SOCIAL AND SOCIO-TECHNICAL SYSTEMS

Coherence and Integration Interaction and Bridges	Pere Colet	Víctor M. Eguíluz	Ingo Fischer	Damia Gomila	Emilio Hernández-García	Cristóbal López	Rosa López	Manuel Matías	Sandro Meloni	Claudio Mirasso	José J. Ramasco	David Sánchez	Maxi San Miguel	LLorenç Serra	Tomàs Sintes	Raúl Toral	Roberta Zambrini
1) Complex Systems: Statistical and Nonlinear Physics	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2)Transport and Information in Quantum Systems							x					x		x			x
3) Nonlinear Photonics	x		x	x				x		x			x				x
4) Nonlinear Dynamics in Fluids.					x	x									x		
5) Biocomplexity		x	x	x	x	x		x	x	x	x				x	x	
6) Collective phenomena in Social and Socio-technical Systems	x	x		x	x				x		x	x	x			x	

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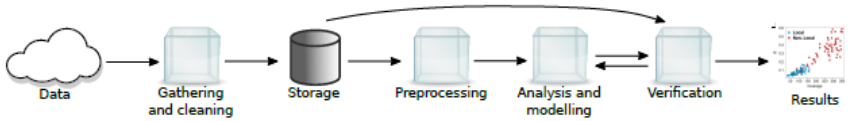
IFISC LABS

COMPUTING and BIG DATA

Data mining



Data harvesting

File download
text-like, image-like files, geospatial data, ...

APIs
set of method definitions and tools for building software

Web scraping
technique in which a computer program extracts data from human-readable output coming from another program.(a website)

Data storage and preprocessing

Storage

Files
for specific formats such as
geographical data: shp, geojson, ...
image-like data: png, svg, eps, pdf, ...

MongoDB database
for both structured and non-structured data

Preprocessing
Gathered data might have errors and inconsistencies.
Some tasks have to be done before analysis:
cleaning irrelevant and redundant data
extraction of selected data
transformation to a suitable format

Data sources

Data gathering

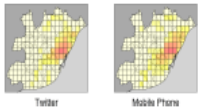
flightradar24 · MarineTraffic · idealista · airbnb

Agreements

BBVA · RED ELÉCTRICA · cuebiq · Sabre

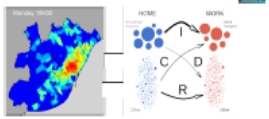
Analysis and modelling

ICT data validation for urban mobility
PLoS ONE 9, e105184 (2014)

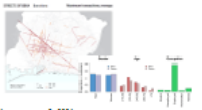


Tweets on the road
PLoS ONE 9, e105407 (2014)

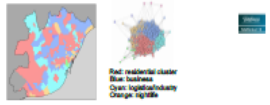
City hotspots
Nature Communications 6, 6007 (2015)



Influence of sociodemographic characteristics on human mobility
Scientific Reports 5, 10075 (2015)

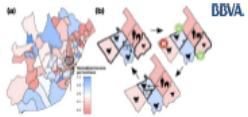


Modeling land use in cities
Royal Society Open Science 2, 150449 (2015)



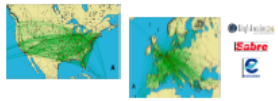
Twitter, mobility and city influence
J. Roval Soc. Interface 12. 20150473 (2015)

Crowdsourcing the Robin Hood effect in cities
Applied Network Science 2, 11 (2017)

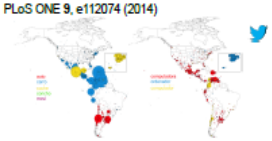


Touristic site attractiveness
EPJ Data Science 5, 12 (2016)

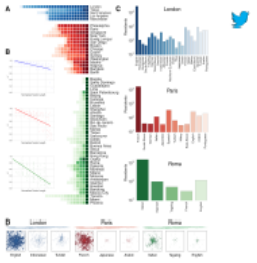
Modeling delay propagation in air traffic networks
J. Air Transport Management 56, 12 (2016)



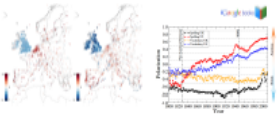
Dialect characterization
PLoS ONE 9, e112074 (2014)



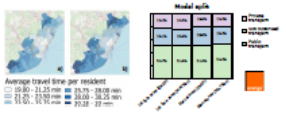
Immigrant community integration
PLoS ONE 13, e0191612 (2018)



Mapping the Americanization of English in space and time
PLoS ONE 13, e0197741 (1-15) (2018)



Studying a cordon toll policy in Barcelona



NONLINEAR PHOTONICS

Semiconductor Lasers (SL)

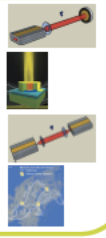
- versatile and modern photonic sources
- interesting physics: laser and cavity physics, nonlinear (semiconductor) optics, complex dynamics, ...
- small size, electr. pumping, high efficiency
- multitude of structures, materials, wavelengths, power ranges
  - structures: Fabry-Perot, DFB, DBR, VCSEL, multi-section, µ-cavities, Photonic Crystal cavities, Photonic Integrated Circuits, .
  - active media: quantum wells, quantum dashes, quantum dots, quantum cascade structures
  - wavelengths: UV .. FIR (THz)
  - power ranges: µW .. kW
- particularities
  - fast time scales of the dynamics (ns..ps)
  - semiconductor band structure high gain bandwidth, high gain
  - strong nonlinearities in the interaction light - semiconductor medium

Experimental / Characterization Methods

- modern photonics lab
  - multitude of photonic sources
  - various characterization techniques
- temporal characterization of emission dynamics
  - multichannel16GHz real-time acquisition
- spectral characterization of emission dynamics
  - real-time spectrum analysis with 14 GHz bandwidth
  - spectral analysis with 30 GHz bandwidth
- optical characterization
  - grating spectrometers
  - Fabry-Perot spectrometers
- spatio-temporal characterization with
  - picosecond resolution
  - polarization resolution
  - spectral resolution

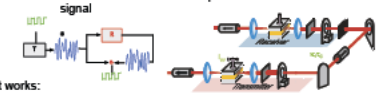
Main Research Activities

- nonlinear semiconductor laser emission properties
  - fundamental emission properties
  - semiconductor lasers as complex systems lab
- controlling and tailoring SL emission properties
  - controlling dynamical instabilities and synchronization
  - controlling temporal and spatial coherence
- dynamics of (delay-)coupled SL systems
  - dynamical instabilities
  - synchronisation properties
- utilization of complex dynamics, functional chaos
  - communication using chaotic carriers, key exchange
  - random number generation
  - information processing
  - optical coherence tomography

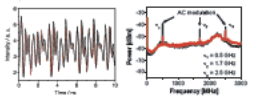


Utilization of Complex Dynamics

communication using chaotic carriers / key exchange
- principle:
  - generation of **suitable chaotic carrier** by the Transmitter
  - **encryption** of message by mixing it within the chaotic carrier of the Transmitter
  - **transmission** of entire signal to (matching) Receiver
  - **chaos synchronisation** if, and only if, Receiver is a "Twin system"
  - **extraction** of data via comparison of Transmitter and Receiver signal



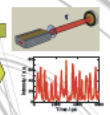
- it works:
  - chaos generation and synchronisation
  - signal extraction
  - field experiment
  - in the Metropolitan Area Network of Athens
  - 100 km fibre
  - transmission at l = 1552 nm
  - BER: 10^{-9} for 1.0 Gbit/s transmission with NRZ PRBS



Nonlinear SL Emission Properties

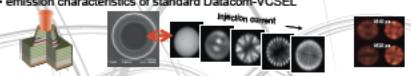
- SL exhibit dynamical instabilities under various conditions
  - current modulation, light injection, or delayed optical feedback
  - high-power edge emitters (broad area lasers)
  - broad area VCSEL

semiconductor lasers as complex systems lab
- study of delayed feedback instabilities



- instabilities in several applications due to delayed feedback from fibre or CD, DVD,..
- delay renders the system dynamically infinite dimensional
- aspects: dynamics, bifurcations, mechanisms, chaos-control, interaction with noise
- excellent testbed, has boosted studies of delay-systems

characterizing picosecond spatio-temporal emission
- emission characteristics of standard Datacom-VCSEL



- emission characteristics are a "fingerprint" of light-semiconductor interactions: spatial hole burning, spectral hole burning, temperature effects,..
- interactions lead to complex dynamical behaviour

Utilization of Complex Dynamics II

Generation of random bit sequences
- principle:
  - utilize unpredictability of chaotic laser dynamics
  - continuous dynamical system with noise avoids periodicities and recurrences
- advantages:
  - high bit-rate sequences
  - optical implementation

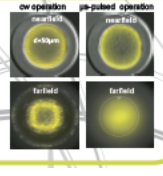
Information processing
- principle:
  - photonic implementation of a Liquid State Machine
  - information processing based on classification
  - utilizing delay-coupled elements to obtain high-dimensional state-space projection

traditional approach · our approach

Controlling and Tailoring SL Emission

tailoring spatial coherence

broad area VCSEL
- cw operation:
  - emission in large number of transverse modes
- µs-pulsed operation
  - only slightly blurred nearfield, but
  - drastically changed farfield! (Gaussian)
- origin: breakdown of modal emission
- possible applications: speckle-reduced source, projection

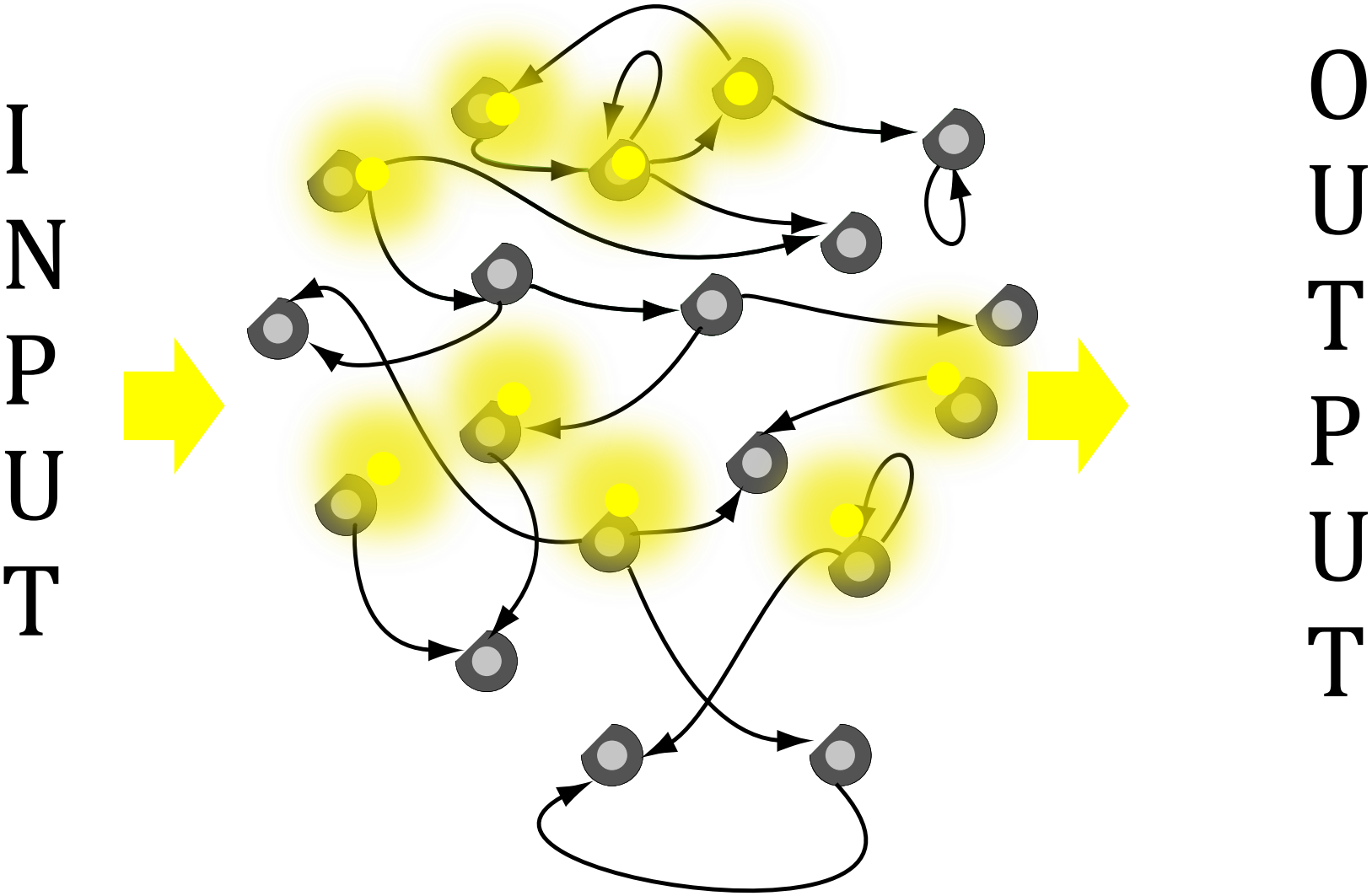


Current Goals & Future Perspectives

- tailor emission properties using nonlinear physics
- benefit from modern photonic sources
- towards networks of delay-coupled lasers
- develop novel applications based on complex behavior
- bio-mimetic photonic architectures

Information Processing (IP) in and by Complex Systems

PI: Claudio Mirasso

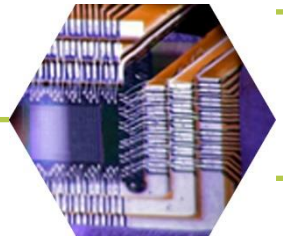


in: Processing, transmission, storage and retrieval of information in complex systems.

by: Designed information processing and sensing.

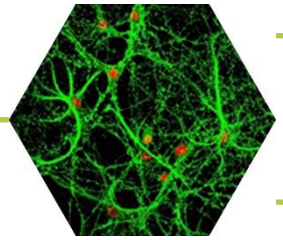
Complex Systems Science

Synthesize novel methods connecting the know-how of the individual fields.

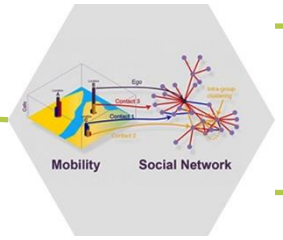


Quantum information processing

Machine learning/brain (-inspired) computing concepts



Bio-Complex Systems



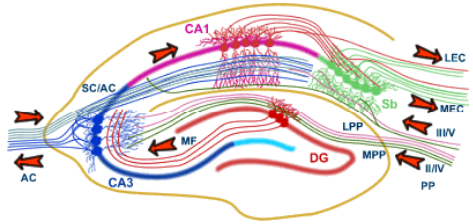
Socio-technical Systems

Big-data analysis

Complex Networks Theory

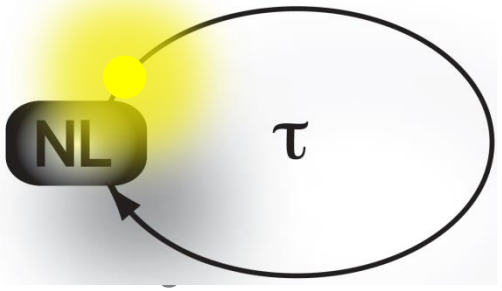
María de Maeztu Unit of Excellence: Objectives

L1: Information processing in biological systems



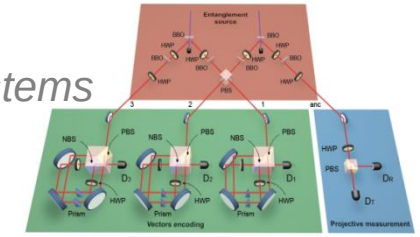
- *Information processing in biochemical networks, brain circuits and structures, and ecological networks*
- *Genetic diversity in ecosystems and its response to environmental changes*
- *Biodiversity patterns, especially in microbial communities; alternative ways to encode and store information*

L2: Brain-inspired analog computing in photonic and electronic syst



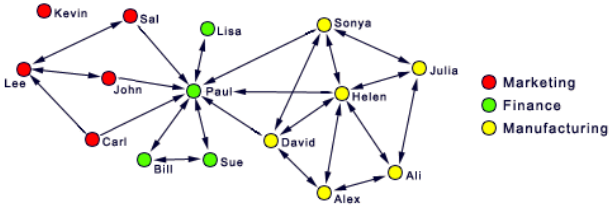
- *Hardware implementations of reservoir computing and their applications in*
- *telecom and datacom*
- *Autonomous operation of recurrent networks*
- *Development of novel computing concepts, theoretical framework for scaling and*

L3: Quantum information: decoherence, dissipation, and transmission



- *Emergent quantum phenomena and information retrieval in extended and network systems*
- *New functionalities based on nanoelectronic devices*
- *Information processing using quantum materials*

L4: Information processing in socio-technical systems



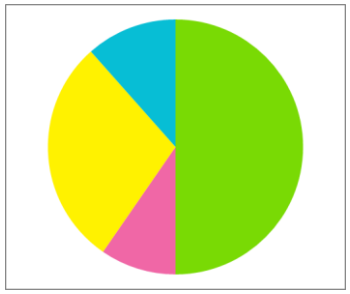
- *Evolution of social-system and processing of information: opinion, consensus, meme spreading, fake news, etc.*
- *Studies of mobility of people and animals;*
- *Data-driven modeling and response of urban systems to external perturbations.*

IFISC Live Seminars

Our seminars are webcast live

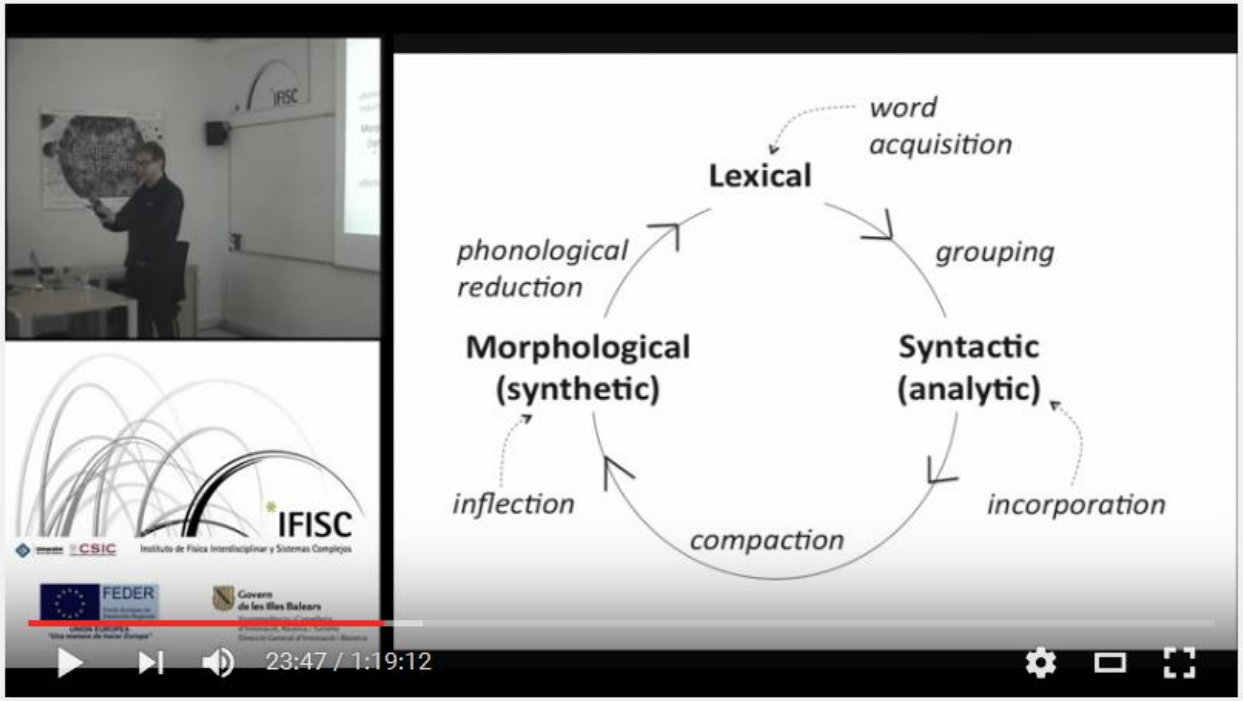
http://ifisc.uib-csic.es/live.php

383 webseminars 2009-17

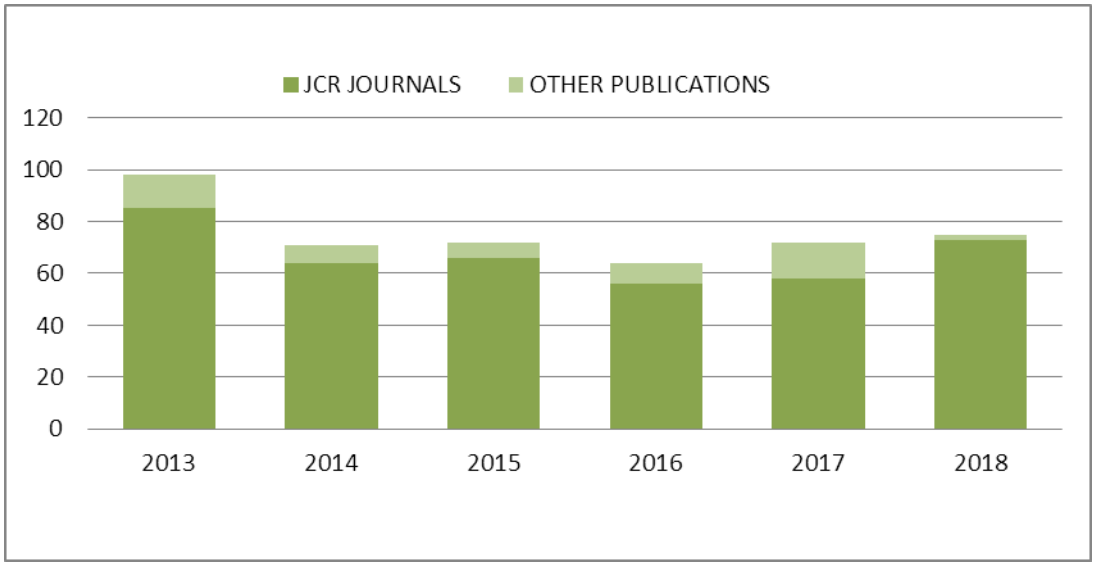


2018:
71 seminars

IFISC: 26
Spain: 5
Europe: 15
Rest of the World: 6



Publications



https://ifisc.uib-csic.es/en/publications/

High impact 2012-2018:

1 Rev. Mod. Phys,

4 PNAS,

4 Nature Comm,

1 Nature Geophysics

24 Phys. Rev. Lett.

	2013	2014	2015	2016	2017	2018	TOTAL
JCR JOURNALS	85	64	66	56	58	73	402
OTHER PUBLICATIONS	13	7	6	8	14	2	50
TOTAL	98	71	72	64	72	75	452

JOURNALS WITH THE LARGEST NUMBER OF PUBLICATIONS

IFISC PUBLICATIONS	2013	2014	2015	2016	2017	2018	TOTAL
Physics journals							
Physical Review E	9	14	12	9	4	10	58
Physical Review B	8	7	7	5	4	5	36
Physical Review Letters	8	3	4	1	1	3	20
Physical Review A	5	5	2	3	3	1	19
New Journal of Physics	2	3	1	5	3	4	18
European Physical Journal B	3	1	1	2	3	3	15
Chaos	1	0	3	2	5	4	13
Multidisciplinary journals							
Scientific Reports	4	2	3	7	11	3	30
Plos One	0	5	6	2	1	4	18
Nature Communications	1	0	3	0	0	0	4
IEEE journals	4	0	3	2	1	0	10

Contributions outside traditional basic physics (2013-18):

61 + IEEE(14)

* Nature Geoscience, Journal of Geophysical Research, Geophysical Research Letters, Deep-Sea Research I, Nonlinear Processes in Geophysics, Continental Shelf Research, ICES Journal of Marine Science, Earth Science Dynamics, Progress in Oceanography, Frontiers in Marine Science, and Journal of Climate

* Trends in Ecology and Evolution, Journal of Theoretical Biology, Bulletin of Mathematical Ecology, Journal of the Royal Society Interface, Neuroimage, PLoS Computational Biology, Ecological Complexity, Macromolecules, Ecography, Frontiers in Computational Neuroscience, Frontiers in Neuroscience, Frontiers in Neuroinformatics, Journal of Heredity, Physiological Reports, Journal of Applied Ecology, Theoretical Biology and Medical Modelling, ISME Journal, and Global Ecology and Biogeography..

* Journal of Artificial Societies and Social Simulation, International Journal of the Sociology of Language, Transportation Journal, Transportation, Journal of Air Transport management, Built Environment, and Journal of Transport Geography

* Computing and Informatics, EPJ Data Science, Journal of Machine Learning Research, Cognitive Computation, and Applied Network Science.

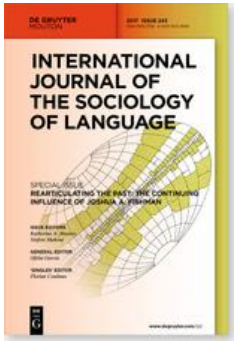
* Pioneering role in opening new cross-disciplinary research fields.

Publications in top physics, multidisciplinary and non-physics journals (Biology, Ecology, Neuroscience and Social Sciences).

JMLR Journal of Machine Learning Research

Trends in Ecology & Evolution

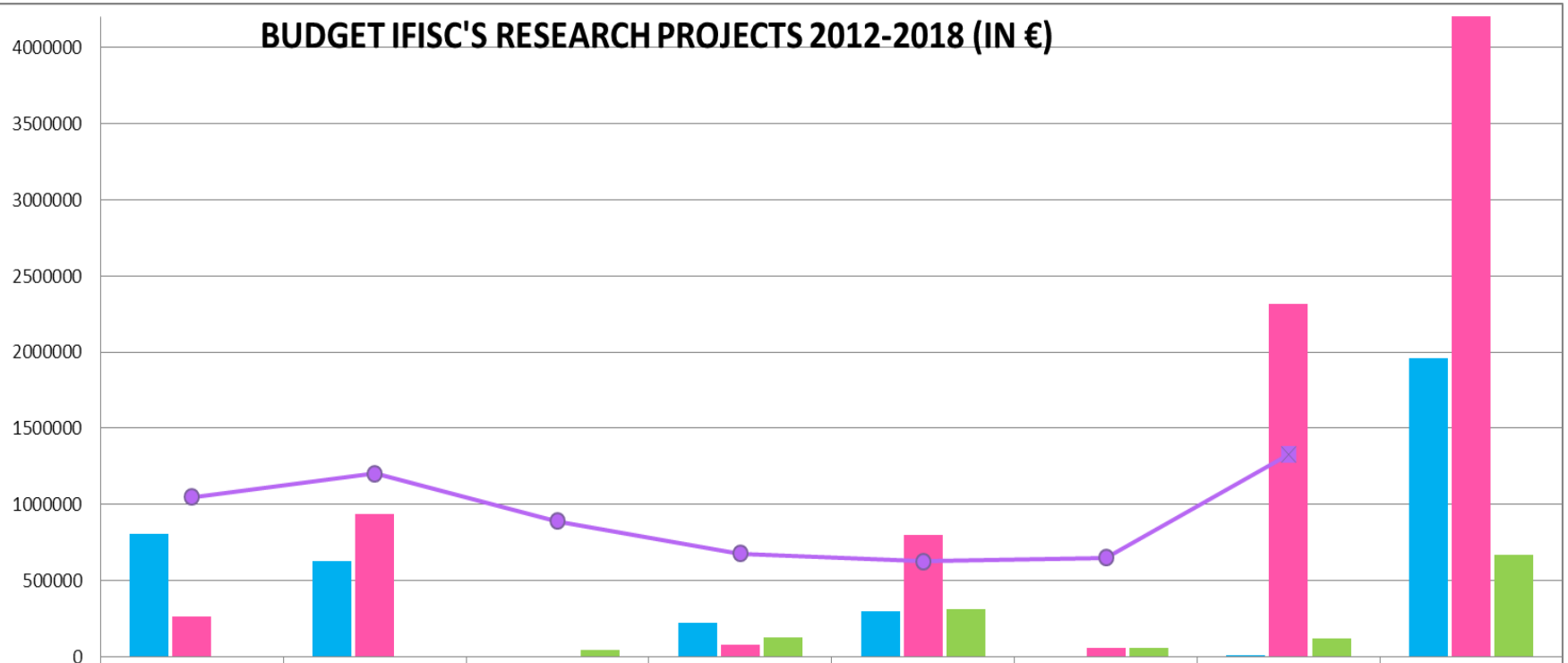
AJS American Journal of Sociology



nature geoscience

- Citation per paper in 2012-17: 11,66
  (Max Planck Dresden: 11,53; ISC(CNR,Italy): 8,88)

IFISC FUNDING



	2012	2013	2014	2015	2016	2017	2018	TOTAL
European Commission	803952	625.349 €	0 €	219.875 €	298.121 €	0 €	12.000 €	1.959.297 €
Spanish National Plan for Science	261360	934.830 €	0 €	77.000 €	799.084 €	54.450 €	2.320.000 €	4.446.724 €
Other Funding	0	0 €	47.250 €	123.813 €	312.740 €	60.500 €	122.573 €	666.876 €
Total	1.065.312 €	1.560.179 €	47.250 €	420.688 €	1.409.945 €	114.950 €	2.454.573 €	7.072.897 €
Anualized Total	1.049.669 €	1.201.140 €	890.914 €	676.039 €	625.961 €	648.528 €	1.326.489 €	

Grand total budget of active projects in 2018: **2.284.475 €**

Budget of EC-funded active projects in 2018: **34 % of total**

+ 2.000.000
Maria de Maeztu
Unit of Excellence

IFISC FUNDING (2015-19)

Spanish National Science Plan projects

(areas: Physics, ICT, Marine Sciences, Material Sciences)

Granted projects 2015-19: 12

European Commission Framework Program projects:

Granted projects 2015-18: 4 + 1 contract

Collaboration Networks:

EC COST actions, Spanish representative in Management Committee:

Running COST actions 2015-18: 3
Granted COST actions 2015-19: 1

Spanish Plan funded networks:

Granted networks 2015-18: 6 +1 (SOMMa)

Research contracts (private funding): 7 contracts in 2015-18

Spanish National Science Plan (MINEICO)

SET@QT: Spintronics, Energy, and Topology @ Quantum Transport (2015-17) PI. R. López

NOMAQ: Non-Markovian quantum evolutions in structured environments (2015-17). PI. R. Zambrini

QuStruct: Quantum information preserving with structured embeddings (2016-17) PI. F. Galve

EPHEQUCS: Emergent Phenomena and Decoherence in Quantum Complex Systems (2017-2019) PI. R. Zambrini

IDEA: Improving data DEcoding in optical communication networks All-optically using neuro-inspired photonic systems (2017-2019) PI. I. Fischer, C. Mirasso

ESOTECOS: Emergent Social, Technological and Ecological Complex Systems (2016-18). PI. P. Colet, M. San Miguel

LAOP: Lagrangian studies of Oceanic Processes: connectivity patterns, barriers to transport and marine populations (2016-18) PI. C. López

SPASIMM: Spatiotemporality in sociobological interactions, models and methods (2017-2019) PI. V. M. Eguíluz

TQM@Nano: Transport in Quantum Materials at the Nanoscale (2018-2020) PI. D. Sánchez, R. López

Spanish National Science Plan (MINEICO)

PACSS: Physics approach to complexity in sociotechnical systems (2019-21)
PI. R. Toral, J. Ramasco

SuMaECO: Sustainability of marine coastal ecosystems in the context of global change in the Mediterranean sea: Modeling and simulations (2019-21).
PI. D. Gomila

EUROPEAN COMMISSION

LINC: Learning about Interacting Networks in Climate (2012-15) PI. E. Hernández-García

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

EUNOIA: Evolutive User-centric Networks for Intraurban Accessibility **(**2012-15) Coordinator and PI. M. San Miguel

LASAGNE: Multi-Layer Spatiotemporal Generalized Networks.(2012-15) PI. M. San Miguel

INSIGHT: Innovative Policy Modelling and Governance Tools for Sustainable Post-Crisis Urban Development (2013-16) PI. J. Ramasco

TREE: Data-driven modelling of network-wide extension of the Tree of REactionary delays in ECAC área (2013-16) PI. J. Ramasco

QuProCS: Quantum Probes for Complex Systems, H2020, (2015-17) PI R. Zambrini

BIGDATA4ATM: Passenger-centric Big Data Sources for Socio-economic and Behavioural Research in ATM,H2020 (2016-18) PI. J. Ramasco

CENTURION: Signal proCEssing in optical communication NeTworks Using ReservoIr cOmputiNg, H2020 MSCA IF (2016-18) PI I Fischer

CAFE: Climate Advanced Forecasting of sub-seasonal Extremes (2018-23) PI. E. Hernández-García

ESPON EGTC : Big data for territorial analysis and housing dynamics (2018) PI. J. Ramasco

COLLABORATION NETWORKS (2014-18)

EC COST actions:

KNOWeSCAPE: Analyzing the dynamics of information and knowledge landscapes. COST ACTION TD1210. (2012-2017). IFISC Spanish member of MC: M. San Miguel.

QTD:Thermodynamics in the Quantum Regime. COST Action 1209 (2014-2017). IFISC Spanish member of MC: R. Zambrini.

COSTNET: European Cooperation for Statistics of Network Data Science. COST Action 15109. (2016-2020). IFISC Spanish member of MC: M. San Miguel

Spanish National Plan collaboration networks:

COMSOTEC: Complex Sociotechnical systems (2015-17) M. San Miguel
IBERSINC: Dynamics and synchronization in complex networks (2016-17) M.C. Soriano
RFE2017: Network of non-equilibrium statistical physics and its multidisciplinary applications (2017-19) D. Sanchez
TNT: Thermoelectricity network: new theories (2017-19) R. López
RICTE: Quantum Information and Technologies network (2017-19) R. Zambrini
SOMMa Alliance: The ‘Severo Ochoa’ Centres and ‘María de Maeztu’ Units of Excellence Alliance (2018-2022) C. Mirasso

BILATERAL INTERNATIONAL COLLABORATIONS

ND-PHOT: Nonlinear Dynamics in photonics for future information and communication technologies (2016-2018). PICS CNRS (Bensançon)-CSIC (IFISC). D. Gomila

MOREHOUSE: Modeling housing markets dynamics thanks to emerging and heterogenoeus data sources (2019-2021). PICS CNRS (Institute for Humanities and Social Sciences, Paris)-CSIC (IFISC) J. Ramasco.

IN-TREE: Intersdisciplinary and Transdisciplinary Studies in Ecology and Evolution (2016-2022) CNPq, CAPES, FAPESB Brazil. E. Hernández-García

Collaborations with International Organizations:

UNWTO
World Tourism Organization

unicef
Data, Research and Policy (DRP)

Migrant mobility flows

PRIVATE FUNDING (2015-18)

XARION: Research Collaboration Agreement with XARION Laser Acoustics (2014-15). PI. I. Fischer

LOGITRAVEL: Research contract on Data Analysis with LOGITRAVEL (2015). PI. J. Ramasco and P. Colet

NUUBO: Research Collaboration Agreement with Nuubo Wearable Medical Technologies (2015-2016). PI. M.C. Soriano and C. R. Mirasso.

NeuroQNet: Neuromorphic Computing using QD-Networks**,** Volkswagen Foundation, (2016-2018), PI. I. Fischer

CAASE: Coupled Animal and Artificial Sensing for Sustainable Ecosystems, King Abdullah University of Science and Technology (2016-18), PI. V.M. Eguiluz

IL.LUMINAT: Exhibition on the International year of light and light-based technologies, Red Electrica Española (2015), PI C.R. Mirasso

TEAMS: Towards an Ecological Approach of Information Systems (Fondazione Cassa di Risparmio di Padova e Rovigo (2018), PI S. Meloni

Contracts

xarion laser acoustics

nuubo WEARABLE MEDICAL TECHNOLOGIES

KAUST

Isdefe su mejor aliado

Fondazione Cassa di Risparmio di Padova e Rovigo

SESAR JOINT UNDERTAKING

EUROCONTROL

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Joint Projects

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BBVA INNOVATION CENTER

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Kineo

SThAR

apsl

2GN Two Good Neighbors

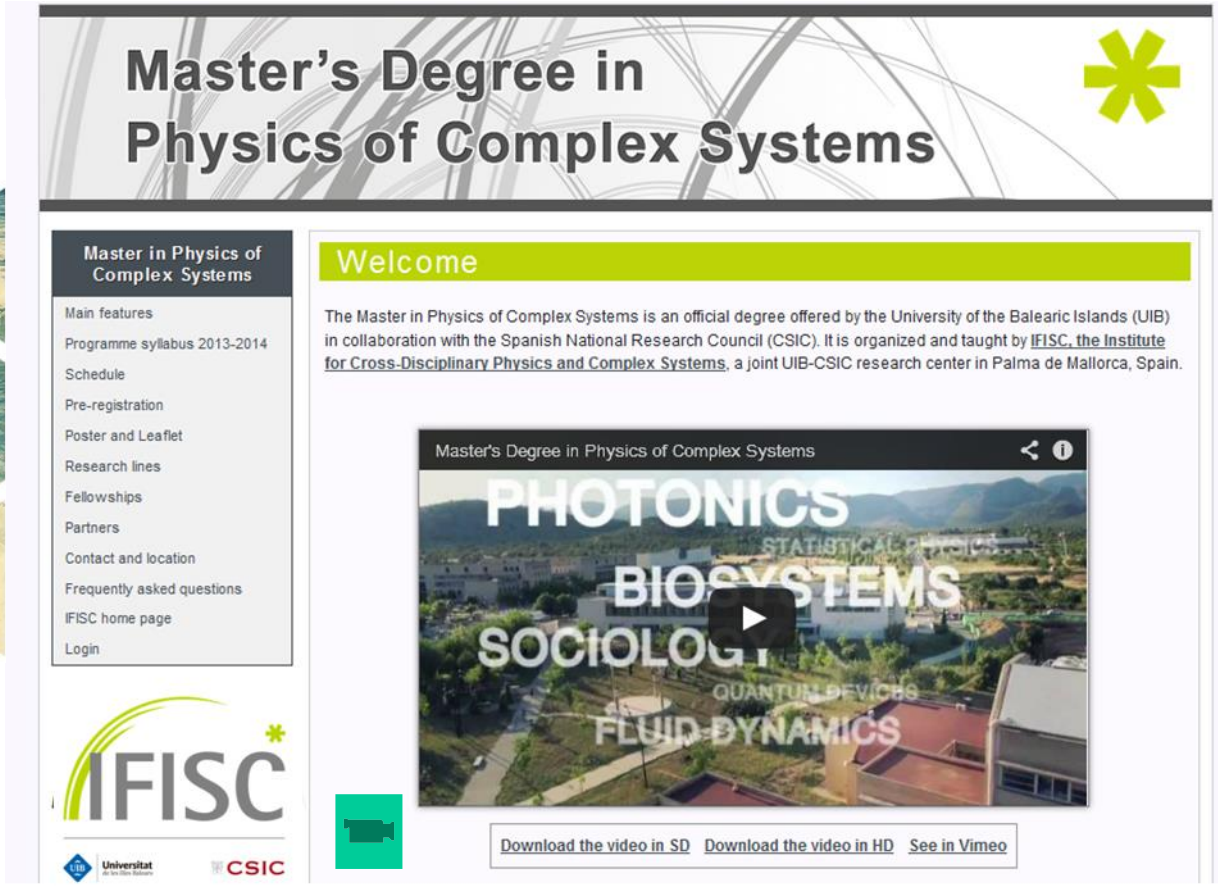
iBit Illes Balears innovació tecnològica

LOGITRAVEL.com

altair

Biolinea|com

Summer Undergraduate Research Fellowhips



- **Shared PhD program of excellence in Physics of UIB**
- **Summer schools**

IFISC WORKSHOPS

CEWQO

25th CENTRAL EUROPEAN WORKSHOP ON QUANTUM OPTICS
May 21-25, 2018

IFISC 10y
CROSSROADS IN COMPLEX SYSTEMS
June 5-8, 2017

QUANTUM PROBES FOR COMPLEX SYSTEMS
April 6-7, 2017

MAJORANA STATES IN CONDENSED MATTER: TOWARDS TOPOLOGICAL QUANTUM COMPUTATION
May 14-20, 2017

YOUNG RESEARCHERS AT THE CROSSROADS
June 2-4, 2017

COSTNET WORKSHOP ON STATISTICS OF NETWORK DATA SCIENCE
October, 2017

ICE-3 QUANTUM INFORMATION IN SPAIN
April 13-15, 2016

2nd QUANTUM THERMODYNAMICS CONFERENCE
April 19-24, 2015

EXPLORATORY WORKSHOPS

QUANTUM CONTROL IN COMPLEX NETWORKS
January 2018

NEW TRENDS IN FREQUENCY COMB GENERATION
November, 2017

TREE: DATA-DRIVEN MODELLING OF NETWORK-WIDE EXTENSION OF THE TREE OF REACTIONARY DELAYS IN ECAC AREA
January, 2014

WORKSHOP THEfoDA: THEORY AND MECHANISMS OF SOCIAL INTERACTIONS IN THE BIG DATA ERA
February, 2013

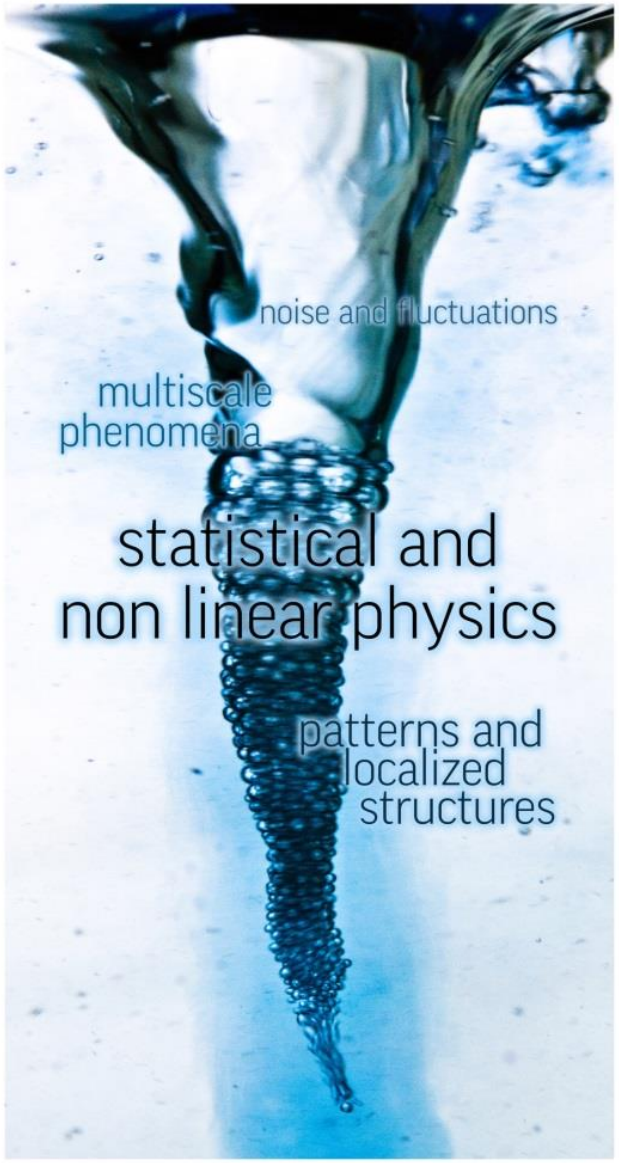
IFISC SUMMER SCHOOLS

VII and VIII SUMMER SCHOOL ON STATISTICAL PHYSICS OF COMPLEX AND SMALL SYSTEMS
June 19-30, 2017
July 2-13, 2018

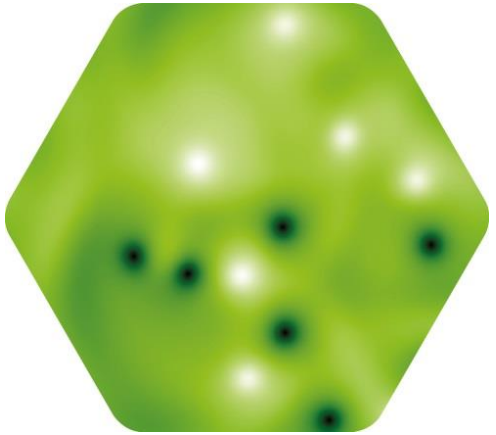
SUMMER SCHOOL ON COMPLEX SOCIO-TECHNICAL SYSTEMS
September 4-8, 2017

RICE SCHOOL
April 11-12, 2016

COMPLEX SYSTEMS. STATISTICAL AND NONLINEAR PHYSICS



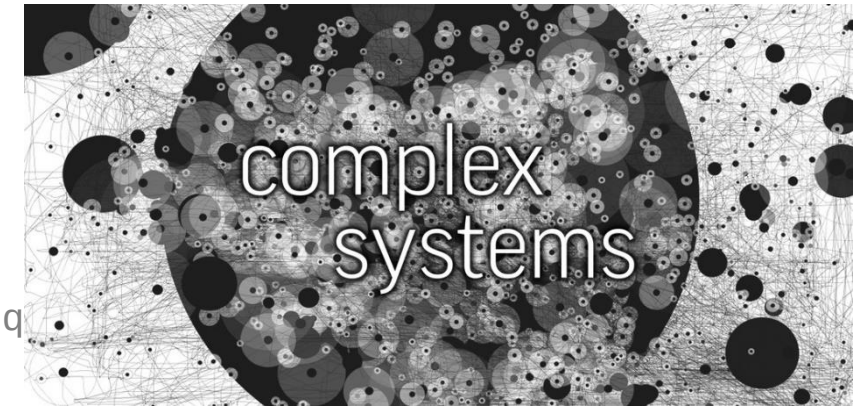
Complex systems are characterized by **emergent** and **collective** phenomena of many interacting units. Fundamental understanding of these systems comes from Statistical Physics together with the Theory of Dynamical Systems, which includes the study of **chaos** and the effect of **fluctuations** and random events on systems evolution.

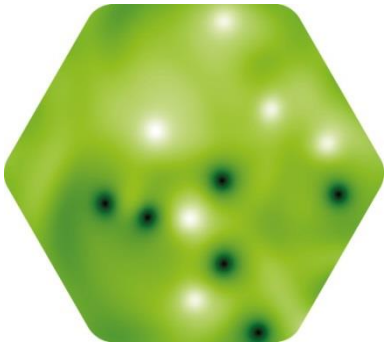


This research line of exploratory nature is the backbone of **IFISC**: We develop new concepts and methods for the study of **Complex Systems**, and we analyze generic phenomena such as synchronization, phase transitions, nonequilibrium instabilities, spatiotemporal pattern formation, and the dynamics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

COMPLEX SYSTEMS. STATISTICAL AND NONLINEAR PHYSICS

Research projects:





-ESoTECoS
Emergent Social, Technological and Ecological Complex Systems
PI. P. Colet, M. San Miguel

-EPheQuCS
Emergent phenomena and decoherence in q complex systems. PI. R. Zambrini

-SPASIMM
Spatiotemporality in sociobological interactions, models and methods. PI. V. M. Eguíluz

-IDEA
Improving Data Decoding in optical communication networks all-optically using neuroinsopired photonic systems. PI. I. Fischer

-PACSS
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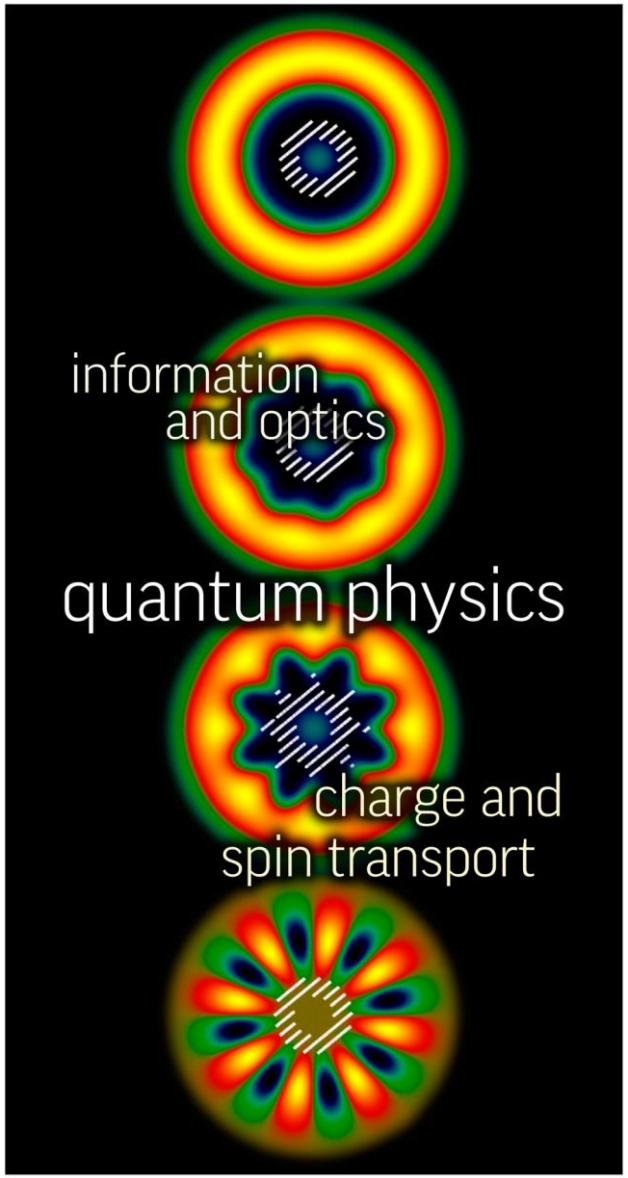
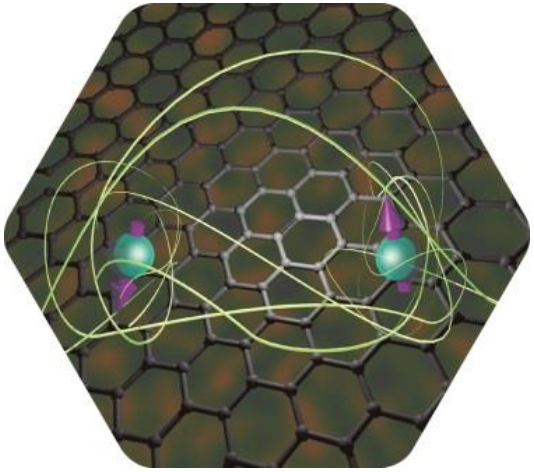
-SuMaECO
Sustainability of marine coastal ecosystems in the context of global change in the Mediterranean sea: Modeling and simulations. PI. D. Gomila

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.

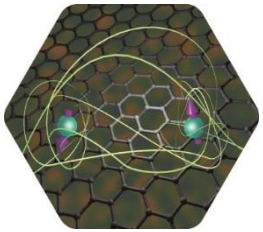


In this research line, we are devoted to questions related to quantum transport for charge(nanoelectronics), spin (spintronics), energy (thermoelectrics) and information (quantum correlations), with a particular focus on nanostructures.

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.

TRANSPORT AND INFORMATION IN QUANTUM SYSTEMS

Research projects:



-QuProCS
Quantum Probes for Complex Systems
PI R. Zambrini

-SET@QT
Spintronics, Energy, and Topology @ Quantum Transport
PI. R. López

Rosa López

David Sánchez

-NOMAQ
Non-Markovian quantum evolutions in structured environments
PI. R. Zambrini

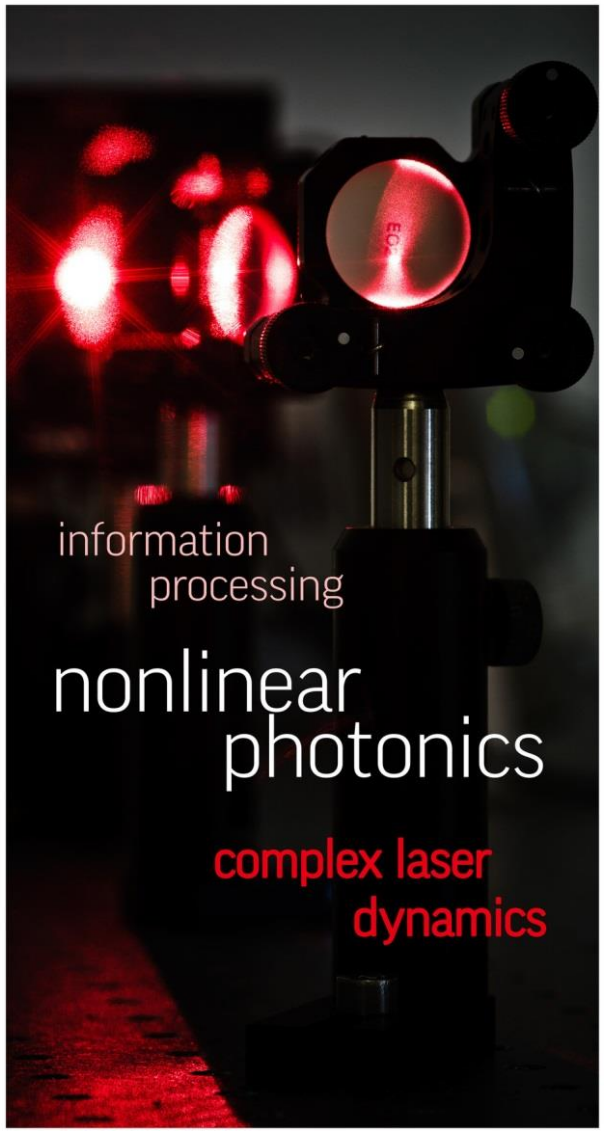
-EPheQuCS
Emergent phenomena and decoherence in quantum complex systems
PI. R. Zambrini

Llorens Serra

Roberta Zambrini

-TQM@Nano
Transport in Quantum materials at the Nanoscale
PI. D. Sanchez and R. López

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.

NONLINEAR PHOTONICS

Research projects:

-IDEA
Improving data Decoding in optical communications networks All-optically using neuro-inspired photonic systems
PI. I. Fischer, C. Mirasso

-NeuroQNet
Neuromorphic Computing using Quantum Dot-Networks
PI. I. Fischer

-CENTURION
Signal proCEssing in optical communication NeTworks Using ReservoIr cOmputiNg
PI. I. Fischer

-ND-PHOT
Nonlinear dynamics in photonics for future information and communication technologies
PI. D. Gomila

Pere Colet

Ingo Fischer

Damià Gomila

Claudio Mirasso

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.

NONLINEAR DYNAMICS IN FLUIDS

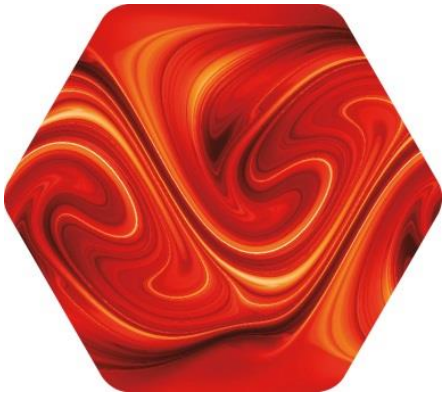
Research projects:

-LAOP
Lagrangian studies of Oceanic Processes: connectivity patterns, barriers to transport and marine populations
PI. C. López

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

-CAFE
Climate Advanced Forecasting of sub-seasonal extremes
PI. E. Hernández-García

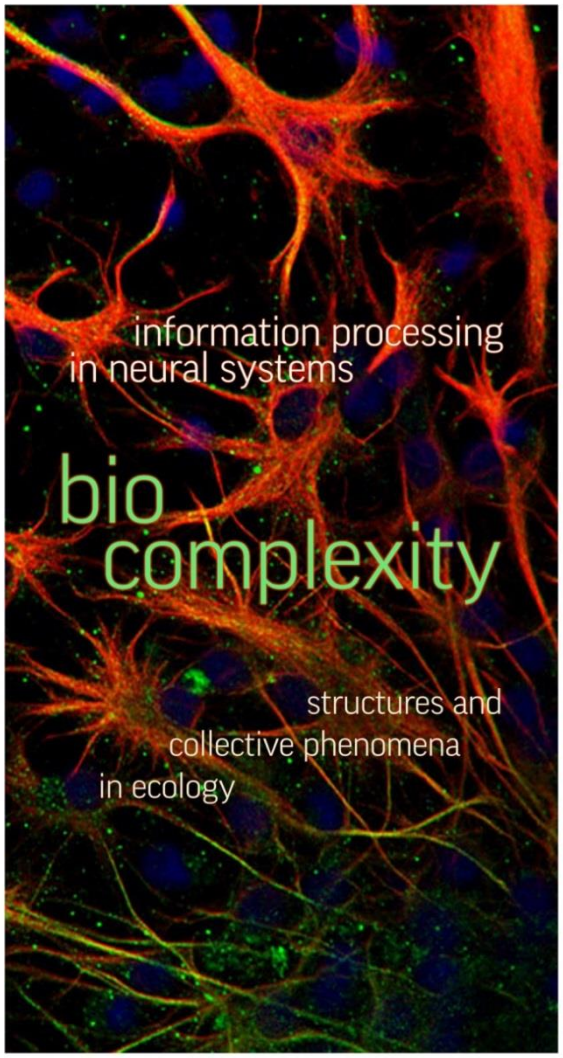
Emilio Hernández

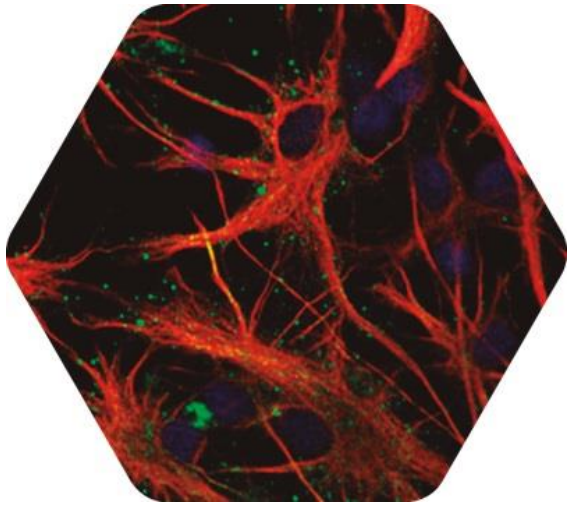


Cristóbal López

Tomàs Sintes

BIOCOMPLEXITY



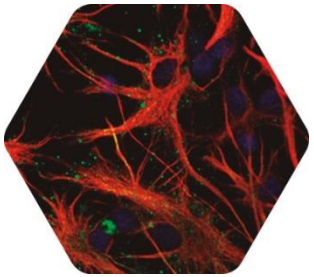


Living systems are the paradigm of complex systems, with nonlinear interactions occurring at all spatial and temporal scales, from molecules and genes to the planetary scales defining the global biosphere.

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.

BIOCOMPLEXITY



Research projects:

-ESoTECoS Emergent social, technical and ecological complex systems. PI P. Colet, M. San Miguel

-CAASE Coupled Animal and Artificial Sensing for Sustainable Ecosystems: The Red Sea as a case Study. PI. V. Eguíluz

-SPASIMM Spatiotemporality in sociobological interactions, models and methods. PI. V. M. Eguíluz, K. Klemm

-SuMaECO Sustainability of marine coastal ecosystems in the context of global change in the Mediterranean sea: Modeling and simulations. PI. D. Gomila

-IN-TREE. NCT in Interdisciplinary and Transdisciplinary Studies in Ecology and Evolution. PI. E.Hernández-García

Víctor Eguíluz

Damia Gomila

Ingo Fischer

Emílio Hernández-García

Cristóbal López

Manuel Matías

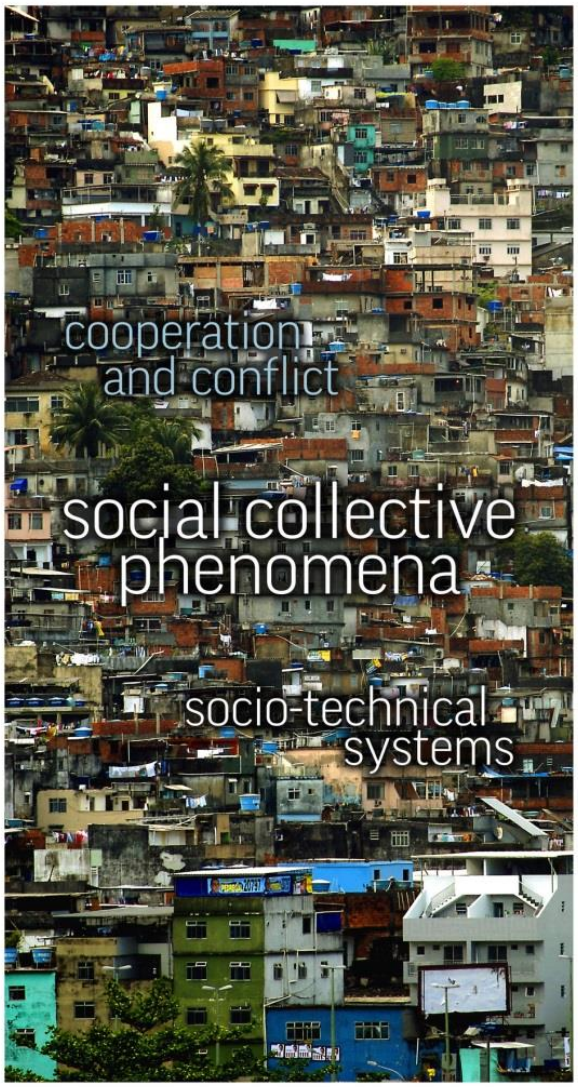
Sandro Meloni

Claudio Mirasso

Tomàs Sintes

Raúl Toral

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.

IFISC Research Lines

COLLECTIVE PHENOMENA IN SOCIAL AND SOCIO-TECHNICAL SYSTEMS

Research projects:

-EUNOIA
Evolutive User-centric Networks for Intraurban Accessibility
PI. M. San Miguel

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

-TREE
Data-driven modelling of network wide extension of the tree of reactionary delays in ECAC area
PI. J. J. Ramasco

-BigData4ATM
Passenger-centric BigData Sources for Socio-economic and Behavioural Research in ATM
PI. J. J. Ramasco

-ESoTECoS
Emergent social, technical and ecological complex systems
PI P. Colet, M. San Miguel

-PACSS
Physics approach to complexity in sociotechnical systems.
PI. R. Toral, J. Ramasco

-ESPON EGTC + MOREHOUSE
Big data for territorial analysis and housing dynamics
PI. J. J. Ramasco

Pere Colet

Damia Gomila

Víctor M. Eguíluz

Emilio Hernández-García

Sandro Meloni

Jose J. Ramasco

Maxi San Miguel

Raúl Toral

Science Fairs

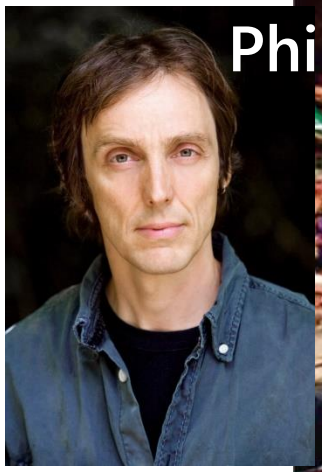
EXPLORANDO
LAS FRONTERAS
ENTRE SABERES X
DE LA BIOLOGÍA
A LAS CIENCIAS SOCIALES:
NUEVOS RETOS EN EL CAMPO
DE LOS SISTEMAS COMPLEJOS
Del 24 de mayo al 6 de junio 2017
10 YEARS IFISC

NAVEGANDO
POR LA COMPLEJIDAD
DEL SIGLO XXI
CIENCIA, INTELIGENCIA Y CREATIVIDAD
Del 19 de abril al 3 de mayo 2018
IFISC
CSIC
CaixaForum Palma

IFISC Open Doors

4.200 visitors, Casal Solleric
Il·lumina't
Laser Graffiti

2015 International Year of Light


Philip Ball

10 YEARS IFISC
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PORTADA › CIENCIA › UN ESTUDIO DESVELA CÓMO SE FORMAN CÍRCULOS VACÍOS EN LA POSIDONIA

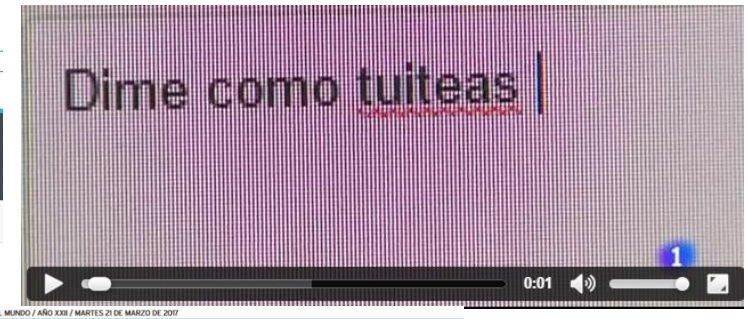
CIENCIAS MARINAS

Un estudio desvela cómo se forman círculos vacíos en la posidonia

La competencia entre las plantas por los recursos existentes es la responsable de los llamados "círculos de hadas", unos claros circulares sin vegetación que se forman en las praderas de posidonia oceánica, según revela un estudio que puede contribuir a su conservación.

EFEFUTURO PALMA | SÁBADO 16.09.2017

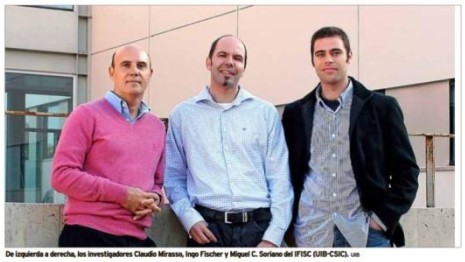
Pradera de Posidonia. (Blog Nos Mojamos)



EL MUNDO / AÑO XXII / MARTES 21 DE MARZO DE 2017

>Investigación / Física

Un equipo de investigadores del IFISC (CSIC-UIB) demuestra la viabilidad del esquema de Verman sobre el cifrado con clave de un solo uso. / El método se ha probado en sistemas electrónicos y fotónicos. Por **E. S.**



De izquierda a derecha, los investigadores Claudio Mirasso, Ingo Fischer y Miguel C. Soriano del IFISC (UIB-CSIC).

Señales caóticas como herramienta de encriptación

La Almudaina

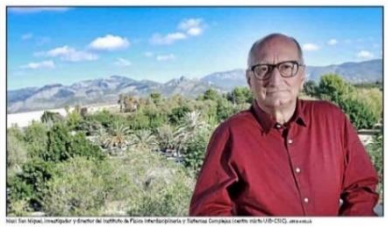
Suplemento dominical de Diario de Mallorca

B@LEÓPOLIS

EL SUPLEMENTO DE LA INNOVACIÓN EN LAS ISLAS

>Divulgación / Humor

Ciencia a carcajadas, monólogos con conocimiento



>ENTREVISTA

«Ser físico es una actitud»

doctor en Física, catedrático de la UIB desde 1986 y director e investigador del Interdisciplinar y Sistemas Complejos (IFISC) un centro mixto UIB-CSIC. **Elena Soto**

El IFISC toma altura

Diez años de investigación avanzada en la Universidad

Se cumple una década de la creación del Instituto de Física Interdisciplinar y Sistemas Complejos (IFISC) de la UIB. Un

Balears Fa Ciència IB3 @BalearsFCiencia · 6 abr.

Saps què és l'efecte Robin Hood? Mira el vídeo complet goo.gl/fT5vwR #BalearsFaCiènciaIB3 @IB3televisio @FECYT_Ciencia @IFISC_mallorca

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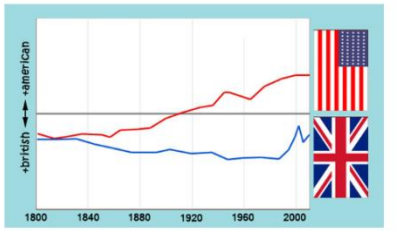
La americanización del inglés es real: lo co

Twitter y Google Books



1 COMENTARIOS

12 Agosto 2017 · Actualizado 13 Agosto 2017, 18:55

SERGIO PARRA

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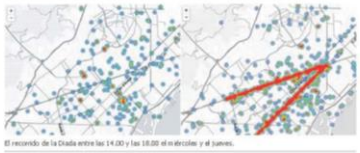
POLÍTICA

Los tuits dibujan la V de la Vía Catalana

Un equipo de investigadores dibuja un mapa de la manifestación en forma de V gracias a tuits



El recorrido de la Diada entre las 14.00 y las 18.00 el miércoles y el jueves.

Los tuits geolocalizados enviados este jueves desde Barcelona han permitido a un equipo de investigadores dibujar en el mapa la manifestación en forma de V que ha celebrado la Diada en las calles de Barcelona y a la que han asistido cientos de miles de personas. Los investigadores, del Instituto de Física Interdisciplinar y Sistemas Complejos (IFISC), en Baleares, ya había realizado un trabajo similar el año pasado coincidiendo con la cadena humana realizada el 11 de septiembre de 2013.

Los investigadores han descargado tuits geolocalizados en Cataluña (con datos de la hora y las coordenadas desde donde se han enviado) durante cada hora a largo del día nacional de Cataluña. Al contrario que el año pasado, no se ha hecho ningún tipo de preselección en base a *hashtag* o palabra clave, solo por localización geográfica, según informa el IFISC en una nota. Como control, los investigadores han medido los tuits geolocalizados en la misma zona

SINC

La ciencia es noticia

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CIENCIAS NATURALES: Ciencias de la Vida

Focas, ballenas y aves marinas hacen los mismos viajes por el océano

Los movimientos de los animales marinos por el océano abierto y la costa son una fuente de información crucial para su conservación. Un estudio liderado por centros de investigación australianos revela que a pesar de las diferencias en el tamaño corporal y la forma, todos los animales marinos se mueven a través

europa press

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Italy, en Nueva CONGRESO DE EE.UU.

El cable submarino podría haber implicado propagar el apagón de Menorca a parte de Mallorca, según científicos

Un nuevo método matemático mide la integración o segregación de los inmigrantes a partir de sus tuits

La medición muestra ciudades con alta integración, como Londres, San Francisco, Tokio o Los Ángeles, y otras con un nivel bajo, como Detroit, Miami, Toronto o Ámsterdam.

Un equipo internacional dirigido por investigadores del Consejo Superior de Investigaciones Científicas (CSIC) ha desarrollado un método que permite medir la integración o segregación de los inmigrantes a partir de los mensajes que escriben en la red social Twitter.

En este trabajo, publicado en la revista PLOS ONE, se desarrolla un método para usar datos de Twitter para analizar el grado de segregación espacial de las comunidades inmigrantes. "La comunidad de origen de los usuarios se determina mediante el idioma de los tweets emitidos, estableciéndose una algebra idiomática para asignar la comunidad más probable a la que se pertenece", explica el director del estudio, José Javier Ramasco, investigador del CSIC en el Instituto de Física Interdisciplinar y Sistemas Complejos, de Mallorca. "Si todos los mensajes son en idioma local, entonces se considera al usuario como residente local. Si, al contrario, algunos mensajes son en idiomas propios de las comunidades inmigrantes se puede asumir que dicho usuario conoce esa lengua y

Le Monde.fr

Un algorithme joue les Robin des bois

Des chercheurs ont homogénéisé virtuellement les dépenses effectuées dans les magasins de différents quartiers et montré qu'une modification de 5 % des transactions réduit de 80 % les inégalités géographiques entre commerçants.

Viet Times

Bí ẩn "vòng tròn thần tiên" dưới biển đã được giải mã?

01:00' 15-08-2017

Các chuyên gia mới cho hay đã giải mã được bí ẩn về những vòng tròn thần tiên (fairy circles) ở các vùng biển Địa Trung Hải và biển Baltic.

- Quái vật bí ẩn xuất hiện ở hồ nước tại Trung Quốc gây xôn xao
- Xác tàu đắm hàng nghìn năm chứa tiền vàng dưới biển Ai Cập
- Cuối cùng cũng có lời giải mã cho những bí ẩn lịch sử từng khiến các nhà khoa học đau đầu

nature physics

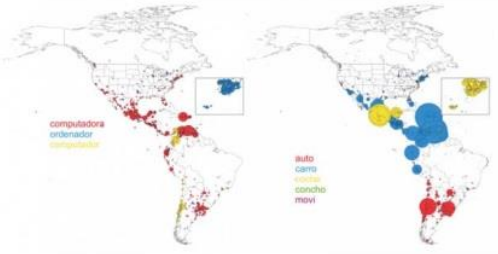
Theoretical ecology: Sea fairies

MIT Technology Review

Emerging Technology From the arXiv
August 7, 2014

Computational Linguistics of Twitter Reveals the Existence of Global Superdialects

The first study of dialects on Twitter reveals global patterns that have never been observed before.

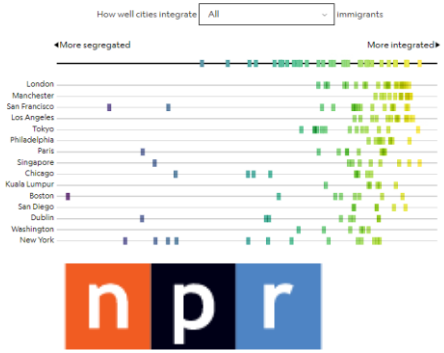


NATIONAL GEOGRAPHIC

CULTURE & HISTORY

Researchers Are Now Turning to Twitter to Track Immigrant Migration

Explore the results of the social media–driven study through this interactive graphic.



npr

OPINION CULTURE

Could You Help Rewire Income Disparity?

June 27, 2017 · 7:31 AM ET

ADAM FRANK

Newsweek

Using Twitter, Linguists Find Global 'Superdialects'

By Taylor Wofford

NewScientist

City and rural super-dialects exposed via Twitter

11 August 2014 by Aviva Rutkin

THE SUN

THE SUN, A NEWS UK COMPANY

FAIRY STRANGE Mystery of why bizarre underwater 'fairy circles' are appearing across the world solved

Strange glowing patches could show foreign plants are putting entire ecosystems at risk of extinction

theguardian

Do you want fries with that? Data shows Americanization of English is rising

A new study documents the speed at which American English has stretched around the globe – and its influence is even felt within the UK

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How Flight Delays Spread Across U.S. Airports

By Lisa Raffensperger | January 11, 2013 2:38 pm

15

Real data for three days in 2010, with, from L to R, low, intermediate, and high levels of congestion. Orange and red are congested airports; green airports are not congested. Links connecting airports in the largest cluster of delays are in red.

Mail Online

How flight delays spread like a virus: Graphic reveals how late departures in one airport can cause chaos across America

May,2019

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