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2023

EXCELENCIA
MARÍA
DE MAEZTU
2023 - 2027

IFISC

Universitat
de les Illes Balears

CSIC

Institute for Cross-Disciplinary Physics and Complex Systems

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Index

1

PRESENTATION AND RESEARCH LINES

IFISC (**Institute for Cross-Disciplinary Physics and Complex Systems**) is a joint research institute of the **University of the Balearic Islands** (UIB) and the **Spanish National Research Council** (CSIC) created in 2007 building upon the former Cross-Disciplinary Physics Department of the Mediterranean Institute for Advanced Studies (IMEDEA).

IFISC has been awarded by the Spanish Research Agency (AEI) with the **Maria de Maeztu (MdM) Unit of Excellence** seal since 2018 and it has established itself as a reference center in complex systems and an important actor in the definition of new trends in this field at national and international level.

IFISC tackles mainly theoretical but also experimental challenges situated at the dynamic intersection of complex systems and interdisciplinary applications across diverse fields including photonics, quantum physics, biology, ecology, environment, and social systems. Our research is distinguished by its integration of fundamental principles spanning network theory, statistical and nonlinear physics, stochastic processes, mathematical modeling of collective phenomena, and quantum physics. We extend our focus into complex societal contexts, exploring various facets of information technology, while actively participating in unconventional computing and learning endeavors. Moreover, our investigations delve deeply into the dynamic behaviors of life and environmental systems, underscoring the inherently interdisciplinary character of our work.

Physics approaches to interdisciplinary research in complex systems are instrumental to solving many of society's challenges. The 2021 Nobel Prize in Physics "*for providing innovative contributions to our understanding of complex physical systems*" highlighted the relevance of this field and the uniqueness of its physics methodology, making clear that complex systems modeling is key to providing understanding and forecast and also to developing practical solutions and advice for governments and policymakers. Complex systems research is key to addressing known challenges such as digitalization, health, or climate change. A healthy research base in complex systems is also necessary to be able to react to future unexpected societal changes and a principal element of a scientific preparedness strategy.

1.1 IFISC RESEARCH LINES

IFISC's research is structured around four non-disjoint **research lines**: a first one developing methodologies and concepts of broad applicability, and the other three concerning the transfer of these ideas to specific **physical**, **biological** or **social** domains of application, thus giving us a unique opportunity to contribute to future challenges in the areas of digitalization, artificial intelligence, health, mobility or climate and environment, among others.

IFISC researchers participate in several of these research lines, based on **transversality, collaboration and interdisciplinarity**, which are IFISC's distinctive marks. IFISC´s organization and structure encourages joint publications, joint participation in projects, scientific discussions and collaborations, joint supervision of PhD and master students, and cross-cutting seminars.
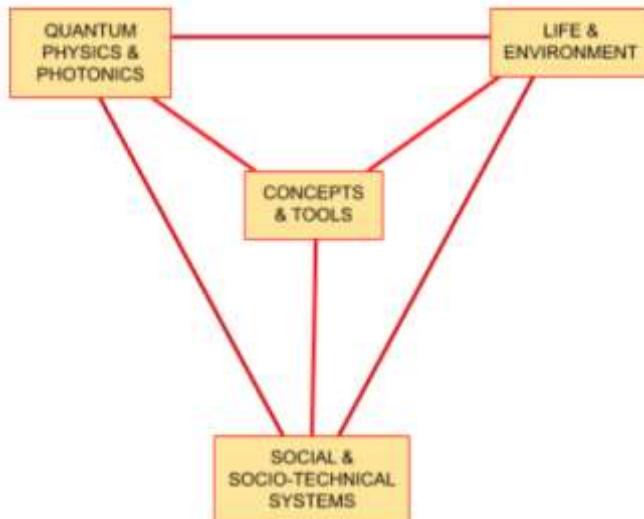
Concepts and Tools

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 a variety of disciplines and techniques which we develop and integrate: Statistical Physics, Network theory, Machine Learning and other Artificial Intelligence methods, Big Data and Data Science, Dynamical Systems, Classical and Quantum Information, Quantum thermodynamics, Information Processing methods and, in general, physics thinking for complex systems that allows tackling concepts such as Emergence, Collective Phenomena, Determinism or Stochasticity.

This research line is the backbone of IFISC: we develop new concepts and methods for the study of Complex Systems, and we analyze generic phenomena.
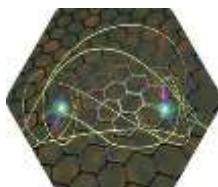
Photonics and Quantum Systems

In this research line, IFISC researchers have been investigating approaches based on complex systems to study processes in physical systems, mostly in quantum physics and in photonic information processing. For example, work has been done in synchronization and information transmission in quantum networks, quantum transport in nanodevices, graphene, thermoelectricity, Josephson junctions and Majorana physics in nanostructures. Quantum machine learning is also a topic of interest, which explores different learning approaches to identify a quantum advantage for data analysis.

Dynamical properties of photonic systems, such as lasers, optical amplifiers and fibers, have been studied in detail and used in data decoding applications for datacom and telecom. They are ideal hardware platforms for brain-inspired and neuromorphic computing, which has led to the development of novel computing concepts such as dendritic computing and folded-in-time deep neural networks and reservoir computers, heading towards more versatile and energy-efficient brain-inspired information processing and artificial intelligence..

Life and Enviroment

Living systems and their environment are perhaps the most archetypical examples of Complex Systems. Their study involves the consideration of a huge range of time and space scales, from small biomolecules to the whole Earth, and has implications in health, conservation, and global change.

At IFISC, researchers have investigated genetic circuits, virus-host interactions, or microbial population dynamics, together with the different effects of noise and the statistical properties of the resulting communities. At a larger scale, different neuroscience topics, such as the role of inhibitory neurons on information processing, coding, and learning, their effects on the computational properties of cortical layers, or the impact of brain-network organization on mental diseases. Epidemics has been the focus of a number of studies, as well the use of ideas from statistical mechanics to the optimal use of medical have been also topics of interest.

Ecological modeling, aerial and satellite observations, and machine learning methods have allowed describing and understanding vegetation distributions on landscapes and seascapes, to detect the occurrence of plagues in plants, and to infer the evolution of seagrass meadows or coral reefs, all under the effects of global change. Animal motion has been tracked and studied. Innovative network-based methodologies have been used to characterize flow structures and transport in oceans, and their influence on the dispersion of abiotic properties and materials (temperature, microplastics), and of organic and living matter (detritus, phytoplankton). Teleconnections in the atmosphere and in the climate system have been investigated and used to anticipate weather and climate patterns associated to extreme events.

Social and Socio-technical systems

We draw on our expertise in the modeling of social and socio-technical complex systems with the aim of expanding our fundamental understanding of collective effects in social systems, and of deploying digital twin technologies for realistic data-driven social simulations and its interplay with critical infrastructures. IFISC researchers have been investigating, among others: models of opinion dynamics, including non-linear interactions and aging; the relation between mobility efficiency and quality of life in cities; migration and integration of migrant communities in cities, using Big Data from ICT and online social network; understanding structure and competition processes between languages and cultural traits; or monitoring and modeling the dynamics of social networks.

When considering the interplay between society and infrastructures, methodologies to increase the stability and resilience of the power grid subject to demand fluctuations and analyzing the robustness of renewable-energy power grids has been a topic of interest. Air transportation has been analyzed focusing on the dynamics of delays from an information processing and macro-scale perspective, identifying correlation and causality relationships.

COMPUTING LAB

The Computing Services Unit manages the computational resources at IFISC. They include:

- Capabilities to perform intensive numerical calculations are provided by a High Performance Computing Cluster (HPC) integrated by 20 Atos Bull Sequana diskless nodes with AMD Epyc Rome processors with a total of 960 cores and 12TB of RAM and with low-latency 25Gb/s communications which is used for big data analysis and memory intensive simulations and a High Throughput Computing (HTC) cluster with 46 IBM iDataPlex dx360M4 nodes and a total of 552 cores and 3.1TB of RAM and GbE communications which is used for less demanding calculations.
- Big Data storage and management is handled using a MongoDB non-relational database including a primary node with 512GB of RAM and 42 TB SSD raw storage and two replica nodes with 256GB of RAM and 40TB HD raw storage each.
- A NFS server with 96TB of raw storage capacity, 192 cores and 384GB of RAM manages users' homes.
- A Data repository is available with 82TB of raw storage capacity under the same hardware the NFS server.
- Private Cloud virtualization is integrated by one management node and 6 compute nodes with a total of 180 cores, 1.7TB of RAM and 70 TB SSD raw storage.
- IFISC network is complemented with an NFS and a backup server, more than 150 linux desktops, mac and windows desktops and laptops and a number of peripherals, and it is integrated to provide a transparent environment.

PHOTONICS LAB

Since 2009 a Photonics Laboratory of highest standards has been established. The lab is equipped with a Faraday cage for electromagnetic shielding and houses several experiments of delay-coupled lasers and laser arrays, optoelectronic systems, as well as photonic information processing systems using the latest technology to characterize the optical emission with multi-Gigahertz bandwidth: in the temporal domain via fast detectors and 40 GHz analog bandwidth real-time oscilloscope, and in the spectral domain via a 44 GHz signal and spectrum analyzer. In addition, high-resolution optical characterization can be performed via heterodyne techniques and different spectrometers. Finally, optical and electrical laser modulation can be implemented with arbitrary waveforms up to 92 GigaSamples/second.

1.2 "MARIA DE MAEZTU" EXCELLENCE AWARD

In 2018, **IFISC** was awarded the "**Unidad de Excelencia María de Maeztu**" distinction, for the period 2018-2022, entering the selective **SOMMa Alliance**. This distinction was renewed for the period 2023-2026 underscoring the outstanding achievements of IFISC during the years 2018-2022. The award is granted by the Agencia Estatal de Investigación (AEI), belonging to the Ministry of Science, Innovation and Universities, after a highly selective process and a thorough evaluation according to the highest standards by an international panel.

According to the Ministry, being awarded as "Severo Ochoa" or "María de Maeztu" represents "the recognition and accreditation of the best centers and units that stand out for their international impact and the relevance of their results obtained in the last four years". Moreover, it targets "the financing of strategic research programmes with the aim of consolidating their scientific capacities and contributing to their international leadership".

All distinguished centers and units excel due to the global resonance of their scientific contributions, their commitment to postgraduate teaching, their innovation prowess, and their robust engagement with the social and economic spheres. They are categorized as world-class entities with highly competitive frontier research programs that are capable of attracting international talent.

The units that have been selected in the "Maria de Maeztu" (MdM) category, like IFISC, receive a total funding of 2,000,000 Euros during four years plus six pre-doctoral contracts as well as access to funding sources restricted to the units of excellence.

This award consolidated IFISC as a reference institute in the research field of complex systems and allowed a growth of approximately 30% in personnel with respect to 2018. **IFISC was the first institute in the Balearic Islands receiving the Maria de Maeztu award.**

The research project associated to the MdM award covers the activities of the entire institute defining a strategic plan and focusing the research effort for the period 2023 – 2026. The following scheme summarizes the research lines on which the Maria de Maeztu award focusses:

RP2. Unconventional computing & learning

Information Processing in Complex Systems: from adaptation and learning to emerging collective effects

RP1. Complex Society: Information & Technology

RP3. Life & Environment
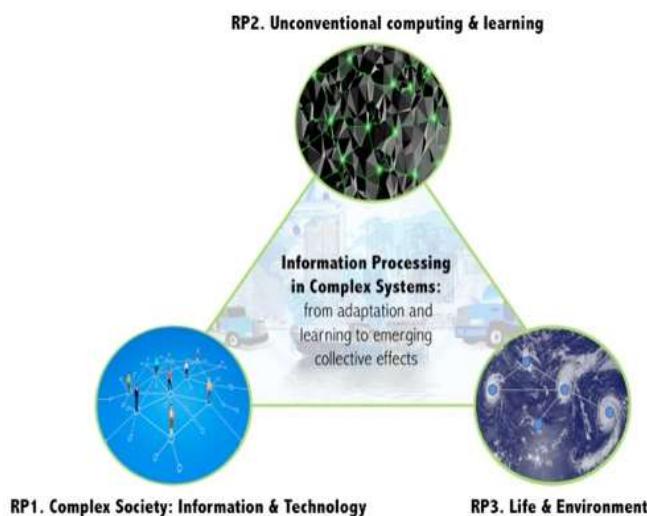
Our newly initiated MdM project endeavors to conduct strategic research in information processing within complex systems, emphasizing novel dimensions of adaptation, learning, and emergent collective effects. This initiative is structured around three intricately intertwined research pillars (illustrated in the figure above), which are designed to tackle contemporary societal challenges while aligning closely with EU priorities. These pillars encompass:

RP1. Complex society: information & technology

RP2. Unconventional computing & learning

RP3. Life & environmental dynamics

IFISC – MdM PERSONNEL

All IFISC researchers actively contribute to the MdM scientific program, underscoring the institute's commitment to fostering a collaborative environment that thrives on diversity, interactions, and scientific dialogue. Personnel who have been recruited since the program's inception on January 1st, 2023, include:

<u>Postdoctoral Researchers</u>:

Andrés A. Aguado

<u>PhD Students</u>:

Miguel Álvarez

Beatriz Arregui

Annalisa Caligiuri

Juan I. de Gregorio

Fernando Diaz

Irene Estébanez

Mar Ferri

Javier Galván

Rodrigo Martínez Peña

Jorge Medina

<u>Project Manager</u>: Simona Obreja

<u>Communication and dissemination</u>: Adrian García Candel

1.3. IFISC SERVICE UNIT: DataAnalytics@IFISC

Solutions based on Big Data for

* Social Sciences

* Ecology

* Biomedicine

Relying on the experience gained in research projects and contracts with companies, IFISC has created DataAnalytics@IFISC as a **service unit** devoted to data mining and big data analysis.

IFISC know-how includes analysis of data from social networks, mobile phone and credit card records, transport networks at the urban scale, air transport, census and surveys, electoral results in the space, electrocardiograms, electro and magneto encephalograms, marine currents and animal populations. Previous results include works on population levels, mobility, transport and tourism, land use, economic inequalities in urban areas, epidemic spreading, delay propagation in air transportation, heart arrhythmia and encephalogram series analysis using machine learning, hospital emergency demand, and marine megafauna migrations and spatial connectivity studied with satellite data.

Data Analytics@IFISC provides solutions to CSIC, UIB and external entities based on big data for computational social sciences, ecology and biomedicine, including:

- Sampling from our databases and the preparation of reports based on aggregated data.
- Development of new analysis methods ad hoc including machine learning techniques.
- Consulting on social, economic and technical questions through Big Data analytics.

*IFISC also participates together with other UIB researchers in the UIB Innovation Unit "Data Anaytics@IFISC_UIB".

- Urban mobility
- Tourism
- Sociodemographics
- Air transportation networks
- Epidemic spread
- Opinion dynamics & elections
- Language use
- Biomedics
- Population mobility in ecology

1.4 IFISC STRUCTURE CHART
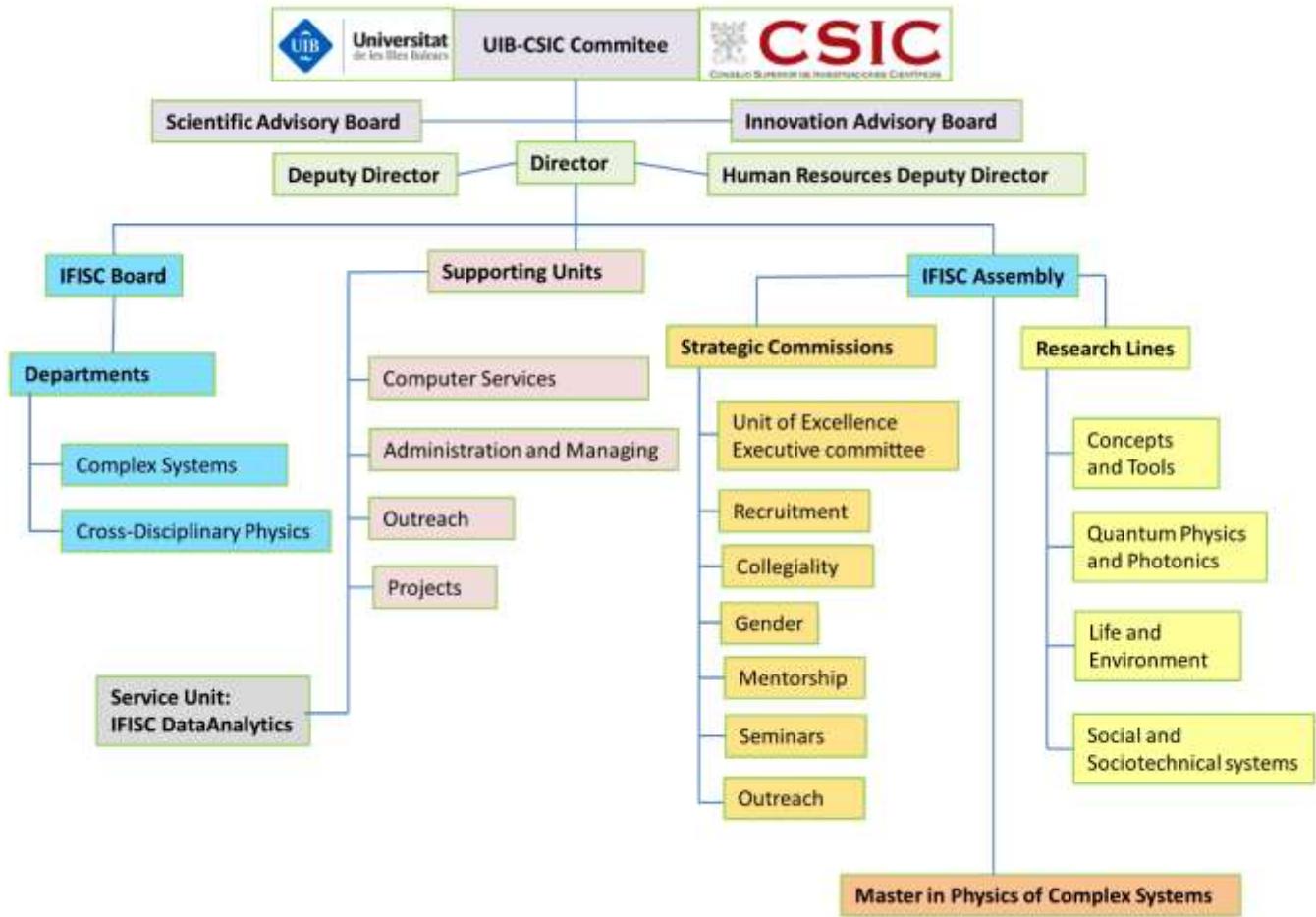
1.5 2023 REPRESENTATIVE RESEARCH RESULTS

Here are some research results published during 2023. They are representative of the different research lines and thus illustrate the range of topics studied at IFISC.

Network bypasses sustain complexity

Estrada, Ernesto; Gómez-Gardeñes, Jesús; Lacasa, Lucas
PNAS **120**, e2305001120

Real-world networks are neither regular nor random, a fact elegantly explained by mechanisms such as the Watts–Strogatz or the Barabási-Albert models, among others.These are considered nowadays as canonical mechanisms underpinning network "complexification". And yet, while both mechanisms naturally create shortcuts and hubs that indeed enhance the network's connectivity, they also might yield several undesired navigational effects, as geodesic navigational processes tend to overuse hubs and shortcuts and thus make the networks fragile. At the same time, an overuse of shortcuts and hubs naturally makes the network prone to undesired jamming of these special regions, thus making navigation to stall.

Why, then, networks with complex topologies are ubiquitous in the real-world?

In this paper we tackle this fundamental question. Starting from first principles, we develop a mathematical theory that geometrizes networks, where such geometrization is solely induced by the local topology. When our theory is applied to networks generated by the Watts–Strogatz or the Barabási-Albert models, it shows that these models not only produce shortcuts and hubs: they also produce entropically (i.e., "for free") an excess of a class of topological paths in the network that we call network bypasses: these are alternative routes to shortest paths which are topologically longer but easier to navigate. In some sense, these bypasses provide the necessary resilience to the topology that results from the Watts–Strogatz or the Barabási-Albert models: shortcuts and hubs are indeed sustained by hidden bypasses.

In a nutshell, bypasses sustain complexity.
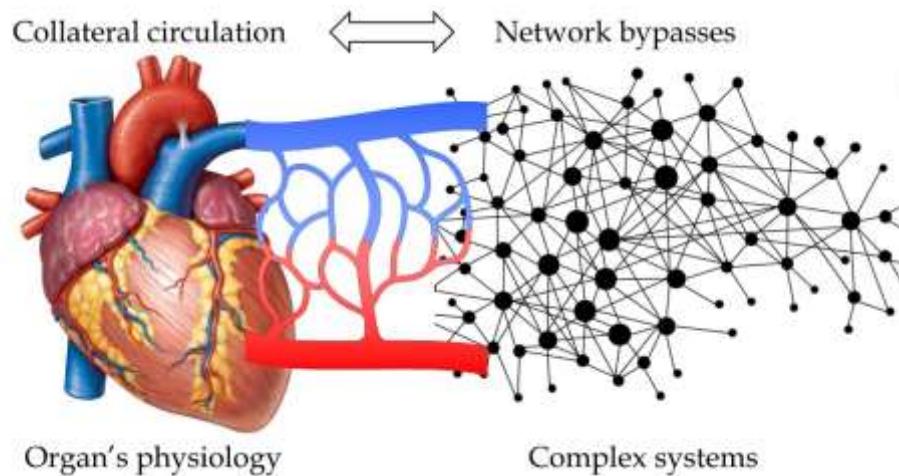
Our theory elucidates the existence of bypasses in physiological systems, such as the concept of collateral circulation in the cardiac system. Recently, evidence also suggests that information flow in the brain cannot be purely geodesic, as this would have an unaffordable energetic cost. Our theory allows us to quantify the net navigability gain induced by the amount of network bypasses present in any given network. When applied to a range of empirical networks, we indeed find that the network with the largest navigability gain induced by its hidden bypass structure is the human brain. At the bottom of the ranking we find some man-made networks such as the power grid: a very well known example of a system which is highly vulnerable to localized damages.

Overall, our results provide insight into the plasticity of complex systems, settles down the apparent paradox of how complex topologies are ubiquitous, and provide a principled recipe to measure –and thus optimize— the robustness of networked architectures.

Breakdown of Random-Matrix Universality in Persistent Lotka-Volterra Communities

Baron, Joseph W.; Jewell, Thomas Jun; Ryder, Christopher; Galla, Tobias

The eigenvalue spectrum of a random matrix often only depends on the first and second moments of its elements, but not on the specific distribution from which they are drawn. The validity of this "universality principle" is often assumed without proof in applications.

Here, we offer a pertinent counterexample in the context of the generalized Lotka-Volterra equations. Using dynamic mean-field theory, we derive the statistics of the interactions between species in an evolved ecological community. This is the community of species that survive when the Lotka-Volterra dynamics is started from a large pool of species subject to random interactions. The set of extinct species is determined by the initial interactions, and thus the statistics of the interactions between surviving species is different to those in the original pool. These interactions between surviving species turn out to be non-Gaussian, even if the initial ensemble is Gaussian.

We show that the full statistics of the interactions between survivors, beyond those of a Gaussian ensemble, are required to correctly predict the eigenvalue spectrum and therefore stability. Consequently, the universality principle fails in this system.

Our results also have relevance for the field of theoretical ecology. In the widely used approach pioneered by Robert May one supposes that the Jacobian governing small deviations of species abundances about a fixed point can be represented by a random matrix. May does not say what the dynamics are that lead to this Jacobian. One particular objection to this approach is hence that the statistics of May's random matrices do not necessarily correspond to "feasible" equilibria, that is bona fide equilibria with positive species abundances.

The fixed point of the generalised Lotka-Volterra equations is feasible by construction. Therefore, our work shows that the stability of a feasible equilibrium in a complex ecosystem can be found by studying the eigenvalues of a random interaction matrix. Feasibility is reflected in the higher-order statistics of the interactions between species. Our work shows that these intricate statistics cannot be ignored if one is to correctly predict stability.
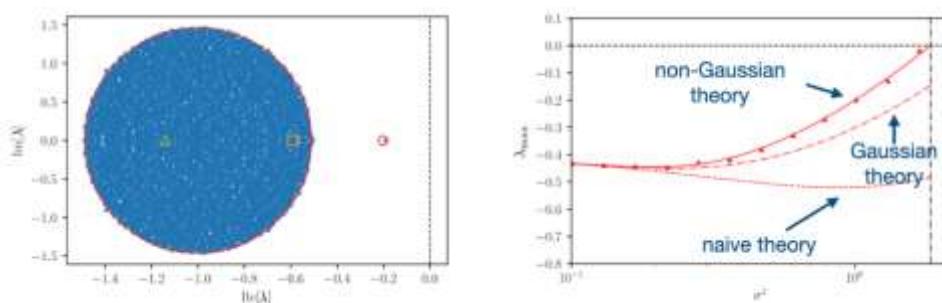
Figure 1. Left: Sample spectrum of a reduced community matrix, showing a bulk spectrum of eigenvalues and one additional outlier. **Right:** Calculation of the leading eigenvalue as a function of the variance of interactions: naïve and Gaussian theories do not agree with simulations (markers), whereas the full non-Gaussian calculation captures the leading eigenvalue correctly. The vertical dashed line shows the onset of instability determined by a complementary approach (dynamic mean-field theory).

Implementation of input correlation learning with an optoelectronic dendritic unit

Ortín, S.; Soriano, M.C.; Tetzlaff, C.; Wörgötter, F.; Fischer, I.; Mirasso, C.; Argyris, A.
Frontiers in Physics 11, 1112295

The implementation of machine learning concepts using optoelectronic and photonic components is rapidly advancing. In this work, we draw inspiration from the fields of neuromorphic computing, synaptic plasticity, and dendritic computing to demonstrate for the first time, as a proof-of-concept, a hardware-based that implements a modified Hebbian learning model, called input correlation (ICO) learning in a reconfigurable and flexible optoelectronic setting.

The Input Correlation (ICO) learning rule is a variant of the classical Hebbian learning rule, in which the strength of synaptic connections can be strengthened or weakened based on the correlation between synapses on the same dendrite. With our system, we target an ultra-fast implementation of ICO learning, with information processing and adaptation times of the nanosecond scale.

We design and build a fiber-based optoelectronic dendritic unit (ODU), which consists of multiple single-mode fiber pathways, each with a semiconductor optical amplifier, that allows the implementation of fast plasticity rules. These pathways emulate the dendritic branches of biological neurons (Figure 1). The proposed ODU naturally accommodates adaptive mechanisms required for the application of the ICO learning rule. In its full deployment, this optoelectronic ICO learning analogue can be an efficient hardware platform for ultra-fast control.
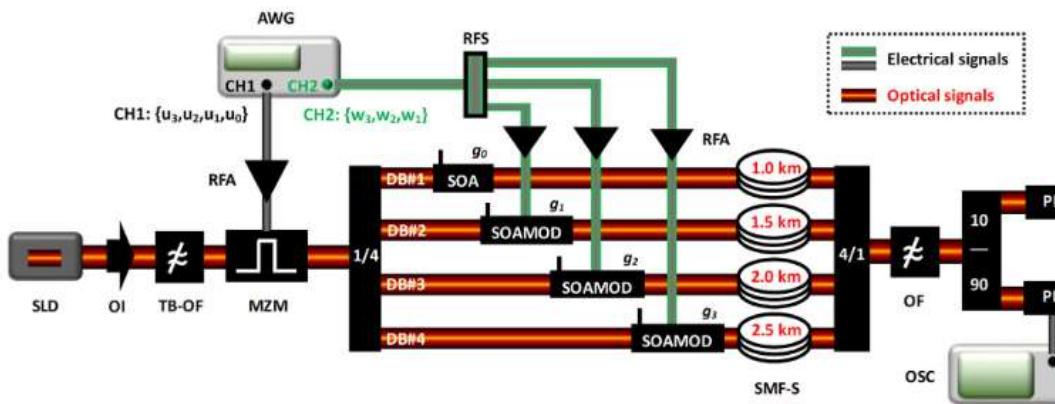
Figure 1: Optoelectronic dendritic unit (ODU) with four dendritic branches (DB), in a coincidence detection architecture. SLD: Superluminescent diode, OI: Optical isolator, TB-OF: Tunable-bandwidth optical filter, MZM: Mach-Zehnder modulator, SOA: Semiconductor optical amplifier, SOAMOD: Semiconductor optical amplifier operating as modulator, SMF-S: Single-mode fiber spool, 4/1: Four-to-one optical coupler, OF: Tunable optical filter, 10/90: Optical splitter, PM: Powermeter, PD: Photodetector, OSC: Real-time oscilloscope, AWG: Arbitrary waveform generator, RFA: RF amplifier, RFS: RF splitter.

Time-resolved Coulomb collision of single electrons

Fletcher, J.D.; Park, J. D, W.; Ryu, Sungguen; See, P.; Griffiths, J.P.; Jones, G.A.C.; Farrer, I.; Ritchie, D.A.; Sim, H.S.; Kataoka, M.
Nature Nanotechnology 18, 727-732

A recent series of experiments has revealed that the collision of ballistic electrons within semiconductors offers a means to investigate the indistinguishability of single-electron wavepackets. Surprisingly, their Coulomb interaction effect has remained elusive due to screening. Here, we demonstrate the prevalence of Coulomb-dominated collisions involving high-energy single electrons in counter-propagating ballistic edge states. This phenomenon is elucidated through the measurement of partition statistics while adjusting collision timing. While some experimental observations hint at antibunching behavior, we argue that this is not attributable to quantum statistics but rather to the significant repulsive Coulomb interactions at play. These interactions inhibit the necessary wavepacket overlap for fermionic exchange statistics but offer avenues for novel applications of Coulomb interactions. Specifically, microscopically isolated and time-resolved interactions among ballistic electrons present opportunities for leveraging Coulomb interaction in high-speed sensing or gate operations on flying electron qubits.
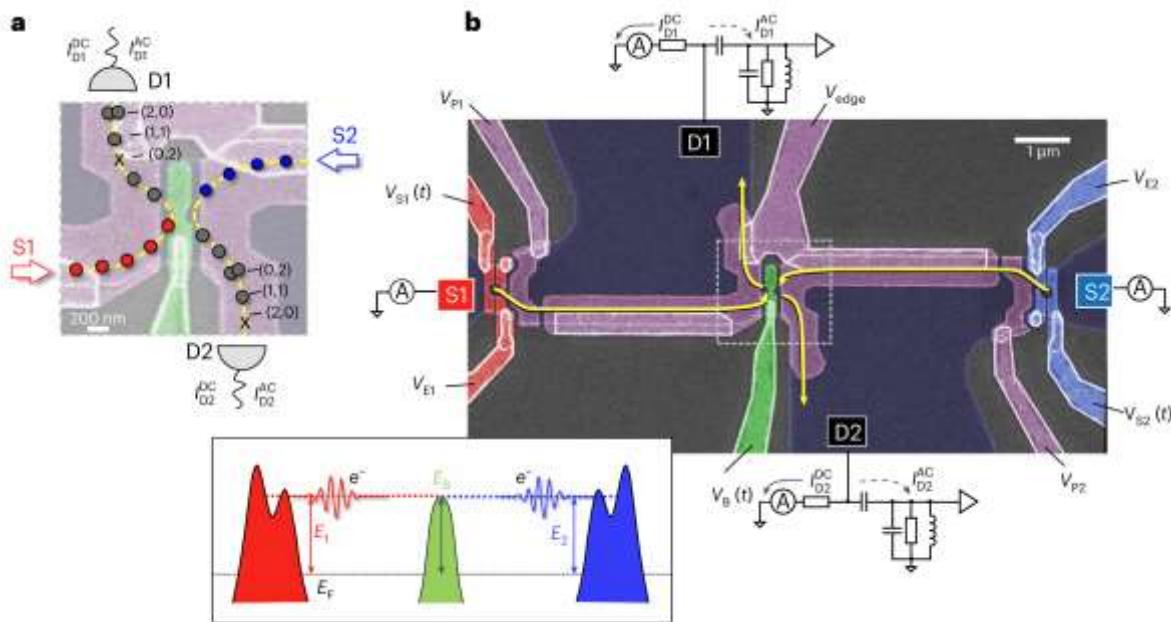
Time-series quantum reservoir computing with weak and projective measurements

Mujal, Pere; Martínez-Peña, Rodrigo; Giorgi, Gian Luca; Soriano, Miguel C.; Zambrini, Roberta
npj, Quantum Information, 9, 16

In the context of quantum machine learning, we propose the first protocol that includes the intrinsically quantum effect of measurement in the processing of temporal data sequences using quantum systems. Examples of these computational tasks are handwriting recognition or the prediction of chaotic series. One of the advantages of using *quantum* systems for these purposes lies in the large processing power provided by the Hilbert space of quantum states, an exponential advantage over classical systems. In spite of the fragility of quantum states in the presence of decoherence, we demonstrate the feasibility of online quantum machine learning in presence of the decoherence effect of multiple measurements. Our theoretical predictions, illustrated by a numerical simulation of a quantum reservoir computer for memory and forecasting tasks, focus on the performance, optimization, and efficiency of our original proposal compared to previous protocols.

Quantum reservoir computing (QRC) is a method for processing time series based on quantum complex systems. It is timely opportunity but also faces several challenges. One, also common to quantum computing, is its stochastic nature. It is necessary to repeat the processing of the information several times to estimate the observable quantities computed as expectation values with low statistical uncertainty. Furthermore, quantum systems are crucially affected by measurements, unavoidable to extract the processed information. After the realization of a measurement on a quantum system, its state will be perturbed and updated according to the resulting outcome. In an implementation of quantum reservoir computing this back-action effect is especially relevant, as it can impair the memory and the quality of the processing at different times. Typically, measurement back-action was neglected in most proposals and this would correspond to restart the experiment, reintroducing the data sequence from the beginning, which is clearly inefficient. In addition, following this restarting protocol, it would be necessary to store the data in an external memory buffer. A remarkable improvement in terms of resources is achieved in the context of QRC by considering one of the dynamical features of a proper reservoir, specifically, the fading memory concerning past dynamics. In the rewinding protocol, only the recent input history is necessary to be reinserted. Besides the restarting and rewinding approaches, designed to avoid the measurement back-action, we propose a sequential approach based on weak measurements, instead of standard projective measurements, that allows continuous online monitoring of the data without external storing (as shown in the picture), allowing to operate in real time.
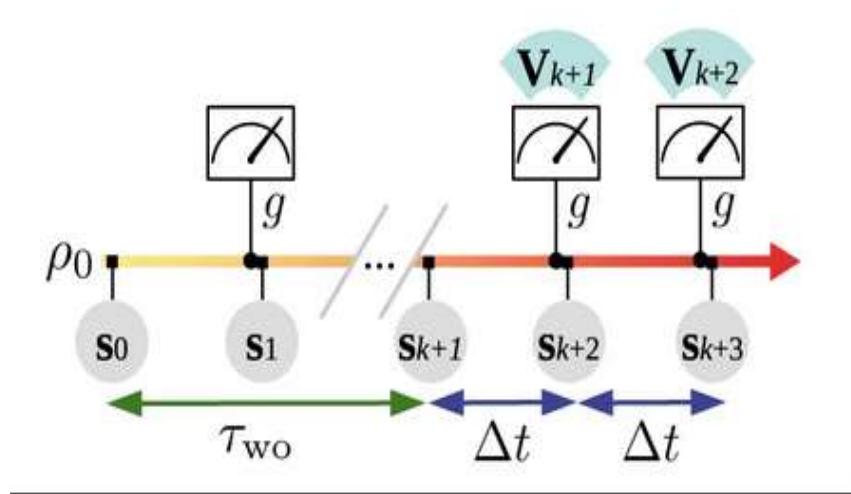
This online protocol, reported in the journal npj Quantum Information, introduces the effect of the measurement on data processing. Typically, weak measurements provide less information and are noisier, but in this way of obtaining processing results the quantum system is not repeatedly projected, making it possible to identify situations in which effective data processing is achieved in *both accuracy and resources* by tuning the measurement strength. This study establishes the advantage of quantum reservoirs in realistic scenarios and is expected to pave the way for efficient experimental implementations involving continuous time series processing with quantum systems. In addition, this research may also contribute to the development of concrete applications such as quantum time tomography, quantum recurrent neural networks or quantum neuromorphic computing, among other advances.

A Lagrangian model for drifting ecosystems reveals heterogeneity-driven enhancement of marine plankton blooms

Ser-Giacomi, Enrico; Martinez-Garcia, Ricardo; Dutkiewicz, Stephanie; Follows, Michael J.
Nature Communications 14, 6092

Phytoplankton provide important ecosystem services at the global scale, fueling higher trophic levels and fisheries, and mediating large ocean carbon reservoirs. It is recognized that Lagrangian perspectives – that is following the water patch within which plankton live – help disentangle the effect of fluid transport and biological activity, to provide mechanistic understanding of plankton dynamics and productivity. At the same time, phytoplankton blooms exhibit spatial structure and "patchiness" over a vast range of scales. It is important to understand the effects of patchiness even within the Lagrangian frame. Despite the recognized relevance of both Lagrangian frameworks and patchiness, to date no studies have considered them in combination.

Here we develop a general theoretical framework that connects biochemical dynamics, tracer heterogeneity, and the dilution of a moving patch of water containing a plankton ecosystem. Our approach reveals that the dilution rate of the patch with surrounding waters and the spatial heterogeneity of the tracers within it are mediated by the strain and diffusion of the oceanic flow.

Importantly and somewhat counterintuitively, our study shows that dilution-driven tracer patchiness, and in particular the covariance between resource and consumer, can enhance the integrated biomass within the patch by several fold. This surprising result suggests that *identical resource injections can lead to very different bloom signatures depending on the local physical forcing*. The consequences of this mechanism for nutrient fertilization events are significant as we illustrate explicitly in a simulation of an artificially-stimulated phytoplankton bloom (the SOIREE experiment). This finding has important implications for the interpretation of remotely sensed phytoplankton blooms and the representation of unresolved patchiness in models of ocean ecology and biogeochemistry.

The new framework that we present here is widely applicable to any physical and biochemical process happening in a water patch in the ocean and it could be of broad interest, with connections to marine ecology and biogeochemistry, as well as the climate-carbon cycle modeling community.
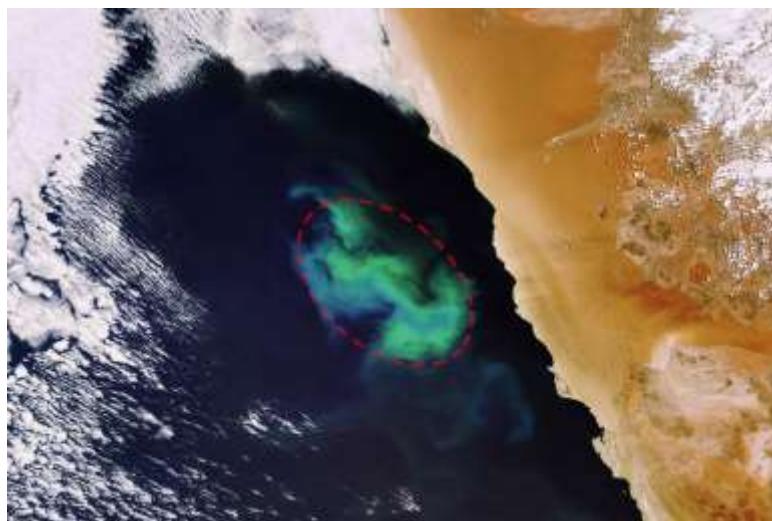

Figure: The picture was taken by the MERIS (Medium Resolution Imaging Spectrometer) instrument aboard ESA's Envisat satellite on 6/11/2007. The red dashed elliptical line indicates the water patch where a bloom is occurring. Coupled biophysical processes lead to a marked spatial heterogeneity - i.e patchiness - within the region.

Self-organized sulfide-driven traveling pulses shape seagrass meadows

Seagrass meadows, such as those formed by the endemic plant of the Mediterranean *Posidonia oceanica*, are an important source of ecosystem services and act as carbon sinks in coastal regions around the world. However, these seagrass meadows are known to be under threat due to multiple anthropogenic pressures, leading to increased seagrass mortality. In general, when reproduction and mortality rates are close to equilibrium, scale-dependent feedbacks govern the spatio-temporal evolution of seagrass meadows. These interactions between plants can generate regular patterns in the spatial distribution of vegetation, which hold diagnostic value to assess the health of the meadows.

In this work, we discovered that high mortality conditions lead to the formation of traveling pulses of vegetation, strips of Posidonia, approximately 1.5 m wide that advance without changing shape at a speed of a few centimeters per year, and that generate complex spatio-temporal patterns in the form of rings, spirals or arcs (Fig. 1). These structures arise due to high plant mortality caused by the absorption by the roots of sulfides resulting from the decomposition of organic matter by bacteria in the absence of oxygen. The identified spatiotemporal patterns resemble those formed in other excitable media, such as cardiac tissue or the Belousov-Zhabotinsky reaction, but on a much larger scale.

We developed a mathematical model that reproduces the observed seascapes and predicts the annihilation of these circular structures when they collide with each other, a hallmark of excitable pulses. We have also shown that field images and radial profiles of vegetation, as well as the concentration of sulfide in the sediment, are consistent with the predictions of the model (Fig. 1K). The simulations reproduce remarkably well the evolution of the rings from 1973 to the present, including the self-destruction of two vegetation strips upon collision.

The results of the study have diagnostic value and allow the identification of these ring-shaped structures as terminal states of the meadows before their collapse. New monitoring technologies based on artificial intelligence can automatically detect these ring structures in aerial or satellite images and thus warn of the risk of collapse of key ecosystems in coastal areas.
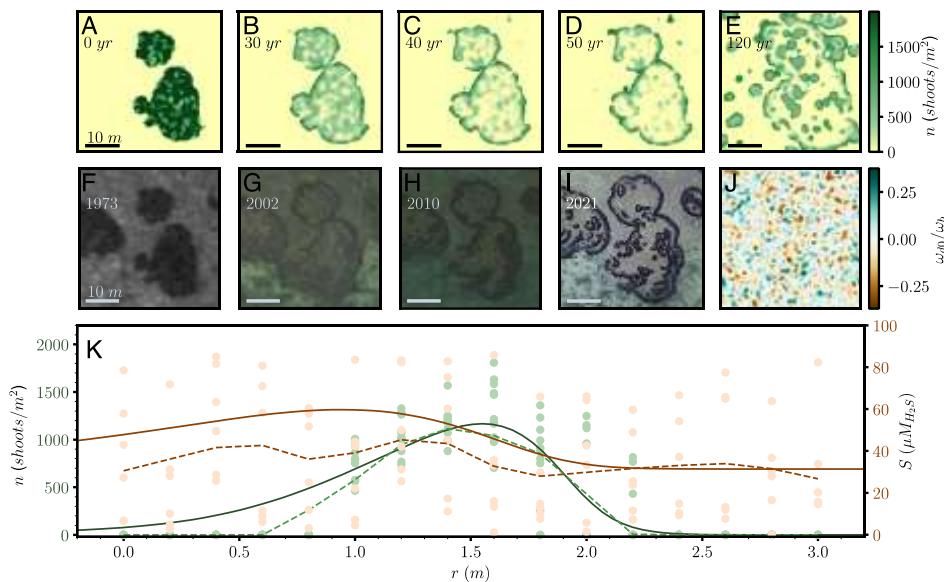
Figure 1: Excitable rings of *Posidonia oceanica*. Panels (A–E) show numerical simulations with spatial heterogeneity shown in (J) starting from an initial condition resembling the initial distribution of vegetation from the 1973 orthophoto in panel (F). Panels (F-I) show the actual evolution of the vegetation over the years and the annihilation of two pulses after colliding. Panel (K) shows the comparison between experimental data (dashed lines) and the theoretical radial profile of a ring (solid lines).

Effect of global warming on Western Mediterranean seagrasses: a preliminary agent-based modelling approach

Llabrés, Eva; Blanco-Magadán, Aina; Sales, Marta; Sintes, Tomás
Marine Ecology Progress Series **710**, 43-56

The Mediterranean Sea is warming more rapidly than the global average, leading to dire consequences for its inhabiting organisms. Seagrasses are key structural elements in coastal ecosystems and studying how temperature affects these species is crucial to anticipate the implications of global warming.

In this work, we implement a numerical growth model based on microscopic clonal growth rules to study the combined dynamics of Posidonia oceanica and Cymodocea nodosa and their resilience to sea warming. The model is parametrised using seagrass growth rates measured in the Western Mediterranean Sea. Under favourable growth conditions, our simulations predict the emergence of a coexistence region at the front between monospecific meadows. This region can be characterised by its width and local shoot densities, which are found to depend on the coupling parameter between P. oceanica and C. nodosa species. Such regions have been empirically observed and measured in Ses Olles de Son Saura (Menorca, Balearic Islands). A comparison between the field measurements at the study site with the model predictions was used to fit the value of the coupling parameter. Field data also relate the width of the coexistence region to the average length of P. oceanica leaves at the front.

In the presence of sea warming, the model predicts an exponential decay in the population of P. oceanica, which is highly sensitive to the temperature. This behaviour is a direct consequence of the clonal nature of the plant and can be characterised by the model parameters. Considering a scenario of high greenhouse gas emissions RCP8.5 - taken from the IPCC 5thAR- ($8.5 W/m^2$ of radiative forcing by the year 2100, corresponding to an average temperature increase of $3.5^{\circ}C$), our model forecasts that P. oceanica meadows will experience a 70% population decline by the year 2050 and its functional extintion by 2100. On the contrary, C. nodosa, with higher thermal resilience, acts as an opportunistic species and will colonise the space left by the degraded P. oceanica.
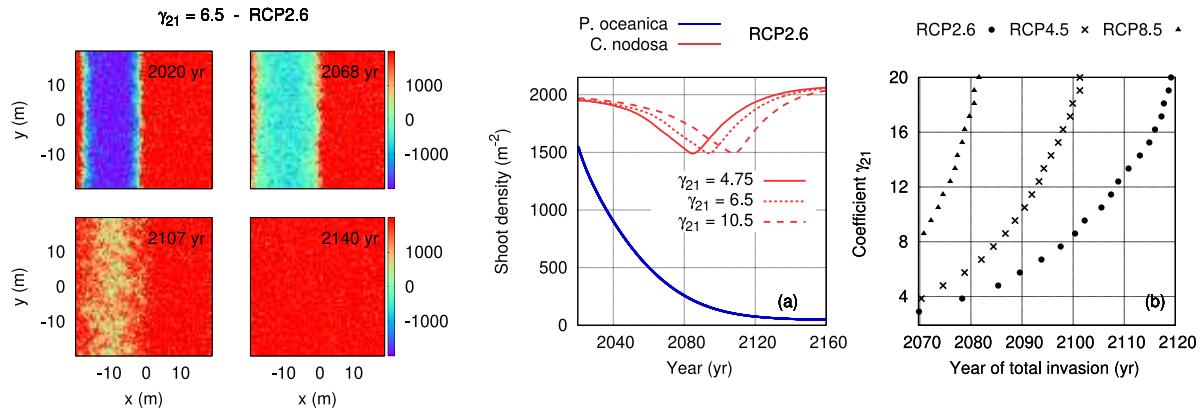
Figure: (left) Domain separation between P. oceanica (blue) and C. nodosa (red) patches considering the greenhouse gas emissions scenario RCP2.6 and a coupling parameter between species g$_{21}$=6.5. (center) Shoot densities as a function of time. The exponential decay of P. oceanica is compared to the C. nodosa behavior. Remarkably, the time required by C. nodosa to colonise the P. oceanica meadow correponds to the position of the minimum in the C. nodosa shoot density. (right) Year of the total invasion of C. nodosa as a function of the coupling parameter g$_{21}$ under different scenarios of greenhouse gas emissions.

A compartmental model for Xylella fastidiosa diseases with explicit vector seasonal dynamics

Giménez-Romero, A.; Moralejo, E.; Matías, Manuel A.
Phytopathology **113**, 1686-1696

This study aims to confront empirical data of the progression of the diseases caused by the vector transmitted bacterium *Xylella fastidiosa* (Xf) on characteristic plants that make part of the Mediterranean landscape. In particular, different strains of Xf have caused the death of elimination of 21 Million olive-trees in the Salento Peninsula (Apulia, Italy), and of an estimated 80% of almond-trees in Mallorca island. The mathematical model is based on a generic compartmental model for vector-borne diseases, including vector seasonal dynamics to mimic the dynamical evolution of the main European vector of Xf: *Philaenus spumarius*. This vector is an univoltine insect (presenting one generation per year), with nimphs hatching in late Winter or Spring, and then dying with a certain decay rate, with the model being able to match this decay.

Using a Bayesian inference framework, we show how the model successfully reproduces the field data in both diseases. The Bayesian inference determination of the parameters leaves an uncertainty regarding the infectivity parameters, because the only data available to monitor the progression of the disease correspond to infected hosts, and no information about the vector populations that produced these infections are available, and this leads to a family of parameters compatible with the available data.

In a global sensitivity analysis, the vector-to-plant and plant-to-vector transmission rates, together with the vector removal rate, were the most influential parameters in determining the time of the infectious host population peak, the incidence peak, and the final number of dead hosts. We also used our model to check different vector-based control strategies, showing that a joint strategy focused on increasing the rate of vector removal while lowering the number of annual newborn vectors is optimal for disease control.

Using these parameters we estimate that the recently reported Apulian strain in Mallorca was introduced in 2016-2018 or earlier using the fitted temporal parameters of the model.
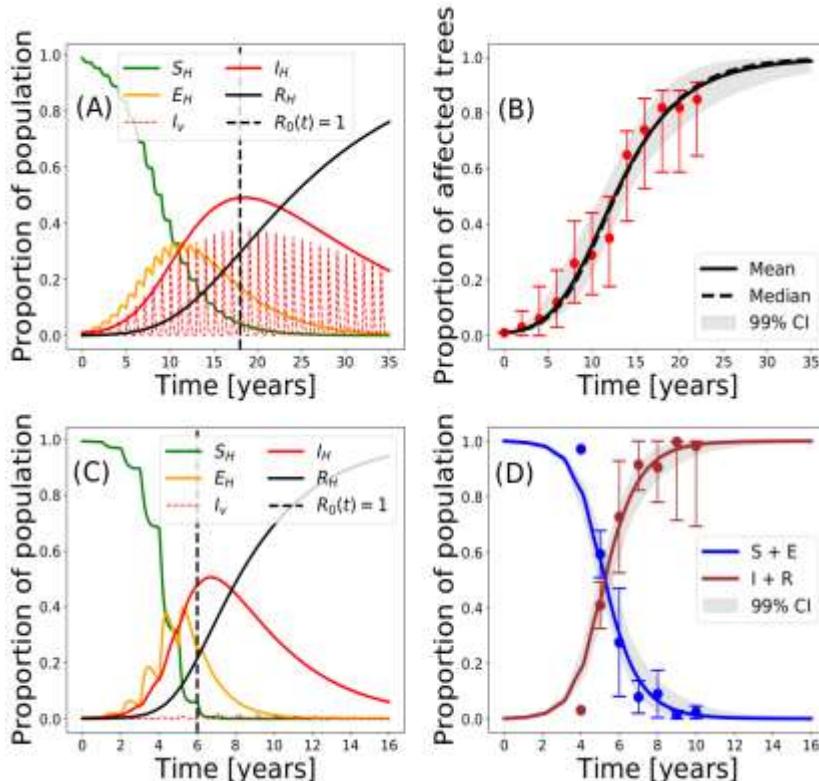
Fig. 1 A and B: temporal evolution and fit to data for best fit parameters for the olive-tree epidemic in Apulia. C and D: temporal evolution and fit to data for best fit parameters for the almond-tree epidemic in Mallorca.

Spatial immunization to abate disease spreading in transportation hubs

Proximity social interactions are crucial for infectious diseases transmission. Crowded agglomerations pose serious risk of triggering superspreading events. Locations such as transportation hubs (airports and stations) are designed to optimize logistic efficiency, not to reduce crowding, and are characterized by a constant in and out flow of people.

In this work, we analyze the paradigmatic example of London Heathrow, one of the busiest European airports.

Thanks to a dataset of anonymized individuals' trajectories, we can study the typical mobility of people in the airport and use it for modeling the spread of infectious diseases should one infectious person arrive. With the model, we can localize the contagion hotspots, where most of the new contagions appear (see Figure), and we can also propose a spatial immunization policy targeting them to reduce disease spreading risk. We also detect the most vulnerable destinations to contagions produced at the airport and quantify the benefits of the spatial immunization technique to prevent regional and global disease diffusion.

This method is immediately generalizable to train, metro and bus stations and to other facilities such as commercial or convention centers.
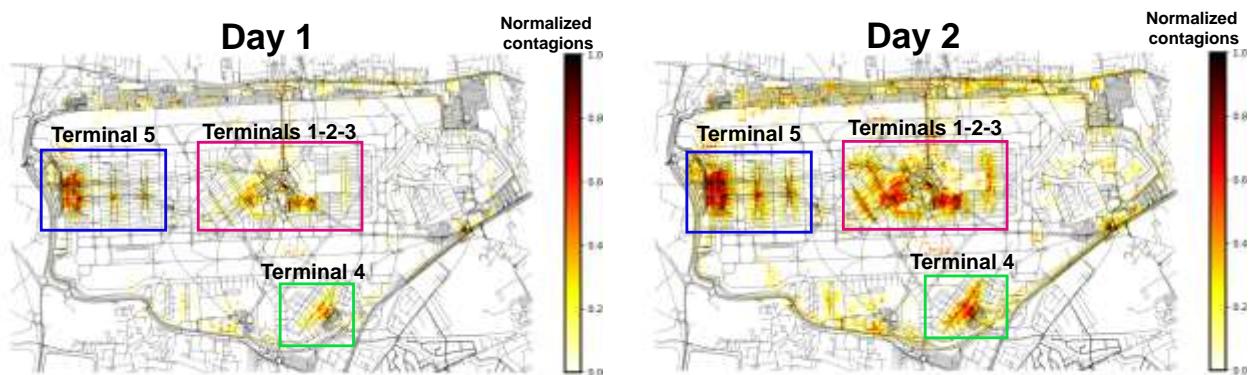
Figure.- Risk of contagion in space. Cells in the airport area with a heatmap showing the fraction of contagions occurring in them when running the SIR model. On the left, after one day of simulation and on the right after two days.

Modeling language ideologies for the dynamics of languages in contact

Pablo Rosillo-Rodes, Pablo; San Miguel, Maxi; Sánchez, David
Chaos **33**, 113117

Languages come in different forms or varieties. The way people speak a language depends on various factors like how highly it is regarded in society. Additionally, individual speakers often have their own preferences for specific language varieties, which can balance out the influence of societal views. To understand the evolution of language varieties we develop a dynamic model that considers both personal preferences and societal opinions. We show that when communities with opposing language preferences are more interconnected, it becomes challenging for different varieties to coexist. These findings could have important implications for public language policies.

We first consider shift phenomena between two varieties of the same language (e.g., standard and vernacular) in a fully connected population, as illustrated in Fig. 1a). We find that although the standard variety is always more prestigious than the vernacular variety, the speakers' preference quite generally determines the dynamics of the system, allowing for variety coexistence in situations in which prestige alone would lead the system towards the extinction of the vernacular variety, as seen in Figs. 2a) and 2b). We quantify the speakers' preference using parameter $0 \leq \alpha \leq 1$, which accounts for the proportion of speakers with preference for the standard variety.
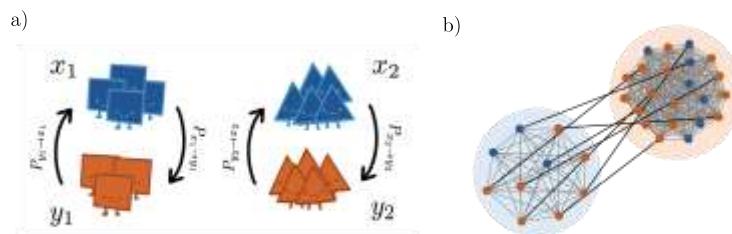
Figure 1: a) Illustration of the model, with 4 population groups indicating their spoken variety (x, y) and their preference (1 for x and 2 for y). b) Partial interconnection between two fully connected communities, each of them with a fixed preference denoted by its background color.

Secondly, we take into account a varying degree of interconnectivity or coupling, $0 \leq \gamma \leq 1$, between the two speech communities with different preferences as we show in Fig. 1b). We find that increasing coupling reduces the domain of parameters in which there is language coexistence. We also show that by increasing the coupling parameter we identify transitions between phases (Fig. 2c).
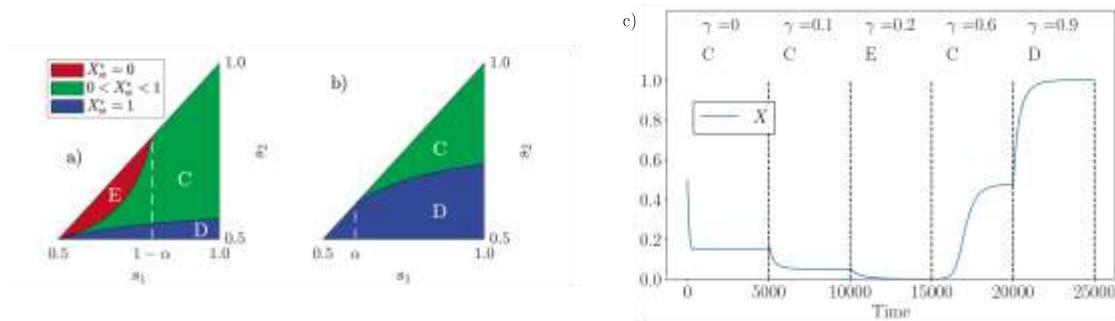
Figure 2: Phase diagrams of X, the proportion of standard-variety speakers, for the model with $\gamma = 1$ a) $\alpha < 0.5$ and b) $\alpha > 0.5$. Prestige parameters s_i account for the status of the standard variety for standard-variety preferers (s_1) and for the status of the vernacular variety for the vernacular-variety preferers (s_2). We show how the area of the coexistence (C) phase depends on α. c) By increasing γ, we can see three global phases of coexistence (C), standard variety dominance (D), or vernacular variety dominance, i.e., standard variety extinction (E).

Dynamical Model for Power Grid Frequency Fluctuations: Application to Islands with High Penetration of Wind Generation

Martínez Barbeito, Maria; Gomila, Damià; Colet, Pere
IEEE Transactions on Sustainable Energy, 14, 1436-1445

Stable power grid operation is based on the continuous balance between generation and demand. A good indicator of this balance at any time is the frequency of the grid. Traditionally, due to the lack of large-scale storage capacity, generation is adapted to demand in real time to meet consumer needs. This is done by using controllable energy sources, such as fossil fuels. However, with the increasing integration of Variable Renewable Energy Sources (VRES), such as sun or wind, achieving the generation-demand balance becomes more challenging.

One of the difficulties in increasing the share of VRES generation is that these are unpredictable, intermittent, and uncontrollable sources. Since production depends on environmental factors, it is not instantly available whenever it is needed. Knowing how the grid, and in particular its frequency, will respond to an increasing VRES generation is key for the energy transition.

In this work, we propose a general model that emulates how the high-voltage power grid behaves when a large amount of variable renewable generation is introduced into it. The grid is treated as a network in which each node corresponds to a power plant or substation. The power plants are assumed to have conventional power generation including control capacity, whereas substations aggregate the consumption of an area.

As a case study, we analyze the grid of the Spanish island of Gran Canaria. After validating the model to accurately reproduce the statistics of the real grid frequency nowadays (Fig. a,b,c), we analyze different scenarios characterized by increasing wind capacity. We observe that frequency fluctuations in those scenarios would be well above the established limits. These limits, regulated by law, exist to ensure the integrity of the infrastructure, which could be damaged if the frequency variations exceed a certain value. In such a case, the supply and generation of some parts of the grid would have to be shut down to avoid further damage.

Finally, we show that increasing the secondary control of conventional plants is an effective measure to reduce frequency variations to an acceptable range. We estimate these additional control needs for both summer and winter (Fig. d). Moreover, since this is a twin-model of the actual grid, it also allows for checking the state of transmission lines (Fig. e), among other quantities.

(a) Evolution of the demand and wind generation in Gran Canaria from 12:00 07-02-2018 to 12:00 08-02-2018. (b) Frequency fluctuations given by the model compared to the measured data. (c) Rolling average of frequency deviations using a 30-minute window.

(d) Secondary control needed to decrease frequency fluctuations to the reference case.

(e) 1-hour maximum line stress in an scenario with 8 times the reference wind capacity. Thicker links indicate overloaded transmission lines.

2

PERSONNEL

2 PERSONNEL

2.1 PERMANENT SCIENTIFIC STAFF

APOSTOLOS ARGYRIS	Associate Professor UIB
PERE COLET	CSIC Research Professor
MIGUEL C. SORIANO	CSIC Tenured Scientist (since December 21st)
ERNESTO ESTRADA	CSIC Research Professor
JUAN FERNÁNDEZ GRACIA	CSIC Tenured Scientist (since December 13th)
INGO FISCHER	CSIC Research Professor
TOBIAS GALLA	CSIC Senior Researcher
DAMIÀ GOMILA	CSIC Tenured Scientist
EMILIO HERNANDEZ-GARCÍA	CSIC Research Professor, IFISC Director
LUCAS LACASA	CSIC Senior Researcher
CRISTOBAL LÓPEZ	University Full Professor UIB
ROSA LÓPEZ	University Full Professor UIB
VÍCTOR M. EGUÍLUZ	CSIC Senior Researcher (until June 30th)
MANUEL MATÍAS	CSIC Senior Researcher
SANDRO MELONI	CSIC Tenured Scientist
CLAUDIO MIRASSO	University Full Professor UIB, IFISC Deputy Director
MAXI SAN MIGUEL	University Full Professor UIB, Emeritus
JOSE J. RAMASCO	CSIC Research Professor
DAVID SÁNCHEZ	University Full Professor UIB
LLORENÇ SERRA	University Full Professor UIB, IFISC Academic Secretary
TOMÀS SINTES	University Full Professor UIB
RAÚL TORAL	University Full Professor UIB, HR Deputy Director
ROBERTA ZAMBRINI	CSIC Senior Researcher

Contribution of the permanent staff to the IFISC research lines:

Every senior researcher participates in the transversal line on Concepts and Tools. In addition, typically a senior researcher participates in one or two other focused lines. This collaborative organization provides coherence and integration as well as interaction and bridges. It is an alternative to static schemes with disjoint groups of researchers devoted exclusively to one line of research. The following table summarizes the participation of the senior researchers in the different lines during 2023.

	Concepts and Tools	Photonics and Quantum Systems	Life and Environment	Social and socio-technical systems
Apostolos Argyris	✓	✓		
Pere Colet	✓			✓
Miguel C. Soriano	✓	✓		
Ernesto Estrada	✓		✓	✓
Ingo Fischer	✓	✓	✓	
Juan Fernández-Gracia	✓		✓	✓
Tobias Galla	✓		✓	✓
Damià Gomila	✓		✓	✓
Emilio Hernández-García	✓		✓	
Lucas Lacasa	✓		✓	✓
Cristóbal López	✓		✓	
Rosa López	✓	✓		
Manuel Matías	✓		✓	
Sandro Meloni	✓			✓
Claudio Mirasso	✓	✓	✓	
Víctor M. Eguíluz	✓		✓	✓
José Ramasco	✓		✓	✓
David Sánchez	✓			✓
Maxi San Miguel	✓			✓
Llorenç Serra	✓	✓		
Tomás Sintes	✓		✓	
Raúl Toral	✓			✓
Roberta Zambrini	✓	✓		

2.2 TENURE TRACK AND SENIOR RESEARCH FELLOWS

GIAN LUCA GIORGI	*Beatriz Galindo* contract
GONZALO MANZANO	*Ramon y Cajal* contract
ENRICO SER GIACOMI	*Beatriz Galindo* contract
MASSIMILIANO ZANIN	ERC Starting Grant
CARLOS J. MELIAN	*Maria Zambrano* fellow
MICHAEL MOSKALETS	*CSIC-Ukraine collaboration* contract

2.3 SCIENTIFIC ASSOCIATES

JUAN CARLOS GONZÁLEZ-AVELLA
STEFANO LONGHI
HORACIO WIO
KONSTANTIN KLEMM

2.4 POSTDOCTORAL RESEARCH ASSOCIATES

ANDRES A. AGUADO	*Maria de Maeztu*
LLUIS AROLA	Project DYNDEEP
CHRISTOS CHARALAMBOUS	Balearic Government
SARA CLOUX	Project LAMARCA
JUAN FERNANDEZ GRACIA	Balearic Government
ELIANA FIORELLI	Projects QUARESC and Marie Curie fellow CoQHoNet
EVA LLABRÉS	Balearic Government, *Vicenç Mut* fellow
FELIPE E. OLIVARES	Project ARTIC
SILVIA ORTIN	Project ADOPD, assistant professor since Sept.
LUCIA S. RAMIREZ	*Juan de la Cierva*
JORGE P. RODRIGUEZ	Project AIAM
SUNGGUEN RYU	*Vicenç Mut* Programme, assistant professor since Sept.
MATTEO SCANDI	Associated to the *Ramon y Cajal* programme
FATIMA VELASQUEZ-ROJAS	Project FACE until June
MIHIR S. UMARANI	Project LOCAL CORAL SPECIES

2 PERSONNEL

2.5 PHD STUDENTS

DAVID ABELLA	Balearic Government Project APASOS
JAVIER AGUILAR	Balearic Government and Project APASOS
HIRA ALI	*SOIB Research and Innovation*
JOSE A. ALMANZA	*SOIB Research and Innovation*
ALEJANDRO ALMODOVAR	UIB contract
MIGUEL ALVAREZ	FPI *Maria de Maeztu*
BEATRIZ ARREGUI	FPI *Maria de Maeztu*
NASSIMA BENCHTABER	FPI Project TQM@NANO
HELENA BORDINI	Univ. Federal de Alagoas, Brasil
GORKA BUENVARON	*The Red Sea Functional Biodiversity* contract
CARLSON BÜTH	Project ARCTIC
ALBERT CABOT	FPI fellow Balearic Government
ANNALISA CALIGIURI	FPI *Maria de Maeztu*
VIOLETA CALLEJA	Project APASOS
MARCO CATTANEO	Univ. Helsinki, Findland
DIMITRIOS CHALKIADAKIS	*SOIB Research and Innovation*
PARIDE CRISAFULLI	Fundacio La Caixa Project INPHINIT
MAR CUEVAS	FPI fellow, MISLAND Project
JUAN I. DE GREGORIO	*Maria de Maeztu*
REBECA DE LA FUENTE	FPI Project LAOP
FERNANDO DIAZ	FPI *Maria de Maeztu*
DANIELE DI MICELI	Project MAGMA
GIOVANNI DONATI	Univ. Trento
NOEMIE EHSTAND	Project DYMOBIE
CRISTIAN ESTARELLAS	Project DECAPH
IRENE ESTÉBANEZ	FPI *Maria de Maeztu*
PAU ESTEVE	Project ARCTIC
MAR FERRI	*Maria de Maeztu*
JAVIER GALVAN	FPI *Maria de Maeztu*
JORGE GARCÍA BENI	FPI Balearic Government
ALEX GIMENEZ	Project SEDIMENT
MIRKO GOLDMANN	*Marie Curie* Network Postdigital
GIOVANNI GUARNIERI	Brazilian Government
ADRIA LABAY	Associated to the *Beatriz Galindo* Program
JAUME LLABRÉS	UIB contract
GUILLEM LLODRA	Project Quantum Complex Systems
ERJIAN LIU	Beijing Jiaotong University, China
THOMAS LOUF	Project CAFECONMIEL
JORGE MAMPEL	Project European Citizen

MAGDALENA F. MARCINIAK   Lodz University of Technology, Poland
MARIA MARTINEZ BARBEITO   Project VPP4ISLANDS
RODRIGO MARTÍNEZ PEÑA   FPI *Maria de Maeztu*
GRAÇA R. M. DE ALMEIDA   Univ. Federal de Alagoas, Brasil
JORGE MEDINA   FPI *Maria de Maeztu*
MANUEL MIRANDA   FPI Project OLGRA
JESUS A. MORENO   FPI Project PACCS
PABLO MORENO   FPI Project SUMAECO
SARA OLIVER   Project APASOS
LUISINA PASTORINO   Project ARCTIC
KATIELE V. PEREIRA BRITO   Univ. Federal de Alagoas, Brasil
PABLO ROSILLO   *SOIB Research and Innovation* contract
JAIME SANCHEZ CLAROS   FPI Balearic Government, Project UpMemo
ANTONIO SANNIA   Project QUARESC
MORITZ PFLÜGER   Project ADOPD
LUCAS R. TALANDIER   *Marie Curie* Network Postdigital
FANG ZHAO   Beijing Jiaotong University, China

2.6 TECHNICAL AND ADMINISTRATIVE SUPPORT

ROBERTO J. ALCARAZ   Computing Lab Data Engineer Project FACE
MIQUEL ARTIGUES   Computing Lab Data Engineer Project FACE
DHAFER FERCHICHI   Technician Project Sediment
ADRIAN GARCÍA   Communication and Dissemination
NEUS LACOMBA   UIB Proximity Technician
JOSEP MATEU   Administration Unit Head, IFISC Manager (until May)
SIMONA OBREJA   Project Manager
MARTA OZONAS   IFISC Administration
ALBERTO J. SANCHEZ   Accounting Administration
ANDREU SIMONET   Computer Internship contract
AKSHAY TIWARI   *SOIB Research and Innovation* contract
RUBEN TOLOSA   Computing Lab Technician
ANTONIA TUGORES   Data Engineer
FATIMA VELASQUEZ-ROJAS   Management Support since July

2.7 VISITORS

LONG-TERM VISITORS
(more than one month)

FIONA PICHON	IMF, Barcelona, Spain (January)
ISABEL M. CEREZO	Univ. Malaga, Spain (January-February)
OSVALDO A. ROSSO	Univ. Federal Alagoas, Brasil (Feb.-April)
ANA RUIZ VARONA	Univ. San Jorge, Zaragoza (March-April)
FEDERICO BELLISARDI	Univ. Bologna, Italy (March-June)
BENJAMÍN CARRERAS	University of Alaska, USA (March – April)
ENRIQUE CANO SUÑEN	Univ. Zaragoza, Spain (March- April)
FRANCESCA CALLEGARI	Univ. Genova, Italy (March-July)
GUILLAUME POURCEL	Univ. of Groningen, Netherlands (May-June)
FEDERICO VAZQUEZ	CONICET, Argentina (June-July)
ANA MARTINS SEQUEIRA	Australian National University (June)
TIGERS JONUZI	Univ. Politecnica Valencia, Spain (July)
LUIS GORDILLO	Utah State University. USA (Sept.-Oct.)
ALIREZA VALIZADEH	IASBS, Iran (Sept.-Oct.)
MURIELLE V. TCHAKUI	University of Yaounde, Cameroon (Sept.-Nov.)
STEPHANO CAMPAGNOLA	Univ. Padova, Italy (Oct.-Dec.)

SHORT-TERM VISITORS
(Less than one month)

RAINER HEGSELMANN	University of Bayreuth, Germany (January)
KUN WOO KIM	Univ. Chung-Ang, South Korea (Jan.-Feb.)
CELIA ANTENEODO	PUC-Rio, Brasil (Feburary)
MASSIMILIANO LUCA	Univ. Bolzano, Italy (Feburary)
JOHANNES NOKKALA	Univ. Turku, Finland (Feburary)
RAMON FERRER CANCHO	UPC, Barcelona, Spain (March)
DAVID WOLPERT	Arizona State University, USA (June)
CLAUDIO GALLICCHIO	Univ. Pisa, Italy (June)
STEPHANIE DUTKIEWICZ	MIT, Boston, USA (June)
DANIELE IUDICONE	Stazione Zoologica, Napoli, Italy (June)
EDGAR KNOBLOCH	University of California at Berkeley, USA (June)
CHRISTOPHER KITCHING	Univ. Manchester, UK (October)
ANTOINE VENDEVILLE	Univ. College London, UK (November)
EDUARDO ALTMANN	Univ. Sidney, Australia (November)
MARKUS MÜLLER	Univ. Autónoma Morelos, México (November)

2.8 MASTER AND COLLABORATION STUDENTS

In addition to the IFISC personnel, master and collaboration students have been also involved in IFISC research:

2022-2023 IFISC Master

CAMILO CELA
SAMUELE CIARDELLA
KALOYAN DANOVSKI
MIQUEL DURAN
MARC DURAN
JUAN A. GARCÍA
PEDRO JIMENEZ
ALVARO LUQUE
DAVID ORTIZ
IVONNE P. ROJAS
ZITA SZABO
DANIEL VISA

2023-2024 IFISC Master

DANIEL AGUILAR
AIDA ATAEI
ALBERT CAÑELLAS
ELENA DEL CAMPO
ARNAU DOLS
SOFIA GIL
LUIS IRISARRI
JAVIER MARIN
DANIEL MONTESINOS
ADRIAN NADAL
LAIA PALACÍN
MIGUEL R. SHAW
ADRIAN ROIG
SAULO J. RONQUILLO
SERGIO SICILIA
VICTOR TARASSOV
LUCAS TRIGAL
ARNAU VIVET

Collaboration students

MIKOLAJ JANCZAK   Univ. Lodz, Poland (Oct.-January)

2.9 HUMAN RESOURCES OVERVIEW

HUMAN RESOURCES IFISC 2023

	Total	Male	Female
Permanent staff	23	21	2
Tenure track & senior fellows	6	6	0
Postdoctoral fellows	15	9	6
PhD students	56	38	18
Long-term visitors	16	10	6
Support personnel	14	9	5
Total	130	93	37

PERSONNEL IFISC 2018-2023

	2018	2019	2020	2021	2022	2023
■ PERMANENT STAFF	17	18	18	20	22	23
■ POSTDOCS, SENIORS & ASSOCIATED	18	16	24	24	25	25
■ PhD STUDENTS	24	24	28	39	50	56
■ LONG TERM VISITORS	11	9	7	8	7	16
■ SUPPORT PERSONNEL	8	10	12	14	13	14
TOTAL	78	77	89	105	117	134
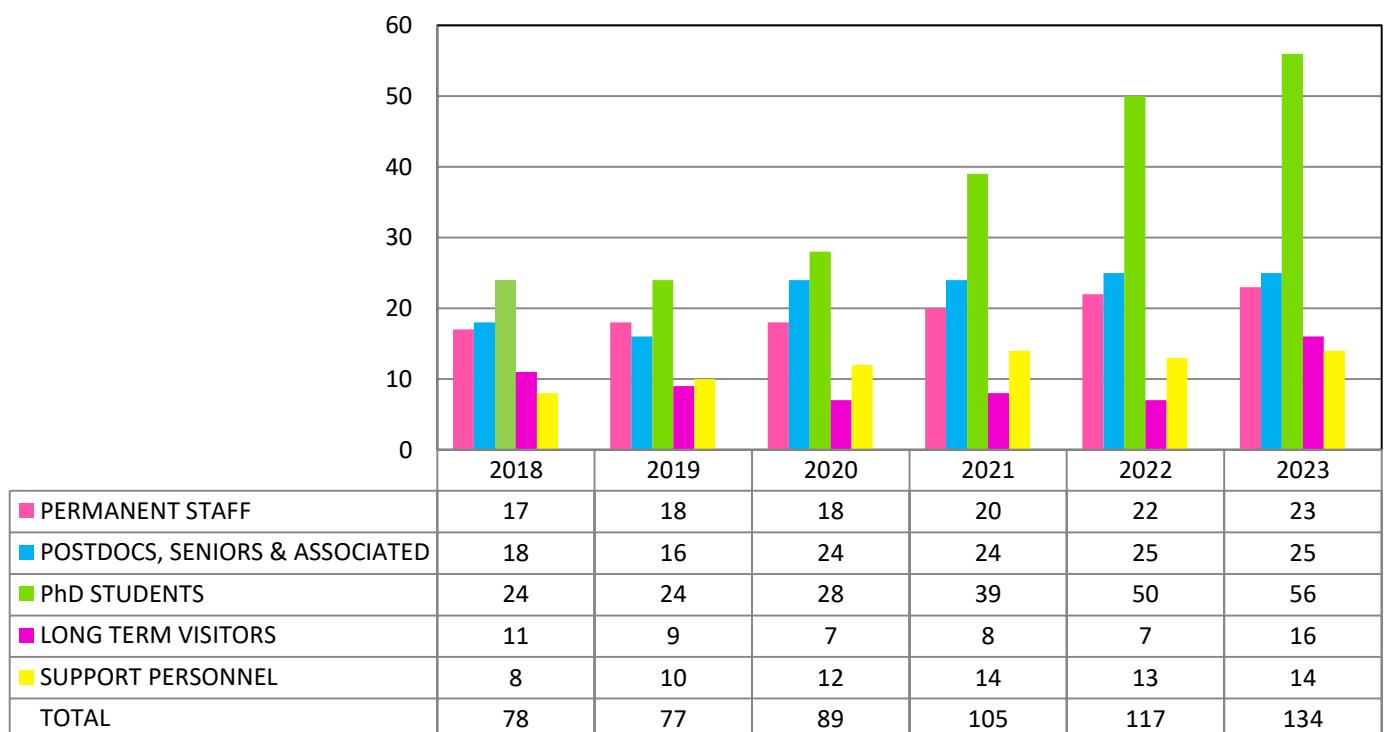
VISITING SCIENTISTS AT IFISC 2023

		Short visits	Long visits	Total visits
🟪	SPAIN	1	5	6
🟦	EUROPE	7	4	11
🟩	REST OF THE WORLD	7	7	14
	TOTAL	**15**	**16**	**31**

Short visits
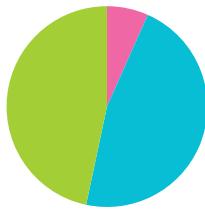
Long visits
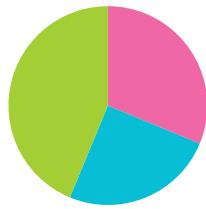
Total visits

3
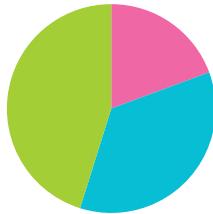
RESEARCH PROJECTS AND FUNDING

3 RESEARCH PROJECTS AND FUNDING

**DURING 2023 IFISC HAS RECEIVED FUNDING VIA THE ACTIVE
RESEARCH PROJECTS LISTED IN THE FOLLOWING PAGES. IN BRIEF:**

- European Commission Framework Program projects: **10**
- Spanish National Plan: **13**
- Collaboration Networks: **4**

Grand total budget of active projects in 2023: **8.580.408 € (including 2.000 k€ MdM)**
Average yearly project funding in 2017-23:   **1.936.605 €**
Average EC funding in 2017-23:   **30,24 % of total**

**BUDGET FIGURES FOR THE PERIOD 2017-2023 ARE SUMMARIZED
IN THE FOLLOWING TABLE**
**(With budget of a project assigned to the year it is granted. The *Annualized total*
is the sum of one-third of the budged granted in that year and in the two previous
years):**

BUDGET IFISC´S RESEARCH PROJECTS 2017-2023 (IN €)

	2017	2018	2019	2020	2021	2022	2023	TOTAL
European Commission	€0	€12.000	€250.904	€3.045.987	€169.007	€128.799	€493.737	€4.100.434
Spanish National Plan for Science	€54.450	€2.320.000	€969.227	€212.120	€246.865	€966.145	€2.365.150	€7.133.957
Other Funding	€60.500	€122.573	€20.000	€347.136	€1.181.210	€102.344	€488.081	€2.321.844
Total	€114.950	€2.454.573	€1.240.131	€3.605.243	€1.597.082	€1.197.288	€3.346.968	€13.556.235
Annualized total	€648.528	€1.326.489	€1.269.885	€2.433.316	€2.147.485	€2.133.204	€2.047.113	

3 RESEARCH PROJECTS AND FUNDING

3.1 RESEARCH FUNDED BY THE EUROPEAN COMMISSION

CAFE

Climate Advanced Forecasting of sub-seasonal Extremes. Marie Sklodowska-Curie Innovative Training Network. CSIC. [813844]. IFISC Principal Investigator: Emilio Hernández- García (2019-2023) .
Budget: 250.904,88 €

ADOPD

Adaptive Optical Dendrites. Program H2020-EU1.2.1. [899265] IFISC Principal Investigators: Claudio Mirasso and Ingo Fischer. (2020-2023) Budget: 955.250 €

RE-TE

Regional Economy / Travel Expectations. [101112847] ERC Proof of Concept. Principal Investigator: Massimiliano Zanin (2023-2025) Budget: 150.000€

CoQHoNet

Connecting Quantum Hopfield Networks. [IP-101105267] Marie Curie Intra-European Fellowships for career development. Principal Investigator: Roberta Zambrini (2023-2025) Fellow: Eliana Fiorelli. Budget: 165.312,96€

Ocean Citizen

Marine forest coastal restoration: an underwater gardening socio-ecological plan. [HORIZON-MISS-2021-OCEAN-02: 101093910] Innovation Action. Principal Investigator: Damià Gomila (2023-2026) Budget: 178.424,70€
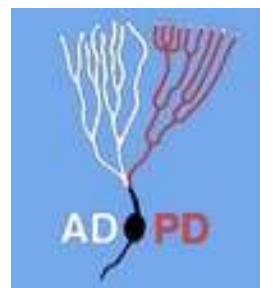
VPP4ISLANDS

Vitual Power Plant for Interoperable and Smart Islands. Innovation Action [957852] IFISC Principal Investigator: Pere Colet. (2020-2024) Budget: 309.903 €

POST-DIGITAL

Neuromorphic computing in photonic and other nonlinear media. Marie Skolodowska-Curie Initial Training Network [860360] IFISC Principal Investigators: Claudio Mirasso and Ingo Fischer. (2020-2024) Budget: 483.810 €

ARCTIC

Air Transport as Information and Computation. European Research Council Starting Grant [851255] IFISC Principal Investigator: Massimiliano Zanin. (2020-2025) Budget: 1.297.024 €

DYNDEEP

Dynamics of Temporal Networks: Memory and Deep Learning. Special Action AEI associated to ERC call. IFISC Principal Investigator: Lucas Lacasa. (2021-2023) Budget: 93.202 €

MAGMA

Magnetic topological insulators for robust majorana bound states. International collaboration Project AEI-PCI-ERA. (2022-2025) Principal Investigator: Llorenç Serra. Budget: 128.799,96 €

3.2 RESEARCH PROJECTS OF THE SPANISH NATIONAL PLAN FOR SCIENCE

MdM – IFISC -2

Accreditation of IFISC as "Maria de Maeztu, Unit of Excellence". [CEX2021-001164-M] Principal Investigator: Claudio Mirasso. (2023-2026) Budget: 2.000.000€

Next4Mob

Next Generation Tools for advanced mobility solutions. [PLEC2021-007824] Strategic Line Project. IFISC Coordinator: Jose J. Ramasco (2021-2024) Budget: 62.340 €

INFOLANET

Information processing with coupled laser networks. [PID2022-139409NB-I00] Principal Investigators: Apostolos Argyris and Miguel C. Soriano (2023-2026) Budget: 127.500€

CoQuSy

Complex Quantum Systems: machine learning, thermodynamics and emergent phenomena. [PID2022-140506NB-C21 y C22] Principal Investigators: Gian Luca Giorgi, Roberta Zambrini and Gonzalo Manzano (2023-2026) Budget: 261.250€

QUARESC

Quantum Machine Learning using reservoir computing. [PID2019-109094GB-C21] IFISC Principal Investigators: Miguel C. Soriano and Roberta Zambrini (2020-2023) Budget: 104.060 €

OLGRA

Operadores Laplacianoss en grafos y redes con repulsores/atractores y dinámicas relacionadas. [PID2019-107603GB-I00] IFISC Principal Investigator: Ernesto Estrada. (2020-2023) Budget: 27.830 €

MISLAND

Modelling Island Ecological Complexity in the context of global change. [PID2020-114324GB-C22] IFISC Principal Investigators: Lucas Lacasa and Victor M. Eguiluz (2021-2024) Budget: 84.095 €

QuTTNAQMa

Transporte cuántico y termodinámica: nuevas avenidas en materiales cuánticos. [PID2020-117347GB-I00] IFISC Principal Investigators: Rosa López and Llorenç Serra. (2021-2024) Budget: 72.600 €

SEDIMENT

Seagrass diversity in the Mediterranean basin in a global change scenario: a machine learning approach from satellite images. [TED2021-131836B-I00] (2022-2024) Ecological Transition project. Principal Investigators: Tomas Sintes, Manuel Matías. Budget: 193.200 €

APASOS

A Physics approach to sociotechnical systems: from theory to data analysis [PID2021-122256NB-C21/C22] (2022-2025) Principal Investigators: Tobias Galla, Sandro Meloni, Maxi San Miguel and Raul Toral. Budget: UIB: 193.600 € and CSIC: 181.500 €

CYCLE

Complex DYnamics of CoastaL Ecosystems: Resilience to Climate Change. Modelling and Simulations. [PID2021-123723OB-C22] (2022-2025) Principal Investigators: Tomas Sintes and Damia Gomila. Budget: 124.630 €

LAMARCA

Lagrangian transport of marIne litter and microplastics in coastal waters: structures of transport and connectivity patterns [PID2021-123352OB-C32] Principal Investigators: Emilio Hernández-García, Cristóbal López (2022-2026) Budget: 102.850 €

UpMEMO

Updating the brain's memory base: computational perspective [PID2021-128158NB-C22] Principal Investigator: Claudio Mirasso (2022-2025) Budget: 340.365 €

3.3 OTHER PUBLIC AND PRIVATE FUNDING

ESPOM
Ecosystemic services in posidonia oceanica meadows. Balear Government [PRD2018/18] IFISC Principal Investigator: Tomas Sintes. (2020-2023) Budget: 50.000 €

NouLloguer
Influence of new models of vacation renting on residential housing: ICT Data economic analysis. Balearic Government. [PED2018/43] IFISC Principal Investigator: Jose Ramasco. (2020-2023). Budget: 60.671 €

QUAREC
Machine learning with quantum reservoir computing. Balear Government. [PRD2018/47] IFISC Principal Investigator: Roberta Zambrini. (2020-2023) Budget: 99.750 €

CAFECONMIEL
Corpus Automático y Fenómenos de Contacto en Mallorca: Inteligencia, Entrenamiento y Lengua. Balearic Government. IFISC Principal Investigator: David Sánchez (2021-2024) Budget: 47.510 €

MACTOPE
Materia Cuántica Topológica: Precisión y Energía. [PDR2020/12] Balearic Government. IFISC Principal Investigator: Rosa López (2021-2023) Budget: 37.200 €

UCRAN20029
Floquet quantum information processing devices. Accion Complementaria CSIC. Principal Investigator: David Sánchez (2022-2024) Budget: 102.344 €

Quantum Spain
Principal Investigator: Roberta Zambrini (2023-2025) Agreement. Budget: 273.404€

EUR2J
De l'Euro al Joule. Principal Investigator: Raul Toral. La Caixa Foundation (2023-2025) Budget: 107.902€

QTD-InFlexity
Quantum thermodynamics: information, fluctuations and complexity. [20235AT009] PIE - Proyecto Intramural Especial CSIC. Principal Investigator: Gonzalo Manzano (2023-2026) Budget: 50.000€

iCOOP
Analysis of stability and resiliance fo Cameroon's power grid on the incorporation of renewable energy sources. Bilateral Project. CSIC. Principal Investigator: Pere Colet (2023-2024). Budget: 23.950,30€

3 RESEARCH PROJECTS AND FUNDING

AIAM | **Artificial Intelligence & Animal Movement**. [DO17] Project with Foundation SOA – Sustainable Ocean Alliance. Principal Investigator: Jorge P. Rodriguez (2023-2024) Budget: 9.225,20€

i-LINKB20072 | **Quantum fluctuations and dissipation: towards highly efficient and precise nano engines** [LINKB20072] CSIC Thematic Research Network. Principal Investigator: Rosa López (2022-2023) Budget: 23.600 €

3.4 RESEARCH PROJECTS AND COLLABORATION NETWORKS WITH PARTICIPATION OF IFISC MEMBERS

MOBILITY2030 | **Sustainable and healthy urban mobility**. CSIC Interdisciplinary Thematic Platform (PTI). Principal Investigator at IFISC: J.J. Ramasco

Global Health | **Global Health.** CSIC Interdisciplinary Thematic Platform (PTI+). Principal Investigator at IFISC: J.J. Ramasco

AIHUB | **HUB CSIC for fomenting the research and services on Artificial Intelligence.** CSIC Interdisciplinary Thematic Platform (PTI). Principal Investigator at IFISC: J.J. Ramasco

QTEP | **Quantum Technologies Platform**. CSIC Interdisciplinary Thematic Platform (PTI+). Principal Investigators at IFISC: Roberta Zambrini and Llorenç Serra.

3.5 RESEARCH CONTRACTS

CQD | **Activities in the area of electron/hole transport in carbon quantum dot polymer.** Services contract with eM-TECH, Inc. FUEIB. Principal Investigator: David Sanchez (2023-2024) Budget: 15.000€

3.6 **NON-DISCLOSURE AND COLLABORATION AGREEMENTS WITH NON-ACADEMIC INSTITUTIONS**

3

RESEARCH PROJECTS AND FUNDING

4

IFISC
SEMINARS

4

IFISC SEMINARS

Coordinators:
Tobias Galla
Sandro Meloni

A total of 88 seminars, including weekly regular seminars and talks, were given at IFISC in 2023. The full list of seminars can be found at the website: **http://ifisc.uib-csic.es/en/events/seminars/** as well as in the Appendix of this report.

Seminars are broadcasted live and recorded. They are globally available at **http://ifisc.uib-csic.es/en/events/seminars/**, and also on our youtube channel **https://www.youtube.com/user/IFISCseminars/**
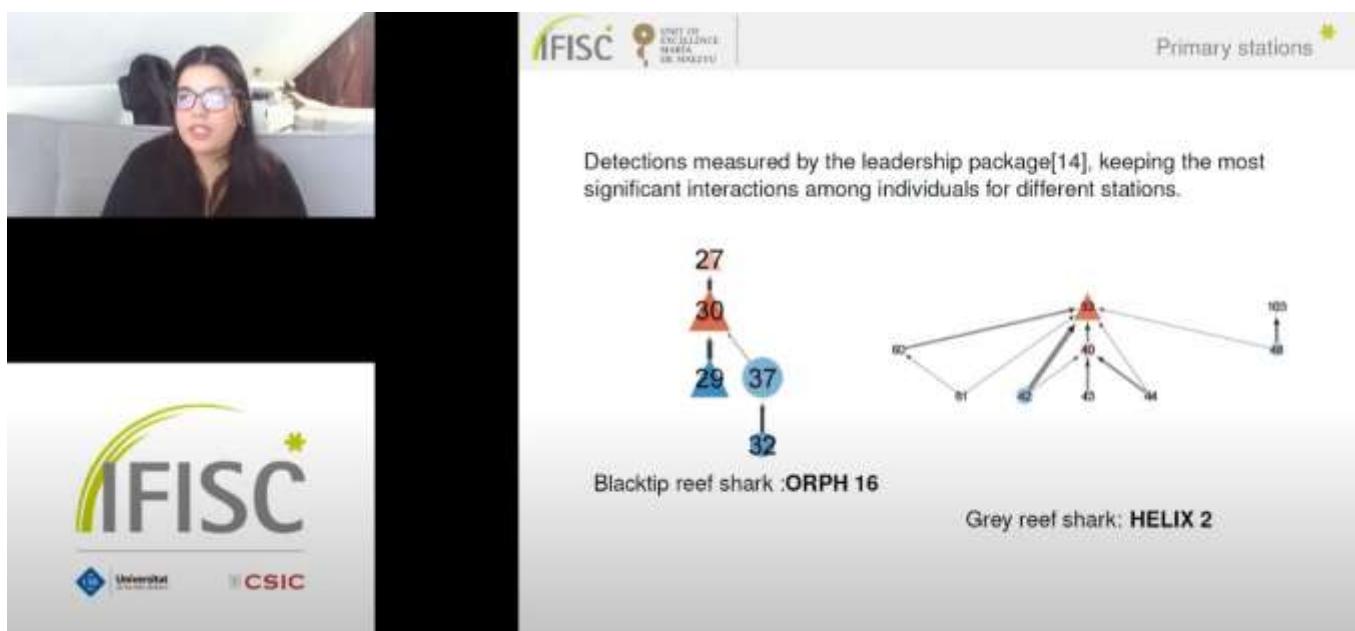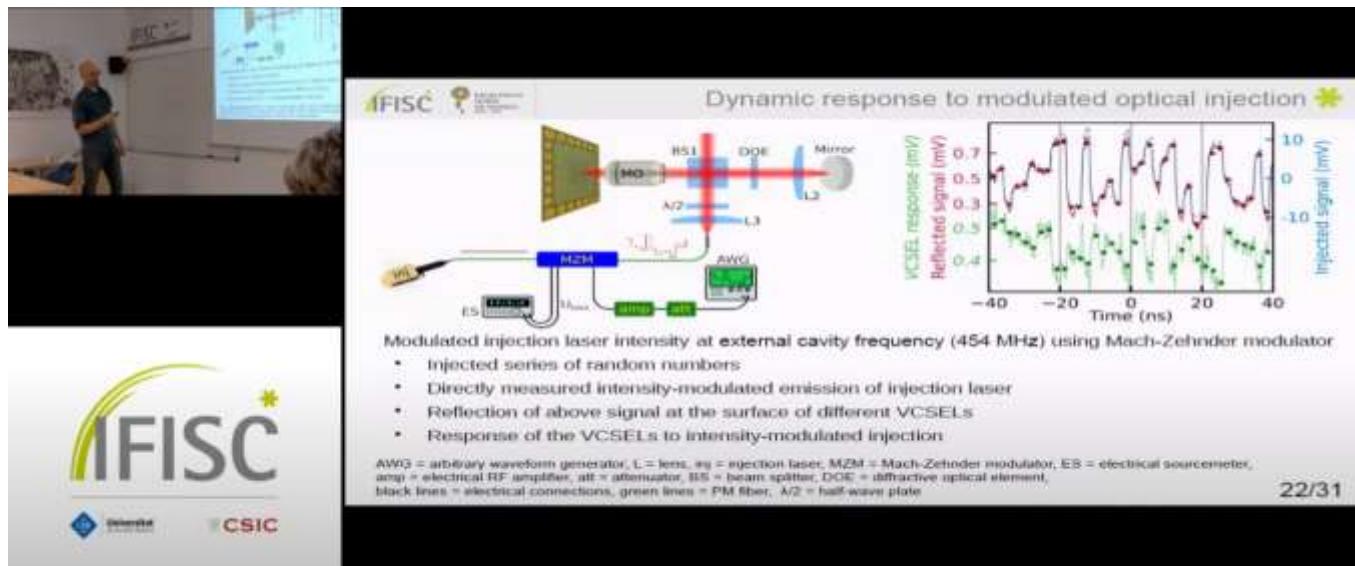
The following graphs show the distribution of seminars by geographical provenance of the speaker for 2023 and for the previous years:

PROVENANCE OF SPEAKERS AT IFISC SEMINARS 2023

IFISC: 55
Spain: 8
Europe: 14
Rest of the World: 11

TOTAL: 88
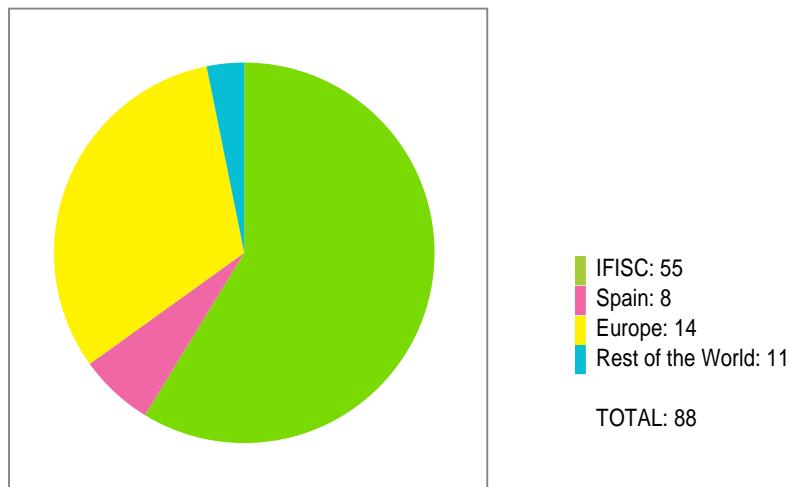
IFISC SEMINARS 2018-2023

IFISC SEMINARS 2018-2023

	2018	2019	2020	2021	2022	2023	TOTAL
IFISC	26	26	24	37	59	55	227
SPAIN	5	7	4	4	5	8	33
EUROPE	15	15	11	20	19	14	94
REST OF THE WORLD	6	10	1	2	5	11	35
TOTAL	52	58	40	63	88	88	389
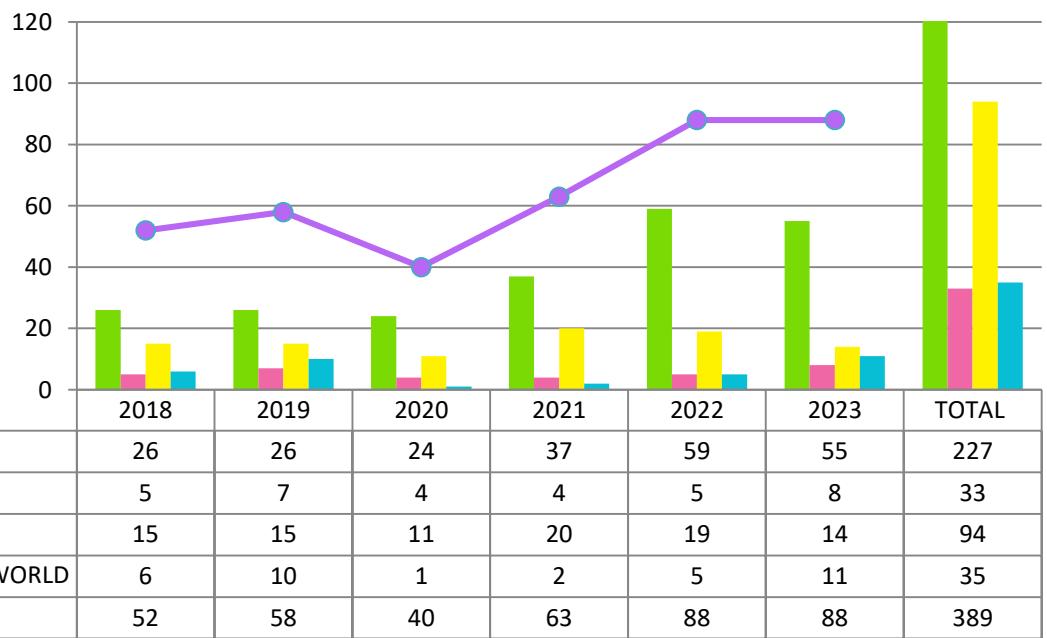
5
PUBLICATIONS

5 PUBLICATIONS

IFISC RESEARCH RESULTS HAVE BEEN REPORTED IN THE FOLLOWING PUBLICATIONS DURING 2023:

• Papers in indexed journals: **118**
• Other publications: **6**

The following tables place these numbers in the context of the publication activity during the past years, specifying the main journals in which IFISC papers are published. It is a strategic commitment of IFISC to target cross-disciplinary research areas lying outside the domain of traditional physics. The success in this objective is highlighted in the tables by indicating the number of publications in *non-physics journals*.

With respect to publications in high impact journals, in 2023 IFISC has published 3 papers in PNAS, 2 papers in Nature Communications, 1 in Nature Nanotechnology, 1 in Nature Computational Science, 1 in Nature Physics, 1 in Nature Biotechnology, 1 in Science Advances, 1 in ACS Nano, 2 in Physical Review X Quatum, and 3 in Physical Review Letters.

• Non Physics Journals: **26**
• High Impact Journals: **16**

In addition, 2 books addressed to the general public have also been published.

Full listing of publications and links to the full text are available here: **http://ifisc.uib-csic.es/en/publications/** and in the Appendix of this Report.

IFISC PUBLICATIONS 2018-2023
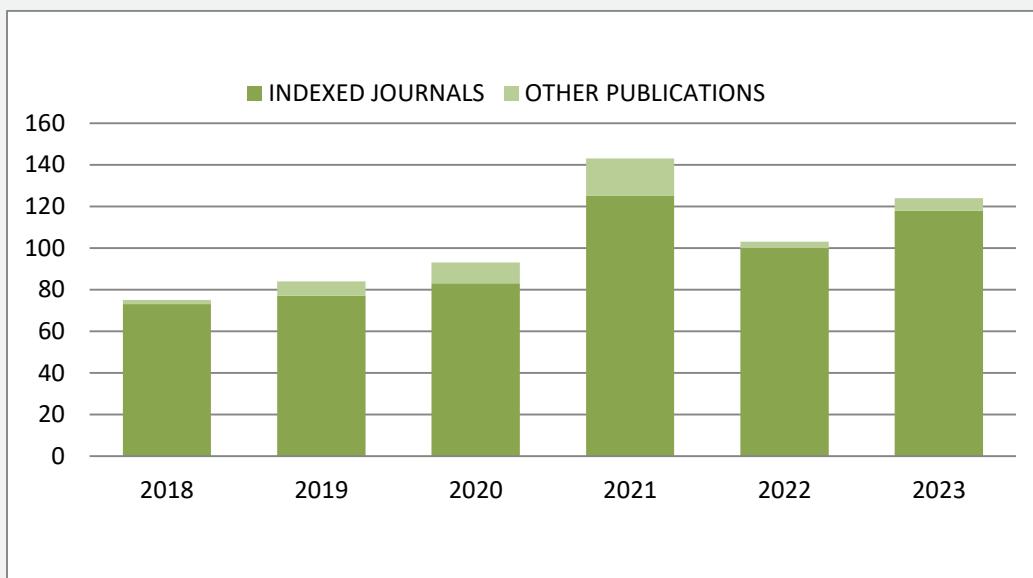
	2018	2019	2020	2021	2022	2023	TOTAL
INDEXED JOURNALS	73	77	83	125	100	118	576
OTHER PUBLICATIONS	2	7	10	18	3	6	46
TOTAL	75	84	93	143	103	124	622

JOURNALS WITH THE LARGEST NUMBER OF PUBLICATIONS

IFISC PUBLICATIONS	2018	2019	2020	2021	2022	2023	TOTAL
Physics journals							
Physical Review E	10	8	3	9	10	14	54
Chaos	4	4	8	5	1	10	32
Physical Review B	5	2	5	7	4	7	30
Optics Letters	0	0	7	5	4	5	21
New Journal of Physics	4	3	2	5	3	1	18
Physical Review Letters	3	1	2	4	5	3	18
Physical Review A	0	1	2	2	3	0	8
Multidisciplinary journals							
Scientific Reports	3	9	5	8	8	7	40
Nature Communications	0	2	2	4	5	2	15
Plos One	4	0	3	0	3	0	10
IEEE journals	0	2	4	3	4	2	15
Other non-physics journals	13	21	11	40	20	24	129

The journals included in the "other non-physics journals" category are the following:

Biosciences:

Trends in Ecology and Evolution, Journal of Theoretical Biology, Bulletin of Mathematical Biology, Journal of the Royal Society Interface, eLife, PLoS Computational Biology, PLoS Genetics, Ecological Complexity, Ecological Modelling, Ecography, Biomolecules, NPJ Systems Biology and Applications, Frontiers in Systems Neuroscience, Frontiers in Medicine, Computer Methods and Programs in Biomedicine, Environmental Microbiology, The ISME Journal, Biological Conservation, Viruses, Methods in Ecology and Evolution, Theoretical Population Biology, Journal of Theoretical Biology, Briefings in Bioinformatics, Ecological Applications, Oikos, Communications Biology, BMC Health Services Research, Computational and Structural Biotechnology Journal, Statistics in Medicine, Neuroimage, JAMA Network Open, Human Brain Mapping, Brain Topography, Brain Sciences, Phytopatology, and Enviromental entomology.

Earth sciences:

Journal of Geophysical Research, Nonlinear Processes in Geophysics, ICES Journal of Marine Science, Earth Systems Dynamics, Progress in Oceanography, Frontiers in Earth Science, Frontiers in Marine Science, Journal of Marine Systems, Tellus A, Ocean Science, Journal of Climate, Land, and Journal of the air transport research society.

Sociotechnical and Social systems:

Palgrave Communications, Journal of Economic Interaction and Coordination, Transportation Research, International Journal of Electrical Power and Energy Systems, Games and Economic Behaviour, and Cybergeo.

Data science, Neural Computation and Machine learning:

Mathematical models and Methods in the Applied Sciences, Frontiers in Neuroinformatics, Neuroinformatics, Neural Networks, EPJ Data Science, Cognitive Computation, Nature Machine Intelligence, Neurocomputing, IEEE Transactions on Neural Networks and Learning Systems, Research Synthesis Methods, Applied Network Science and Frontiers in neuroscience.

6

CONFERENCES AND WORKSHOPS

6 CONFERENCES AND WORKSHOPS

6.1 PRESENTATIONS AT SCIENTIFIC CONFERENCES 2023

- Invited talks: **51**
- Oral presentations: **72**
- Posters: **54**
- Total in 2023: **177**

Full listing in the Appendix of this Report.

CONFERENCES AND WORKSHOPS 2018-2023

	2018	2019	2020	2021	2022	2023	TOTAL
INVITED TALKS	35	42	9	40	36	51	213
ORAL PRESENTATIONS	43	29	20	44	75	72	283
POSTERS	31	16	9	16	68	54	194
TOTAL	109	87	38	100	179	177	513

6

CONFERENCES AND WORKSHOPS
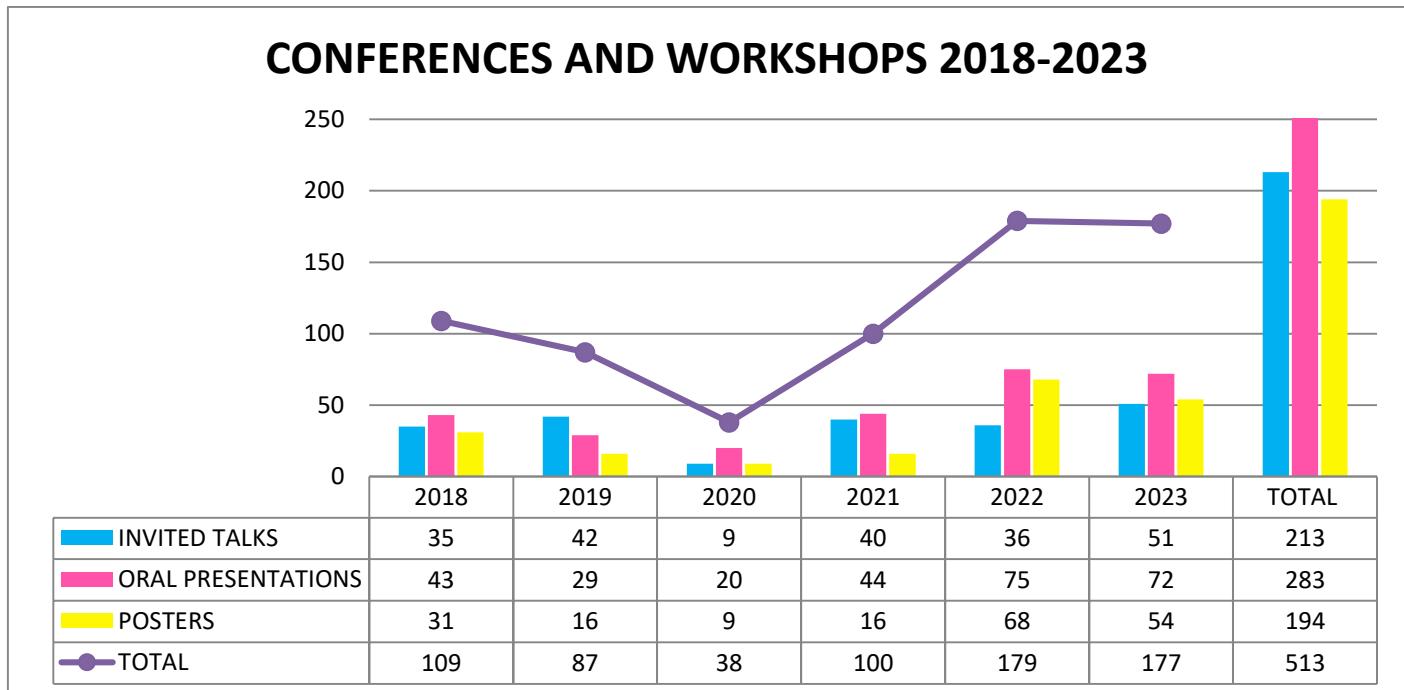
6.2 ORGANIZATION OF CONFERENCES AND WORKSHOPS

- **Colet, Pere**

Member of the Organizing Commitee of Complexity 72h.

Member of the Scientific Commitee of XI GEFENOL Summer School on Statistical Physics of Complex Systems. Barcelona, Spain

- **Soriano, Miguel C.**

Member of the Porgram Committee of the Emerging Topics in Artificial Intelligence (ETAI) conference, SPIE.

Program Committee Member of SPIE Photonics Europe 2024- Semiconductor Lasers and Laser Dynamics.

- **Ramasco, J.J.**

Chair of the Steering Committee of the Conference on Complex Systems.

Member of the Organizing Commitee of Complexity 72h.

- **Zambrini, Roberta**

Woman in Quantum. Calvia.

- **Martínez-Barbeito, María**

Member of the Advisory Board of the Complex Systems Society, CCS2023 Young Researchers warm-up. Salvador, Bahia, Brazil.

- **Matias Manuel A.**

Comité Científico FISES.

- San Miguel, Maxi

Member of steering committee of Statphys 28, Tokio.

- **Sánchez, D.**

Automatic analysis of genre variation in historical corpora of Spanish in contact with Catalan. NARNiHS (North American Research Network in Historical Sociolinguistics) Research Incubator 2023 (online).

Complexity in Language Variation and Change (COMPILA 2023). STATPHYS28 Satellite Meeting.

- **Diaz-Diaz, Fernando**

Organizing committee of FISES joven 23.

- **Lopez, Rosa**

Novel trends in topological systems and quantum thermodynamics, i-LINK workshop, Mallorca.

Fundamental bounds in nano engines. Mini-colloquium at the CMD30 (Condensed Matter Division) conference at Milan

- **Fernandez Gracia, Juan**

Complexity72h is an interdisciplinary workshop for young researchers in complex systems. IFISC, Palma de Mallorca, Spain.

2023 International Conference on Social Computing, Behavioral-Cultural Modeling, Prediction and Behavior Representation in Modeling and Simulation.

- **Mirasso, Claudio**

32nd Annual Computational Neuroscience Meeting. Leipzig, Germany.

- **Klemm, Konstantin**

Member of the Program Committee of the Complex Networks 2023. Menton Riviera, France.

- **Several IFISC members**

Organization of the mini-workshop celebrating Raul Toral's 65 anniversary at IFISC: Statistical Physics @ 65

6 CONFERENCES AND WORKSHOPS

7

OTHER ACTIVITIES

7 OTHER ACTIVITIES

7.1 PhD PROGRAM

IFISC participates in the PhD Program in Physics of the University of the Balearic Islands. During 2023, 56 PhD students developed their research project at IFISC, and 9 PhD thesis was completed and successfully defended:

Complex Optical Networks based on Vertical-Cavity Surface-Emitting Lasers (VCSELs)
Pflüger, Moritz (Supervisors: Brunner, Daniel; Fischer, Ingo)
October 20

Research and application of intervening opportunity class models for predicting human mobility
Liu, Erjian (Supervisors: Yan, Xiao-Yong and Ramasco, Jose J)
October 17

Reservoir computing in quantum systems
Martínez-Peña, Rodrigo (Supervisors: Zambrini, Roberta; C. Soriano, Miguel)
September 9

Complexity in Computational Sociolinguistics: Exploring the Interplay between Geography, Culture and the Social Fabric
Louf, Thomas (Supervisors: Ramasco, José J.; Sánchez, David)
September 8

A time-delay reservoir computing neural network based on a single microring resonator with external optical feedback
Donati, Giovanni (Supervisors: Argyris, Apostolos; Mirasso, Claudio R.; Pavesi, L.)
July 28

Exploring ecological and social interactions through the lens of complex systems
Calleja-Solanas, Violeta (Supervisors: Meloni, Sandro & Hernández-García, Emilio)
July 19

Generation of stochastic trajectories: applications to complex systems
Aguilar, Javier (Supervisors: Toral, Raul & Ramasco, Jose J.)
May 12

Characterization and simulation of multipartite open quantum systems
Cattaneo, Marco (Supervisors: Zambrini, Roberta; Maniscalco, Sabrina; Rossi, Matteo A.C. and Giorgi, Gian Luca)
February 24

Electronic and topological properties of bilayer graphene nanostructures
Benchtaber, Nassima (Supervisors: Serra, Llorenç and Sanchez, David)
February 6

7.2 SURF@IFISC

The Summer Undergraduate Research Fellowships program is part of one of the IFISC commitments. For the 2023 program we received 50 applications from 30 universities belonging to 13 different countries.The following six were selected:

Marina Camps Nebot, from the University of Illes Balears, Spain

Leyla Gómez Birrer, from the University of Barcelona, Spain

Ignacio Megía Pérez, from the University of Salamanca, Spain

Jacob Rifá Estol, from the University of Barcelona, Spain

Iván Salvador García, from the University of Barcelona, Spain

Gala Tomás Portalés, from the University of Valencia, Spain

7.3 IFISC MASTER

IFISC Master in *Physics of Complex Systems*

https://ifisc.uib-csic.es/master/

In October 2012 IFISC started a Master program in Physics of Complex Systems. It is a one year (60 ECTS) official Master of the University of the Balearic Islands, in collaboration with CSIC. The courses provide an innovative entry point to Complex Systems fundamentals and applications and introduce the students in the research lines developed at IFISC. For the 2023-2024 academic course 18 students of 3 different nationalities and 12 different universities are registered in the master.
In the year 2024, 14 master thesis were defended. They are listed in the Appendix of this Report.

This is the 2022-2023 Master syllabus:

Structural module courses (33 credits):

Simulation methods (6 credits)	P. Colet, R. Toral
Cooperative and critical phenomena (6 credits)	E. Hernández-García, T. Sintes
Dynamical systems, chaos and patterns (6 credits)	D. Gomila, M. Matías
Stochastic Processes (3 credits)	P. Colet, R. Toral
Complex Networks (3 credits)	E. Estrada, J. Fernández-Gracia
Complex Quantum Systems (3 credits)	G. Giorgi, Ll. Serra, R. Zambrini
Introduction to data analysis and machine learning I (3 credits)	L. Lacasa, J. Ramasco
Information Theory (3 credits)	D. Sánchez

Specific module courses (9 credits minimum)

Non equilibrium collective phenomena (3 credits)	C. López
Spatiotemporal dynamics (3 credits)	D. Gomila
Systems Biology (3 credits)	M. Matías, T. Galla
Statistical Biophysics (3 credits)	T. Sintes
Modeling and dynamics of neural systems (3 credits)	C. Mirasso
Complex Photonics (6 credits)	A. Argyris, M. C. Soriano, I. Fischer
Open quantum systems (3 credits)	R. Lopez, G. Manzano
Computational social sciences (6 credits)	P. Colet, J.Ramasco, M.San Miguel, D.Sanchez, M. Zanin
Collective quantum phenomena (3 credits)	G. Giorgi, G. Manzano, L. Serra
Quantum Information (3 credits)	D. Sanchez
Nonlinear phenomena in fluid flows and climate (3 credits)	C. Lopez
Advanced complex networks (3 credits)	S. Meloni
Ecology and population dynamics (3 credits)	T. Galla
Modeling based on complex systems in economics (3 credits)	P. Colet, R. Lopez
Introduction to data analysis and machine learning II (3 credits)	M. C. Soriano, M. Zanin

Master thesis (12 credits)	Responsible: P. Colet

7.4 OTHER POSTGRADUATE COURSES

Other Postgraduate Courses taught in 2023

The following courses were also taught in the **Master of Advanced Physics and Applied Mathematics**, University of the Balearic Islands:

• **Cooperative and critical phenomena (6 credits)**
Tomàs Sintes, Emilio Hernández-García

• **Stochastic simulation methods (6 credits)**
Pere Colet, Raúl Toral

• **Scientific presentation and visualization (3 credits)**
José J. Ramasco, Sandro Meloni

• **Spintronics (3 credits)**
Rosa López, Llorenç Serra, David Sánchez

• **Electronic nanostructures (3 credits)**
David Sánchez, Llorenç Serra

The following courses were also taught in the **Master in Quantum Technologies**, International University Menendez Pelayo, Santander, Spain:

• **Quantum machine learning and computing (3 credits)**
Roberta Zambrini

• **Open Quantum systems and Thermodynamics (3 credits)**
Gian Luca Giorgi, Roberta Zambrini, Rosa Lopez, Gonzalo Manzano

7.5 MEMBERS OF EDITORIAL BOARD OF SCIENTIFIC JOURNALS
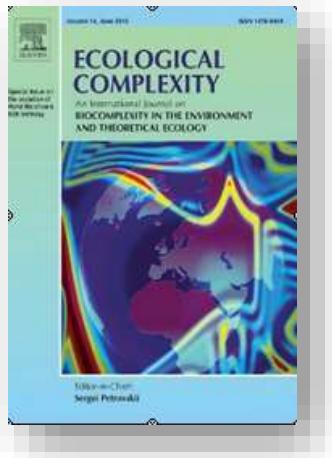
Ecological Complexity.
Hernandez-Garcia, Emilio (advisory board)

Frontiers in Complex Systems.
San Miguel, Maxi (editor in chief)

Journal of Physics Complexity (IOP).
San Miguel, Maxi

Proceedings of the Royal Society A.
Giorgi, Gian Luca
Estrada, Ernesto (associate editor)

Journal of Complex Networks.
Estrada, Ernesto (editor in chief)
Lacasa, Lucas

MATCH Communications in Mathematical and in Computer Chemistry.
Estrada, Ernesto

SIAM Journal of Applied Mathematics.
Estrada, Ernesto (associate editor)
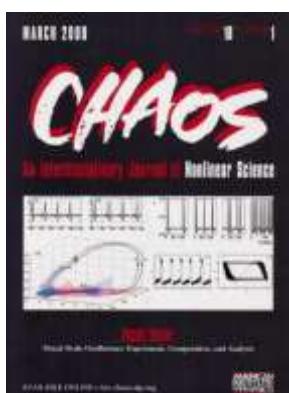
Chaos: An Interdisciplinary Journal of Nonlinear Science.
Fischer, Ingo (advisory board)

European Physical Journal Special Topics.
Colet, Pere

Mathematics.
Estrada, Ernesto (associate editor)

Physical Review Letters.
Zambrini, Roberta (divisional associate editor)

Entropy.
Lacasa, Lucas
Wio, Horacio

Division C3: Statistical Physics of the International Union for Pure and Applied Physics (IUPAP).
Toral, Raúl

Nanophotonics. Special Issue "Neural network learning for photonic circuit design".
Soriano, Miguel Cornelles (guest editor)

Frontiers in Physics.
Apostolos Argyris, Apostolos
Lacasa, Lucas
Wio, Horacio (advisory board)

European Physical Journal B.
Wio, Horacio

Physica A.
Wio, Horacio

Scientific Reports.
Meloni, Sandro

7.6 SCIENTIFIC COMMITTEES

- **Colet, Pere**

Member of the Board and Treasurer of the Topical Group on Statistical and Nonlinear Physics (GEFENOL) of the Spanish Physical Society.

- **Ramasco, Jose J.**

Elected member of the council of the Complex Systems Society.

President of COMSOTEC, Spanish Association for the Study of SocioTechnical Systems.

Coordinator PTI Mobility 2030 of CSIC.

Adjunct coordinator of the CSIC area of MATERIA.

- **Cornelles Soriano, Miguel**

Elected Member of IEEE Task Force on Reservoir Computing.

Elected member of the Quantum Optics and Nonlinear Optics Committee of the Spanish Society of Optics (SEDOPTICA).

- **Fischer, Ingo**

Elected Member of IEEE Task Force on Reservoir Computing.

Member of the advisory board of the Japanese national project "Photonic Computing Highlighting Ultimate Nature of Light\" (MEXT Grant-in-Aid for Transformative Research Areas).

- **Calleja Solanas, Violeta**

Elected member of the advisory board of the Young Researchers of the Complex Systems Society.

Elected member of the council of the Complex Systems Society.

- **Zambrini, Roberta**

Gestora AEI. Area Physics; Subarea Physics and applications.

Responsible and moderator of the Quantum Thermodynamics website.

Member and reviewer of the Barcelona Supercomputing Center's Access Commitee.

- **Martínez-Barbeito, María**

Elected member and chair of the advisory board of the Young Researchers of the Complex Systems Society (yrCSS).

- **San Miguel, Maxi**

Chair of the International Scientific Advisory Board of the Internet Interdisciplinary Institute (IN3) of the Open University of Catalunya (UOC).

- **Estrada, Ernesto**

Elected as Fellow of the Institute of Mathematics and its Applications (IMA) of the U. K.

- **Tugores, Antonia**

Member of Authentication and Authorization Infrastructure Architecture (AAI) Task Force of the European Open Science Cloud, EOSC.

- **Sintes, Tomas**

Member of the IUPAP Working group on the Green Economy.

7.7 RESEARCH STAYS IN OTHER CENTERS

During 2023 IFISC Researchers visited 18 external research centers.

These visits are listed in the Appendix to this Report.

7. 8 'WOMEN IN SCIENCE' ACTIVITIES

11F: CONNECT WITH CSIC WOMEN SCIENTISTS IN THE BALEARIC ISLANDS

The Representation of the Spanish National Research Council (CSIC) in the Balearic Islands, in collaboration with IMEDEA (CSIC-UIB), IFISC (CSIC-UIB), ICTS SOCIB, the IGME unit in the Balearic Islands, and COB-IEO, organized live streams on YouTube on February 9 and 10, 2023, to celebrate the International Day of Women and Girls in Science.

In these informal meetings, participants had the opportunity to meet some of the prominent female scientists and technicians from the CSIC in the Balearic region who shared their experiences as women studying and working in STEM careers.

The dates of the events were:

- Thursday, February 9: 12:00-12:45 pm
- Friday, February 10: 12:00-12:45 pm

On 10 February, technician Antònia Tugores took part in Jo també Puc Fer-ho, also part of the 11F activities. This activity consisted of a day aimed at secondary school students to encourage vocations related to science and engineering studies and the choice of a university career in these fields. This type of initiative is promoted by a very low enrolment rate of women in fields of knowledge related to experimental sciences and, above all, engineering, which leads to gender imbalances in the choice of higher education studies at university.

7

OTHER ACTIVITIES

8

OUTREACH ACTIVITIES

8 OUTREACH ACTIVITIES

8.1 POSTER WEEK

The IFISC Poster Party is an annual activity where PhD students and postdoctoral researchers of IFISC present their research in a poster format. In a relaxed atmosphere, you can get to know first-hand what the young researchers a IFISC are working on. It was a great opportunity for undergraduates to know what it means to dedicate themselves to research, as they had the opportunity to chat directly with the IFISC researchers themselves as well as with doctoral students who can tell their personal experience and solve doubts.

8
OUTREACH ACTIVITIES

8.2 PINT OF SCIENCE

IFISC has organized and participated in "Pint of Science" which is a festival that aims to deliver interesting and relevant talks on the latest science research in an accessible format to the public, mainly across bars and pubs. The festival provides a platform which allows people to discuss research with the people who carry it out and no prior knowledge of the subject is required. It is run mainly by volunteers and was started by a community of British postgraduate and postdoctoral researchers in 2012.

During two of three days of the event (May 22, 23 and 24), three scientists from our institute were in the iconic bar Café a Tres Bandas (Plaza de Barcelona, Palma) giving a dissemination talk about their work:

- *Detrás del enchufe: cómo funciona la red eléctrica* by María Martínez-Barbeito
- *¿Puede un grafo borracho volver a casa?* by Manuel Miranda
- *Flamenco: el arte que habla por sí solo* by Pablo Rosillo

8.3 CIÈNCIA A TOT TREN

A group of about twenty scientists from various public research institutions in the Balearic Islands came together to carry out "Ciència a tot tren", a unique proposal inviting audiences of all ages to experience science through a journey on the iconic Sóller train. The event took place on November 11 and consisted of mini scientific talks and activities in Sóller.

This event aimed to bring to the public the science developed in the laboratories of the Balearic Islands in an environment that combines cultural, ethnological, and natural aspects of great value. Specifically, scientists shared their latest advancements and knowledge with the passengers of the century-old wooden train through a series of thematic micro-talks, on a journey with the Tramuntana mountain range in the background. Upon arriving in Sóller, the public had the opportunity to visit some of the most important cultural and scientific centers in the area, such as the Jardí Botànic de Sóller, the Museu Balear de Ciències Naturals, and the Museu de la Mar in the Port de Sóller. The informative talks continued on the return journey to Palma.

The event was open to people of all ages interested in science, offering an opportunity for participants to learn about the research conducted in their region in an accessible and entertaining way. On the IFISC side, three pre-doctoral researchers participated:

- ¿Por qué se habla más de una lengua? by Pablo Rosillo (UIB-IFISC)
- Desxifrant el fons marí des de l'espai amb els ulls de la inteligencia artificial by Álex Giménez (UIB-IFISC)
- Animales, matemáticas y caos by Manuel Miranda (UIB-IFISC)

8
OUTREACH ACTIVITIES

8.4 SCIENCE FAIR

Members of IFISC participated in the "Fira de la Ciència i la Tecnologia d'Inca" (October 21-22). Both seniors and children were able to visit the IFISC stand in order to learn more about our institute and the importance of complex systems in the study of nature. Among the experiments shown, the attendees highlighted the chaotic pendulum, the synchronization of metronomes, ambiguous cylinders and ferromagnetic fluid.

Science Fair located in the Parque del Mar with stands from the Oceanographic Centre of the Balearic Islands - Spanish Institute of Oceanography (COB-IEO), the Balearic Islands Health Research Institute (IdISBa), the Institute of Cross-disciplinary Physics and Complex Systems (IFISC), the Mediterranean Institute of Advanced Studies (IMEDEA), the Balearic Islands Institute of Agri-Food and Fisheries Research and Training (IRFAP), and the University of the Balearic Islands (UIB).

In addition, there was a final party show called "Els Actors de la Ciència!" for the **Research Night**, where scientists from our islands explained their work in a fun and entertaining way. On behalf of IFISC, the pre-doctoral researcher Manuel Miranda participated with his talk "La sincronización de los sistemas complejos".

The event was hosted by the TV host and musician David Ordinas.

8.5 NAUKAS PALMA

On Saturday 2nd December the second edition of Naukas 360º was held in Palma de Mallorca, organised by the UIB with the collaboration of the Govern de les Illes Balears and the Ajuntament de Palma. Naukas is Spain's most famous science outreach event series. The event was held in Palma's famous Palacio de Congresos with high-level local and national speakers. Among them, IFISC researcher Ernesto Estrada gave the informative talk "Viviendo en un mundo enREDado".

8.6 OUTREACH TALKS

"Investigación interdisciplinar en epidemias desde la Plataforma de Salud Global del CSIC: ¿preparados para la próxima pandemia?"

The CSIC Representation in the Balearic Islands, the University of the Balearic Islands (UIB), and the Institute of Cross-disciplinary Physics in Complex Systems (IFISC, UIB-CSIC) organized the lecture "Investigación interdisciplinar en epidemias desde la Plataforma de Salud Global del CSIC: ¿preparados para la próxima pandemia?" given by the leading scientist Margarita del Val.

As coordinator of the CSIC Global Health Platform and expert in immunity and vaccines against viral diseases, Margarita del Val shared her valuable knowledge and experience in this scientific dissemination activity. The lecture took place on Tuesday 20 June at 11 am, in the Aula Magna of the Guillem Cifre de Colonya building, on the UIB campus. Admission was free and open to the public.

"Conciencia artificial en la ciencia y en la ficción"

On June 12nd the IFISC organised the outreach conference "Artificial Consciousness in Science and Fiction". In this informative talk open to the public, held at the Club Diario de Mallorca, researcher and writer Miguel Hoyuelos presented to the audience the latest advances in artificial intelligence, a topical and recurring theme in science fiction literature and cinema. A few decades ago, the idea of machines equipped with attributes of human intelligence or consciousness was firmly in the realm of the imaginary. Recently, however, everyday interaction with conversational mobile devices, as well as advanced technologies such as the Generative Pretrained Transformer (GPT), has brought the notion of a conscious machine closer to a potential reality in the not-too-distant future. In the first section of his presentation, Hoyuelos addressed a selection of science fiction films, focusing particularly on those in which artificial intelligence exhibits human characteristics in a notable way.

Subsequently, the topic of artificial consciousness and current scientific perspectives on it was explored. The researcher discussed various forms of artificial intelligence, approaches to the definition of consciousness and the feasibility of achieving true artificial consciousness.

"Próximos avances de la IA Generativa, ¿más humana que los humanos?"

On September 14th IFISC organised the informative talk "Forthcoming advances in Generative AI, more human than humans?" at the Sa Riera building, given by corporate innovation expert Néstor Guerra.

Generative Artificial Intelligence is an emerging branch of AI that focuses on creating new and original content, from images and text to music and design. These technologies have the potential to revolutionise multiple sectors, allowing us to generate solutions and content at unprecedented speed and accuracy. However, they also pose ethical and professional challenges, as they could displace traditional jobs and generate inauthentic or manipulated content. As these tools become integrated into our daily and working lives, it will be essential to address these challenges and ensure that they are used responsibly and in ways that benefit society.

During the talk, Nestor explained its origin, the most relevant tools that currently exist and what the near future of Generative AI will look like in our lives.

8.7 OTHER EVENTS

Ciència i Tecnologia en Femení

As part of the "Ciència i Tecnologia en Femení" conference organised by the Bit Foundation, the round table discussion: "Per què vaig decidir estudiar STEM?" was held by 5 renowned women scientists from the Balearic Islands. They will explain why they chose a STEM career, what their work consists of and some tips for choosing STEM studies, which can be followed live. On behalf of the IFISC, the technician Antònia Tugores spoke.

Visit of the Aula Balear Students

Students from the science baccalaureate at the Aula Balear secondary school visited the IFISC on 18 January to find out first-hand what IFISC is, its facilities and what Complex Systems research is all about.

Sistemes Complexos i divulgació a l'IFISC

On 3 April, IFISC outreach technician Adrián García visited high school students at the IES Madina Mayurqa secondary school to explain the science carried out at IFISC and what Complex Systems research consists of.

8.8 PRESS & MEDIA

News about IFISC and its research results are regularly posted in the 'News' section of the web site: https://ifisc.uib-csic.es/en/news/.

IFISC research has also received attention from newspapers and other media. During 2023, IFISC activities produced 99 press releases and appearances in written and digital press (national and international), and 15 clips on radio and TV. See the full lists in the Appendix.

THE CONVERSATION

Descifrando el fondo marino desde el espacio con los ojos de la inteligencia artificial

LA RAZON

Sociedad

El virus del aeropuerto

Los pasajeros de líneas aéreas pueden ser el foco de inicial de futuras pandemias. Las matemáticas ayudan a evitarlo
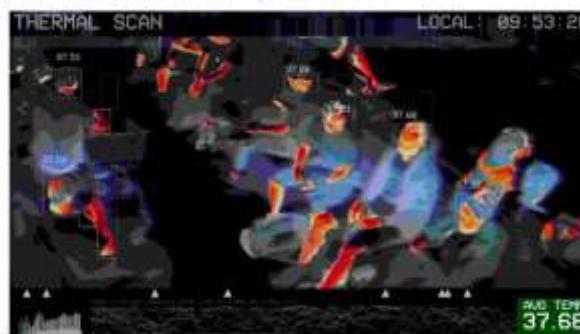
▲ Los aeropuertos, un posible coladero de rebrotes del Covid-19 Dreamstime / Dreamstime

PHYS.ORG

When languages collide, which survives?

November 14 2023

Modelos matemáticos en Baleares y Madrid que predicen las 'guerras internas' en cualquier ecosistema

La universidad balear y la politécnica madrileña desarrollan aplicaciones científicas que permiten descubrir comportamientos 'antipuladores' o 'mutualistas' en bancos de posidonia o microbios, respectivamente.

SER 100

Elige tu emisora

Una nueva herramienta permite predecir la eclosión de las ninfas del insecto que transmite la Xylella

El investigador del IFISC, Manuel Matías, ha explicado cómo funciona y las ventajas que puede aportar a los propietarios de terrenos para tomar medidas antes de que la bacteria se expanda

COPE ♫ Podcast

ACTUALIDAD
Noticias

CIENCIA NATURALEZA

Descubrén cómo se forman espirales en las praderas de Posidonia

Las praderas de Posidonia oceánica forman, en ocasiones, unos patrones de anillos que crecen de forma radial o como espirales giratorias, que surgen por una alta mortalidad de las plantas debido a la absorción de sulfuro por las raíces producto de la descomposición de materia orgánica.

8

OUTREACH ACTIVITIES

SOCIAL MEDIA IMPACT SUMMARY

TWITTER @IFISC_mallorca

Total Followers 3.249 (10% increase of number of followers in 2023)

http://www.facebook.com/ifisc

Facebook fans: 1.136 (4% increase of fan number in 2023)

62% men / 38% women

Mostly located in Spain, Brazil and Mexico

http://www.youtube.com/user/IFISCseminars

Visualizations: 33.094 in 2023 of a total of 301.067

YouTube subscribers: 2.454 (25% increase of subscribers in 2023)

84% men / 16% women

Mostly located in USA, Spain, Mexico and India

https://www.linkedin.com/company/ifisc-institute-for-cross-disciplinary-physics-and-complex-systems-csic-uib-

Total Followers: 857

APPENDIX

APPENDIX

a.4. IFISC seminars and talks 2023

In the electronic version of this report, titles are hyperlinked to the recording of the seminar, if available.

December 20
Modelling carbon dynamics in Lagrangian oceanic ecosystems: applications to fertilization experiments and mesoscale eddies
Stefano Campagnola, IFISC

December 12
Different levels of approximations in Open Quantum Systems and their applications
Ricard Ravell Rodríguez, Basque Center for Applied Mathematics – BCAM, Spain

December 7
Modeling Taxa-Abundance Differential in Microbial Communities Using Environmental Sequence Data
Somaye Sheykhali, IFISC

December 4
Time-Spatial Interleaving Photonic Convolutional Accelerators
Tigers Jonuzi, VLC Photonics, Valencia, Spain

November 30
2023 Winter Solstice IFISC Project Presentations
IFISC Principal Investigators, IFISC

November 29
Information dynamics or dynamics from information
Matteo Scandi, IFISC

November 23
Fourier Phase Index for Extracting Signatures of Determinism and Nonlinear Features in Time Series
Markus F. Müller, Centro de Investigación en Ciencias, Universidad Autónoma del Estado de Morelos, Centro de Ciencias de la Complejidad, Ciudad de México

November 22
Bifurcations and multistability in adaptive vascular networks
Konstantin Klemm, IFISC

November 21
Sociomeeting: Efficient simulation of age-dependent opinion dynamics
Konstantin Klemm, IFISC

November 17
Variational quantum algorithms for many-body simulation and machine learning problems
Abolfazl Bayat, University of Electronic Science and Technology of China

November 15
Complex-systems methods for text analysis
Eduardo Altmann, University of Sydney, Australia.

November 7
Sociomeeting: Echo chambers and opinion diversity in the Voter Model: towards regulation strategies for social networks
Antoine Vendeville, University College London, UK.

November 2
Machine Learning-Based Species and Breeding Stage Classification in Animal Movement Trajectories
Jorge Medina, IFISC

October 31
Sociomeeting: Nonlinear voters and partisanship
Jaume Llabrés Rubio, IFISC

October 31
Introduction to Quantum Thermal Machines
Gonzalo Manzano, IFISC

October 26
Visual Alchemy and Beyond: Exploring Top-Down Effects in Visual Processing
Javier Galván, IFISC

October 23
Delay-based photonic reservoir computing: phase encoding in long vs. short cavity reservoirs
Lucas Talandier, IFISC

October 20
Complex optical networks based on vertical-cavity surface-emitting lasers (VCSELs)
Moritz Pflüger, IFISC

October 19
Higher-order interactions as stabilising mechanism for competitive communities
Marc Duran Sala, IFISC

October 19
Artificial neural networks through the lens of dynamical systems theory
Kaloyan Danovski, IFISC

October 19
How efficient is air transport? A network perspective
Daniel Visa, IFISC

October 18
Inference of leadership networks of marine megafauna from acoustic data
Mª Teresa Corzo López, IFISC

October 18
Age of infection disease modeling: from Kermack and McKendrick to multi-compartment models
Mustapha Bousakla El Boujdaini, IFISC

October 17
Non-linear transitions in air transport delays: models and data
Zita Szabó, IFISC

October 16
Research and application of intervening opportunity class models for predicting human mobility
Erjian Liu, IFISC

October 16
Aging effects in coordination games
Samuele Ciardella, IFISC

October 16
Online learning strategies for optical neural networks and photonic circuits
Mirko Goldmann, IFISC

October 13
Big Data, memes, information diffusion in online social networks and opinion dynamics
Alvaro Luque, IFISC

October 11
Time and wavelength multiplexing in photonic neural networks
Pedro Jiménez González, IFISC

October 11
Anticipated synchronisation in stochastic individual-based models
David Ortiz, IFISC

October 10
Cluster formation, order and aggregation in Active Matter: different classes of active phase separation
Sudipta Pattanayak, CY Cergy Paris Université , France

October 4
Intermittent precipitation-dependent interactions, encompassing Allee effect, may yield vegetation patterns in a transitional parameter range
Luis Gordillo, Utah State University, Logan UT, USA

September 28
Lagrangian studies in the Western Mediterranean Sea
Ivonne Paola Rojas Martínez, IFISC

September 27
Information processing in oscillating brain
Alireza Valizadeh, Institute for Advanced Studies in Basic Sciences, Zanjan, Iran

September 8
Complexity in computational sociolinguistics: Exploring the interplay between geography, culture and the social fabric
Thomas Louf, IFISC

September 7
Reservoir computing in quantum systems
Rodrigo Martínez-Peña, IFISC

July 28
An Introduction to Higher-Order Interactions for Social Systems and Epidemic Modeling
Beatriz Arregui García, IFISC

July 28
A time-delay reservoir computing neural network based on a single microring resonator with external optical feedback
Giovani Donati, IFISC-University of Trento, Italy

July 19
Exploring ecological and social interactions through the lens of complex systems
Violeta Calleja Solanas, IFISC

July 18
Dynamics of seagrass meadows with two species
Pablo Moreno-Spiegelberg, IFISC

July 13
Harnessing ordered chaotic systems for quantum reservoir computing
Guillem Llodrà Bisellach, IFISC

July 7
Lagrangian transport of floating plastics at local and regional scales using MOHID-Lagrangian
Sara Cloux, IFISC

June 26
A city digital twin for a sustainable mobility: big data analytics and predictive models
Armando Bazzani, Universita di Bologna, Italy

June 22
Instability-driven turbulence
Edgar Knobloch, University of California, Berkeley, USA

June 21
Resolution of a hundred year old problem on lattice random walks and its application to study inert and reactive interactions in complex systems
L. Giuggioli, Bristol Univ. UK

June 20
On the formation of coral reefs
Miguel Álvarez, IFISC

June 16
The architecture of Multifunctional Ecological Networks
Mar Cuevas-Blanco, IFISC

June 15
Stochastic thermodynamics of Boolean circuits, finite automata and Turing machines
David Wolpert, Santa Fe Institute, International Center for Theoretical Physics, Complexity Science Hub, and Arizona State University, USA

June 14
Transition probabilities and diffusion coefficient in interacting particle systems
Miguel Hoyuelos, IFIMAR, Universidad Nacional de Mar del Plata, Argentina

June 13
A climate-driven epidemiological model for Pierce disease of grapevines
Alex Giménez Romero, IFISC

June 8
Understanding the structure and functioning of oceans' microbiomes: toward a holistic view
Daniele Iudicone , Stazione Zoologica Anton Dohrn, Italy.

June 1
Implementing engrams from a machine learning perspective: matching for prediction
Jesús Marco, Instiituto de Física de Cantabria, Spain

May 25
Interactive visualisation Dashboards : Transforming Research Papers into Dynamic Web Applications
Akshay Tiwari, IFISC

May 12
Generation of stochastic trajectories: Applications to complex systems
Javier Aguilar Sánchez, IFISC

May 10
Diversity in and of languages: how we can measure and model its emergence to unveil underlying social drivers
Thomas Louf, IFISC

May 5
Quantum Fisher Information and its dynamical nature
Matteo Scandi, ICFO, Barcelona, Spain

April 27
Modelling and dynamics of the CA3 and CA1 hippocampal circuit
Jaime Sánchez Claros, IFISC

April 27
Constructive effects of squeezing in loop-based quantum photonic architectures for quantum reservoir computing
Jorge García, IFISC

April 21
Digital Platforms for a Sustainable World
Bruno Campanelli, IFISC and Sony Lab Rome, Italy.

March 28
Computational methods to analyse lexical semantic change and variation from historical texts: my experience so far
Barbara McGillivray, King's College London, UK.

March 16
Quantum trajectories of dissipative time-crystals
Albert Cabot, Institut für Theoretische Physik, Eberhard Karls Universität Tübingen, Germany.

March 14
In-memory Computing – Fundamentals, Current Trends, and Future Directions
Naresh R. Shanbhag, Department of Electrical & Computing Engineering, University of Illinois, USA.

March 8
Word order theory. Swap distance minimization
Ramon Ferrer-i-Cancho , UPC, Barcelona, Spain

February 24
Characterization and simulation of multipartite open quantum systems
Marco Cattaneo, Algorithmiq, University of Helsinki, Finland and PhD student of UIB, IFISC

February 20
Experimental investigation of a microring-based time-delay reservoir computing
Giovanni Donati, IFISC and University of Trento, Italy

February 20
Entropy estimators for Markovian systems
Juan I. Gregorio, IFISC

February 10
Local probing of dynamical phase transitions by repeated partial information erasure
Hira Ali, IFISC

February 9
Information ecosystems: an ecological approach to computational social science
Violeta Calleja, IFISC

February 8
The faster, the better: How to accelerate photonic computing to meet the requirements of optical transmission systems
Irene Estébanez, IFISC

February 7
Modeling a minimal thermal diode
Celia Anteneodo , Department of Physics, PUC-Rio, Rio de Janeiro, Brazil

February 3
Interacting particle systems with mobility and demographic dynamics as biological models
Alejandro Almodovar, IFISC

February 3
Spatial memory in rats under non-life-threatening conditions
Jorge Medina, IFISC

February 2
Analysing multidimensional inequalities from housing and transport in Madrid
Jesús A. Moreno López, IFISC

February 2
Balearic power grid stability in scenarios with large photovoltaic generation
María Martínez-Barbeito, IFISC

February 1
Beyond simple dynamics: coevolutionary dynamics
Alessio Cardillo, UOC, Spain

January 27
Maximum Lyapunov Exponent for Temporal Networks
Annalisa Caligiuri, IFISC

January 25
Metaplex networks: influence of the exo-endo structure of complex systems on diffusion
Gissell Estrada, University of Oxford, UK.

January 18
Bounded Confidence: A deceptively simple model
Rainer Hegselmann, University of Bayreuth and Frankfurt School of Finance & Management, Germany

January 13
Inferring microbial interaction networks from abundance data
Somaye Sheykhali, Deutsche Bank, Germany

January 11
Oceanic big data for marine megafauna conservation
Jorge P. Rodriguez, Instituto Mediterráneo de Estudios Avanzados (IMEDEA), Spain

January 10
Quantum reservoir computing in finite dimensions
Rodrigo Martínez, IFISC

a.5. Publications

In the electronic version of this report, titles are hyperlinked to the summary and PDF file of the publications

a.5.1 Indexed Publications

Self-organized sulfide-driven traveling pulses shape seagrass meadows
Ruiz-Reynés, Daniel; Mayol, Elvira; Sintes, Tomàs; Hendriks, Iris E.; Hernández-García, Emilio; Duarte, Carlos M.; Marbà, N.; Gomila, Damià
Proceedings of the National Academy of Sciences 120, e2216024120

Network bypasses sustain complexity
Estrada, Ernesto; Gómez-Gardeñes, Jesús; Lacasa, Lucas
Proceedings of the National Academy of Sciences 120, e2305001120

Reconfigurable refraction manipulation at synthetic temporal interfaces with scalar and vector gauge potentials
Ye, Han; Qin, Chengzhi; Wang, Shulin; Zhao, Lange ; Liu, Weiwei; Wang, Bing; Longhi, Stefano; Lu, Peixiang
Proceedings of the National Academy of Sciences 120, e2300860120 (1-8)

Spatial immunization to abate disease spreading in transportation hubs
Mazzoli, Mattia; Gallotti, Riccardo; Privitera, Filippo; Colet, Pere; Ramasco, Jose J.
Nature Communications 14, 1448

A Lagrangian model for drifting ecosystems reveals heterogeneity-driven enhancement of marine plankton blooms
Ser-Giacomi, Enrico; Martinez-Garcia, Ricardo; Dutkiewicz, Stephanie; Follows, Micheal J.
Nature Communications 14, 6092

Time-resolved Coulomb collision of single electrons
Fletcher, J. D.; Park, W.; Ryu, Sungguen; See, P.; Griffiths, J. P.; Jones, G. A. C.; Farrer, I.; Ritchie, D. A.; Sim, H.-S.; Kataoka, M.
Nature Nanotechnology 18, 727-732

The role of complexity for digital twins of cities
Caldarelli, G; Arcaute, E; Barthelemy, M; Batty, M; Gershenson, C; Helbing, D; Mancuso, S; Moreno, Y; Ramasco, J J; Rozenblat, C; Sánchez, A; Fernández-Villacañas, J L
Nature Computational Science 3, p. 374-381

A zoom lens for networks
Klemm, Konstantin
Nature Physics 19, 318-319

Wearable sensors for monitoring marine environments and their inhabitants
Kaidarova, A.; Geraldi, N.R.; Wilson, R.P.; Kosel, J.; Meekan, M.G.; Eguíluz, V.M.; Hussain, M.M.; Shamim, A.; Liao, H.; Srivastava, M.; Saha, S.S.; Strano, M.S.; Zhang, X.; Ooi, B.S.; Holton, M.; Hopkins, L.W.; Jin, X.; Gong, X.; Quintana, F.; Tovasarov, A.; Tasmagambetova, A.; Duarte, C.M.
Nature Biotechnology 41, 9, p. 1208-1220

Photonic Floquet Landau-Zener tunneling and temporal beam splitters
Wang, Shulin; Qin, Chengzhi; Zhao, Lange; Ye, Han; Longhi, Stefano; Lu, Peixiang ; Wang, Bing
Science Advances 9, eadh0415 (1-10)

Many-Body Contributions in Water Nanoclusters
Abella, D.; Franzese, G.; Hernández-Rojas, J.
ACS Nano, 17, 3, p. 1959-1964

Quantum associative memory with a single driven-dissipative non-linear oscillator
Labay-Mora, Adrià; Zambrini, Roberta; Giorgi, Gian Luca
Physical Review Letters 19, 190602 (1-6)

Pulsed interaction signals as a route to biological pattern formation
Colombo, Eduardo H.; Lopez, Cristobal; Hernandez-Garcia, Emilio
Physical Review Letters 130, 058401 (1-5)

Breakdown of Random-Matrix Universality in Persistent Lotka-Volterra Communities
Baron, Joseph W.; Jewell, Thomas Jun; Ryder, Christopher; Galla, Tobias
Physical Review Letters 130, 137401

Experimental Optical Simulator of Reconfigurable and Complex Quantum Environment
Renault, P.; Nokkala, J.; Roeland, G.; Joly, N.Y.; Zambrini, R.; Maniscalco, S.; Piilo, Y.; Treps; N.; Parigi.P
Physical Review X Quantum 4, 040310

Quantum simulation of dissipative collective effects on noisy quantum computers
Cattaneo, Marco; Rossi, Matteo A. C.; García-Pérez, Guillermo; Zambrini, Roberta; Maniscalco, Sabrina
Physical Review X Quantum 4, 010324

Optimal storage capacity of quantum Hopfield neural networks
Bödeker, Lukas; Fiorelli, Eliana; Müller, Markus.
Physical Review Research 5, 023074

Optimal superconducting hybrid machine
Lopez, Rosa; Lim, Jong Soo; Kim, Kun Woo
Physical Review Research 5, 013038

Quantum-enhanced performance in superconducting Andreev-reflection engines
Manzano, Gonzalo; López, Rosa
Phys. Rev. Research 5, 043041

Self-consistent quantum measurement tomography based on semidefinite programming
Cattaneo, M.; Rossi, M.A.C.; Korhonen, K.; Borrelli, E.M.; García-Pérez, G.; Zimborás, Z.; Cavalcanti, D.
Physical Review Research, 5, 3, 033154

Scalable Photonic Platform for Real-Time Quantum Reservoir Computing
García-Beni, Jorge; Giorgi, Gian Luca; Soriano, Miguel C.; Zambrini, Roberta
Phys. Rev. Applied 20, 014051

Measuring the arrival time of an electron wave packet using a dynamical potential barrier
Park, Wanki; Sim, Heung-Sun; Ryu, Sungguen
Physical Review B 108, 195309

Absence of mobility edges in mosaic Wannier-Stark lattices
Longhi; Stefano
Physical Review B 108, 064206 (1-8)

Phase transitions and bunching of correlated particles in a non-Hermitian quasicrystal
Longhi; Stefano
Physical Review B 108, 075121 (1-12)

Conductance asymmetry in proximitized magnetic topological insulator junctions with Majorana modes
Di Miceli, Daniele; Zsurka, Eduard; Legendre, Julian; Moors, Kristof; Schmidt, Thomas L., Serra, Llorenç
Physical Review B 108, 35424 (1-11)

Superconductor-quantum dot hybrid coolers
Hwang, S.-Y.; Söthmann, B.; Sánchez, D.
Physical Review B 107, 245412 (1-9)

Phase transitions in non-Hermitian superlattices
Longhi; Stefano
Physical Review B 107, 134203 (1-14)

Complex Berry phase and imperfect non-Hermitian phase transitions
Longhi; Stefano; Feng, Liang
Physical Review B 107, 085122 (1-14)

Lyapunov Exponents for Temporal Networks
Caligiuri, Annalisa; Eguiluz, Victor; Di Gaetano, Leonardo; Galla, Tobias; Lacasa, Lucas
Physical Review E 107, 044305

Inverse percolation by removing straight semirigid rods from bilayer square lattices
Pimentel, F.M.L.; De La Cruz Félix, N.; Ramirez, L.S.; Ramirez-Pastor, A.J.
Physical Review E 107, 064128

Random sequential adsorption of self-avoiding chains on two-dimensional lattices
Ramirez, L S; Pasinetti, P. M.; Ramirez-Pastor, A.J.
Physical Review E 107, 064106

Network percolation provides early warnings of abrupt changes in coupled oscillatory systems: An explanatory analysis
Ehstand,Noémie; Donner,Reik V.; López,Cristóbal; Hernández-García, Emilio
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Noisy voter models in switching environments
Caligiuri, Annalisa; Galla, Tobias
Physical Review E 108, 044301

Quantifying the diversity of multiple time series with an ordinal symbolic approach
Zunino, Luciano; Soriano, Miguel C.
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Niche overlap and Hopfield-like interactions in generalized random Lotka-Volterra systems
Rozas Garcia, Enrique; Crumpton, Mark J; Galla,Tobias
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Physical Review E 108, 054106

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Arola-Fernández, Lluís; Lacasa, Lucas
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Physical Review E 107, 035306

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Poley, Lyle; Baron, Joseph W.; Galla, Tobias
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Abella, David; San Miguel, Maxi; Ramasco, José J.
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Di Miceli, Daniele; Serra, Llorenç
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Online quantum time series processing with random oscillator networks
Nokkala; Johannes
Scientific Reports 13, 7694

A hybrid classical-quantum approach to speed-up Q-learning
A. Sannia, A. Giordano, N. Lo Gullo, C. Mastroianni, F. Plastina
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Network coevolution drives segregation and enhances Pareto optimal equilibrium selection in coordination games
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Ortín, Silvia; Soriano, Miguel Cornelles; Tetzlaff, Christian; Wörgötter, Florentin; Fischer, Ingo; Mirasso, Claudio Rubén.; Argyris, Apostolos
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Pinotti, Ermanno; Longhi, Stefano
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Min, Byungjoon; San Miguel, Maxi
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Longhi; Stefano
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Optics Letters 48 (9), 2449-2452

Anderson localization without eigenstates in photonic quantum walks
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Optics Letters 48, 2445-2448

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Goldmann, Mirko; Fischer, Ingo ; Mirasso, Claudio R.; Soriano, Miguel C.
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Klemm, Konstantin; Martens, Erik Andreas
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Olivares, Felipe; Zunino, Luciano; Zanin, Massimiliano
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Longhi; Stefano
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Endemic infectious states below the epidemic threshold and beyond herd immunity
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Communications Physics 6, 187

Stochastic Entropy Production:

Fluctuation Relation and Irreversibility Mitigation in Non-unital Quantum Dynamics
Fiorelli, Eliana; Gherardini, Stefano; Marcantoni, Stefano.
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Journal of the Air Transport Research Society 1, 63-80

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Onsaker, Thorbjørn Lund; Nygård, Heidi S.; Gomila, Damià; Colet, Pere; Mikut, Ralf; Jumar, Richard; Maass, Heiko; Kühnapfel, Uwe; Hagenmeyer, Veit; Schäfer, Benjamin
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A multisource transportation network model explaining allometric scaling
Jia, X.Y.; Liu, E.J.; Yang, Y.; Yan, X.Y.
Journal of Statistical Mechanics: Theory and Experiment, 8, 083404

Effect of global warming on Western Mediterranean seagrasses: a preliminary agent-based modelling approach
Llabrés, Eva; Blanco-Magadán, Aina; Sales, Marta; Sintes, Tomas
Marine Ecology Progress Series 710, 43-56

Degree-day-based model to predict egg hatching of Philaenus spumarius (Hemiptera: Aphrophoridae), the main vector of Xylella fastidiosa in Europe
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A Lagrangian study of summer upwelling along the Uruguayan coast
de Mello, Camila; Barreiro, Marcelo; Hernandez-Garcia, Emilio; Trinchina, Romina; Manta, Gaston
Continental Shelf Research 258, 104987 (1-11)

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Humanities & Social Sciences Communications 10, 133

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Martin, Andres; Estrada, Ernesto
Mathematics 11, 1-13

Neural network learning with photonics and for photonic circuit design
Brunner, D.; Soriano, M. C.; Fan, S.
Nanophotonics 12, 773-775

Electrostatic Tuning of Bilayer Graphene Edge Modes
Ali, Hira; Serra; Llorenç
Nanomaterials 13, 2102 (1-9)

Time-Series Quantum Reservoir Computing with Weak and Projective Measurements
Mujal, Pere; Martínez-Peña, Rodrigo; Giorgi, Gian Luca; Soriano, Miguel C.; Zambrini, Roberta
NPJ, Quantum Information 9, 16

Measuring landing independence and interactions using statistical physics
Olivares, Felipe; Sun, Xiaoqian; Wandelt, Sebastian; Zanin, Massimiliano
Transportation Research Part E: Logistics and Transportation Review 170, 102998

Structure, resilience and evolution of the European Air Route Network from 2015 to 2018
Esteve, Pau; Ramasco, Jose J.; Zanin, Massimiliano
IEEE Transactions on Network Science and Engineering 10 (4), 2045-2058

Dynamical Model for Power Grid Frequency Fluctuations: Application to Islands with High Penetration of Wind Generation
Martínez-Barbeito, María; Gomila, Damià; Colet, Pere
IEEE Transactions on Sustainable Energy , 1-10

Understanding small-scale COVID-19 transmission dynamics with the Granger causality test
Romero García, Carolina; Briz-Redón, Álvaro; Iftimi, Adina; Lozano, Manuel; De Andrés, José; Landoni, Giovanni; Zanin, Massimiliano
Archives of Environmental & Occupational Health 78 (5), 273-281

Analysis of the blackout risk reduction when segmenting large power systems using HVDC lines
Gomila, D.; Carreras, B.A.; Reynolds-Barredo, J.M.; Colet, P.; Gomis-Bellmunt, O.
International Journal of Electrical Power & Energy Systems 148, 108947

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SIAM Journal on Applied Dynamical Systems 22, 2693-2731

Every nonsingular spherical Euclidean Distance Matrix is a resistance distance matrix
Estrada, Ernesto
Linear Algebra and its Applications 656, 198-209

Local and Network-Wide Time Scales of Delay Propagation in Air Transport: A Granger causality Approach
Pastorino, Luisina; Zanin, Massimiliano
Aerospace 10 (1), 36

Propagation of Interactions among Aircraft Trajectories: A Complex Network Approach
López-Martín,Raúl; Zanin,Massimiliano
Aerospace 10, 213

Secondary frequency control stabilising voltage dynamics
Tchawou Tchuisseu, Eder Batista; Dongmo, Eric Donald; Procházka, Pavel; Woafo, Paul; Colet, Pere; Schäfer, Benjamin
European Journal of Applied Mathematics , 1-17

Biodiversity dynamics in landscapes with fluctuating connectivity
Marco Palamara, G.; Rozenfeld, A.; de Santana, C.N.; Klecka, J.; Riera, R.; Eguíluz, V.M.; Melián, C.J.
Ecography 2023, e06385

Bulk-boundary eigenvalues for bilaplacian problems
Buoso, D.; Falcó, C.; del Mar González, M.; Miranda, M.
Discrete and Continuous Dynamical Systems- Series A, 43, p. 1175-1200

Dynamics of a chain of unidirectionally coupled non-identical Van der Pol oscillators with a sinusoidal input at the first node
Tchakui, M.V.; Woafo, P.; Gomila, D.; Colet, P.
Pramana - Journal of Physics 97, 3, 126

Editorial to the Special Issue “ Information Processing in Neuronal Circuits and Systems&rdquo
Valizadeh, A.; Mirasso, C.
Biology, 12, 3, 359

Relationships of life satisfaction with commuting and built environment: A longitudinal analysis
Wang, X.; Wang, W.; Yin, C.; Shao, C.; Luo, S.; Liu, E.
Transportation Research Part D: Transport and Environment, 114, 103513

a.5.2. Other Publications

Calidad del aire: avances y mejores prácticas
Ramasco, JJ
Informes de la Oficina de Ciencia del Congreso de los Diputados

Algoritmos de agrupamiento y lingüística de corpus: ortografía y léxico en documentos mallorquines del siglo XVIII
Louf, T.; Sánchez, D.; Miguel Franco, R.
Scripta manent. Historia del español, documentación archivística y humanidades digitales (edited by Calderón Campos, M. and González Sopeña, I.) p. 563-586

Thermoelectric energy harvesting with nanomaterials
Amado, M.; Domínguez-Adame, F.; Sánchez, D.
Sustainable Nanomaterials for Energy Applications (edited by Cremades, A. and Maestre, D.) 7 (1-48)

Análisis estadístico del contacto entre lenguas: El caso de las grafías b y v en la documentación en castellano de Mallorca (siglo XVIII)
Miguel Franco, Ruth; Sánchez, David
Spanish in Context 20, 1-25

The physics of languages
Patriarca, M.; Heinsalu, E.; Sánchez, D.
Physics World, 36, 8, p. 25-29

A Merced de las Redes
Estrada, Ernesto
Editorial Universo de Letras del Grupo Planeta

Caos, orden y otras movidas del universo: la física que no conocías.
García Candel, Adrián.
Ed. Oberon.

a.6. Presentations at conferences and academic centers

a.6.1 Invited talks at conferences and workshops

Dendritic-like computation using optical fibres.
Rank Symposium on Neuromorphic Photonics, Grasmere, UK.
Soriano, Miguel Cornelles
February 6 - 9

Quantum Reservoir Computing.
Quromorphic Winter Workshop 2023, Erlangen, Germany.
Zambrini, Roberta
February 14 - 16

Non-Gaussian random matrices predict the stability of feasible Lotka-Volterra communities.
APS March Meeting, Las Vegas, USA. (online)
Galla, Tobias; Baron, Joseph W.; Jewell Jun T; Ryder, Cris
March 21

Deep Learning in Neuroscience: going beyond classification tasks.
1st International Computational Neuroscience Symposium.Istanbul.
Zanin, Massimiliano
April 15

Fluctuation relation and irreversibility mitigation in thermalizing quantum dynamics.
QSAIL 2023, Isola d'Elba, Italy.
Fiorelli, Eliana; Gherardini, Stefano; Marcantoni, Stefano.
May 14 - 20

Emergence and Dynamics of Prediction Error Neurons in Mouse Primary Visual Cortex.
Brazilian Physics Society Autumn Meeting, Ouro Preto, Brazil.
Mirasso, C.
May 21 - 25

Conductance of electrostatic wire junctions in bilayer graphene.
EMRS-2023 Spring Meeting (European Materials Research Society), Strasbourg France.
Serra, Llorenç
May 29 – June 2

Quantum-enhanced performance in superconducting Andreev-reflection engines.
First I-Link workshop (LINKB20072) on Novel Trends in Topological Systems and Quantum Thermodynamics. IFISC, Palma, Spain.
Manzano, Gonzalo
June 5 - 6

Characterizing migration with Twitter data,.
Workshop " Data for the Wellbeing of the most Vulnerable" part of the International AAAI Conference on Web and Social Media (ICWSM), hold in Pyrgos, Limassol, Cyprus.
Ramasco, JJ
June 5

Quantum associative memory with a single driven-dissipative non-linear oscillator.
Numerical Computations: Theory and Algorithms NUMTA 2023 . Pizzo Calabro, Italy.
Giorgi, Gian Luca
June 14 - 20

Benchmarking the role of particle statistics in Quantum Reservoir Computing.
NUMTA - Numerical computations: Theory and Algorithms, Calabria, Italy.
Guillem Llodrà, Christos Charalambous, Gian Luca Giorgi, Roberta Zambrini
June 16

Lagrangian betweenness: connecting network theory, dynamical systems and fluid flows.
Nolineal2023, 13th Conference on Nonlinear Mathematics and Physics. Centre de Recerca Matematica, Univ. Autonoma de Barcelona, Spain.
Hernandez-Garcia, Emilio
June 26

Linear/ non linear analysis of EEG in dementia.
Erol Basar's legacy 5 years from his last travel: EEG biomarkers of vigilance and cognitive disorders in Alzheimer's, Parkinson's and Lewy body diseases. At IOP 2023 Conference, Geneva.
Zanin, Massimiliano
June 26 – 30

Hardware sostenible.
Escuela de verano AI-HUB, CSIC. Barcelona, Spain.
Argyris, Apostolos
July 3 - 7

Vector-borne epidemics driven by human mobility.
Lipari Summer School SECS-2023, Lipari, Italy.
Meloni, Sandro
July 3 – 9

Monitoring time series processing.
23th Central European Workshop on Quantum Optics, CEWQO23, Milan, Italy.
Zambrini, Roberta
July 3 - 7

Neuromorphic and quantum computing.
WOQE 23, first international workshop on quantum ecology. Leysin, Switzerland.
Zambrini, Roberta
July 5 – 7

Physical reservoir computing: advancements and applications in photonic reservoir computing.
Netsci 2023. Viena, Austria.
Ortín, Silvia
July 10 – 14

How to achieve maximum frustration during your PhD.
NetPLACE session, NetSci conference, Vienna.
Galla, Tobias
July 11

Photonic reservoir computing using time-multiplexed systems with classical and quantum resources.
2nd Workshop on "Neuromorphic photonics and applications", University of West Attica, Athens, Greece.
Soriano, Miguel Cornelles
July 13 - 14

The interplay of motion and spatial nonlocal competition.
Summer School on Mathematics of Movement. Cambridge, UK.
López, Cristóbal
July 17 - 21

Backtracking, walking backwards to reach further.
Statistical Physics @ 65, IFISC, Palma de Mallorca, Spain.
Toral, Raúl
July 21

The significance of quantum effects in optimizing engine performances.
Quantum Thermodynamics 2023 Conference Wien, Austria.
Rosa López, Gonzalo Manzano, Kun Woo Kim, Jong Soo Lim
July 21

Link-Node co-evolution dynamics.
New Frontiers in Complex Networks, KIAS Conference, Asia Pacific center for Theoretical Physics, Pukyong National University, Busan, Korea.
San Miguel, Maxi
August 2 - 6

Competitive non-local interactions as a route to pattern formation.
StatPhys28, the 28th International Conference on Statistical Physics. Tokyo, Japan.
Hernandez-Garcia, Emilio
August 7 - 11

Ecology of online social interactions.
3rd latin-american conference on complex networks, LANET 2023, Cusco, Perù.
Meloni, Sandro
August 21 - 25

Spatial immunization to abate disease spreading in transportation hubs.
3rd latin-american conference on complex networks, LANET 2023, Cusco, Perù.
Ramasco, JJ
August 21 – 25

Blackout risk reduction by segmenting large power grids with controllable HVDC lines.
Statphys28 Satellite on Dynamics On and Of Complex Networks: Cascading Failures in Complex Networks Tokio, Japan.
Colet, Pere
August 28 - 29

Probabilities in physics, paradoxes and populations.
Conference of Germany Physical Society, Germany.
Galla, Tobias
September 4

Link-node co-evolution dynamics.
Insight workshop on netwrok models and processes, SFI research center for Data Analytics, University College Dublin, Ireland.
San Miguel, Maxi
September 5

Vision vs. Inhibition: The Cortical Duel during Visual Flow Perturbations.
4th Symposium of the Spanish Network for the Interaction between Computational and Cognitive Neuroscience (SINC2), Granada, Spain.
Mirasso, C.
September 8

Quantum associative memory with a single driven-dissipative non-linear oscillator.
"Quantum 2023" From Foundations of Quantum Mechanics to Quantum Information and Quantum Metrology \& Sensing. Turin, Italy.
Giorgi, Gian Luca
September 11 - 15

Time-multiplexed photonic systems for information processing.
Artificial Intelligence Photonics 2023, San Sebastián, Spain.
Soriano, Miguel Cornelles
September 11 - 14

Photonic Quantum reservoir computing.
Artificial Intelligence Photonics 2023, San Sebastián, Spain.
Zambrini, Roberta
September 11 – 14

Generation of rare events in stochastic systems.
36th Marian Smoluchowski Symposium, Cracovia, Poland.
Toral, Raúl
September 24 - 28

Epidemic modeling: simple models with practical implications.
Physics of Data and Societal Challenges Workshop 2023, Asiago, Italy.
Meloni, Sandro
September 25 – 27

Spatial immunization to abate disease spreading in transportation hubs.
Workshop " The scales of epidemic modeling" organized by the Institute of Complex Systems of Paris, the INSERM and the Pasteur Institute, hold in Paris, France.
Ramasco, JJ
September 26

Thermodynamics of Gambling Demons.
4th Workshop on Statistical Physics 2023, Bogotá, Colombia.
Manzano, Gonzalo.
October 2 - 6

Descifrando la complejidad microbiana.
II Jornadas sobre Avances en el Estudio de la Microbiota y Sistemas Acuáticos y I Workshop sobre el Estudio de la Microbiota en Ambientes Acuáticos. Universidad de Málaga, Spain.
Fernández-Gracia, Juan; Herrada, Alex
October 5 - 6

Conservative vs. Nonconservative diffusion towards a target in a networked enviroment
Discrete Probablility Days, Centre de Recerca Matemàtica, CRM, Barcelona, Spain
Estrada, Ernesto
October 16 – 20

Urban mobility and liveability.
UBD Policy Workshop on Cities, form, environmental exposures and health impacts , hold in Sitges, Spain.
Ramasco, JJ
October 24 -25

Mechanisms behind collective social phenomena.
FisEs´ 23, XXIV Congreso de Fisica Estadistica, Pamplona, Spain.
San Miguel, Maxi
October 25 - 27

Quantum complex systems for machine learning.
FisEs´ 23, XXIV Congreso de Fisica Estadistica, Pamplona, Spain
Zambrini, Roberta
October 25 - 27

The use of mobility data for improving city livability.
International Conference on Smart and Sustainable Cities Colombia\– ICSSC 2023, online, hold in Bogotá, Colombia.
Ramasco, JJ
November 2

Phase transitions in persistent and run-and-tumble walks.
Workshop Modelling non-Markov Movement Processes, Isaac Newton Institute, Cambridge, UK.
Toral, Raúl
November 6 - 10

Time and space generalized diffusion on graphs
Fractional Differential Equations, Applications and Complex Networks
Estrada, Ernesto
November 27 – December 1st

Ultrafast Information Processing with Delay-Coupled Semiconductor Lasers.
International Symposium on Physics and Applications of Laser Dynamics 2023 (IS-PALD 2023), Metz, France.
Soriano, Miguel Cornelles
November 29 – December 1st

Pattern formation in Posidonia meadows.
Cameroon Physical Society 7th International Conference on "High Level Physics and Appropriate Solutions to Real Life Problems in Developing Countries" Dchang, Cameroon.
Gomila, Damià
December 5 - 8

Power grid frequency fluctuations in scenarios of large penetration of variable renewables.
Physical Society. 7th International Conference on High Level Physics and Appropriate Solutions to Real Life Problems in Developing Countries, Cameroon.
Colet, Pere
December 5 – 8

Estimation of Shannon entropy from finite sample data with applications to systems with memory.
Mini-workshop of entropies for complex processes, Mathematical Institute of the Serbian Academy of Sciences and Arts, Serbia, and L'institut CY Advanced Studies, CY Cergy Paris Université, France.
Toral, Raúl
December 9

Métodos de lingüística cuantitativa para humanidades y variación de lengua.
Docencia e investigación lingüística en la era de la inteligencia artificial. Logroño, Spain.
Sánchez, D.
December 12 - 13

a.6.2 Other talks at conferences and workshops

Hybrid-coherent reservoir computing for 200 km PAM-4 transmission links.
SPIE Photonics West, San Francisco, USA.
Talandier, Lucas; Fischer, Ingo; Argyris, Apostolos
January 28- February 2

Few-mode fibers as optical dendrites for 40 Gbps computing.
SPIE Photonics West, San Francisco, USA.
Ortín, Silvia; Soriano, Miguel Cornelles; Fischer, Ingo; Mirasso, Claudio R.: Argyris, Apostolos
January 28- February 2

HCG VCSELs as one-device gas detectors.
Photonics West 2023, San Francisco, USA.
M. Marciniak, Ł. Piskorski, W. Głowadzka and T. Czyszanowski
January 28- February 2

Integrated optical output layer for a reservoir computer based on frequency multiplexing.
SPIE Photonics West, San Francisco, USA.
Jonuzi, Tigers; Lupo, Alessandro; Soriano, Miguel Cornelles; Domenech, David; Massar, Serge
January 28- February 2

Periodically driven chiral engine beyond the Carnot limit.
XII Reunión de la División de Física de la Materia Condensada de la RSEF (GEFES2023, Salamanca), Spain.
Ryu, Sungguen; López, Rosa; Serra, Llorenç; Sánchez, David
February 1 - 3

Dynamics of seagrass meadows with two species.
Dynamical systems applied to biology and natural sciences DSABNS 2023. Bilbao, Spain.
Moreno-Spiegelberg, Pablo
February 5 – 8

A percolation framework to anticipate fast changes in irregular climate oscillations.
Conference "Nonlinear Data Analysis and Modeling: Advances, Applications, Perspectives", Potsdam, Germany.
Ehstand, Noémie; Donner, Reik V.; López, Cristóbal; Hernández-García, Emilio
March 15 - 17

Towards a robust Majorana platform based on magnetic topological insulator nanoribbons.
APS March meeting 2023, Las Vegas, NV., USA.
Schmidt, T.L.; Di Miceli, D.; Serra, L., et al.
March 20 - 22

Order-disorder transition in the zero-temperature Ising model on random graphs.
DPG Spring Meeting, Dresden, Germany.
Pournaki, Armin; Olbrich, Eckehard; Banisch, Sven; Klemm, Konstantin
March 26 - 31

Exact statistical mechanics of spin models on networks.
DPG Spring Meeting, Dresden, Germany.
Klemm, Konstantin
March 26 – 31

Study and implementation of optical dendritic units.
XI Ibero-American Conference on Optics XIV Latin-American Meeting on Optics, Lasers, and Applications, San José, Costa Rica.
Mirasso, C., Ortín, S., Pflüger, M.; Soriano, M. C.; Fischer, I., Argyris, A. A
March 27 – 31

Assessing blackout risk with high penetration of variable renewable energies.
Trobada científica sobre dinàmica complexa de xarxes elèctriques, Palma de Mallorca, Spain.
Colet, Pere
April 20 - 21

Power grid frequency fluctuations and smart devices with dynamic demand control.
Trobada científica sobre dinàmica complexa de xarxes elèctriques, Palma de Mallorca, Spain.
Gomila, Damià
April 20 - 21

Frequency fluctuations and stability of power grids with a large renwables penetration ratio.
Trobada científica sobre dinàmica complexa de xarxes elèctriques, Palma de Mallorca, Spain.
Martínez-Barbeito, María
April 20 - 21

Networking the Species-Functions in Ecosystems.
14th Congress on Complex Networks. Aveiro, Portugal.
Cuevas-Blanco, Mar; Hervías-Parejo, Sandra; M. Eguíluz, Víctor; Lacasa, Lucas; Donoso, Isabel; Travesser, Ana
April 25 - 28

Worlwide multiscale analysis of coral reefs.
Coral growth rates and marine landscapes Workshop II. Palma de Mallorca, Spain.
Giménez-Romero, Àlex;
May 2

New simple model for pattern formation in coral reefs.
Coral Growth Rates and marine landscapes Workshop II. Palma de Mallorca, Spain.
Álvarez-Alegría, Miguel; Matías, Manuel A.; Gomila, Damià.
May 3

Network science meets history: local balance in global international relations.
Spanish Chapter of the Complex Systems Society, Santander, Spain
Diaz-Diaz, Fernando; Bartesaghi, Paolo; Estrada, Ernesto
May 4 – 5

Aging in Complex Contagion Models.
1rst Meeting of the Spanish Chapter of the Complex System Society. Santander, Spain.
Abella, David
May 4

Cultural regions from regional patterns of topic variation: The American case.
First Meeting of the Spanish Chapter of the Complex Systems Society. Santander, Spain.
Sánchez, D.
May 4 – 5

Disentangling epidemics: a multiplex structure perspective.
Spanish Chapter of the Complex Systems Society (CS3), Santander, Spain.
Arregui-García, Beatriz; Meloni, Sandro
May 4 - 5

Housing and Transport: Analysing multidimensional inequalities from data and infrastructure in Madrid.
1st meeting of the Spanish Chapter of the Complex Systems Society (CS3) in Santander, Spain.
Moreno López, Jesús A.
May 4 - 5

Reducing blackout risk by segmenting the European power grid with HVDC lines.
1st Meeting of the Spanish Chapter of the Complex Systems Society, CS3, Santander, Spain.
Colet, Pere; Gomila, Damiá; Carreras, Benjamín A., Reynolds-Barredo, José M., Martínez-Barbeito, María; Gomís-Bellmunt, Oriol
May 4 - 5

Beating Carnot efficiency with periodically driven chiral conductors.
The 17th Capri Spring School on Transport in Nanostructures, Capri, Italy.
Ryu, Sungguen; López, Rosa; Serra, Llorenç; Sánchez, David
May 7 – 14

Bifurcation Structure of Traveling Pulses in Type-I Excitable Media.
SIAM Conference on Applications of Dynamical Systems (DS23). Portland, Oregon, U.S.A.
Moreno-Spiegelberg, Pablo
May 14 - 18

Aging in the Threshold model.
FisEs Joven Congress 2023. (online).
Abella, David
May 16

Vector-borne diseases with non-stationary vector populations.
FisEs Joven (Online).
Giménez-Romero, Àlex; Flaquer-Galmés, Rosa; Matías, Manuel A.
May 16 – 17

Entropy estimation for Markovian sequences.
FisEs Joven'23 (online).
De Gregorio, Juan; Sánchez, David; Toral, Raúl
May 16

Disentangling epidemics: a multiplex structure perspective.
FISES Joven 2023 - Comunicación online.
Arregui-García, Beatriz; Meloni, Sandro
May 16 – 17

Distinguishing chaos from noise: a deep learning approach to nonlinear time series analysis.
FisEs Joven 23 (Online).
Esteve, Pau; Zanin, Massimiliano
May 16 – 17

Quantum reservoir computing in finite dimensions.
Quantum information in Spain (ICE-8), Santiago de Compostela, Spain.
Rodrigo Martínez Peña, Juan Pablo Ortega
May 29 – June 1

Quantum-enhanced performance in superconducting Andreev-reflection engines.
XXVII Sitges Conference on Statistical Mechanics. Sitges, Spain.
Manzano, Gonzalo
May 29 – June 2

Coherence for quantum-enhanced thermodynamic performance in steady-state quantum thermal machines.
XXVII Sitges Conference on Statistical Mechanics. Nonequilibrium Phenomena: from Quantum to Macroscopic Scales. Sitges, Spain.
Lopez, Rosa
May 29 – June 2

Bifurcations and multistability in adaptive vascular networks.
Developing a mathematical theory for co-evolutionary dynamical networks, Lund, Sweden.
Klemm, Konstantin
May 30 – 31

New simple model for pattern formation in coral reefs.
Resilience and recovery in aquatic systems. ASLO Aquatic Sciences Meeting 2023 - Palma de Mallorca, Spain.
Álvarez-Alegría, Miguel; Matías, Manuel A.; Gomila, Damià.
June 4 - 9

Connectivity bottlenecks in ocean flows characterized by the Lagrangian betweenness.
Resilience and recovery in aquatic systems. ASLO Aquatic Sciences Meeting 2023. Palma de Mallorca, Spain.
Hernandez-Garcia, E.
June 5

Topological Superconductivity and Majorana Modes in Magnetic Topological Insulators.
First I-Link workshop (LINKB20072) on Novel Trends in Topological Systems and Quantum Thermodynamics. IFISC, Palma, Spain.
Di Miceli, Daniele
June 5 - 6

The effects of coherence in quantum absorption refrigerators.
I-Link workshop (LINKB20072). Novel Trends in Topological Systems and Quantum Thermodynamics, Palma de Mallorca, Spain.
Lopez, Rosa
June 5 – 6

Marine currents shape coral reefs: a simple agent-based model for pattern formation.
ASLO 2023, Palma de Mallorca, Spain.
Llabres, Eva; Sintes, Tomas
June 9

Topologically-induced suppression of explosive synchronization on graphs.
25th Conference of the International Linear Algebra Society, Madrid, Spain.
Miranda, Manuel; Frasca, Mattia; Estrada, Ernesto
June 12 – 16

Generalized diffusion equation on graphs/networks.
25th Conference of the International Linear Algebra Society, Madrid, Spain.
Diaz-Diaz, Fernando; Estrada, Ernesto
June 12 – 16

Air transport from a complex network perspective: Insights into mobility and delay propagation.
VIII Mediterranean School of Complex Networks. Catania, Italy.
Esteve, Pau; Zanin, Massimiliano
June 25 - 30

Language dynamics within adaptive networks: An agent-based approach of nodes and links coevolution.
VIII Mediterranean School of Complex Networks, Catania, Italy.
Christos Charalambous, David Sanchez, Raul Toral
June 25 - 30

Phase vs. Intensity Encoding in an Experimental Time Delay Reservoir Computing Scheme.
CLEO Europe / World of Photonics Congress. Munich, Germany.
Estébanez, Irene; Talandier, Lucas; Fischer, Ingo; Argyris, Apostolos
June 26 - 30

Speeding Up a Time-Delay Photonic Reservoir.
CLEO Europe / World of Photonics Congress. Munich, Germany.
Goldmann, Mirko; Estebanez, Irene; Vlieg, Elger A.; Mirasso, Claudio R. ; Fischer, Ingo; Argyris, Apostolos; Soriano, Miguel Cornelles
June 26 – 30

An Evolutionary Game Theory Analysis of Human-AI populations.
Complexity72H. Palma de Mallorca, Spain.
Moreno López, Jesús A.
June 26 – 30

Network science meets history: local balance in global international relations.
International School and Conference on Network Science. NetSci23, Vienna, Austria.
Diaz-Diaz, Fernando; Bartesaghi, paolo; Estrada, Ernesto
July 10 - 15

Lyapunov Exponents for Temporal Networks.
International School and Conference on Network Science. NetSci23. Vienna, Austria.
Caligiuri, Annalisa; Eguíluz, Victor M.; Di Gaetano, Leonardo; Galla, Tobias; Lacasa, Lucas
July 10 - 14

The architecture of multifunctional ecological networks.
International School and Conference on Network Science. NetSci 2023.Viena, Austria.
Cuevas-Blanco, Mar; Hervías-Parejo, Sandra; Donoso, Isabel; Traveset, Ana; Lacasa, Lucas; M. Eguíluz, Víctor
July 10 - 14

Mobility Rhapsody: Unleashing the Power of Deep Learning and XAI to Decode Urban Flows at City Scale.
International School and Conference on Network Science (NetSci2023), Viena, Austria.
Velásquez-Rojas, Fátima
July 10 - 14

Aging in Complex Contagion Models.
International School and Conference on Network Science (NetSci2023) Viena, Austria.
Abella, David
July 12

Numerical sampling rare of rare trajectories using stochastic bridge.
28th International Conference on Statistical Physics STATPHYS28. Tokyo, Japan.
Toral, Raúl
August 7 - 11

Order and entropy estimation of discrete Markov systems.
28th International Conference on Statistical Physics STATPHYS28. Tokyo, Japan.
Sánchez, David
August 7 - 11

Local and Global Ordering dynamics in the Voter Model with Multiple Opinion States.
28th International Conference on Statistical Physics STATPHYS28. Tokyo, Japan.
Lucia Ramirez, Maxi San Miguel, Tobias Galla
August 7 - 11

Online learning strategies for optical neural networks.
SPIE - Emerging Topics in Artificial Intelligence. San Diego, USA.
Goldmann, Mirko; Skalli,Anas; Brunner, Daniel
August 18 - 22

HBP SGA3 Workshop: Roles of dendrites for computing and learning in cortical microcircuit models.
Workshop on exploring state of art evidence for dendrites role in information processing. Sankt Gilgen, Salzburgo, Austria
Galván Fraile, Javier
September 3 - 7

Bifurcation Structure of Traveling Pulses in Type-I Excitable Media.
XLIII Dynamics Days Europe. Naples, Italy.
Moreno-Spiegelberg, Pablo
September 3 – 9

Conductance asymmetry in proximitized magnetic topological insulator junctions with Majorana modes.
CMD30 - FisMat 2023. Milan, Italy.
Di Miceli, Daniele
September 4 - 8

Lyapunov Exponents for Temporal Networks.
XLIII Dynamics Days Europe. Naples, Italy.
Caligiuri, Annalisa; Eguíluz, Victor M.; Di Gaetano, Leonardo; Galla, Tobias; Lacasa, Lucas;
September 3 - 9

Emergence of collective learning in coupled neural networks.
XLIII Dynamics Days Europe. Naples, Italy.
Arola Fernández, Lluís; Lacasa, Lucas
September 3 - 9

Dissipation as a resource for Quantum Reservoir Computing.
Frontiers of Neuromorphic Computing, Erlangen, Germany.
Antonio Sannia, Rodrigo Martínez-Peña, Miguel C. Soriano, Gian Luca Giorgi, and Roberta Zambrini
September 5 - 7

Predictability and memory of discrete sequences.
XLIII Dynamics Days Europe. Naples, Italy.
De Gregorio, Juan; Sánchez, David; Toral, Raúl
September 7

Lexical differentiation of flamenco genres using machine learning.
17th Granada Seminar. Granada, Spain.
Rosillo-Rodes, Pablo; San Miguel, Maxi; Sanchez, David
September 12

Engineered dissipation to mitigate barren plateaus.
17th Granada Seminar. Granada, Spain.
Antonio Sannia, Francesco Tacchino, Ivano Tavernelli, Gian Luca Giorgi, and Roberta Zambrini
September 12 – 15

VCSELs with noncircular optical apertures.
VCSEL Day 2023, Torino, Italy.
M. Marciniak, M. Janczak, M. Gębski, M. Więckowska, M. Pflüger, M. Wasiak, M. Dems, J. A. Lott, I. Fischer, T. Czyszanowski
September 22

Inferring unseen complex dynamics of a semiconductor laser subject to feedback with a digital twin.
International Symposium on Nonlinear Theory and Its Application, NOLTA, Catania, Italy.
Goldmann, Mirko; Mirasso, Claudio R.; Fischer, Ingo; C. Soriano, Miguel;
September 25 - 29

Does big data help answer big questions? The case of airport catchment areas & competition.
Complex Systems CCS2023. Salvador de Bahia, Brazil.
Ramasco, JJ
October 16 - 20

Physical implementation of a deep recurrent neural network folded in time.
International Conference on Neuromorphic, Natural and Physical Computing (NNPC 2023), Hannover, Germany.
Soriano, Miguel Cornelles; Gallicchio, Claudio
October 25 – 27

Dynamical Model for Power Grid Frequency Fluctuations: Application to Islands with High Penetration of Renewables.
XXIV Congreso de Física Estadística FISES 2023. Pamplona, Spain.
Martínez-Barbeito, María; Gomila, Damià; Colet, Pere
October 25 - 27

The architecture of multifunctional ecological networks.
Fises Joven (online). Pamplona, Spain.
Cuevas-Blanco, Mar; Hervías-Parejo, Sandra; Donoso, Isabel; Traveset, Ana; Lacasa, Lucas; M. Eguíluz, Víctor
October 25 - 27

Variational Approach to the KPZ Equation: Myths-Busting and Some Results.
Modelling non-Markov Movement Processes Issac Newton Institute, Univ. Cambridge, UK.
H.S.Wio, R.R. Deza, R.Gallego, R.Garcia-Garcia, J.A. Revelli, M.A.Rodriguez
November 6 - 10

Modeling Xf diseases: transmission dynamics, global spatiotemporal risk predictions and design of control strategies.
Conferencia Internacional sobre Xylella fastidiosa. Madrid, Spain.
Giménez-Romero, Àlex; Lago, Clara; Moralejo, Eduardo; Fereres, Alberto; Matías, Manuel A.
November 14

a.6.3 Poster presentations

Vector-borne diseases with non-stationary vector populations: the case of growing and decaying populations.
14th Conference on Dynamical Systems Applied to Biology and Natural Sciences (DSABNS 2023) – Bilbao, Spain.
Giménez-Romero, Àlex; Flaquer-Galmés, Rosa; Matías, Manuel A.
February 5 - 8

New simple model for pattern formation in coral reefs.
14th Conference on Dynamical Systems Applied to Biology and Natural Sciences (DSABNS 2023) – Bilbao, Spain.
Álvarez-Alegría, Miguel; Matías, Manuel A.; Gomila, Damià
February 5 - 8

Local characterization of transient chaos on finite times in open systems.
Nonlinear Data Analysis and Modeling: Advances, Applications, Perspectives. Potsdam, Germany.
Drótos, G. ; Hernández-García, E.; López, C.
March 15 - 17

Majorana Modes Break Voltage Gauge Invariance in NSN Junctions of Magnetic Topological Insulators.
Topological Matter Conference. Athens, Greece.
Di Miceli, Daniele; Llorenç, Serra
March 28 - 31

Inferring networks from microgenomic abundance data.
Complenet 2023, Aveiro, Portugal.
Buenvarón-Campo, Gorka; Cuevas-Blanco, Mar; M. Eguiluz, Víctor.
April 24 - 28

Survival and extreme statistics of entropy production.
Workshop on Signatures of Nonequilibrium Fluctuations in Life. ICTP, Trieste, Italy.
Manzano, Gonzalo
May 15 – 19

Majorana modes and gauge invariance of NSN junctions of magnetic topological insulators.
International Quantum Matter Conference, Madrid, Spain.
Serra, L.; Di Miceli, D.; Schmidt, T.L., Moors, K.
May 23 - 25

Periodically driven chiral engine beyond the Carnot limit.
International Quantum Matter Conference, Madrid, Spain.
Ryu, Sungguen; López, Rosa; Serra, Llorenç; Sánchez, David
May 23 – 25

Quantum associative memory in a single drive-dissipative nonlinear oscillator.
Quantum Information in Spain ICE-8 Santiago de Compostela, Spain.
Labay Mora, Adrià
May 29 to June 1

Benchmarking the role of particle statistics in Quantum Reservoir Computing.
ICE-8 Quantum Information in Spain.
Guillem Llodrà, Christos Charalambous, Gian Luca Giorgi, Roberta Zambrini
May 29 to June 1

Dynamics of seagrass (Posidonia oceanica) fairy rings.
Resilience and recovery in aquatic systems. ASLO Aquatic Sciences Meeting 2023, Palma de Mallorca, Spain.
Mayol, E.; Ruiz-Reynés, D.; Gomila, D.; Gimenez, A.; Morell, C.; Matías, M.; Sintes, T.; Hernández-García, E.; Duarte, C.; Hendriks, I.; Marbà, N.
June 4 - 9

Dynamics of seagrass meadows with two species.
ASLO AQUATIC SCIENCES MEETING 2023 (Palma de Mallorca).
Moreno-Spiegelberg, Pablo; Gomila, Damià
June 4 - 9

Periodically driven chiral quantum conductors beyond Carnot limit.
Summer School on Open Quantum Systems and Mesoscopic Physics, Hyytiälä, Finland.
Ryu, Sungguen; López, Rosa; Serra, Llorenç; Sánchez, David
June 4 - 9

Mode distribution in VCSELs with non-cylindrical symmetry.
Nonlinear Dynamics in Semiconductor Lasers 2023, Berlin, Germany.
Marciniak, Magdalena; Gębski, Marcin; Pflüger, Moritz; Janczak, Mikolaj; Czyszanowski, Tomasz; Fischer, Ingo.
July 3 - 5

Echo chambers and information transmission biases in homophilic and hetwrophilic networks.
NetSci 23, Vienna, Austria.
Diaz-Diaz, Fernando; San Miguel, Maxi; Meloni, Sandro
July 10 - 14

A Metagenomic Baseline of Red Sea Functional Biodiversity.
NetSci 2023, Viena, Austria.
Buenvarón-Campo, Gorka; Cuevas-Blanco, Mar; M. Duarte, Carlos; M. Eguíluz, Víctor
July 10 - 14

Structure, resilience and evolution of the European Air Route Network from 2015 to 2018.
NetSci 2023. Viena, Austria.
Esteve, Pau; Ramasco, José Javier; Zanin, Massimiliano
July 10 - 14

Local and global ordering dynamics in multistate voter models".
Interdisciplinary Workshop on Opinion Dynamics and Collective Decision 2023. Breiman, Germany.
Ramirez, Lucia: San Miguel, Maxi: Galla, Tobias
July 12

Language dynamics within adaptive networks: An agent-based approach of nodes and links coevolution.
Opinion Dynamics and Collective Decision, Bremen, Germany.
Christos Charalambous, David Sanchez, Raul Toral
July 12 - 14

Modelling the theta-gamma interactions in the hippocampal CA1-CA3 areas.
*CNS*2023 in Leipzig, Germany.*
Chalkiadakis, Dimitrios; Jaime Sánchez-Claros; Santiago Canals; Claudio Mirasso
July 15 - 19

Periodically driven chiral quantum conductors beyond Carnot limit.
Quantum Thermodynamics 2023, Vienna, Austria.
Ryu, Sungguen; López, Rosa; Serra, Llorenç; Sánchez, David
July 17 – 21

Self-organized motion in persistent random walk models: large deviations and collective behavior.
Conference Frontiers in nonequilibrium physics: Active matter, topology and beyond, Satellite of Staphys28, Kyoto, Japan.
Toral, Raúl
July 31 to August 2

Sea surface temperature modulation of the Madden-Julian oscillation: a stochastic skeleton model approach.
Dynamics Days Europe 2023. Naples, Italy.
Ehstand, N.; Donner, R.; López, C.; Hernández-García, E.; Barreiro, M.
September 3 - 8

Language dynamics within adaptive networks: An agent-based approach of nodes and links coevolution.
European Conference on Social Networks, Ljubljana, Eslovenia.
Charalambous, Christos; Sanchez, David; Toral, Raul
September 4

Modeling circuit mechanisms of opposing cortical responses to visual flow perturbations.
IBRO 2023 - IBRO World Congress of Neuroscience, Granada, Spain.
Galván, J.; Ramasco, J.J.; Arkhipov, A.; Scherr, F.; Maass, W.; Mirasso, C.
September 8 - 14

Experimental multi-bit header recognition using step-index fibers.
Artificial Intelligence Photonics, Donostia / San Sebastián, Spain.
Pflüger, Moritz; Ortín González, Silvia; Cornelles Soriano, Miguel; Fischer, Ingo; Mirasso Santos, Claudio R.; Argyris, Apostolos
September 11 - 14

On the formation of coral reefs.
Modelling Diffusive Systems 2023: Theory \& Biological Applications (MoDiS 2023) - ICMS, Edimburgo, UK.
Álvarez-Alegría, Miguel; Matías, Manuel A.; Gomila, Damià
September 11 - 15

Photonic platform for real time Quantum Reservoir Computing.
17th Granada Seminar about a quantum photonic platform proposal for performing real time information processing.
García-Beni, Jorge; Giorgi, Gianluca; C. Soriano, Miguel; Zambrini, Roberta
September 12 - 15

Massive Agent-Based Models and High Performance Computing for Human Mobility and Urban Systems.
1st Spanish Congress on Mobility at the Zaha Hadid Bridge, Mobility City HQ in Zaragoza, Spain.
Moreno López, Jesús A.
October 5 - 6

Topologically-induced suppression of explosive synchronization on graphs.
FisEs'23, Pamplona, Spain.
Miranda, Manuel; Frasca, Mattia; Estrada, Ernesto
October 18 - 20

A pattern-formation mechanism arising from pulsed interaction signals.
FISES'23, XXIV Congreso de Física Estadística. Pamplona, Spain.
Colombo, E.H.; Lopez, C.; Hernandez-Garcia, E.
October 25 - 27

Quantum memories for squeezed and coherent superpositions in a driven-dissipative nonlinear oscillator.
XXIV Congreso de Física Estadística (FisEs'23), Pamplona, Spain.
Labay-Mora, Adrià; Zambrini, Roberta; Giorgi, Gian Luca
October 25 – 27

On the binomial method for the generation of stochastic trajectories.
FISES 2023, Pamplona, Spain.
Toral, Raúl; Aguilar, Javier; Ramasco, Jose Javier
October 25 – 27

Language shift dynamics: Role of size and coupling strength of communities with different preferences.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Rosillo-Rodes, Pablo; San Miguel, Maxi; Sanchez, David
October 25 - 27

Communicability geometry reveals antagonistic factions in signed networks.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Diaz-Diaz, Fernando; Estrada, Ernesto
October 25 - 27

A compartmental model for Xylella fastidiosa diseases with explicit vector seasonal dynamics.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Giménez-Romero, Àlex; Moralejo, Eduardo; Matías, Manuel A.
October 25 - 27

A Metagenomic Baseline of Red Sea Functional Biodiversity.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Buenvarón-Campo, Gorka; Cuevas-Blanco, Mar; M.Duarte, Carlos; M.Eguíluz, Víctor
October 25 - 27

Sampling rare trajectories in stochastic processes.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Sara Oliver, Javier Aguilar, Tobias Galla, Raúl Toral
October 25 - 27

Spatial Memory in rats under non life-threatening conditions.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Medina, Jorge; Segura, Andrés P.; Lacasa, Lucas; Canals, Santiago; Martínez Eguíluz, Víctor
October 25 - 27

Partisan Voter Model: stochastic analysis and noise-induced transitions.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Llabrés, Jaume; San Miguel, Maxi; Toral, Raul
October 25 - 27

Estimating Entropy of Correlated Discrete Sequences: Performance Analysis and a New Estimator.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
De Gregorio, Juan; Sánchez, David; Toral, Raúl
October 25 - 27

Shaping coral reef growth. The role of nutrient diffusion and erosion.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Sintes, T; Llabrés, E.
October 25 - 27

Interplay of inertia and damping in power grids.
XXIV Congreso de Física Estadística FISES 2023. Pamplona, Spain.
Martínez-Barbeito, María; Gomila, Damià; Colet, Pere
October 25 - 27

Unveiling the airspace structure and aircraft mobility in Europe: a complex network perspective.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Esteve, Pau; Ramasco, José Javier; Zanin, Massimiliano
October 25 – 27

Inverse percolation by removing straight semirigid rods from bilayer square lattices.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Ramirez,LS; Pimentel, F.; De La Cruz-Felix, N.; Ramirez-Pastor, A.J.
October 25 - 27

The following network of Olympic athletes.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Rodríguez, Jorge P.; Arola-Fernández, Lluís
October 25 – 27

Entropy production and fluctuation theorems for monitored quantum systems under imperfect detection.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Almanza, Jose Antonio
October 25 - 27

Degree-day-based model to predict egg hatching of Philaenus spumarius, the main vector of the bacterium Xylella fastidiosa in Europe.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Lago, C.; Giménez-Romero, À; Morente, M.; Matías, M.A.; Moreno, A.; Fereres, A.
October 25 - 27

Interacting particle systems with mobility and demographic dynamics as biological models.
XXIV Congreso de Física Estadística (FisEs'23). Pamplona, Spain.
Almodóvar, Alejandro; López, Cristóbal; Galla, Tobias;
October 25 – 27

Optimization of number and location of solar plants and storage in a power grid with high penetration of renewables.
XXIV Congreso de Física Estadística FISES 2023. Pamplona, Spain.
Benjamín A. Carreras, Pere Colet, José M. Reynolds-Barredo, and Damià Gomila
October 25 – 27

Modeling circuit mechanisms of opposing cortical responses to visual flow perturbations.
Workshop: The many challenges of Artificial Intelligence. Madrid, Spain.
Galván Fraile, Javier
November 13 – 15

A Machine Learning Approach for Animal Trajectory Classification.
Workshop: The many challenges of Artificial Intelligence. Madrid, Spain.
Medina, Jorge; Rodríguez, Jorge P.; Sequeira, Ana; Martínez Eguíluz, Víctor
November 13 – 15

Engineered dissipation to mitigate barren plateaus.
Quantum Techniques in Machine Learning 2023, CERN, Switzerland.
Sannia, Antonio; Tacchino, Francesco; Tavernelli, Ivano; Giorgi, Gian Luca; Zambrini, Roberta
November 19 – 24

Quantum memories for squeezed and coherent superpositions in a driven-dissipative nonlinear oscillator.
Quantum Techniques in Machine Learning CERN, Switzerland.
Labay-Mora, Adrià; Zambrini, Roberta; Giorgi, Gian Luca
November 20 – 24

a.6.4 Seminars and talks in other research centers

Statistical validation of co-morbidity networks.
University of Palermo, Italy
Crisafulli, Paride; Mantegna, Rosario
January 3-9

Power grid frequency fluctuations in scenarios of large penetration of variable renewables.
Seminar at University of Cologne, Germany.
Colet, Pere
January 14

IFISC: El potencial de la IA y los sistemas complejos en el sector salud
Hospital Son Espases, Palma de Mallorca, Spain
Mirasso, Claudio
January 19

Tracing down quantum phase transitions in Josephson Junctions.
Colloquium at the Basel University, Switzerland.
Rosa López, Minchul Lee, Hongqi Xu, Gloria Platero
April 7 - 8

Taller IFISC: Detectando arritmias con IA.
Innovation Day HUSE. Palma de Mallorca, Spain.
Ortín, Silvia
April 28

Statistical validation of machine learning models.
4-day course delivered at the Marie-Curie ITN project SSECOID. Universidad Politécnica de Madrid, Madrid, Spain.
Lacasa, Lucas
May 15 - 19

The process of doing a PhD - lessons learned as a student and as a supervisor.
Talk for PhD students, University of Bath, UK.
Galla, Tobias
June 8

Non-Gaussian random matrices predict the stability of feasible Lotka-Volterra communities.
University of Bath, UK.
Galla, Tobias
June 8

Análisis de datos de movimiento en Python.
Cursos de Extensión Universitaria, UNED Illes Balears. Palma de Mallorca, Spain.
Rodríguez, Jorge P.
June 15

Sustainable hardware.
AIHUB - Escuela de verano sobre IA y educación. Palma de Mallorca, Spain.
Argyris, Apostolos
July 6

Statistical validation of machine learning models.
4-day course delivered at the Data in Fluids Summer Programme. Cambridge University, Cambridge, United Kingdom.
Lacasa, Lucas
July 3 - 7

Network meta-analysis: A statistical physics perspective.
King's College, London, UK.
Galla, Tobias; Davies, Annabel
September 13

Quantum Thermodynamics: fluctuations and thermal machines.
Tutorial course at 4th Workshop on Statistical Physics 2023, Bogotá, Colombia.
Manzano, Gonzalo
October 2 - 6

How to achieve maximum frustration during your PhD.
Talk for PhD students, University of Siegen, Germany.
Galla, Tobias
November 15

Stability of complex ecosystems: the physicist's frustration.
University of Siegen, Germany.
Galla, Tobias
November 16

Modeling power grid frequency fluctuations.
Training course at University of Yaoundé I, Cameroon.
Colet, Pere; Gomila, Damià
December 1

Ecology of Online Social Interactions.
Invited Seminar at Centro Study Enrico Fermi, Italy.
Meloni, Sandro
December 6

Stochastic thermodynamics with Martingales.
Santa Fe Institute seminar, New Mexico, USA.
Manzano, Gonzalo
December 12

Communicability in complex networks
Honda Research Institute, Frankfurt, Gemany
Estrada, Ernesto
December 13

Ecology of Online Social Interactions.
Invited seminar at FBK foundation Trento, Italy.
Meloni, Sandro
December 14

Inteligencia artificial para salud y gestión hospitalaria.
Trobada UIB amb el Clúster BIOIB. Palma de Mallorca, Spain.
Ortín, Silvia
December 19

a.7. Other Activities

a.7.1. Master Thesis

Asymmetric language shift in bilingual communities
Duran, Miquel (Supervisors: San Miguel, Maxi and Sánchez, David)
October 27

Artificial neural networks through the lens of dynamical systems theory
Danovski, Kaloyan (Supervisors: Lacasa, Lucas; Soriano, Miguel C.)
October 24

Age of infection disease modeling: from Kermack and McKendrick to multi-compartment models
Bousakla El Boujdaini, Mustapha (Supervisors: Matias, Manuel A.; Giménez-Romero, Alex)
October 20

Reservoir Computing on Quantum Circuits
Morgui Sancho, Oriol (Supervisors Giorgi,Gian Luca; Zambrini,Roberta)
October 19

Anticipated synchronization in stochastic individual-based models
Ortiz del Campo, David, (Supervisors: Raul Toral, Tobias Galla)
October 19

Higher-order interactions as stabilising mechanism for competitive communities
Duran Sala, Marc (Supervisors: Calleja-Solanas, Violeta; Meloni, Sandro)
October 19

How efficient is air transport? A network perspective
Visa Scheimann, Daniel (Supervisor: Zanin, Massimiliano)
October 19

Aging effects in Coordination games
Ciardella, Samuele (Supervisors: San Miguel, Maxi; Galla, Tobias)
October 19

Inference of leadership networks of marine megafauna from acoustic data
Corzo López, M. Teresa (Supervisors Fernández-Gracia, Juan; Eguíluz, Víctor M.)
October 18

Non-linear transitions in air transport delays: models and data
Szabó, Zita (Supervisor: Zanin, Massimiliano)
October 16

Big Data, memes, information diffusion in online social networks and opinion dynamics
Luque, Alvaro (Supervisor: Ramasco, JJ)
October 13

Time and wavelength multiplexing in photonic neural networks
Jiménez González, Pedro (Supervisors: Miguel C. Soriano, Claudio R. Mirasso)
October 11

Lagrangian studies in the Western Mediterranean Sea
Rojas Martinez, Ivonne (Supervisors: Lopez, Cristobal; Ser-Giacomi, Enrico)
September 29

Local probing of dynamical phase transitions by repeated partial information erasure
Ali, Hira (Supervisors: Giorgi, Gian Luca; Zambrini, Roberta)
February 15

a.7. 2. Research stays in other centers

University of Cologne, Germany.
Colet, Pere
January 24 - 25

LKB, Sorbonne University, France.
Visit to V. Parigi and N. Treps labs.
Zambrini, Roberta; Giorgi, Gian Luca; Soriano, Miguel Cornelles; García Beni, Jorge
January 29 - 31

ICTP. Trieste, Italy.
Manzano, Gonzalo
January 29 – February 12

Sevilla University, Spain.
Visit to Prof. Diego Frustaglia to treat common research interest on topological materials and quantum thermodynamics.
Lopez, Rosa
February 16 – 20

Poirazi Lab – IMBB-FORTH. Heraklion, Greece.
Research stay of three months in the Dr. Panayiota Poirazi Neurosience lab.
Sanchez Claros, Jaime
March 1 – June 2

Instituto de Física de Cantabria (IFCA), Spain.
Collaboration on the effects of climate change on the spread of Pierce's disease in Europe with the group of Prof. José M. Gutiérrez.
Matias, Manuel A.
May 18 - 20

Allen Institute for Brain Science, USA.
Research stay to work together with Anton Arkhipov group in the development of a microcircuit joint model of primary visual cortex and lateromedial visual area.
Javier Galván Fraile
June 18 – August 13

ICFO. Barcelona, Spain.
PhD thesis defence jury.
Manzano, Gonzalo
July 12 - 14

Isaac Newton Institute for Mathematical Sciences.
Cambridge, UK.
López, Cristóbal
July 15 – August 31

University of Trento, Italy.
Member of the PhD thesis committee of Giovanni Donati at the University of Trento.
Soriano, Miguel Cornelles
July 28

Reikiavik University, Iceland.
Visit to the group of Prof. Andrei Manolestcu.
López, Rosa
August 17 - 21

Universiteit Utrecht (Utrecht), Netherlands.
Research stay at the Utrecht University hosted by Prof. Max Rietkerk.
Moreno-Spiegelberg, Pablo
September 16 – December 22

University of Hawaii.
Visitor researcher at the Hawaii Institute of Marine Biology, as a part of a Marie-Curie Global fellowship.
Llabrés, Eva
October 1 to December 31

Research Stay at Centro Ricerche Enrico Fermi, Rome, Italy.
Meloni, Sandro
October 2 – December 20

University of Yaounde I, Cameroon.
Colet, Pere; Gomila, Damià
December 1 – 2

Santa Fe Institute. New Mexico, USA.
Working group and collaboration.
Manzano, Gonzalo
December 11 – 21

FBK foundation Trento Italy.
Visit to the group of Riccardo Gallotti at Bruno Kessler Foundation in Trento.
Meloni, Sandro
December 13 – 15

Université Paris-Saclay, Paris, France.
Member of the PhD thesis committee of Ivan Boikov at Université Paris-Saclay.
Soriano, Miguel Cornelles
December 19

a.8. Press and Media

The titles are linked to the document or media clip

a.8.1 Press and digital Media

Descubren cómo se forman espirales en las praderas de Posidonia
EFE
COPE
Yahoo!
Mallorca Diario
January 10

Les prades de posidònia es mouen, poden col·lidir entre elles i es poden anihilar
Fora Vila
January 11

Modelos matemáticos en Baleares y Madrid que predicen las 'guerras internas' en cualquier ecosistema
El Español
January 17

Model reveals role of pungent gas in seagrass ring patterns
Nature Middle East
January 18

Was es mit den mysteriösen Feenkreisen im Meer vor Mallorca auf sich hat
Mallorca Zeitung
January 19

Modelizando la expansión de la enfermedad de Pierce de la viña
El diari de la UIB
February 3

Males notícies per a la vinya: un estudi de la UIB adverteix que la malaltia de Pierce serà una amenaça global
Fora Vila
February 4

Una investigación del IFISC de la UIB sobre el análisis de la movilidad humana y las epidemias gana el premio a tesis relevantes del CSIC
Salud Ediciones
El diari de la UIB
CSIC
February 28

Diseñan un método para prevenir la propagación de enfermedades infecciosas en aeropuertos
CSIC
Salud a Diario
OK Diario
NoticiasDe
21 Noticias
DICYT
Crónica de Cantabria
Infosalus
Siglo XXI
65 y más
Salut i Força
El Diari de la UIB
Ara Balears
20 minutos
El Debate
Gente Digital
La Vanguardia
Europa Press
News Es Euro
La Razón
March 21

El virus del aeropuerto
La Razón
March 26

Un centre de supercomputació i un institut de recerca, en el full de ruta de la intel·ligència artificial a les Illes Balears
El Diari de la UIB
March 31

Una herramienta predice el momento óptimo para controlar el vector de la Xylella
Phytoma
May 4

Una herramienta predice el momento óptimo para controlar el vector de la Xylella
Agrogip
May 16

La inteligencia artificial consciente o el fin de la civilización
Diario de Mallorca
June 13

Tomás Sintes Olives, el segundo catedrático de física en la familia 'Iluïsera' de Alicia
Menorca.info
June 14

La científica Margarita del Val hablará en la UIB sobre la investigación interdisciplinaria en epidemias
Diario de Mallorca
June 16

Mejorar la calidad del aire en espacios cerrados ayudaría a prevenir epidemias futuras por aerosoles, según el CSIC
Salamanca 24 horas
June 20

El CSIC cree que mejorar la calidad del aire en espacios cerrados ayudaría a prevenir epidemias futuras por aerosoles
Europa Press
June 20

Margarita del Val: "Todavía me preguntan si hay que limpiar la compra en casa"
Diario de Mallorca
El Periódico de España
El Periódico
Faro de Vigo
Levante el Mercantil Valenciano
Información.es
La Nueva España
Opinión de Zamora

Diario de Ibiza
El Dia
Opinión de Málaga
La Provincia - Diario de Las Palmas
Diario Córdoba
El Periódico Mediterráneo
El Periódico Extremadura
June 21

Margarita del Val: «Controlando mejor la calidad del aire evitaremos la bofetada de esta pandemia»
Menorca
June 21

«No será necesario vacunarse de COVID cada otoño, quizás sólo los primeros años»
Última Hora
June 21

Margarita del Val: "La Covid sigue existiendo pero la emergencia sanitaria ya ha acabado"
Sport
June 21

Alicia en el país de los diablillos de Maxwell: relato de un físico a su hija de 7 años
The Conversation
El Obrero
El Club de Ciencias
July 7

Els científics descobreixen com controlar l'insecte que s'encarrega de dispersar la Xylella
Fora Vila
August 2

Una herramienta desarrollada con la participación de la UIB predice la desclosión de las ninfas del insecto transmisor de la Xylella fastidiosa en Europa
Salud Ediciones
August 8

La UE financia proyectos del CSIC sobre nuevos alimentos, economía en tiempo real y desafíos en inteligencia artificial
CSIC
21noticias
August 17

A USC incorpórase a Quantum Spain, un consorcio cara a un ecosistema estatal de computación cuántica
May
August 30

Una nueva herramienta puede ayudar a limitar las poblaciones del insecto transmisor de la Xylella fastidiosa en Europa
Mercacei
August 30

Acrobatica, la nuova sfida oceanica di Alberto Riva
Press Mare
September 5

Néstor Guerra: «La Inteligencia Artificial amplifica nuestras capacidades y aumenta nuestra productividad»
Última Hora
September 14

Una nueva herramienta permite predecir la eclosión de las ninfas del insecto que transmite la Xylella
SER Ibiza
September 18

Un seminario organizado por el IFISC de la UIB analizará cómo las oscilaciones cerebrales afectan al procesamiento de información
Salud Ediciones
September 26

Reacciones: Nobel de Química a Bawendi, Brus y Ekimov por descubrir los puntos cuánticos
Science Media Centre
October 4

Data Analytics: la UIB al servicio de las empresas
El Económico
Periódico de Ibiza y Formentera
Menorca.info
October 6

Un modelo revela que la heterogeneidad produce un aumento de las floraciones de plancton marino
BioTech
October 25

Claudio Mirasso: «Mientras el ojo del médico ve 200 imágenes, la máquina es capaz de ver 10.000»
Última Hora
October 26

El Govern otorga ayudas por 4 millones de euros para la contratación de 42 investigadores
Última Hora
November 1

Una veintena de científicos de Baleares divulgará sus investigaciones este sábado en el tren de Sóller
La Vanguardia
NoticiasDe
COPE
Europa Press
November 10

El andén de los curiosos
Última Hora
November 11

When languages collide, which survives?
Phys
EurekAlert!
Science Daily
News Beezer
November 14

Language Collision: Survival of Fittest?
Mirage News
ScienMag
November 15

Investigadors de la UIB publiquen un estudi sobre les preferències lingüístiques en societats multilingües
Diari de Balears
El Diari de la UIB
November 15

Vivir entre dos lenguas: un estudio matemático desvela cómo las creencias sobre un idioma determinan su futuro
El Diario
November 23

Naukas Palma 2023
Naukas
La Palmesana
December 2

50 científics de les Balears, entre els més influents del món
Ara Balears
December 12

Descifrando el fondo marino desde el espacio con los ojos de la inteligencia artificial
The Conversation
December 21

La posidònia oceànica, clau per lluitar contra inundacions associades al canvi climàtic
Fora Vila
El Diari de la UIB
December 25

a.8.2 Radio and TV

Científics de les illes descobreixen el misteri dels anells de posidònia viatgers
IB3 TV, Notícies
January 11

Entrevista Damià Gomila
IB3 Ràdio, Nautilus
January 21

Entrevista Diego Burlando - VPP4 Islands
IB3 Ràdio, Al Dia
April 3

Investigadors de la UIB creen un mètode per a detectar la transmissió de virus als aeroports
IB3 TV, Notícies
April 9

La investigació en antibiòtics és clau per prevenir la resistència i reduir les operacions a causa d'infeccions, destaca Margarita del Val
IB3 Ràdio, Al Dia
June 20

La científica Margarita del Val aboga por la investigación interdisciplinaria para evitar pandemias antes de que surjan.
Radio Mallorca
June 20

Margarita del Val: "Cada vegada més agents infecciosos posaran en risc la societat humana"
IB3 TV, Notícies
June 20

El trànsit aeri com a termòmetre econòmic
IB3 TV, Notícies
September 11

Entrevista Manuel Matías
IB3 Ràdio, Nautilus
September 16

Entrevista Manuel Matías
Cadena SER Ibiza, Hoy por Hoy
September 18

Premio Nobel de Química 2023
IB3 Ràdio, Entre avui i demà
October 4

El tren de Sóller fa un trajecte ple de ciència
IB3 TV, Notícies
November 11

Noosfera 179. Sistemas complejos no tan complejos | Ernesto Estrada
La Razón, Noosfera
November 17

Naukas Palma celebra a ciutat la seva segona edició
IB3 TV, Notícies
December 5

Entrevista Adrià García, técnic de divulgació de l'IFISC
IB3 Ràdio, Nautilus
December 9