ICFO

ICFONIANS 43

Community News Winter 2021

2020
What a year for science

LETTER FROM THE DIRECTOR

Lluís Torner
ICFO Director

2020 (Gregorian calendar)

What a year we have lived. Many of us took for granted that upheavals such as we have experienced this year would be relegated to history books or Hollywood movies.

This is in contrast to many fellow humans who currently live in other parts of the world, to everybody's great-grandmothers wherever they lived, and to the entire human race over many millennia – in the case of fast-spreading pandemics, at least since the start of the agricultural revolution and thus relatively large cities some 120 centuries ago. So far, it seems that the current version of SARS-COV-2 is not as efficient at killing as other viruses, but it has deeply disrupted the world in ways that have a profound impact on everyone, particularly those who have fallen ill, become poorer, or worse.

The current state of affairs reminds us how immensely fortunate we are in general, while shedding light on the many people and living creatures who are struggling, enduring difficult conditions. It also reminds us that climate change and its consequences and possibly even more deadly viruses pose very real threats to the near future. All this prompts a deep desire in many of us to contribute to keep making life on Earth better – and from now on not only for humans, please.

Fortunately, we can all contribute a lot. Our lives have many axes, but as ICFOnians we share mostly one: Science and pushing its limits, namely conducting research. We know that, admittedly with some detours along the way, Science is one of the salient ingredients that has made today's world possible, and is one of the key tools that Humankind has to keep advancing. We are devoting our lives to enlarging the available scientific knowledge and its impact in society in different ways: many of us will contribute only a few millimeters to the advance, some a couple of meters and a handful will shift the edge or its societal impact kilometers ahead.
As long as it points forward, every angstrom counts. What a wonderful role we have, ICFOnians!

I want to thank all of you for your outstanding attitude during this complex period. The end of the current difficulties may be in sight, illuminated by vaccines, although we still have a long way to go. We will continue to push the limits of knowledge thanks to everybody's efforts and dedication – from the super-skilled colleagues who do the admin or keep facilities operating, and the generous supporters who provide the funds and means, to those that spend days and nights in actual or numerical labs. I feel honored to have the opportunity to express to you the institution's deepest gratitude.

PS. For what it's worth, please recall that 2021=43x47; 43 is the 14th prime number; 47 is the 15th; in turn, 14=2x7, 15=3x5, where 2, 3, 5 and 7 are the 1st, 2nd, 3rd, and 4th prime numbers. I let you crack 5781 (Hebrew), 4719 (Chinese), 1942 (Hindu Shaka), 1442 (Hijri), 1399 (Persian), etc.

Mystery ICFOnian
Solution Ed #42

Dr Alina Hirschmann
ICFO Communications

Science Quiz
Answers from p.20 **1**:A **2**:C **3**:C **4**:B

COVER

2020 will be remembered as the year of the COVID pandemic. It will also be talked about as a year of unprecedented scientific productivity and cooperation- a moment when the entire world understood with brutal clarity the importance of the scientific mission. ICFOnians are members of the global scientific enterprise and had an unforgettable year because of and in spite of the pandemic. This edition gives an abridged overview of some of our high points.

2020- What a year for Science: For fun, help us think of some alternative headlines. ex."Light in the time of COVID"; "Maxwell's equations and mascarillas"; "2020- The year we don't make contact"; "2020 Hindsight"... Send them to us at communications@icfo.eu and we will share the winning suggestions on social media.

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Outreach, Knowledge and Technology Transfer
Tomás Charles
Visual Communication
Brook Hardwick
Corporate Communications Head
Alina Hirschmann
Communications
Laia Miralles
HR and Education Head
Morgan Mitchell
ICREA Group Leader at ICFO, Atomic Quantum Optics
Andrea Morales
Alumni, Communications
Emilià Pola
ICREA
Rob Sewell
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Human Resources and Education

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HAPPENINGS

COLLABORATION

RIS3CAT

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ICFO NEWCOMERS

Welcome to ICFO

Many new colleagues joined ICFO in 2020

Silvia Tognetti
KTT

Victor Herrero
KTT

Mercè Latorre
Management

Alba Berenguer
Management

Anna Cicres
Management

David González
Management

Andrea Morales
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Management

Helena Lozano
Management

Giorgio Di Battista
PhD Student

Niccolo Baldelli
PhD Student

Michael T. Enders
PhD Student

Matteo Ceccanti
PhD Student

Giulia Lo Gerfo
PhD Student

Maria Balanzó Juandó
PhD Student

Stuti Gugnani
PhD Student

Lukas Lau
PhD Student

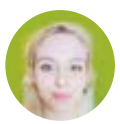
Saurabh Borkar
PhD Student

Igor Tyulnev
PhD Student

Sandra Buob
PhD Student

Guillem Müller Rigat
PhD Student

Costanza Agazzi
PhD Student



Bruna de Moraes
PhD Student

Roop Kumar Mech
PhD Student

Andrés Díez Carlón
PhD Student

Eduardo Beattie
PhD Student

Joseph Wragg
PhD Student

Faruk Beslija
PhD Student

Carlos Pascual García
PhD Student

Geng Li
PhD Student

Javier Rivera Dean
PhD Student

Jessica Angulo
PhD Student

Katerina Gratsea
PhD Student

Laura Zarraoa Sardón
PhD Student

José Javier Ruiz
PhD Student

Marc-Olivier Renou
Postdoc. Research

Mingyu Zhang
Postdoc. Research

Jelena Stanisavljevic
Postdoc. Research

Andrew Maxwell
Postdoc. Research

Máté Farkas
Postdoc. Research

Shadi Karimi
Postdoc. Research

Enky Oudot
Postdoc. Research

Alexandre Jaoui
Postdoc. Research

Luca Barbiero
Postdoc. Research

Marcello Passos
Postdoc. Research

Huimin Zhu
Postdoc. Research

Aleksandra Pidde
Postdoc. Research

Marcio Taddei
Postdoc. Research

Cheng Shen
Postdoc. Research

Fraser Hill Casey
Postdoc. Research

Enrico Castroflorio
Postdoc. Research

Marta Zanoletti
Postdoc. Research

Osman Melih Can
Postdoc. Research

Samael Sarmiento
Postdoc. Research

Victoria Wright
Postdoc. Research

Shuoying Yang
Postdoc. Research

Reiko Yamada
Postdoc. Research

Juan Gasparino
Research Engineer

David Kernan
Research Engineer

Sören Wengerowsky
Research Engineer

Javier Muro Cruces
Research Engineer

Gabriel Fernández
PhD Student

Kevin Schädler
Research Engineer

Álvaro Moreno Abajo
PhD Student

Oriol Vidal
Student

Pau Gallinat
Student

Jesús Diaz
Student

Bernat Molero
Student

Roger Bahí
Student

Maria Torras
Student

Nadja Augst
Student

Aiturgan Zheenbekov
Student

Victor Barizien
Student

Charitra S. Senthil
Student

Rajashree Haldankar
Student

María Rodríguez
Student

Alejandro Sánchez
Student

Mariona Colomer
Student

Simona Barankova
Student

Valentina Renteria
Student

Rimanté Jarockyté
Student

Josep M. Batllori
Student

Carmen Rodilla
Student

Estefanía Guillena
Student

Rebecca Hoffmann
Student

Alejandro Cañete
Student

Santiago Ortiz
Student

Eloy Piñol
Student

Luis F. Morales
Student

Alex Barnadas
Student

Lorena Puhl
Student

Adrià Grabulosa
Student

Bronte Swaby
Student

Hai Hu
Visiting PhD Student

Antonia Weberling
Visiting PhD Student

Marina Frauendorf
PhD Student

Vladimir Kontul
Visiting Scientist

Eleni Diamanti
Visiting Scientist

Heba Abdelmaksoud
Visiting Scientist

Andrew Patton
Postdoctoral Research

HAPPENINGS

ICFO NEWS

BIST Ignite Projects and Awards

The BIST Ignite Program awards excellent, multidisciplinary projects within the BIST community. Five winners are chosen from an annual call for BIST Ignite project proposals to receive €20,000 funding to jumpstart their research collaboration throughout one year.

At the end of the funding year, two projects are selected for the BIST Ignite Awards offering an additional €50,000 funding to continue research.

Two ICFO projects awarded in 2019 call for Seeding Phase Grant:

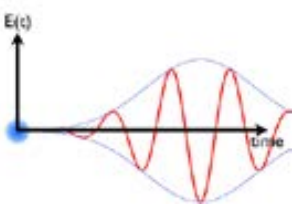
- **QEE2DUP**: **Dr Antoine Reserbat-Plantey** (ICFO) and **Dr César Moreno** (ICN2) will design a new material capable of confining excitons within graphene nanopores for use in the development of new quantum technologies.

- **NANO-GBA**: ICREA Professors **Dr Silvia Muro** (IBEC) and **Dr María García-Parajo** (ICFO) will investigate the workings of biochemical and biophysical alterations in the cell membrane, the mobility and nanoclustering of receptors within the cell, and the transport of substances across the blood-brain barrier.

ICFO recipient of 2020 BIST Ignite Award:

- **BioSpad**: ICREA Professors **Dr Sebastian Grinstein** (IFAE), and **Dr Turgut Durduran** (ICFO) collaborate to produce a fast monolithic multi-channel ASIC for diffuse optical, non-invasive blood flow measurement.

One of Most Cited PRA Papers of All Time



On its 50th anniversary, Physical *Review A* issued a special edition **highlighting the highest impact papers in the history of the journal**. The 1994 study by ICREA Prof at ICFO Dr Maciej Lewenstein, Ph. Balcou, M. Yu Ivanov, A. L'Huillier and P.B. Corkum, entitled "Theory of high-harmonic generation by low-frequency laser fields" was **selected as one of these outstanding studies, with over 3800 citations according to Google Scholar**. The scientific legacy of this work has been such that the theory was named the "Lewenstein model" and, since the 1990s, almost all experimental research groups working in the field of Quantum Physics have been conducting experiments related to HHG, LIED and NSMI in strong fields.

ICFO Receives the Manel Xifra Prize

Each year, the l'*Escola Politècnica Superior de Girona* and the *Comexi Group* with support from the University of Girona, grant the Manel Xifra i Boada Awards as a reflection of their belief that **the human factor is essential for technical, technological and economic development of the country**. The awards were created in 2005 with the aim of promoting and disseminating engineering by rewarding the best professional career and the transmission of technical and technological knowledge. ICFO is honored to receive this recognition in the category of research group or technological center.

SPIE Optics and Photonics Education Scholarship

Álvaro Rodríguez Echarri, a PhD candidate in the Nanophotonics Theory group at ICFO was awarded a 2020 Optics and Photonics Education Scholarship by SPIE, the international society for optics and photonics, for his potential contributions to the field.

In 2020, the Society awarded education scholarships to 78 outstanding SPIE student members.

Photonics will Shape the Future

CORDIS published a Results Pack of 10 of the most promising photonics projects funded by the European Research Council, which included FoQAL, the ERC Starting Grant project carried out by **ICREA Professor Dr Darrick Chang** in which he produced nanophotonic interfaces that promise to reveal quantum phenomena between light and atoms never witnessed before.

The projects featured in this Results Pack are just a few examples of how photonics can change technology and affect our daily lives. Photonics is expected to create exciting new opportunities in the future, exceeding the limits of what can be achieved through conventional technologies.

Incoming Faculty and Group Leaders

ICFO's NEST program, supported by Fundació Cellex and Fundació Mir-Puig, allows the institute to offer outstanding opportunities for young scientists aiming to start and lead an independent research group. In 2021, **ICFO will welcome two new members of this program**.

Dr Georgia T. Papadakis, coming from Stanford University, will lead a program that aims to tailor the flow of thermal radiation using nanophotonics. Thermal radiation provides the means of transferring heat through light, with applications ranging from renewable energy and heat management to spectroscopy, lighting and sensing.

Dr Pelayo García de Arquer, coming from the University of Toronto, will lead a program focusing on CO_2 Mitigation Accelerated by Photons (CO_2MAP). His group will explore the conversion of CO_2 into renewable fuels and commodities using clean energy.

Narcís Monturiol Plaque

Narcís Monturiol was a submarine pioneer and the inventor of several key innovations that solved fundamental problems of underwater navigation. In addition, he was an influential figure in Barcelona in the mid 1800's when the city experienced enormous transformations including the demolition of old city walls and the creation of the Eixample.

The Government of Catalonia created the Narcís Monturiol award in his honor and has granted ICFO the 2020 Narcís Monturiol Plaque **for its outstanding contribution to the development of science and technology in Catalonia**.

ICFO NEWS

Business Economist Recognition Award 2020

The Col·legi d'Economistes de Catalunya has named **ICFO Manager M. Dolors Mateu as the 2020 recipient of the Business Economist Award**. This prestigious award, given to only one person per year, is a reflection of the respect that Dolors has earned from the Economists of Catalonia, and also of the impact that she has had on ICFO through her **skillful administrative, economic and financial management of the institute**. She has played a key role not only in the economic and financial sustainability of ICFO, but also in the organization of the whole administrative operation of the institute at large.

New Board for ICONS

Each year the general assembly of the ICFO Organization and Network of Students (ICONS) appoints a new board of officers by an open vote. The board members for the 2020-2021 term are **Arturo Villega**, taking over from Pilar Pujol as President; **Blanca Belsa** moving into the role of Vice-President; **Monserrat Alvarez** relieving Alexia Stollmann as Secretary; and **Jana Ockova**, who will continue as Treasurer. In order to expand the scope of actions and involvement of ICONS members in the network's activities, the positions of Communications and Diversity Officers have been created this year, with **Cristian Boghiu** and **Pablo Fernandez** respectively assuming these roles.

National Award for Undergraduate Studies

Each year, the Ministry of Science, Innovation and Universities of the Government of Spain recognizes the exceptional final results of students who have completed their undergraduate studies. **Javier Argüello-Luengo**, a PhD candidate and a "la Caixa" Foundation Fellow in the Theoretical Quantum- Nano Photonics research group is one of just five students in all of Spain to receive first prize based on his academic performance and research merits in the broad area of "Sciences".

Highly Cited Researchers

Clarivate Web of Science has released its annual list of Highly Cited Researchers, identifying scientists who produced multiple papers ranking in the top 1% of citations by field and publication year in the Web of Science. The list includes two ICREA Group Leaders at ICFO **Dr Frank Koppens** (Cross Field Category) and **Dr Maciej Lewenstein** (Physics Category) and **Dr Pelayo García de Arquer** (Cross Field Category), who will join ICFO's faculty from the University of in 2021.

Barcelona's Artech Hub

Explore and develop intersections between art, science and technology to boost the digital transformation of society: this is the aim of the Barcelona Art, Science and Technology Hub (Artech Hub), promoted by nine institutions including ICFO to make Barcelona a global centre for research, training, dissemination, transfer and production in this field. This is a cross-sector initiative under a joint-governance model, which has the support of institutions such as Barcelona City Council, the Government of Catalonia and the Barcelona Chamber of Commerce.

Solutions to Global Challenges

ICFO and the International Advanced Material Pandemic & Future Preparedness Taskforce (AMPT) have signed a new cooperative agreement in the form of Memorandum of Understanding (MoU) to collaborate on programs and initiatives to **help fast track advanced material solutions to solve global challenges**.

AMPT is a multidisciplinary taskforce building a global infrastructure and an ecosystem network to enable the advanced material community to respond swiftly and effectively under the umbrella of Future Preparedness, including preparedness for **Emergencies & Disasters** such as pandemics, for Emerging Needs such as Green renewable energy and quantum technology infrastructure and for **Global Challenges** such as climate change and carbon waste.

UPC Thesis Awards 2020

The Extraordinary PhD Thesis Award, given annually by the Technical University of Catalonia (UPC), aim to recognize the best doctoral theses which have obtained "cum laude" in their final PhD defense evaluation.

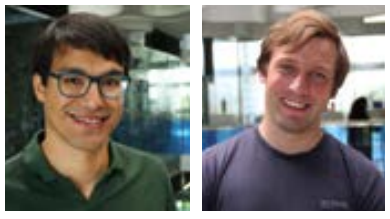
This year, the UPC announced the list of six awardees in the broad area of "Sciences", which include the theses **of ICFO PhD graduates Dr Carlos Abellan, Dr Ivan Supic and Dr Joanna Zielinska** among the list of extraordinary doctoral works for the academic period 2017/2018.

BIST Mother of Science Supporting Grants

The BIST Mothers of Science supporting grants illustrate the commitment of BIST centers to recognizing the excellent research done by female scientists and to supporting them in their career transitions.

The 2020 grant was awarded to 10 powerful women who are motivated to improve their leadership skills and to take a step forward in their careers. **Dr Ewelina Wajs**, postdoctoral researcher in the Optoelectronics research group is one of the recipients of this grant.

Postdoctoral Junior Leader "la Caixa" Foundation Fellowships



In the second call of the "la Caixa" Foundation's prestigious *Postdoctoral Junior Leader programme*, two of the forty-five fellowships awarded went to ICFO postdoctoral researchers.

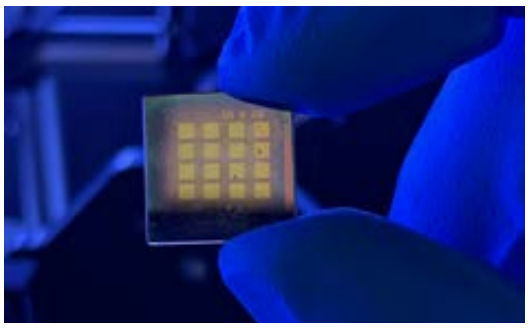
- **Dr Alexandre Dauphin** (*Retaining Fellowship*): joined ICFO in 2015 as a postdoctoral researcher in the Quantum Optics theory group focusing on the study of phases of matter with quantum simulators and machine learning.
- **Dr Valentin Kasper** (*Incoming Fellowship*): recently joined the Quantum Optics theory group from the condensed matter theory group at Harvard University. His research concentrates on non-equilibrium and non-perturbative aspects of quantum many-body systems.

The objectives of this program are to foster high-quality, innovative research in Spain and Portugal and to support the best scientific talent by providing them with an attractive, competitive environment in which to conduct excellent research.

HAPPENINGS

LATEST ADVANCES

Confinement followed by social distancing did not stop researchers from publishing important findings; on the contrary, these are just a small sample of the work that appeared in important journals this year.



Colloidal Quantum Dot Photodetectors can now see further than before

New quantum dot photodetector that is capable of detecting light in the long infrared range using PbS CQDs that, for the first time, are made with mercury-free material

Optical sensing in the mid to long infrared (5 microns - µm) has proven important for environmental monitoring, gas sensing, the pharmaceutical industry, etc. Information obtained within this very rich spectral window opens new possibilities for multi or even hyperspectral imaging, however technologies that can address these challenges are very complex and expensive.

PbS Colloidal Quantum Dots (CQDs) have emerged as a cost-competitive and high performance photodetector technology, compatible with CMOS technology, demonstrated to be successful in the short-wave infrared (1-2 µm). However, to date, there has been a fundamental limit: such quantum dots have relied on interband absorption of light resulting in a lower energy limit that this technology can operate: the bandgap of the material. In a study published in *Nanoletters*, ICFO researchers Iñigo Ramiro and colleagues led by ICREA Prof Dr Gerasimos Konstantatos, used a technique to electronically dope the quantum dots robustly and permanently, enabling a new regime for transitions of electrons. Instead of relying on transitions across the bandgap of the material, they found a way to facilitate transitions amongst higher excited states. By doing this, they were able to excite electrons by absorbing photons with photon energies much lower than before in the mid and long wave infrared. The spectral coverage of such detectors can be tuned by changing the size of the dots, i.e. the larger the quantum dots, the farther the absorption in the infrared.

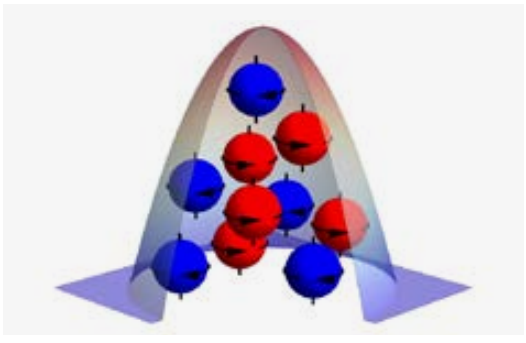
The results of this study could address and solve the challenges that the field of photodetector technologies is facing and may bring about a revolution to extreme broadband as well as multispectral CMOS compatible photodetectors.

An intelligent and compact particle analyzer

In many industrial and environmental applications, determining the size and distribution of microscopic particles is essential

In a paper published in *Light Science & Application*, ICFO researchers Rubaiya Binte Hussain and colleagues led by ICREA Prof Dr Valerio Pruneri, in collaboration with researchers in Spain, the Netherlands, Denmark, Germany, and the UK, have developed a new micro-particle size analyser (PSA) by combining consumer electronics products and artificial intelligence. The device, an order of magnitude smaller in terms of size, weight and cost, measures particle size with a precision comparable to commercial light-based particle size analysers.

The newly developed PSA works in a collimated beam configuration using a simple LED and a single metal-oxide-semiconductor (CMOS) image sensor, similar to those used in smart phones. The key-innovation is the small angular spatial filter (ASF) made with an array of holes with different diameters that is extruded from a polymer rod. On illuminating the target sample, light scatters and passes through the ASF onto the sensor. Light collected from different size holes is representative of a different set of scattering angles. An ad hoc machine learning model converts the sensor image into size of particles. The same device can be easily converted into hazemeter, an essential instrument to characterize many optical materials.



Looking for dark matter with the universe's coldest material

Researchers build a spinor BEC comagnetometer for studying the axion

Studies suggest that dark matter could be made of axions, hypothetical particles with unusual symmetry properties. In an article published in *Physical Review Letters* and highlighted as an Editor's suggestion, ICFO researchers Pau Gomez and colleagues in the group led by ICREA Prof Dr Morgan W. Mitchell, report on how to search for axions using the unique properties of BECs.

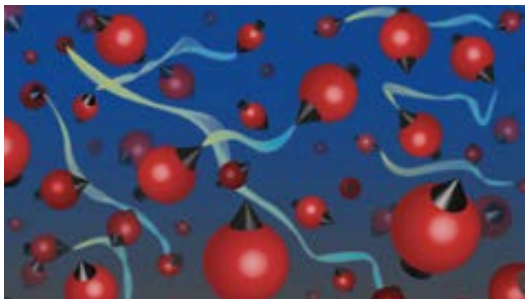
The axion, if it exists, would imply "exotic spin-dependent forces." Magnetism causes electrons to point their spins along the magnetic field, like a compass needle that points north. Magnetism is carried by virtual photons, whereas "exotic" spin-dependent forces would be carried by virtual axions (or axion-like particles). These forces would act on both electrons and nuclei, and would be produced not just by magnets, but also by ordinary matter. To know if axions do exist, a good way is to look and see if nuclei prefer to point toward other matter.

Others have experimented using "comagnetometers" to search for these forces that have to date only been able to look for spin-dependent forces that reach about a meter or more. For short-range spin-dependent forces, a smaller comagnetometer is needed. ICFO researchers solved this challenge by putting two BEC magnetometers in the same small volume using two different internal states of the same 87Rb BEC, each one acting as a separate but co-located magnetometer. The results of the experiment confirm the predicted high immunity to noise from the ordinary magnetic field and the ability to look for exotic forces with much shorter ranges than in previous experiments. Besides looking for axions, the technique may also improve precision measurements of ultracold collision physics and studies of quantum correlations in BECs.

LATEST ADVANCES

A new generation of OPOs

OPOs for tunable soliton pulses with sub-100 fs duration in the near-infrared. For many everyday applications, simplicity and small form-factor of the laser light source are deciding factors for the success or failure of a technology. Despite outstanding performance characteristics, stable long-term operation of femtosecond OPOs requires careful control of dispersion and cavity length, resulting in costly and complex system designs with large device footprint. In a study published in Optica, ICFO researchers Callum F. O'Donnell and colleagues led by Dr S. Chaitanya Kumar and ICREA Prof Majid Ebrahim-Zadeh, reported on the development of the next-generation of OPOs embedded in a novel fiber-feedback architecture, and producing tunable soliton pulses (wave-packets of light that maintain their shape in space and time) with sub-100 fs duration in the near-infrared. The team of researchers realized a viable and stable femtosecond OPO source in a highly compact, practical, and simplified design using a standard telecom fiber within the optical cavity. With this fiber-feedback approach, they were able to generate solitons within an OPO, for the first time, which could be rapidly tuned across a wide wavelength range using the variation of QPM grating period and cavity length. By using this technique, they could also generate such stable soliton pulses even in the presence of continually varying dispersion and nonlinearity effects. These results have proven the feasibility of a compact femtosecond OPO footprint, and enabled the study of soliton dynamics over a broad spectral range.



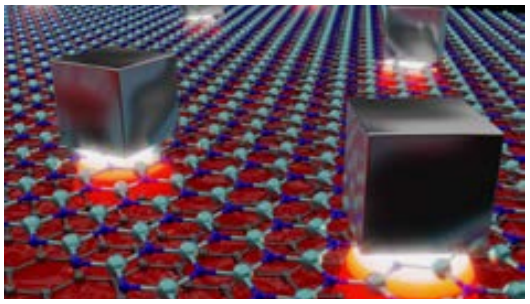
"Hot and messy" entanglement of 15 trillion atoms

Entangled states are at the heart quantum technologies but are of famously fragile. This is why current quantum technologies take great pains to isolate the microscopic systems they work with, and typically operate at temperatures close to absolute zero.

In contrast, in a study published in *Nature Communications* by ICFO researchers Jia Kong and colleagues led by ICREA Prof Dr Morgan Mitchell, in collaboration with HDU and UPV, researchers heated a collection of atoms to 450 Kelvin, millions of times hotter than most atoms used for quantum technology.The individual atoms collided with each other every few microseconds, and each collision set their electrons spinning in random directions.

The researchers used a laser to monitor the magnetization of this hot, chaotic gas. The magnetization is caused by the spinning electrons in the atoms, and provides a way to study the effect of the collisions and to detect entanglement. They observed an enormous number of entangled atoms – about 100 times more than ever before observed. They also saw that the entanglement is non-local. Between any two entangled atoms there are thousands of other atoms, many of which are entangled with still other atoms, in a giant, hot and messy entangled state.

This observation paves the way for ultra-sensitive magnetic field detection. For example, in magnetoencephalography (magnetic brain imaging), a new generation of sensors uses these same hot, high-density atomic gases to detect the magnetic fields produced by brain activity. The new results show that entanglement can improve the sensitivity of this technique, which has applications in fundamental brain science and neurosurgery.

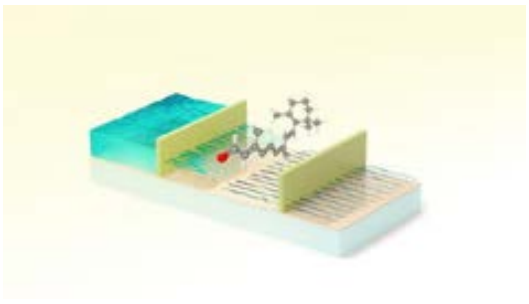


Smallest cavity for light realized by graphene plasmons

One challenge posed by miniaturization is dealing with controlling and guiding light at the nanometer scale. Graphene is capable of guiding light in the form of plasmons with a natural ability to confine light to very small spaces. Until now it was only possible to confine these plasmons in one direction, while the actual ability of light to interact with small particles, like atoms and molecules, resides in the volume that it can be compressed into. This type of confinement, in all three dimensions, is commonly regarded as an optical cavity.

In a study published in *Science*, ICFO researchers Itai Epstein and colleagues led by ICREA Prof Frank Koppens, in collaboration with researchers from MIT, Duke University, Université Paris-Saclay, and Universidad do Minho, have built a new type of cavity for graphene plasmons, by integrating metallic cubes of nanometer sizes over a graphene sheet. Their approach enabled the realization of the smallest optical cavity ever built for infrared light, which is based on these plasmons. Researchers used silver nanocubes of 50 nanometers in size, sprinkled randomly on top of the graphene sheet. Each nanocube, together with graphene, acted as a single cavity. Then they sent infrared light through the device and observed how the plasmons propagated into the space between the metal nanocube and the graphene, being compressed only to that very small volume. To induce the infrared light (very large) to interact with the cubes (very small), they used the special phenomenon called a magnetic resonance.

The generated resonance maintained the plasmons moving between the cube and graphene in a very small volume, which is ten billion times smaller than the volume of regular infrared light, something never achieved before in optical confinement. Researchers also saw that the single graphene-cube cavity, when interacting with the light, acted as a new type of nano-antenna that is able to scatter the infrared light very efficiently.



Chemically identifying molecules through ballistic electron energy losses

2D materials and electron energy losses to detect molecules at the zeptomole level. Infrared absorption spectroscopy can be used to detect minute concentrations of molecules by analyzing and studying the molecule's vibrational and electronic excitations. Electron energy-loss spectroscopy (EELS) has achieved space/energy resolutions of unprecedented levels, enabling the detection and spatial imaging of nanoscale optical excitations. However, this technique requires high vacuum and produces structural damage, which hinders applications to in vivo samples.

In a study published in *Science Advances*, ICFO researchers Renwen Yu and ICREA Prof Javier García de Abajo report on a novel approach that can chemically identify amounts of molecules at the zeptomol level (one 10-21 part of a mole, or about 600 molecules of a substance). They propose a device that uses ballistic electrons moving within a 2D semiconductor to analyze the device. Instead of using photons to interact with the molecules, they inject electrons with well-defined energies through the device and have them interact with the analyte molecules placed close to the 2D-material. The interaction produces energy losses, which are directly associated with the fingerprints of the molecules. The 2D material provides vertical confinement of the electrons without the need of a vacuum chamber to run the experiment. The energy losses produced by interactions between the incident electrons and the analyte are then analyzed in energy to generate a spectrum in the IR range, which exhibits the fingerprints of the molecules.

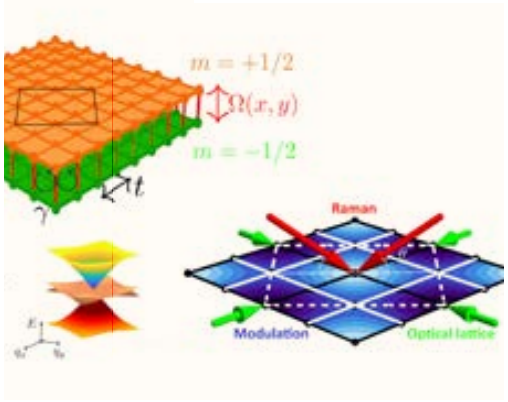
The results reveal a sensitivity down to the zeptomol level within a device of ~ 1 μm^2 footprint, which could be integrated for massive multiplexing using currently available technology.

HAPPENINGS

LATEST ADVANCES

Twistless Simulation of Twistronics

A novel approach using an atomic quantum simulator of twisted bilayers without actually twisting the layers



The interesting phenomenology of twisted materials seems to be related to the formation of moiré patterns around small twist angles. Some of these twisting angles, the so-called magic angles, lead to vast band flattening already at the single-particle level. The geometrical moiré patterns induce spatially varying interlayer couplings that are behind the strong modification of the band structure.

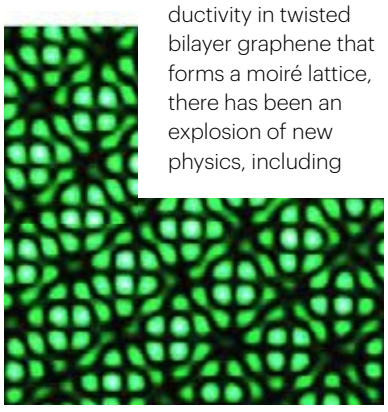
Ultracold atoms in optical lattices are, in principle, a very promising platform to experimentally explore this field. A challenging question is how to engineer such moiré-like optical lattice potentials. ICFO researchers Tymoteusz Salamon and Irénée Frérot, led by Debraj Rakshit and ICREA Prof Maciej Lewenstein, together with ICFO Prof Leticia Tarruell, researchers at UAM, Poland and the UAB propose in a letter published in *Physical Review Letters*, an atomic quantum simulator of twisted bilayers without actual physical twisting between layers. The idea is to elegantly employ another "specialité de la maison": synthetic dimensions.

Atoms are located in a single 2D lattice, but can occupy two internal states, mimicking two layers. Coupling between the layers is realized by Raman transitions that are spatially modulated to mimic the action of twists, or in general arbitrarily desired moiré patterns. The advantages of this scheme show that it is possible to control interlayer tunneling strength over wide ranges, control atom-atom interaction, so that the ratio of kinetic-to-interaction energy can be tuned over wide ranges, and that magic angle physics appears at "larger angles" with smaller moiré supercells, implying less fluctuations of the "twisting angle".

Thresholdless soliton formation in photonic moiré lattices

The observation of soliton formation with a power threshold dictated by geometry in photonic moiré lattices

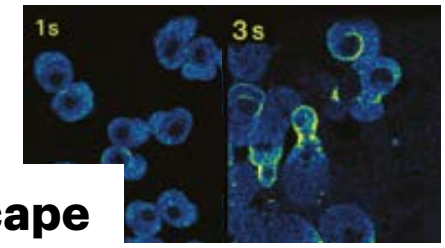
Since the discovery in 2018 at MIT of a new type of unconventional superconductivity in twisted bilayer graphene that forms a moiré lattice, there has been an explosion of new physics, including several landmark contributions by the ICFO team led by Prof Efetov that unveiled a new zoo of unobserved states in such structures.



Moiré lattices optically-induced in a photorefractive nonlinear crystal have been employed to observe the formation of optical solitons under different geometrical conditions controlled by the twisting angle between the constitutive sub-lattices.

In a study published in *Nature Photonics*, ICFO researchers Prof Yaroslav Kartashov and Prof Lluís Torner report on the observation of soliton formation related to moiré lattices. The behavior of the soliton formation threshold was confirmed to be directly linked to the band structure of the moiré lattices resulting from the different twisting angles of the sub-lattices and, in particular, of the band-flattening associated to the geometry of the lattices. Similar phenomena are anticipated to occur in moiré patterns composed of sublattices of other crystallographic symmetries and in other physical systems where flat-bands induced by geometry arise.

When feeling the pinch, nuclei transform cells' structure to escape crowded spaces



The threat of serious deformation triggers a rapid escape reflex that enables cells to move away and squeeze out of tight spaces or crowded tissues

Valeria Venturini and colleagues led by SLN Team leader Dr Stefan Wieser, in close collaboration with researchers from Centre for Genomic Regulation (CRG), reveal in a study published in *Science* that squeezing a cell to the point where its nucleus starts to stretch triggers the activation of motor proteins which in turn transform the cell's cytoskeleton so that it can flee a packed environment.

Each cell has a nucleus, and each nucleus has a membrane that separates the chromosomes from the rest of the cell. At a rest state, the nuclear membrane is saggy, akin to a loose shopping bag.

The researchers have found that when the nuclear membrane is squeezed, the wrinkles on its surface iron themselves out, instigating a cascade of events that transform the cytoskeleton and eventually aid the cell in escaping its crowded environment. This is the first time researchers have been able to explain how single cells measure and respond to acute shape deformation, a real threat to their survival. The reflex is activated in less than a minute, reversing when cells have escaped their packed environment.

New approach to exotic quantum matter

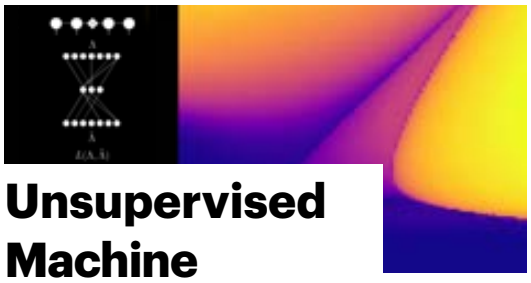
Advances in the understanding of fractional angular momentum and anyon statistics of impurities in Laughlin liquids

While in a three-dimensional world, all particles must be either fermions or bosons, in fewer dimensions, the existence of particles with intermediate quantum statistics, known as anyons, is possible. Experimental evidence of anyons has remained very limited, and, so far, there have been many efforts to improve the experimental evidence of anyons by searching for ways to study the FQH effect and understand its underlying physics in highly controllable quantum systems such as cold atoms or photonic quantum simulators.

In a recent study published in *Physical Review Letters*, ICFO researchers Tobias Grass and colleagues led by ICREA Prof Dr Maciej Lewenstein, and in collaboration with researchers from the University of Barcelona, describe a new approach towards anyon detection, which is a crucial element for increasing our knowledge of exotic quantum matter.

Contrary to earlier detection schemes, the study suggests to trace the behavior of the anyons by binding impurity particles to them. Specifically, the average angular momentum of a single impurity is shown to take characteristic values that are possibly fractional. For a system of multiple impurities, the total angular momentum should then depend on how these effective single-impurity levels are filled. Strikingly, the value obtained by the authors corresponds neither to the filling of a Fermi sea nor to the condensation of a bosonic mode. Instead, the impurity angular momentum interpolates between these limiting cases, and the fractional statistical parameter of the anyons can be straightaway inferred from this interpolation. Their detection scheme only requires density measurements and might be applicable to Abelian quantum Hall phases in electronic materials as well as in photonic or atomic quantum simulators.

LATEST ADVANCES



Unsupervised Machine Learning in Physics

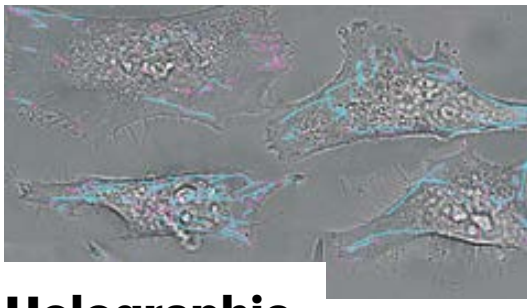
An entirely new anomaly detection method capable of training a system in very few iterations

Machine Learning (ML) analyzes and interprets data structures and patterns in order to learn from them, reason and carry out a decision-making task that is completely independent from human reasoning and engagement. Contrary to supervised learning, unsupervised learning seeks to discover patterns or classify information in large data sets into categories without prior knowledge. With no labeled outputs, it basically infers the natural structure that a dataset may have and extracts categorized information. This learning has proved to be very efficient for identifying phases and phase transitions of many-body systems.

In a study published in *Physical Review Letters*, ICFO researchers Korbinian Kottmann and Patrick Huembeli, led by ICREA Profs Antonio Acín and Maciej Lewenstein report on a method that uses an unsupervised machine learning technique based on anomaly detection to automatically map out the phase diagram of a quantum many body system given unlabeled data.

In ML the most common and known classification task example is to discriminate images. Used in the context of quantum many-body systems, the images become observables, wave-functions or entanglement properties and the classes become different quantum phases. The model that they look at is the extended Bose-Hubbard model, which offers four different phases in the parameter space of interest. Since the researchers do not know the phases in their task a priori, they start by defining a region around the origin of the phase diagram as their starting point to train. Already from there, they are clearly capable of mapping the system in one training iteration, where all four phases of the system are easily distinguishable.

By using this approach they have been able to reveal a phase-separated state between a supersolid and a superfluid, which appears in the system in addition to the standard superfluid, Mott insulator, Haldane-insulating, and density wave phases. This is one of the first times in which a machine detects a previously unknown phenomenon in a quantum many-body context.

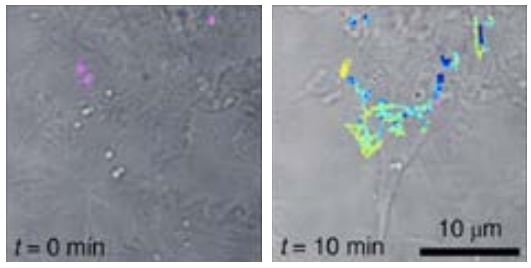


Holographic Fluorescence Imaging

Holography can produce 3D images (holograms) by recording an interference pattern of light scattered by an object with some reference wave.

In biology, fluorescence imaging is widely used in live cell imaging. Studies search to combine fluorescence microscopy with holography and thus retrieve the full 3D distribution of fluorescently labeled entities inside a cell. Unfortunately, fluorescence is incoherent, with a very short coherence length and phase memory, complicating the creation of a reference wave for any fluorescence interference and hence holography.

In a study in *Science Advances,* holographic fluorescence imaging was presented by ICFO researchers Matz Liebel and Jaime Ortega-Arroyo, working in the groups of ICREA Profs Niek van Hulst and Romain Quidant. They used the intrinsic phase information of each individual photon to access its phase via a technique called lateral shearing-interferometry. In essence, rather than directly measuring the phase they measured the position-dependent phase change in wide-field using a CMOS camera. Next, they computationally integrated this information to recover the full electric field of fluorescent light with single-molecule sensitivity. The novel scheme expands the principle of digital holography to fast fluorescent detection by eliminating the need for phase cycling and enables 3D-tracking of individual nanoparticles with an in-plane resolution of 15 nm and a z-range of 8 micrometer. They later worked with the Massachusetts General Hospital in Boston to image and track the 3D motion of extracellular vesicles (EVs) inside live cells. They observed a transition toward anisotropic motion with the EVs being transported over long distances in the axial plane, confined in the horizontal dimension.



Raman Holography

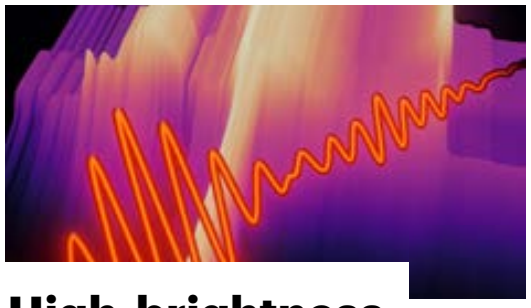
Raman spectroscopy is widely used to identify molecules via their structural fingerprint.

Unfortunately, spontaneous Raman scattering is over ten orders of magnitude weaker than fluorescence. But, Raman scattering can be enhanced dramatically on metal surfaces or in metallic nanogaps, and this surface enhanced Raman scattering (SERS) can even exceed the fluorescence response.

Nanometric SERS probes are thus promising candidates for biological sensing applications, preserving the intrinsic molecular specificity. Still, the effectiveness of SERS probes depends critically on the particle size, stability and brightness, and, so far, SERS-probe based imaging is rarely applied.

Now ICFO researchers Matz Liebel and Nicolas Pazos-Perez, working in the groups of ICREA Profs Niek van Hulst (ICFO) and Ramon Alvarez-Puebla (Univ. Rovira i Virgili) have presented "holographic Raman microscopy" by first synthesizing plasmonic superclusters from small nanoparticle building blocks to generate very strong electric fields in a restricted cluster size. Next they took advantage of the bright SERS probes to realize 3D holographic imaging, using incoherent holographic microscopy developed by Liebel and team in a study in *Science Advances* (See highlight on Holographic Fluorescence Imaging). Remarkably, the incoherent Raman scattering is made to "self-interfere" to achieve Raman holography for the first time.

Researchers were able to localize single-SERS-particles in 3D volumes from one single-shot. They then used these capabilities to identify and track single SERS nanoparticles inside living cells in three dimensions. The results, published in *Nature Nanotechnology* represent an important step towards multiplexed single-shot three-dimensional concentration mapping in many different scenarios, including live cell and tissue interrogation and possibly anti-counterfeiting applications.



High-brightness source of coherent light spanning from the UV to THz

Techniques to achieve hyperspectral spectroscopy and imaging allow scientists to observe the behavior of, for example, molecules when they fold, rotate or vibrate in order to understand the identification of cancer markers, greenhouse gases, pollutants or other potentially harmful substances. These ultrasensitive techniques have proven to be very useful in applications related to food inspection, biochemical sensing or to investigate the structure of the materials used for ancient objects, paintings or sculptures. The absence of compact sources that cover such large spectral range with sufficient brightness has been a challenge. Synchrotrons provide the spectral coverage, but they lack the temporal coherence of lasers, and such sources are available only in large-scale user facilities.

In a study published in *Nature Photonics*, an international team of researchers from ICFO, the Max-Planck Institute for the Science of Light, the Kuban State University, and the Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy, led by ICREA Prof Dr Jens Biegert, report on a compact high-brightness mid-IR-driven source combining a gas-filled anti-resonant-ring photonic-crystal fiber with a novel nonlinear crystal. The tabletop source provides a seven-octave coherent spectrum from 340 nm to 40,000 nm with spectral brightness 2-5 orders of magnitude higher than one of the brightest synchrotron facilities. Future research will leverage the few-cycle pulse duration of the source for the time-domain analysis of substances and materials, thus opening new opportunities for multimodal measurement approaches in areas such as molecular spectroscopy, physical chemistry or solid-state physics, to name a few.

HAPPENINGS

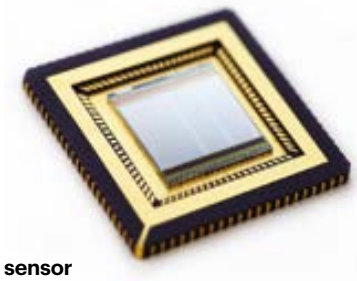
BUSINESS NEWS

Two new Companies Spin-off from ICFO in 2020

Qurv and Sixsenso bring the total number of companies to successfully incubated in the ICFO Launchpad to nine

Through the Knowledge and Technology Transfer unit led by Dr Silvia Carrasco, ICFO has been successful at launching nine technology spin-offs to commercialize ideas and discoveries "made @ ICFO".

"We are thrilled to see both Qurv and Sixsenso enter the club of ICFO spin-offs this year, after years of intense and creative research, development and business efforts. Hand in hand with the KTT Business developers, their teams have managed to bring ICFO technologies to society," explains **Carrasco**.



QURV TECHNOLOGIES

Developing wide-spectrum image sensor technologies and integrated solutions to enable enhanced computer vision applications.

Qurv develops wide-spectrum image sensor technologies and integrated solutions to enable enhanced computer vision applications, addressing the expanding needs of an autonomous and intelligent new world.

Their graphene/quantum dot image sensors platform technology allow operation from the visible to the short-wave infrared (SWIR) range and can be integrated with current CMOS low-cost, high-manufacturability processes. Qurv's "plug and play" approach aims to bring advanced machine vision capabilities to markets that are not accessible by the current state of the art SWIR sensors.

Qurv incubated in the KTT Launchpad for more than 6 years and holds a portfolio of more than 10 patent families. The incubation has received support from the Government of Catalonia, the Ministry of Economy, Industry and Competitiveness of Spain, the European Research Council, the Barcelona City Council and the Castelldefels City Council, the European Regional Development Funds allocated to Generalitat de Catalunya for emerging technology clusters devoted to the valorization and transfer of research results (GraphCAT 001-P-001702) and the European Union's Horizon 2020 research and innovation programme under grant agreement No 649953.

"By harnessing and efficiently processing information that nature hides beyond what is visible, a new era in health, security and decision-making will emerge. However, no mass-deployable solution exists to provide these capabilities at scale and to everyone. We are now ready to achieve precisely this- bringing technology once available only in the lab to the world."
Antonios Oikonomou, CEO

"Our unprecedented expertise of the graphene/quantum dot stack puts us in an optimal position to leverage the benefits of integration with silicon CMOS technology in terms of functionality, performance and addressable markets."
Stijn Goossens, CTO

July 19, 2020: Signature of Qurv's technology transfer agreement. (R to L) ICFO Director Lluís Torner, ICREA Executive Director Emilià Pola, Qurv's CEO Antonios Oikonomou, CTO Stijn Goossens, ICREA Professors at ICFO and co-founders Frank Koppens and Gerasimos Konstantatos, and KTT Director Silvia Carrasco.

SIXSENSO

Contributing to better care of the environment.

The technology and IP developed at ICFO in the Optoelectronics research group led by ICREA Prof Valerio Pruneri, which has now been transferred to Sixsenso, is based on the application of light to detect fluorescence emitted both naturally and by induced labelling techniques emitted by microorganisms. It comprises a microfluidic labelling system and a laser-based fluorescence reader system, both coupled to a front-end sample concentrator system that takes the target waters under investigation and converts them into a useful volume for system analysis.

The complete Sixsenso system is designed to be extremely accurate, portable, cost-effective, and easy to integrate within a process stream or for on-site measurements with a time to result one order of magnitude lower than gold standard methods. It is an innovative solution for early detection of biological contamination in environmental and industrial waters to monitor the water quality and avoid and stop outbreaks. It is suitable for bathing water, harbor water and ballast water regulations compliance, with direct applicability in waste water, industrial water, fresh water, beverage quality control.

The incubation has received support from the Government of Catalonia, the Ministry of Economy, Industry and Competitiveness of Spain, the Barcelona City Council and the Castelldefels City Council, ACCIO under the Programme *Ajuts destinats a incentivar els projectes de creació d'empreses de base tecnològica de les universitats, instituts de recerca hospitalari, centres tecnològics i altres centres de recerca amb una unitat de comercialització tecnològica* (SixSenso-Water, VALUNI16-1-0083 and IMACYT) and the European Union's Horizon 2020 research and innovation programme under grant agreement 642356 (CYTO-WATER).

"Our technology is ready to enter the water market and offer an innovative and attractive solution for end-users in terms of functionality, reliability and rapid time to result. There are new challenges on the horizon but we are encouraged to meet them as a company fully committed to present cutting-edge technology addressing environmental needs."
Pedro Martinez, CTO

"We are developing technology that will push the boundary of laboratory est to field test, bringing cutting-edge technology to environmental water testing and in doing so, creating a better environment. Sixsenso recognizes the immense effort deployed to arrive at its current position. We are all privileged to be caretakers to move the business forward."
Adrian Parker, CEO

Sixsenso, ICFO's 9th spin-off company, launched on October 20th after incubating in the KTT Launchpad for eight years. Members of the company Sixsenso's CTO Pedro Martinez and CEO Adrian Parker, ICREA Professor at ICFO and co-founder Valerio Pruneri, were present, as were ICFO Director Lluís Torner, ICREA Executive Director Emilià Pola, and ICFO's KTT director, Silvia Carrasco.

BUSINESS NEWS

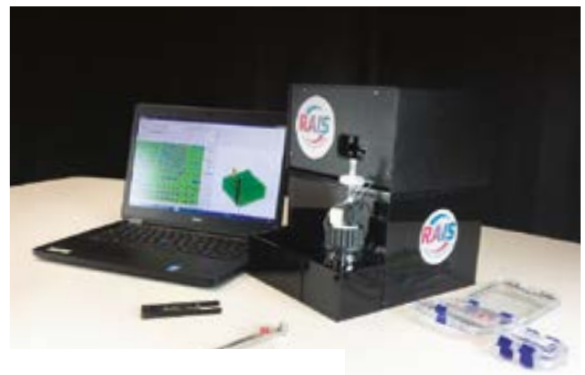
ICFO at the Top in Patent Creation

ICFO ranks in the top 10 entities in the country in terms of innovation as measured in patent registrations

Strong foundations of knowledge and technology are essential for a country's healthy economic development, a fact that explains why results published by the European Patent Office (EPO) showing that in 2019, patent registrations originating in Spain increased by 6% compared to 2018, is good news. ICFO has been an important contributor in terms of innovation, **ranking in the top ten of companies and research institutes in patent applications for the second consecutive year**.

Among the companies and institutions that registered the highest number of patents in 2019, the Consejo Superior de Investigaciones Científicas (CSIC) came out in first place with 34 applications, followed by the Tecnalia Research & Innovation Foundation (26), Telefónica (23), Dalphi Metal (19), Laboratorios Esteve (20), la Universidad Autónoma de Barcelona (14), **ICFO (12)**, and Repsol (11).

ICFO's Knowledge and Technology Transfer (KTT) team plays a key role in connecting industry with exciting developments in ICFO laboratories. One of ICFO's main goals is to maximize business opportunities arising from research being carried out at the Institute and from collaborations with industries, investors and health-care allies. With experience in both business and research, the team develops business plans that are tailored to the unique needs of each company and aligned with the research capabilities of ICFO.



INNOVATORS grant

Support for Knowledge and Tech Transfer projects

Through the INNOVATORS 2019 grant program, the Generalitat de Catalunya helps to provide funding for knowledge and technology transfer projects for innovators working within the Catalan research and innovation system.

The project entitled **"SLIM: Sepsis-screening platform based on lens-free interferometric microscopy"**, technically driven by the Optoelectronics research group led by ICREA Prof Dr Valerio Pruneri, will allow Dr Roland Terborg -the innovator- with the support of ICFO's KTT team on the business side, to carry out activities that will evaluate the creation of a new ICFO spin-off company.

The SLIM project aims at bringing to the clinical market a new platform that provides the information of several biomarkers relevant for sepsis diagnosis and treatment within 30 minutes. The technology has been developed and tested in pre-clinical trials during the European H2020 Project RAIS (www.rais-project.eu) and has already been tested at the facilities of the Hospital de Vall d'Hebrón in Barcelona with human samples.

ICFO Spin-Off takes off in the world of deep tech

Quside: Celebrating the launch of their first quantum randomness module

Since spinning off from ICFO in 2017, **QUSIDE** has been working toward the commercialization of high-performance quantum random number generators. After success with leading enterprises in the telecom, critical infrastructure, and banking sector, Quside recently released the **FMC 400 Randomness Module**.

Quside™ FMC 400 has been designed specifically for high-performance FPGA-based systems. **The technology is based on Quside's proprietary phase-diffusion quantum random number generation technology**. It provides 400 Mb/s of raw random numbers with state-of-the-art min-entropy bounds (above 90%). A standard FMC interface allows easy and versatile integration.

Over the last decade, this proprietary phase-diffusion randomness generation technology has been recognized to meet the requirements of the most demanding applications. The combination of high speed and unmatched signal quality have proven essential to customers and mark the FMC 400 as the most crypto-agile randomness module on the market.

QUSIDE

The QusideTM FMC 400 is the company's **first step towards building a wide** variety of fast and high-quality quantum randomness sources. With new technologies on the horizon, such as 5G and AI, the aim is to address the current and future global cybersecurity concerns and meet the market's growing need - high-speed at the internet-scale.

www.quside.com

COLLABORATION

TRAINING
2019 ICFO PhD Thesis Awards

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INNOVATION

RIS3CAT

Catalonia's Research and Innovation Strategy

For a smarter more sustainable and integrated economic model

RIS3CAT is the Catalan Government's regional research and innovation strategy for smart specialization, aiming to orient the productive sector of the Catalan economy toward a smarter, more sustainable and integrated economic model. **Through strategic actions, Catalonia's strong research base, teams up with top-class infrastructures and entrepreneurial activity.** Through these collaborations, Catalonia moves to consolidate its position as a European knowledge hub with its technological and creative capacities linked to existing and emerging sectors in the territory.

ICFO participates in three of the nine projects approved in the emerging technologies program of RIS3CAT

QuantumCAT: Accelerating the Application of Quantum Technologies

Coordinated by ICFO

Research Groups led by Professors Morgan Mitchell (coord), Antonio Acín, Darrick Chang, Maciej Lewenstein, Valerio Pruneri, Hugues de Riedmatten, and Leticia Tarruell are involved in QuantumCAT.

quantum-cat.cat

QuantumCAT will focus on transferring discoveries made in research laboratories to the market, by means of industrially viable implementations and applications. It will promote specific and high-potential laboratory technologies and encourage their industrial deployment and implementation through collaborative and cooperative research efforts. It will facilitate the dissemination of successful development and innovation strategies at the community level, and will also conduct activities aimed at academic and industry audiences, to discuss experiences and collaborations, as well as share knowledge among the community regarding success stories and use-case studies. The Hub will coordinate activities in various technological areas, mainly in: quantum communication and cybersecurity, quantum computing and simulation, and quantum sensing and metrology. Developments in these fields will seek to facilitate the transformation of scientific concepts into tangible implementations for industry and citizenship in general, through applications ranging from secure Internet communications to ultra-high precision images for the management of natural resources as well as medicine.

GraphCat: The Graphene Community of Catalonia

Co-coordinated by ICFO and the Institut Català de Nanociència i Nanotecnologia (ICN2), co-coordinators

Research Groups led by Professors Frank Koppens (coord), Gerasimos Konstantatos, Valerio Pruneri, Pablo Loza-Alvarez, and Jordi Martorell are involved in GraphCAT.

graphcat.cat

Catalonia is home to a concentration of experts in the field of graphene research and has for many years played a leading role in the pan-European Graphene Flagship initiative.

Building on this strength, the GraphCAT community will curate and develop a project portfolio that simultaneously drives progress and showcases excellence, with the aim of establishing Catalonia as an international reference in the development of advanced graphene-based applications.

It will strengthen and accelerate technology transfer activities to the Catalan industrial community and support the creation of high-tech spin-off companies, creating a strong hub where researchers and industries are positioned to obtain a competitive advantage in the global marketplace through the integration of proprietary graphene technologies into their products and services.

Emerging Cluster of the Human Brain (CECH) Initiative

Coordinated by Universitat Pompeu Fabra (UPF)

Research group led by ICREA Prof Dr Turgut Durduran participates in CECH initiative.

upf.edu/web/cech

The synergies created within this cluster promote the creation and integration of innovative ideas **to provide solutions to current challenges in the field of neuroscience**. The solution to these challenges are framed in 5 cutting-edge projects, each working to develop and transfer an innovative solution to our society. The range of ICFO's involvement in 2 of projects within the CECH cluster demonstrates a wide range of applications of the technologies developed for neuroscience in the Medical Optics group led by ICREA Prof Dr Turgut Durduran.

***Projects are co-funded by the European Regional Development Funds (ERDF) allocated to the Programa operatiu FEDER de Catalunya 2014-2020, with the support of the Secretaria d'Universitats i Recerca of the Departament d'Empresa i Coneixement of the Generalitat de Catalunya for emerging technology clusters devoted to the valorization and transfer of research results (CECH 001-P-001682; QuantumCAT 001-P-001644; GraphCAT 001-P-001702).*

Unió Europea
Fons Europeu
de Desenvolupament Regional

Generalitat de Catalunya
Departament d'Empresa i Coneixement
Secretaria d'Universitats i Recerca

TRAINING

ICFO-SJD Joint Lab

Institut de Recerca Sant Joan de Déu and ICFO create a joint lab to improve neonatal and pediatric health care

Neonatal and pediatric health care must adapt to the needs of the most vulnerable patients, especially those with pathologies that have a significant impact on their quality of life. Improvements in diagnosis, monitoring and treatment are of great importance to increase the likelihood that critically ill pediatric patients will become healthy and independent adults. The ICFO-SJD Laboratory is a joint project between the Institut de Recerca Sant Joan de Déu (IRSJD) and ICFO, created to accelerate the development and application of photonic technologies to benefit the most vulnerable children. It aims to develop more precise and non-invasive techniques that will help understand their pathologies and apply the most advanced photonic solutions for their care.

Interdisciplinary collaborations play a key role in advancing scientific knowledge. For this reason, the ICFO-SJD Laboratory combines IRSJD's expertise and knowledge in biomedical and clinical research in the care of infants, children and adolescents, with ICFO's experience in the development and management of photonic technologies for health innovation. The alliance has been made possible thanks to the support of the Joan Ribas Araquistain Foundation and "Torró Solidari RAC1" by Torrons Vicens. It brings together the experience accumulated by both institutions over the years with the support of the Cellex Foundation and "la Caixa" Foundation, the Catalan Government and the European Commission, among others.

jointlab-sjd.icfo.eu

TRAINING

ICFO Coordinates four new European Projects

Researchers from around the European Union compete for funding through the European Commission's wide range of funding schemes

With limited funding obtainable and a plethora of excellent research proposals competing for financing, each with highly innovative and ambitious projects, it is a momentum achievement indeed for ICFO to obtain funding for four new coordinated research projects in one year.

VASCOVID

New Portable Solution for Scarce Icu Resources

Coordinated by ICREA Prof Dr Turgut Durduran

Funding Scheme: H2020 Innovation Action

Healthcare systems around the world have been overwhelmed by the surge in seriously ill COVID-19 patients who require intensive care unit (ICU) admission. While exact rates differ per EU Member State, 3–12"% of the infected population need mechanical ventilation. The personalization of treatment will allow for the more targeted rationing of scarce ICU resources. With this in mind, VASCOVID is developing a portable, non-invasive and real-time health monitoring platform that combines time-resolved near-infrared spectroscopy and diffuse correlation spectroscopy. The solution will enable the large-scale testing of new treatment procedures and therapies, targeting microvascular impairment. Moreover, it will reduce the incidence of extubation failure (reintubation within seven days) in ICUs.

DAALI

Disruptive Approaches to Atom-Light Interfaces

Coordinated by ICREA Prof Dr Darrick Chang

Funding Scheme: FET Open

Realizing efficient interfaces between photons and atoms forms the basis for a wide range of applications such as quantum memories for light and nonlinear optics at the single-photon level. Despite many spectacular demonstrations of atom–light interactions, current interfaces still face major limitations. Bringing together theoretical and experimental expertise in atomic physics, quantum optics and photonics, DAALI aims to overcome these challenges. In particular, the researchers will develop new physical platforms such as nanophotonic systems that offer unprecedented atom–photon coupling strengths, and develop novel paradigms, such as based on atomic arrays in order to harness the power of wave interference.

LESGO

Light to Store Chemical Energy in Reduced Graphene Oxide for Electricity Generation

Coordinated by UPC Prof at ICFO Jordi Martorell

Funding Scheme: H2020FET Proactive

Electricity generation based on renewables is unpredictable, but hydrogen (H2) could be a promising energy storage route. Since over 95% of H2 comes from breaking the carbon-hydrogen bond in hydrocarbons, storing hydrogen bound to carbon may provide a long-term solution. However, extracting hydrogen from liquid hydrocarbons includes CO2 emissions. To address this problem, LESGO aims to store energy in the C-H bond of reduced graphene oxide (rGO-H). The advantages of rGO-H include safe storage, easy transportation, an energy density over 100 times larger than that of H2 gas and no CO2 emissions in the electricity generation process. The project will promote an affordable and eco-friendly means of supplying electrical power on demand where required.

OPTOlogic

Optical Topologic Logic

Coordinated by ICREA Prof Dr Jens Biegert

Funding Scheme: FET Open

About 10"% of the energy produced globally is used to power electronic circuits that carry out logic operations for the global internet and in consumer devices. OPTOlogic aims to develop a computing architecture that takes advantage of light-induced and controlled topology for energy-efficient logic operations. To artificially induce and control topological protected states, the project will create a new class of dissipationless quantum devices generated through spatially and temporally structured ultrafast pulses of light. The quantum devices prepared will use minimal energy to move and store information, while dramatically increasing computing power. By increasing the energy efficiency and speed of logical operations, the project could have a significant economic, environmental and social impact.

RESEARCH

Three new ERC Consolidator Grants

Professors Darrick Chang, Gerasimos Konstantatos and Leticia Tarruell receive ERC Consolidator Grants for mid-career research leaders

In early December, the ERC announced the awarding of its Consolidator Grants to 327 top researchers in Europe. 2506 research proposals were evaluated in this call, out of which ~13% were selected for funding. ICFO was especially successful, with grants awarded to all three Group Leaders who applied.

ICREA Prof Dr Darrick Chang, awarded for the project ***A New Spin on Quantum Atom-Light Interactions (NEWSPIN)***, which aims to establish that interference in light emission is in fact a much more powerful resource than the level that we currently exploit it within quantum optics. For quantum applications, the project aims to establish protocols with exponentially better error bounds than those currently known.

ICREA Prof Dr Gerasimos Konstantatos, awarded for the project ***Mid- and Long-wave infrared Colloidal Quantum Dot Optoelectronics (INFRADOT)*** addressing the current challenge of high cost and fragmented solutions that limit the potential and wide-spread use of optoelectronic materials in the mid and long-wave infrared in applications in sectors such as safety and security, quality control, environmental monitoring, imaging, just to name a few. It will develop groundbreaking, lowcost, highly efficient material and device platforms operating in this so far under-exploited part of spectrum.

ICFO Prof Dr Leticia Tarruell, awarded for the project ***Unconventional Superfluids in Quantum Gases with Competing Interactions (SuperComp)*** that aims to exploit the full potential of ultracold quantum gases with competing interactions to unlock the observation of unconventional superfluid phases that have until now defied experimental realization. To this end, SuperComp will explore three distinct mechanisms resulting in unconventional superfluid behavior: quantum fluctuations, engineered dispersion relations, and interactions with non-zero orbital angular momentum.

COLLABORATION

TRAINING

2019 ICFO PhD Thesis Awards

The PhD Committee launched an in-depth deliberation of the 23 PhD Theses defended at ICFO in 2019 to determine the recipients of the PhD Thesis Awards

This award was created in order to distinguish particularly brilliant PhD theses presented at ICFO. With this award, ICFO wishes to highlight and reward extraordinary PhD students whose research progress at the Institute has proven to be highly creative and ambitious. **The recipients of the 2019 Thesis Award are:**

THEORETICAL FIELD
2019 THESIS AWARD

Dr RENWEN YU
in recognition of the exceptional thesis:
Toward Next-Generation Nanophotonic Devices.
Supervised by ICREA Prof at ICFO **Dr Javier García de Abajo**

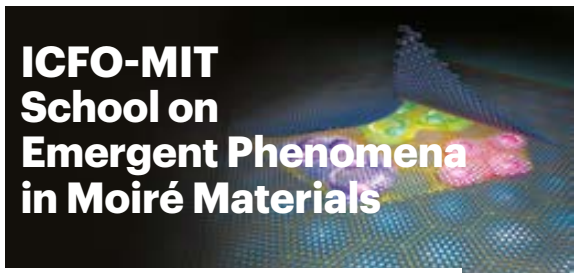
EXPERIMENTAL FIELD
2019 THESIS AWARD

Dr LUCIANA VIDAS
in recognition of the exceptional thesis:
The insulator-metal phase transition in VO2 measured at nanometer length scales and fem-tosecond time scales.
Supervised by Prof **Dr Simon Wall**

Renwen's thesis was notable for the impressive breadth and volume of topics studied, and his outstanding combination scientific creativity, maturity, analytical skills, which led to more than 20 publications during his thesis.

Luciana helped building a new lab from scratch, and developed advanced new experimental techniques for studying quantum materials in collaboration with researchers across three continents. The insights gained from these studies led to several beautiful and high-impact papers.

ICFO congratulates both Luciana and Renwen and wishes them all the best for their future careers!



ICFO-MIT School on Emergent Phenomena in Moiré Materials

For the first time, ICFO's annual summer school was delivered entirely online! Led by ICFO group leaders **Dmitri Efetov** and **Frank Koppens,** along with Professors **Adrian Bachtold** and **Maciej Lewenstein** and Research Fellow Dr **Antoine Reserbat-Plantey**, this year's school was developed in collaboration with MIT's Prof **Pablo Jarillo-Herrero**. Seminars from 20 leading experimentalists and theorists addressed the emerging field of twistronics and exciting new physics emerging from studying Moiré systems with 2D materials. More than 1100 people from over 50 countries attending the school.

Quantum Future Academy Workshop

On July 24th, ICFO hosted an online workshop to select the Spanish delegates for the Quantum Future Academy, a European-wide, one-week school on quantum technologies hosted from Berlin in November. Students from around Spain were invited to present a pitch to the selection committee as to why they should attend the school. Congratulations to the two successful candidates, Alexandra Mestre Tora (CFIS-UPC) and Rubén Ibarrondo López (UPV/EHU).

BIST Symposium on Microscopy, Nanoscopy and Imaging Sciences

BIST Barcelona Institute of Science and Technology

In January 2020, ICFO hosted the third edition of the BIST Symposium on Microscopy, Nanoscopy and Imaging Sciences, part of the MMRES master's program, with talks from international scientists and researchers from the BIST community. Highlights included Prof Sonia Contrera (Oxford) on Measuring viscoelasticity of living systems with AFM, Mathieu Kociak (CNRS-Univ. Paris Sud) on Nanooptics in the electron microscope and ICFO's Emilio Gualda on Light-sheet fluorescence microscopy.

Resilience & Well-Being workshop

A research career path can be demanding on a personal as well as intellectual level, particularly for students relocating from their home countries and in the complicated current circumstances. **ICFO offers a Resilience & Well-Being program in partnership with OnBalance to help researchers strengthen their capacity to undertake ambitious projects and thrive in a competitive research environment.** The workshop was held online in June this year to help students and researchers through the particular challenges thrown up by the COVID-19 pandemic.

COMMUNITY

Committees for Ethics, Diversity and Inclusion

Support for the ICFO community

Committees at ICFO are formal structures with representation from all areas of the institute. They exist to strengthen and support the experience of ICFOnians and the institute's mission of research excellence.

ACADEMIC INTEGRITY ANDRESEARCH ETHICS COMMITTEE

The Academic Integrity and Research Ethics Committee met for the first time in October 2020. The new committee takes over from an ad-hoc Ethics Working Group established several years ago. It holds the responsibility of discussing topics raised by ICFO and the ICFO community at large, acting as a mediation body for appeals and conflicts, proposing policies and training activities, and raising awareness among the ICFO community of relevant topics and issues related to their mandate.

*** ICFOnians** will have a dedicated ***Ethics and Diversity Corner*** in each edition to support the institutional conversation related to this subject. **Watch this space in 2021!**

DIVERSITY AND INCLUSION COMMITTEE

Originally constituted as the Gender Committee to address discrimination and bias, and create an inclusive environment where all staff and students can thrive and fully participate in all the institute's activities, this committee has evolved, changing its name to reflect its expanded scope.

The committee will promote initiatives related to gender such as activities organized in the framework of the annual ICFOnians for Women in Science Month. Additionally, it will implement activities that promote awareness and inclusion of the LGTBIQ community and people with disabilities, as well as other future activities addressing different approaches to diversity in a broad sense.

COMMUNITY

Diversity at ICFO

ICFO has been extraordinarily successful in attracting a very ambitious and talented group of women and men from various technological areas and fields of science

Today the center hosts around 400 researchers and staff from more than 60 different nationalities, an amalgamation of languages, beliefs and cultures which gives the center an extraordinarily rich and diverse atmosphere in terms of ways of thinking, acting, learning and living science.

Since its creation, ICFO has been committed to promoting diversity at the center and has created an international and multi-cultural environment that enables a wide range of perspectives to contribute in unique ways to advancing solutions to complex scientific challenges. It has been active in coordinating and reinforcing inclusion programs for minority groups and those who fall short of equal access to opportunities. Examples include participation in the program offering research stays to senior female researchers from Africa through the **"Women for Africa"** program, doctoral scholarships for young female scientists through the **ENLIGHTEN program**, co-financed by the European Commission, or coordination of **CARLA**, a European project which will develop professional camps for young researchers, focusing specifically on broadening the diversity of profiles in STEM fields.

SPIE DIVERSITY CHAIR

In recognition of ICFO's history of leadership in the area of diversity, SPIE, the International Society of Optics and Photonics based in Bellingham, Washington (USA) announced in June 2020 the formalization of the **SPIE @ ICFO Chair for Diversity in Photonic Sciences with an endowment of US $ 1 million, including a sum of $500,000 in funding from SPIE**. The Chair is part of the SPIE Endowment Matching program that was designed to increase international capacity in the teaching and research of optics and photonics. The program was established in 2019 and prior to the announcement of ICFO's Chair, four institutes in the US had already benefited, however it was the first time that funding of this nature and magnitude was awarded to an institution in Europe.

The remit of the Chair is to reinforce the center's activities for the promotion of diversity in all its forms, starting with programs to support the education and careers of young female scientists, and promote opportunities for students worldwide to access cutting-edge research training. The Chair aims to broaden diversity in photonic sciences by supporting motivated students and researchers in the field who would otherwise not have such opportunities.

To begin, it will support talented young female scientists through scholarships and stays through **the SPIE@ICFO Chair Maria Yzuel Fellowship Award Internships program**. It will provide travel grants to students from around the world to attend international schools organized by ICFO through the **SPIE@ ICFO Chair Travel Fellowships**, and will also support the development of scientific research projects at the institute through **the SPIE@ICFO Chair Research Fellowships**.

> *"This exciting partnership with ICFO beautifully complements our own commitment to enhancing equity, diversity, and inclusion across the optics and photonics community,"* **commented SPIE President John Greivenkamp**. *"We are delighted to support an education program which will focus on active promotion of a tolerant, welcoming work environment that meets the academic and research needs of a diverse population."*
>
> *"We are extremely proud of this long-lasting alliance with SPIE",* **adds ICFO director Lluís Torner.** *"Its visionary endowment program will afford the possibility to launch a unique Chair program supporting a topic both organizations consider to be of paramount importance to enhance innovation, creativity, and excellence across the board."*

Rob Sewell, **Silvia Carrasco**, and **Laia Miralles** have been appointed Chair and Vice-Chairs of this program.

LGBTQ+ AT ICFO

Many would argue that ICFO is succeeding in its commitment to creating a diverse, inclusive and welcoming environment, in many respects, but are we succeeding in providing a welcoming and inclusive environment for the LGBTQ+ community?

ICONS, the OSA student chapter of ICFO, supported two conversation opening events at ICFO this year on just this subject, marking a growing awareness within the institute of issues faced by the LGBTQ+ community as well as a growing commitment from all areas of the institute to build an inclusive, diverse, accepting, welcoming, and safe place for all ICFOnians.

- **In June, known around the world as LGBTQ+ Pride Month**, ICONS hosted an open debate to reflect on the visibility, diversity and inclusion of the LGBTQ+ community at ICFO.
- **November 18th, Pride in STEM Day**, an international initiative to show support for LGBTQ+ people in Science, Technology, Engineering and Math, was celebrated for the first time at ICFO.

Inclusive Communication

The use of inclusive language and visuals is central to a positive working environment, allowing us to communicate within and beyond our community in a productive way that is coherent with and reflective of the value that we place on all kinds of diversity.

Gender and bias-free language and visuals acknowledge positive qualities of all individuals while minimizing irrelevant details that, when otherwise emphasized, may be offensive, creating barriers to interactions and understanding.ICFO's Language Guidelines are available for all on the intranet and at **http://s.ic.fo/Language_Guidelines**

COLLABORATION

OUTREACH

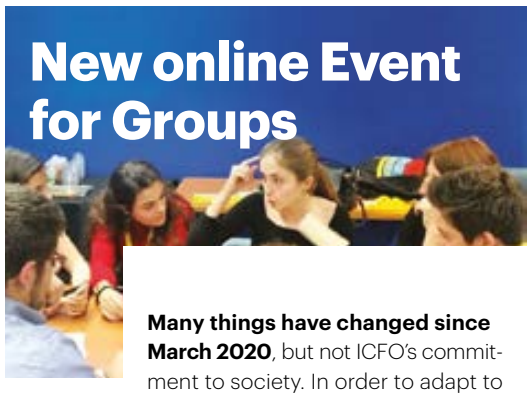
CARLA Kick off

Coordinated by ICFO, a consortium of 11 partners gathered in Barcelona on the 21st and 22nd of January to kick-start CARLA, a new initiative that aims to encourage students and early-stage researchers to pursue careers in photonics. CARLA is a H2020 EU-funded project developing a model for inclusive pan-European career camps of excellence around the opportunities and multidisciplinary dimensions of photonics. The project integrates the inputs of industry, academia, innovation and entrepreneurship, putting special emphasis on empowering diversity, to create a rigorous, tested and reproducible tool to foster growth, leadership and innovation potential in photonics at the EU level. A supporting online structure is also created on LinkedIn and Instagram to encourage networking and the exchange of information around careers in photonics and leverage CARLA beyond the camps' edition.

www.carlahub.eu

On November 3rd ICFO Outreach organized an international, virtual event in the frame of the European Quantum Week by the European Quantum Flagship, in which ICFO itself plays an active leadership role.

The successful event, done in collaboration with CSIC and University of Zaragoza, was directed to secondary school students from 14-18 years old and took place in YouTube Live, drawing the interest of 40 different registered institutions, translating into over 1300 registered participants. For the occasion the organizers brought together a diverse panel of engaging speakers, each giving an inspiring 5-minute flash talk about why quantum technologies have become so important. The students had questions about a wide range of topics, quizzing the panellists about the effect that quantum technologies will have on everyday life as well as what it is like to do research or launch a career in the field of quantum technologies.



Many things have changed since March 2020, but not ICFO's commitment to society. In order to adapt to the current health situation, **ICFO has launched a new digital, interactive and multidisciplinary Outreach activity called "The ICFO Decide Game"**.

This initiative allows us to keep our doors virtually open for young people and adults to discover the institute and Photonics, meet ICFO scientists and immerse themselves in the realm of ICFO and Photonics from wherever they are and in a safe way.

Participants in "The ICFO Decide Game" put themselves in the shoes of the policy makers responsible for research and innovation. Throughout the game, they receive essential information to discuss about Photonics and the importance of science and research in our lives, while discovering cutting-edge scientific projects that are being developed at ICFO. They have the opportunity to talk to scientists at the institute, and with all of this information, make a strategic decision in agreement with the rest of their group.

Young Photonics Congress

The Young Photonics Congress is a scientific congress where the spotlight is on high school students, who present their first research project in photonics.

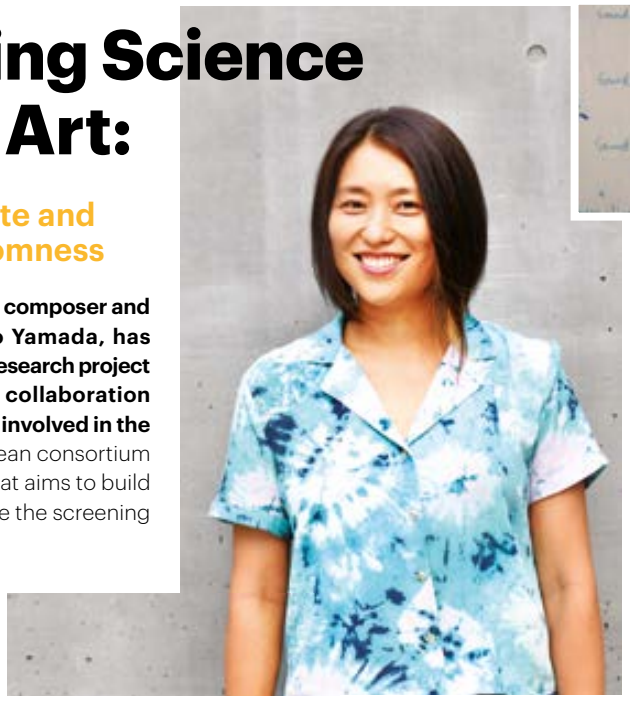
This well-established ICFO program reached this spring its fifth edition at the height of the first wave of the COVID pandemic- a very challenging moment.

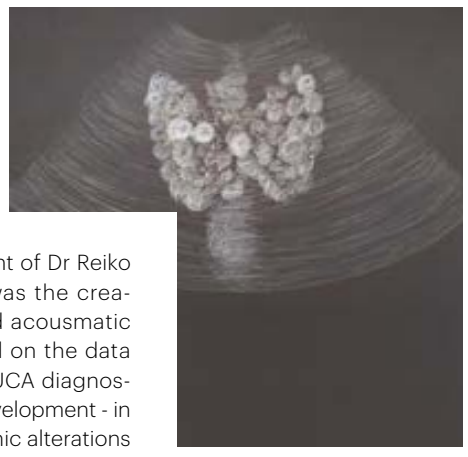
The ICFO team quickly redesigned the format to transform it from an in-person event to a virtual experience using the Teams platform. The event started with flash talks by some ICFO researchers introducing their work, after which the attendants could freely enter several virtual rooms where the young authors could explain their work in the form of a videoconference. This experiment – the first complex event organized by ICFO during the lockdown - successfully allowed more than 20 students from Catalan schools to present their work to an audience of nearly 80 people composed of their peers and teachers and of an international panel of ICFO scientists.

Expressing Science through Art:

Beyond Absolute and quantum randomness

Current ICFO postdoc, composer and sound artist Dr Reiko Yamada, has developed the artistic research project "Beyond Absolute" in collaboration with ICFO researchers involved in the LUCA project, a European consortium coordinated by ICFO that aims to build a new device to improve the screening of thyroid nodules.





The main component of Dr Reiko Yamada's project was the creation of personalized acousmatic soundscapes based on the data generated by the LUCA diagnostic device -under development - in conjunction with sonic alterations that had to represent the subjective mindset of the patients. This project, which was part of the VERTIGO STARTS residency, has led to successful performances at Phonos (Pompeu Fabra University) and at the cultural center Cent Quatre in Paris. Dr Yamada is now working on a new, unrelated project with the Quantum Optics Theory group on capturing the quantum randomness in her compositions.

www.reikoyamada.com

ALUMNI

What Comes Next?

Career perspectives from the Alumni Network

The training that ICFO researchers receive prepares them to make a mark on the world through a wide range of career paths, with Academia being just one of the roads that Alumni choose to follow after ICFO.

The Alumni Network organizes a series of seminars as well as the annual Beyond ICFO Career Day to connect current ICFOnians with members of the network who share their personal and professional experiences to help to map out career options.

ALUMNI Seminars

In the Alumni Seminar Series, members of the network from around the world talk about their current work and how their careers are advancing. Full interviews with some of the Alumni who offered seminars in 2020 are available in ICFO's newsroom (**icfo.eu/newsroom**).

What advice would you give to yourself back at ICFO?

Giovanni Volpe
Professor at the
University of Gothenburg

"The crucial part is that one has to be open to opportunities, so if someone comes to you with a crazy idea, it's probably worth it to listen to that person and see whether you can actually do something."

Danny Krautz
Principal at hy-
Axel Springer Consulting Group

"If you go to ICFO only to do research, you will be missing a very important part. I think ICFO gives you a framework, but at the end of the day it's up to you to do something!"

Alejandra Valencia
Profesor in
Universidad de los Andes

"At ICFO [...] my advice would be to talk with people. Sometimes we spend too much time at our desks and computers. Just go and open your mind!"

BEYOND ICFO

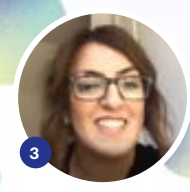
ICFOnians & Science for a Post-COVID World

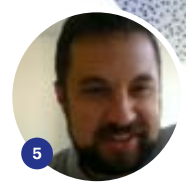
As 2020 was marked by the global pandemic, this year's annual event examined unique ways that ICFOnians are contributing to manage the crisis and its many repercussions

KEYNOTE TALKS:

The event kicked-off with talks by two ICFO group leaders about two very different studies:

- **Prof Javier García de Abajo:** presented a paper on the potential of ultraviolet light to reduce SARS-CoV-2 transmission indoors.
- **Prof Turgut Durduran:** described the mid-pandemic inception and launch of a HemoCovid project with Hospital Parc Tauli.





1. Naeimeh Behbood

COO Sana Meditech. ICFO PhD graduate (2015) Atomic Quantum Optics group. Naeimeh Behbood is co-founder of Sana Meditech, a startup located in Barcelona, dedicated to remote healthcare monitoring systems with the objective of providing IoT solutions in health care ambient.

"Changing fields is a challenge. It means acquiring a lot of new information and knowledge to become stronger. It can be scary but it's good to be open to new things."

2. Miguel Navascués

Institute of Quantum Optics and Quantum Information (IQOQI). ICFO PhD graduate (2007) Quantum Information Theory group. Since 2015, Miguel directs a research group at the Institute of Quantum Optics and Quantum Information (IQOQI) in Vienna. His research interests include quantum information theory, optimization theory and the foundations of quantum mechanics.

"My advice would be to go for it. Try to go to conferences of topics that are alien to you. Those can give you many ideas and inspiration that you can apply to your own projects."

3. Parisa Farzam

Data Scientist and Manager of Clinical Collaborations at IBM Watson Health Imaging. ICFO PhD graduate (2013) Medical Optics group. Following her PhD, she spent a year as a postdoc in the Medical Optics group at University of Bern before joining Harvard Medical School as a Research Fellow with a joint appointment at Massachusetts General Hospital and Brigham Health. In 2019, she moved to IBM as a data scientist to develop AI solutions for medical imaging. Since then she has led the clinical collaborations efforts at IBM Watson Health Imaging.

"Don't stick to your PhD title. Check the terminology of other fields and convert your thesis's title and your projects into a set of skills. What you know may have a different name in another field where it might be a hot topic."

4. Thomas van Zanten

Postdoctoral Fellow at National Center for Biological Sciences (NCBS) – Tata Institute of Fundamental Research. Postdoctoral researcher (2011-2014) Single Molecule Biophotonics group. At ICFO he pursued several facets of nanotechnology to engineer an improved photonics platform for observing nanoscale dynamics in living cells. In 2014 he became a research fellow at NCBS where he applies various microscopy techniques and started using more complex biological systems to understand the behavior of the plasma membrane.

"Talk to people! If you know someone who is working in a field you are interested in, talk to them. You'll see how your skills can be translated into something that other fields may actually need."

5. Moderator Gianvito Lucivero

ICFO Postdoctoral Researcher who is also the founder of PhyABo (Physics Across Borders) a non-profit organization that aims to create a world-wide network of physicists to improve communities' living conditions. The discussion focused on the role of physicists in contributing to global challenges, even when that requires working outside their usual focus area.

Summary: "People shouldn't be afraid of outsiders in Science. We need to find different ways to deal with an emergency and ask people: how is your model relevant for a pandemic?

COLLABORATION

IN FOCUS

ICFOnians and COVID

The ICFO community rises to the occasion

On Friday, March 13, ICFO, as much of the world, closed its doors to all but explicitly authorized critical activities and personnel in order to assure the health and well-being of the ICFO community. And so began our institute's reaction to an unprecedented health crisis that called for exceptional measures, personal responsibilities and cooperation. ICFOnians responded- and continue to respond- individually and as a community to rise above this crisis and to contribute to its containment.

AT ICFO

In March 2020, there was no tried and true protocol for managing a pandemic. When the lockdown began, governments and health officials scrambled to define procedures, restrictions, and recommendations to keep the population safe, and a core team of ICFOnians began to navigate the uncertain waters of how to safeguard the facility, its ongoing work, and its most important assets- ICFOnians.

This required the dedicated efforts of many ICFOnians:

- A steady flow of communication between the institute and the community to translate into real terms the implications of the imposed restrictions and their day-to-day modifications
- Keeping a close watch on ICFO's facilities, laboratories and IT infrastructures, in addition to the resources that would be essential for researchers and management units to advance remotely in all possible institutional activities.
- The definition and implementation of safety protocols as well as their constant revision, ensuring minimal risks for any ICFOnian working within the ICFO premises during the pandemic.
- The preparation of ICFO's facilities and workspaces as well as the procurement of personal protective equipment for the safe return of ICFOnians who would need access to ICFO's facilities to advance in their activities.

Inevitably, the closing of ICFO's facilities had important consequences for ongoing research activities, however the entire community owes a debt of gratitude to the ICFOnians who have remained at the helm throughout the COVID storm to mitigate these consequences and make it possible for critical activities to continue remotely and to resume in person.

Today ICFOnians are back in the labs, adhering to special COVID safety protocols throughout the facility and practicing social distancing, with researchers and administration carrying out all activities that do not require them to be physically present in ICFO, from home.

#ICFOnianStayHome

While remote collaboration and home offices were used sporadically pre-pandemic, social distancing caused a paradigm shift moving everything online.

ICFOnians brought office (and in one case lab) activities home to keep the machinery behind the science in motion. Group meetings, informal consultations and even coffee breaks moved to TEAMS. Seminars and events were held via ZOOM. A group of researchers shared what it was like to be a scientist during the confinement to contain that spread of COVID-19 in a short video series that was shared in social media. **Here are a few examples:**

JAVIER ARGÜELLO
PhD Student in Theoretical Quantum-Nano Photonics group

Javier *worked quite well from home during the confinement, transforming his bedroom into an office, where he kept up with calculations, had meetings, and connected to the computing facilities back at ICFO... all while still in his PJ's!*

LISA SAEMISCH
PhD Student in the Molecular Nanophotonics group

Lisa *was fortunate to have taken a lot of data before the lockdown and had plenty of analysis to do from home. When she came across surprising data, she learned to analyze it from different angles since she could not go into the lab and play with the variables. This ultimately gave her a deeper understanding of the reasons behind her findings.*

PAMINA WINKLER
PhD Student in the Single-Molecule Biophotonics group

During ***Pamina****'s thesis, she worked to answer fundamental cell biology questions by pushing the frontiers of nano-resolution and developing new nanophotonic tools. Her PhD studies stationed her in the optical and biology labs at ICFO, IBEC, Marseille, and Bangalore. Instead of a self-imposed confinement to write her thesis and put all her work into perspective, she found herself in an official one, just at the time when she needed uninterrupted time to focus. She defended her thesis on November 27th!*

KEVIN SCHADLER
Project Leader at Mirall, a KTT Launchpad project

Kevin *is working to develop smart-phone based imaging technology to detect light that cannot be seen with our eyes. Before the confinement, he had just begun work to develop the prototype technology for this project. Thanks to a little lab he set up in his own home and constant contact with his co-founder and the KTT team, he kept his spirits up and the ball rolling.*

ANTOINE RESERBAT-PLANTEY
Research Fellow in the Quantum Nano-Optoelectronics group

Antoine *works with 2D materials and usually carries out his work between the lab, participating in meetings, reading and writing papers, going to conferences... During confinement he could continue with all activiites except collecting new data in the lab. Instead, he and his group worked to analyze old data in a slightly different way. This led to a completely new perspective in their research which made them very excited to get back into the lab to test things out! Changing the time-settings in research, even when caused by the confinement, can lead to advances.*

GO & FLY

25 ICFOnians Successfully defended their theses in 2020.

Some presented their theses in the traditional manner, but most adapted to an online or hybrid format, with the thesis committees, colleagues, friends and family connecting with them virtually.

ICFO PhD graduates now total 224 since the institute's founding in 2002. Each of their accomplishments has played an important role in ICFO's success and reputation as a leading international research institute. Honoring ICFO's tradition, ICFOnians gather to celebrate these important personal, professional and institutional milestones and encourage you to Go & Fly! Remember that wherever you go, you will always be a part of the ICFO community.

200 January 27, 2020

DANIEL SÁNCHEZ PEACHAM

"Development of a High Intensity Mid-Ir OPCPA Pumped by a HO:YLF Amplifier"

TD: ICREA Prof Dr Jens Biegert

201 January 31, 2020

CHRISTOS CHARALAMBOUS

"Quantum Brownian Motion in Bose-Einstein Condensates"

TD: ICREA Prof Dr Maciej Lewenstein and Dr Miguel García-March

202 February 6, 2020

SERGIO LUCIO DE BONIS

"Polaron physics in carbon nanotube electro-mechanical resonators"

TD: Prof Dr Adrian Bachtold

203 February 10, 2020

JULIO SANZ SÁNCHEZ

"Two-Component Bose-Einstein Condensates with Competing Interactions"

TD: Prof Dr Leticia Tarruell

204 February 17, 2020

SANDRA DE VEGA

"Plasmon-Electron Interactions in Low Dimensional Materials"

TD: ICREA Prof Dr Javier García de Abajo

205 February 21, 2020

ESTHER GELLINGS

"Spectral Response of Individual Molecules and Nanoantennas with Two-Beam Excitation"

TD: ICREA Prof Dr Niek van Hulst

206 March 26, 2020

NICOLA DI PALO

"Ultrafast Carrier and Structural Dynamics in Graphite Detected via Attosecond Soft X-ray Absorption Spectroscopy"

TD: ICREA Prof Dr Jens Biegert

207 March 30, 2020

ANGELO PIGA

"Entanglement and Bell Correlations in Strongly Correlated Many-Body Quantum Systems"

TD: ICREA Prof Dr Maciej Lewenstein and Dr Shi-ju Ran

208 April 24, 2020

PABLO GÓMEZ GARCÍA

"Development and Application of Localization-Based Microscopy Methods to Study the Structure and Dynamics of Chromatin Through the Process of Cellular Differentiation"

TD: Dr Stefan Wieser and ICREA Prof at CRG Dr Pia Cosma

209 June 4, 2020

ANUJA ARUN PADHEY

"Novel Continuous-Wave Infrared Parametric Sources and Noise Analysis of Infrared Upconversion Detectors"

TD: ICREA Prof Dr Majid Ebrahim-Zadeh

210 June 8, 2020

VIKAS REMESH

"Spectral Phase Control of Nanoscale Nonlinear Optical Responses"

TD: ICREA Prof Dr Niek van Hulst

211 June 23, 2020

DAVID ALCARAZ

"Study of Graphene Hybrid Heterostructures for Linear and Nonlinear Optics"

TD: ICREA Prof Dr Frank Koppens

212 June 30, 2020

GERARD PLANES

"Levitation and Control of Particles with Internal Degrees of Freedom"

TD: ICREA Prof Dr Romain Quidant and Dr Andreas Schell

213 July 9, 2020

IRENE ALDA

"Levitodynamics on-a-Chip: From Planar Paul Traps to Near-Field Optical Nanocavities"

TD: ICREA Prof Dr Romain Quidant

214 July 3, 2020

EMANUELE TIRRITO

"Investigations of Topological Phases for Quasi-1D Systems"

TD: ICREA Prof Dr Maciej Lewenstein and Prof Alejandro Bermúdez

215 July 16, 2020

ALBERT ALOY

"Exploring Quantum Many-Body Systems from an Entanglement and Nonlocality Perspective"

TD: ICREA Prof Dr Maciej Lewenstein

216 July 27, 2020

MARIA SANZ-PAZ

"Nanoscale Control of Near-Field Interactions Between Single Emitters and Photonic Antennas-on Probe"

TD: ICREA Prof Dr María García-Parajo

217 July 28, 2020

JUAN MIGUEL PÉREZ ROSAS

"Imaging Cytometry Technology for Environmental and Biomedical Applications"

TD: ICREA Prof Dr Valerio Pruneri

218 October 8, 2020

ZAHRA RAISSI

"Quantum Multipartite Entangled States, Classical and Quantum Error Correction"

TD: ICREA Prof Dr Antonio Acín and Dr Christian Gogolin

219 October 30, 2020

IVAN BORDACCHINI

"Discerning Between Thermal and Electronic Effects in Plasmon enhanced Organic Reactions"

TD: ICREA Prof Dr Ramón Quidant

220 November 9, 2020

GORKA MUÑOZ GIL

"Anomalous Diffusion: From Life to Machines"

TD: ICREA Prof Dr Maciej Lewenstein and Dr Miguel Angel García-March

221 November 17, 2020

ZAHRA KHANIAN

"From Quantum Source Compression to Quantum Thermodynamics"

TD: ICREA Prof Dr Andreas Winter (UAB) and ICREA Prof Dr Maciej Lewenstein

222 November 27, 2020

PAMINA WINKLER

"Novel Planar Photonic Antennas to Address the Dynamic Nanoarchitecture of Biological Membranes"

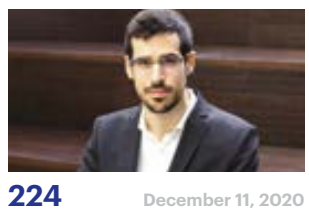
TD: ICREA Prof Dr María García-Parajo

223 December 2, 2020

BIPLOB NANDY

"Development and Study of Novel Mid-Infrared Frequency Conversion Sources"

TD: ICREA Prof Dr Majid Ebrahim-Zadeh and Dr Chaitanya K. Suddapalli



224 December 11, 2020

DANIEL GONZÁLEZ CUADRA

"A Cold-Atom Approach to Topological Quantum Matter Across the Energy Scales"

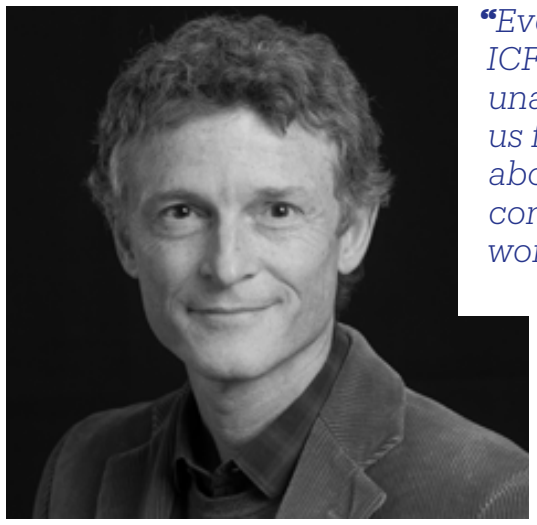
TD: ICREA Prof Dr Maciej Lewenstein and Prof Alejandro Bermúdez (Univ. Completense de Madrid)

THE LAST WORD

HIGH PROFILE

Emilià Pola

Executive Director at ICREA



"Everything you see today at ICFO was once a dream that felt unattainable, but that did not stop us from writing it, and thinking about it, and pursuing people to convince them that this was a worthwhile adventure."

You have a clear passion for research and innovation. Can you share with us your motivation to work in this field?

I studied Biology in University but my grades indicated that I would not have made it far as a researcher, and besides, I am too impatient. Instead, I went into management, but realized that contact with science and scientists is something that I really enjoy- when I don't have it, I crave it and look for ways to get it. After my MBA, the opportunity came to start something new in research management, which was a fledgling thing in the '90s. I think I was in the right place at the right time. Not being able to become a proper scientist, this path still allowed me to get close to science.

How did you come to focus your career on the management of research?

Back in the early 90's, research was managed by researchers and managers looked at marketing reports or financial statements. Although it is much more common today, I was one of the few people in Catalonia that could actually speak both languages. My background in biosciences gave me a general sensitivity of scientific and academic disciplines that few others had at the time.

Your contribution was key for the foundation of the institute back in 2002. What was your capacity at that time?

I worked directly under Andreu Mas-Colell when he served as Commissioner for Universities and Research in the Government of Catalonia. He was responsible for creating ICFO and all of the other CERCA centers and ICREA. He sent me around the world to try to find a magic formula that would allow Catalonia to have one or two research centers of international visibility within a decade. When we found the formula, we tried to replicate it in a number of projects, including Lluís Torner's project for photonic sciences- which didn't even have a name when we started writing the original document. There were many meetings, and drafts, and discussions and debates. Lluís had this idea, but at that time it was unrefined. I was like a sparring partner, helping find the path of least resistance to what he wanted to achieve.

What role is ICREA playing in ensuring excellence and diversity in science in Catalonia?

The research system in Catalonia over the last 20 years has experienced an enormous expansion and change and ICREA is very honored to be part of it (and so am I!) Whatever ICREA does well however, is because we get really good people to start with, people attracted to the quality of the project, the ambition and the vision of the research centers and universities in Catalonia. We select ICREA researchers through a neutral system that is based exclusively on merit and scientific excellence. This provides certain guarantees that assure that no talented scientist is discriminated against because of their orientation, skin color or gender. We support ICREA researchers and look after them as well as we can, but it is the research institutions like ICFO that attract them: they would not have come for ICREA alone, obviously. And that is as it should be.

Has your opinion of the importance of ICREA's role in the scientific enterprise in Catalonia evolved over the past year in response to the COVID pandemic?

The reaction to the crisis has been overwhelming, and lighting fast. All around the system, ICREA researchers were drafting, planning, funding and executing the most daring projects. With just a few weeks' notice, economists were working with doctors, and high energy physicists with computer scientists. Some results made big news, but all were incredible.

What advice would you give ICFOnians today?

Everything you see today at ICFO was once a dream that felt unattainable, but that did not stop us from writing it, and thinking about it, and pursuing people to convince them that this was a worthwhile adventure. Let us all dream about how we want the world to be, and then fall in love with the vision. Then we can change the world. It applies not just to research but many other aspects of life. It seems appropriate to remind all ICFOnians today that ICFO is the result of a dream. Everything is possible- we just have to find out how.

Science Quiz

A team of researchers from ICFO, CRG, UPF, and UASUA (Austria) studied zebrafish cells and their response to mechanical compression. They saw that the nucleus acts as a compression sensor helping it move through tight spaces.

The nucleus measures shape changes for cellular proprioception to control dynamic cell behavior, Valeria Venturini, Fabio Pezzano, Frederic Català Castro, Hanna-Maria Häkkinen, Senda Jiménez-Delgado, Mariona Colomer-Rosell, Monica Marro, Queralt Tolosa-Ramon, Sonia Paz-López, Miguel A. Valverde, Julian Weghuber, Pablo Loza-Alvarez, Michael Krieg, Stefan Wieser, Verena Ruprecht. *Science* 370, eaba2644 (2020)

1 What is "proprioception" ?

A) A sense of where your body parts are

B) Autonomous cell reproduction

C) A Christopher Nolan movie

2 What does "bleb" mean ?

A) Blue-laser-excited barotaxis

B) A newly-formed cell

C) A bulge in the plasma membrane

3 Why might cells move through the body?

A) To respond to an injury

B) To spread cancer

C) Both A) and B)

4 What is a zebrafish ?

A) An anchovy (Engraulidae)

B) A minnow (Cyprinidae)

C) A herring (Clupeidae)

* Find answers on pg. 2

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