Community News from the Institut de Ciències Fotòniques

ICFO spotlight

WINTER 2008 2009 | 02

a first-class research center

Catalonia is increasingly being recognized internationally as a scientific powerhouse, and ICFO is among the research centers that most contribute to this achievement.

According to the '*Trends, Catalonia, 1992-2006*' report commissioned by the *Generalitat de Catalunya*'s Agency for Administration of University and Research Grants (AGAUR), the scientific production in the region, as measured by the number of research papers published in scientific journals, has more than doubled in the last decade. Almost half of the research published by Catalan centers is now done in collaboration with groups abroad, compared to less than a third a decade ago. And today, almost half of the research papers produced in Catalonia are also published in high-prestige journals.

The report also looked at the contribution of the region's individual research centers and highlighted ICFO in particular as a high-quality research center. ICFO came first in one of the report's rankings, which looked at the proportion of research papers published in top journals. "Our only secret has been to be able to hire very good researchers," ICFO Director Lluís Torner recently said to the Spanish newspaper *La Vanguardia*.

Still, this recognition of ICFO's contribution to both Catalan and international research is only one of the many achievements this newsletter has to celebrate this term.

Among other important recent developments, this last October ICFO held a scientific workshop that was sponsored by the Spanish *Fundación Marcelino Botín* and organized in collaboration with the *Collège de France*. Later that month, ICFO also inaugurated the Ignacio Cirac-*Caixa Manresa* Chair, a new program dedicated to promoting world-class research in the area of quantum information science and technology. Then, in November, ICFO hosted the European traveling '*Fascination of Light*' exhibition during its only stay in Spain. Finally, in February President Hble. Mr. José Montilla, president of the regional government (*Generalitat de Catalunya*), visited ICFO at the occasion of the official signing of the contracts that are to provide base funding for 11 regional research institutes over the next 4 years.

This second issue of ICFO Spotlight also features an essay by technical research support engineer Xavier Menino and interviews with new junior group leader Turgut Durduran and former ICFOnian Gajendra Pratap Singh. Spotlight also takes a peek at new state-of-the-art research facilities that were set up at ICFO during the winter… and has more content to offer you still!

Many kudos to you all for your excellent work and for your contribution to the achievements of ICFO. I wish you all a happy reading!

Elisabeth Pain - ICFO Spotlight Coordinating Editor

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Gianluca Battista

cover

President Hble. Mr. José Montilla, president of the regional government (*Generalitat de Catalunya*), visited ICFO on 14 February this year. ICFO Director Lluís Torner gave an overview of the research carried out at the Institute. President Hble. Mr. Montilla then took a guided tour of the labs, during which he could meet ICFO researchers and industrial collaborators.

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HAPPENINGS

ICFO news

by Michele Catanzaro

Signing of New Base Funding Contracts

The official signing of the contracts providing base funding for 11 regional research institutes over the next 4 years took place at ICFO on Saturday 14 February. Altogether the contracts, signed between the regional government of Catalonia and the individual institutes, will provide a total amount of 177,6 million euros, representing an 11,6% increase compared to the previous years.

On that occasion, President Hble. Mr. José Montilla, president of the regional government (*Generalitat de Catalunya*), took a guided tour of ICFO during which he could meet many researchers working at the Institute as well as ICFO industrial collaborators.

President Hble. Mr. Montilla then gave an address in which he highlighted the importance of investing in research to overcome the current economic crisis. The regional Research Minister, Hble. Mr. Josep Huguet, and the Mayor of Castelldefels, Mr. Antonio Padilla, also visited ICFO on that day.

Top Quality Ranking

In spite of its young age, ICFO secured the very top position in a recent regional scientific quality ranking. The study was commissioned by the *Generalitat de Catalunya*'s Agency for Administration of University and Research Grants (AGAUR) to evaluate the activity, visibility, and international dimension of local research institutes. The analysis was carried out over the 1992-2006 period and considered several factors, including the number of publications the institutes produced.

The analysis assessed the quality of the institutes' publications in particular by looking at their impact factor, their citation number, and the percentage of publications involving international collaborations, using data from the Thomson Scientific-ISI National Citation Report. With more than 90% of all its research papers being published in top specialist journals, ICFO ranked first among all other local research institutes in the physical sciences for the quality of its scientific output.

Brand New ICONS

The Optical Society of America (OSA) Student Chapter at ICFO (formerly known as ICFO-OSA) has now officially become the ICFO Organization and Network of Students (ICONS). In addition to having a new name, ICONS now incorporates the ICFO SPIE Student Chapter created during summer 2008 under the umbrella of the international society for advancing light-based research, SPIE. ICONS also elected new board members this term. New President Osamu Takayama will now lead ICONS, with the help of Giorgio Volpe as new Vice-President, Lars Neumann as Secretary, and Sandro Perrone as Treasurer. After helping develop ICFO-OSA over the past year, former president Armand Niederberger will also now coordinate ICONS's international network, the IONS-Project. The mission of the new student chapter remains unchanged however: ICONS will continue to promote new career opportunities for ICFO students by offering them access to the international photonics community and additional training opportunities.

A New Colloquium Series Kicks Off

Last December, ICFO inaugurated a new colloquium series featuring renowned speakers in a broad range of disciplines. Its purpose: to stimulate and infuse ICFO's community with new scientific concepts, research ideas, and ambitions.

The new series kicked off on 15 December with a presentation by David Villeneuve of the National Research Council in Ottawa, Canada on imaging molecules using femtosecond lasers. In January, Kobus Kuipers of the FOM Institute for Atomic and Molecular Physics (AMOLF) in Amsterdam, the Netherlands gave a talk on the behavior of light in and around photonic nanostructures. Romualdo Pastor, of the *Universitat Politècnica de Catalunya* in Barcelona, came to discuss complex networks the following month.

The Colloquia are now held in the Auditorium on the first Monday of each month. They start at noon, but you're all invited to come 15 minutes early for some light refreshments.

ICFO newcomers

Many new faces have joined the ranks of ICFO between last October and January this year… Welcome to you all!

Lukas Kornaszewski
Postdoctoral Researcher

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Labor Relations Secretary

Reddeppa Thanneeru
Ph.D. Student

Christopher Hadley
Postdoctoral Researcher

Reuven Gordon
Visiting Professor

Saurabh Raj
Ph.D. Student

Rodrigo Gallego
Ph.D. Student

Turgut Durduran
Group Leader

Filip Beunis
Visiting Scientist

Jeff Lundeen
Visiting Scientist

Marta Castro López
Ph.D. Student

Mathieu Juan
Postdoctoral Researcher

Koen Thuijs
Master Student

Naeimeh Behbood
Ph.D. Student

Gianluca Coviello
Ph.D. Student

Jan Gieseler
Ph.D. Student

Marc Jofre
Ph.D. Student

Ritwick Das
Postdoctoral Researcher

Na Lou
Ph.D. Student

Yannick De Icaza
Ph.D. Student

Luat Vuong
Postdoctoral Researcher

Marina Mariano Juste
Ph.D. Student

Pietro Massignan
Postdoctoral Researcher

Francesca Arcara
Projects Office

welcome to ICFO

ICFO events

by Michele Catanzaro

Marcelino Botín Foundation Workshop. A workshop sponsored by the Spanish *Fundación Marcelino Botín* took place at ICFO last October. *'Light and matter at the quantum level'* was the central theme of this workshop organized in collaboration with the *Collège de France*. Speakers included 1997 Nobel Laureate in Physics Claude Cohen-Tannoudji, of the *Collège de France* and Kastler Brossel Laboratory in Paris, Ignacio Cirac of the Max Planck Institute of Quantum Optics near Munich in Germany, Luis Viña of the *Universidad Autónoma de Madrid,* and ICFO group leader Maciej Lewenstein.

Fascination of Light. During the last 2 weeks of November ICFO hosted the European traveling '*Fascination of Light*' exhibition during its only stay in Spain. The interactive exhibition aims to promote science, engineering, and technology to schoolchildren by giving them a unique opportunity to spend the day playing with light in scientific experiments. While the exhibition was primarily addressed to schools and drew more than 1,300 pupils, more than a hundred members of the general public also came to ICFO to see the exhibits.

Teleportation at the CosmoCaixa. During a conference held this January at the Barcelona Science Museum *CosmoCaixa,* ICFO group leader Antonio Acín explained to the general public how quantum mechanics revolutionized the concept of teleportation and now allows researchers to transfer information from one place to another at the quantum level. The event was part of a series devoted to science-fiction ideas that have now become a reality.

LATEST ADVANCES

research highlights

by Michele Catanzaro

Red Blood Cells Release Oxygen When Stretched

Stretching a red blood cell coaxes it into releasing oxygen. This is the main result of a piece of research that combines the use of optical tweezers to stretch cells with Raman spectroscopy to monitor cellular changes in oxygenation. The mechanical stress applied to the red blood cells was used to simulate their passage through vessels and smaller capillaries into tissues.

"The tweezers' action on the cells that leads to the release of oxygen is similar to squeezing water out of a sponge," says Satish Rao, an ICFO fellow in Dmitri Petrov's group who is first author of the work.

The research finding appeared on the cover of the January issue of the Biophysical Journal. The work was conducted in collaboration with Victor Guallar's group at the Barcelona Supercomputing Center.

A New Source of Entangled Light

ICFO researchers have participated in the design and building of a new device able to generate pairs of entangled photons with a record ultra-broad frequency spectrum. The pairs were obtained by circulating a light beam through a nonlinear crystal whose properties changed along the direction of light propagation. This new source of quantum light could find applications in the area of biological tissue imaging in particular, helping to enhance the achievable resolution of detection techniques such as optical coherence tomography to below 1 micron. Originally published in Physical Review Letters by ICFO group leaders Juan P. Torres and Lluís Torner in collaboration with researchers at Boston and Stanford Universities in the United States, this work made the cover of the December issue of Optics and Photonics News as one of the most outstanding pieces of optics research performed in 2008.

Shaking a Condensate in an Optical Lattice

Together with researchers at the University of Oldenburg in Germany and the University of Pisa in Italy, ICFOnian André Eckardt has demonstrated that it is possible to coherently control the kinetics of ultra-cold atoms in an optical lattice by shaking it. "The particles in the shaken lattice behave the same way as if they were in a lattice at rest, only they appear to have a modified effective mass. The possibility to tune the effective mass of these particles to negative or infinitely large values simply by varying the intensity of the shaking can have intriguing implications on their collective behavior," says Eckardt, who is a postdoctoral researcher in Maciej Lewenstein's group.

The research was published in the January issue of Physical Review A and was highlighted in the American Physical Society's online magazine, Physics.

Trapping Living Bacteria with Nano-tweezers

Researchers at ICFO have developed a technique that now makes it possible to optically trap bacteria without killing them. This latest development builds upon previous research in which Romain Quidant's and Niek van Hulst's groups produced an ultra-concentrated light spot using a resonant optical antenna consisting of two 500-nanometer long gold rods. Romain Quidant's group then demonstrated, in a research paper published this January in Nanoletters, that the light used in this device has such a low intensity that it can actually trap live E. coli bacteria without damaging them. The new tweezers are also able to systematically align bacteria along the long axis of the antenna, opening up new possibilities for their optical examination. This achievement was done in collaboration with researchers at the CSIC-Optics Institute in Madrid, in part thanks to a generous donation from the *Fundació Cellex Barcelona*.

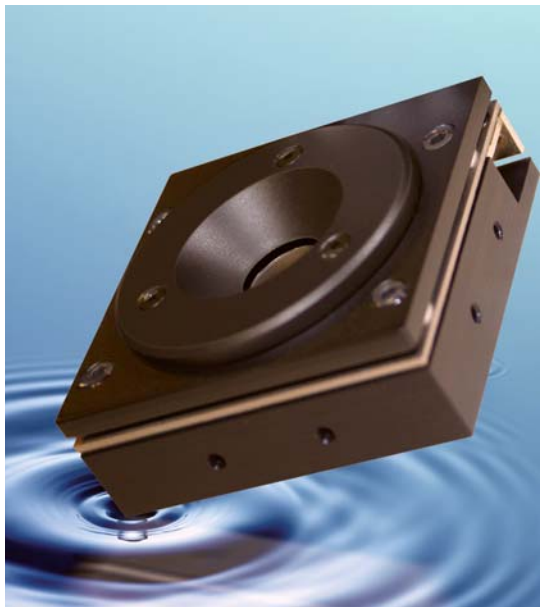
business news

by Silvia Carrasco

Joining Forces to Push Imaging Limits

A world leading provider of Shack-Hartmann wavefront sensing technology has now teamed up with ICFO to develop an ultra-sharp multi-photon imaging system prototype. ICFO and French company Imagine Optic will combine their expertise in light engineering to push the current technological limits of imaging devices in a project supported by the European Commission with a Marie Curie Industry-Academia Grant.

"The development of high-resolution, non-damaging imaging techniques is crucial for understanding the biological processes occurring at the cellular level," says ICFO group leader and project coordinator Pablo Loza-Alvarez. "The combined expertise of both partners will allow for a novel, compact, and powerful tool within nonlinear microscopy, which we expect will open up a new range of applications and commercial opportunities," adds Imagine Optic Business Manager Rafael Porcar Guezenec.



ICFO Secures a New Industrial Project on Solar Cells

Jordi Martorell's research group at ICFO is part of a consortium led by the photovoltaic company TFM Energia Solar Fotovoltaica S.A. to develop a new prototype of efficient transparent organic solar cells.

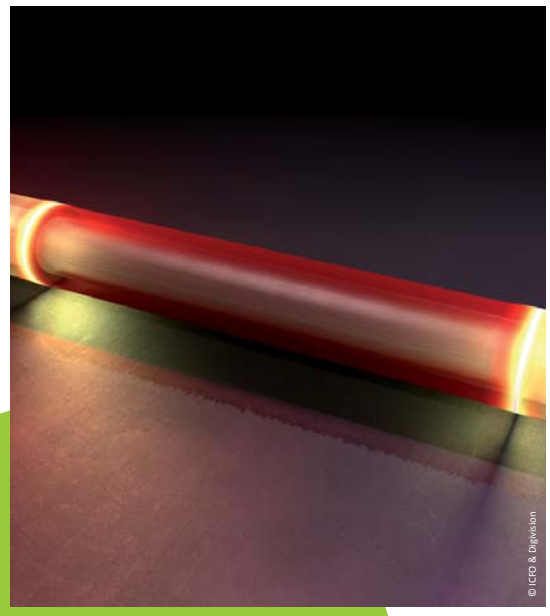
The aim is to design solar cells that have a higher transparency than those available in the current market.

The project is supported by a grant from the *Generalitat de Catalunya*'s funding agency ACC1Ó. ACC1Ó aims to promote interactions between companies and research centers by supporting new technological and industrial consortia that may lead to the creation of high-tech jobs in the region. Altogether ACC1Ó invested a total of 22 million euros in 38 consortium initiatives during 2008.

Designing New High-Temperature Fiber Sensors for Space Vehicles

Aerospace R&D company Emxys is leading a new partnership with ICFO, the Polytechnic University of Valencia (UPV), and the technology consulting company Inasmet-Tecnalia to develop the next generation of fiber optic sensors for space applications.

The aim of this collaborative effort is to prototype and validate a new monitoring system that may then be fitted on space vehicles to measure temperatures above 1,000ºC as well as physical strain. The ICFO Optoelectronics research group led by Valerio Pruneri will contribute its expertise and patented technology in the area of fiber optic sensors for harsh environments. The project is supported by the European Space Agency (ESA).



Top Left: Adaptive optics device to sharpen up multi-photon microscopy images
Right: Optical fiber sensor for space vehicles
Left: Prototype of a transparent organic solar cell developed at ICFO

IN THE LABS

ICFO infrastructure

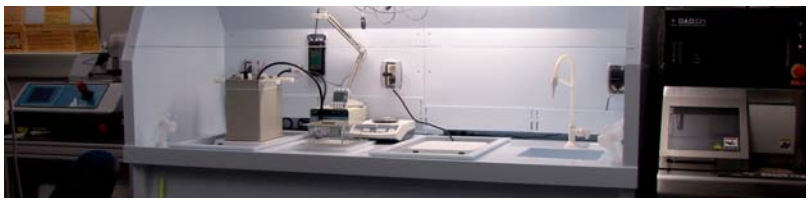
by Michele Catanzaro

ICFO opened several new state-of-the-art research facilities over these last 3 months. Take a guided tour with us!

Post-Processing Lab (PPL)

Manager: Valerio Pruneri

The Post-Processing Lab is designed to support the processing, fabrication, and characterization of optical materials and components, both for fundamental and industrial research projects. Users are offered access to state-of-the-art dicing and polishing machines, electroplating wet benches, wire bonders, solar simulators, fluorimeters, and UV/VIS spectrophotometers, among other equipment. This facility is open to researchers both within and outside ICFO. Training and support are available.



Basic Biology Lab (BBL)

Manager: Pablo Loza-Álvarez

The Basic Biology Lab enables state-of-the-art biophotonics experiments to be conducted at ICFO. The lab is equipped with a class II-A laminar flow safety cabinet, a range of incubators with diverse temperature, humidity, and atmospheric conditions, and a stereo microscope with an Epi-fluorescence attachment to work both with cell lines and model organisms. Currently, the lab grows *Caenorhabditis elegans* and *Escherichia coli* and runs a library of approximately 60 worm strains with different labeling, mutations, and variations. The BBL is used by ICFO researchers for projects in areas as diverse as optical tweezers, ultrafast imaging and nonlinear microscopy, and medical optics.

NanoPhotonics Lab (NPL)

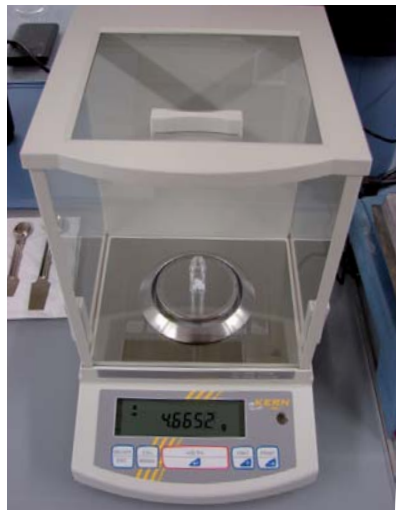
Manager: Gonçal Badenes

The NanoPhotonics Lab aims to provide a platform for the fabrication of micro- and nanostructured materials and devices for photonics applications. The lab is located in a 200m^2 cleanroom environment. Facilities are available for optical and electron-beam lithography, thermal and electron-beam evaporation, sputtering, atomic layer deposition, plasma etching, spectroscopic ellipsometry, atomic force microscopy, profilometry, etc. This crosscutting facility may be used both by ICFO groups and outside researchers. Training and support are also available.

Basic Chemistry Lab (BCL)

Manager: Jordi Martorell

The Basic Chemistry Lab has been set up to give ICFOnians a place to carry out chemical experiments in all safety. The lab is equipped with 2 fume hoods as well as a large set of instruments to prepare solutions and perform chemical reactions. The lab will mainly be used on a self-service basis, but users are required to take a safety training course with a qualified technician before hand.



PEOPLE

in focus
by Xavier Menino

Xavier Menino · Technical Research Support

I always tell my friends that as a kid, I used to get a fail even on the playground. I wasn't a brilliant pupil, nor was I the most popular one. I was however the most different of all. I didn't like playing football. I didn't like playing basketball. I liked drawing, and at the age of 8 I built my first model car out of sheets of paper and Scotch tape. When I was 14, I read Richard Bach's '*Jonathan Livingston Seagull*.' I think that the people who know me well know I'm like in that book, always striving to reach the limit, achieve perfection, do it better, quicker, and be ahead of the game.

I got my first contact with industry when I was 16; back then my father launched a company to produce industrial fridges. My father and his colleagues were then patient enough to teach me how to cut metal sheets, bend them, and weld them. So, at 19, I started working in an injection molding workshop. Just watching the milling machines and the lathes equipped with computer numeric control (CNC) systems fascinated me. These machines could be programmed; they could build new parts that only existed in your imagination, and with such an ease!

I got on several courses to learn how to program CNC systems and I started to draw molds myself. There, I got to know the two best teachers I've had so far, Mr. Camina and Mr. Campillo. We shared the same passion, and they were the first to finally believe in my ideas. During those years, together with a mathematics genius and friend of mine Pablo Rippa, we created a program for two-dimensional drawing as well as a new machining operation. This arose from the ideas that we had and our desire to do things, even though we didn't have any means nor money for it. We also made a replica of the 1968 TSS 360 model of the Bultaco to participate in the world championship of classic motorcycles. That year, we won the race.

After this, I worked for a series of different companies, always with the aim of expanding my knowledge further.

Luis Montesdeoca © ICFO

Like *Jonathan Livingston*, we have to always push the limits and seek perfection

Not all of these changes were positive at the time, but the few steps I took back gave me the momentum to then leap further forward. At the age of 24, I was in charge of a mechanical workshop at COEBSA, supervising 50 people working on making molds for the automotive sector. At 30, I started working for Italdesign, making real-dimension models of cars like the SEAT Ibiza, the Masserati Kubang, and the Alfa Romeo 147.

By the year 2000, everyone in the industrial sector was talking about Asia, so I decided to go and see what was going on there. I got in touch with a company that carried out injection molding and die casting projects in South Korea and China. Over the next 3 years, I lived in hotels, in two different time zones, following projects, writing reports, and feeling lonely. Then, at 35, I joined Seradhe as production manager. There, I built several parts for the Galileo satellite and for the defense system of the Eurofighter military plane.

I started working in the mechanical workshop of ICFO 3 years ago, when I reached 38. My job here fascinates me. Every day is different. Every day, there are some new challenges. Every day, someone else comes through the door with an idea, with a problem. Every day we have to solve things, to improve things, we have to do it quicker, simpler, in a more efficient way. Like *Jonathan Livingston*, we have to always push the limits and seek perfection.

in the frame
by Elisabeth Pain

Meet New Junior Group Leader Turgut Durduran

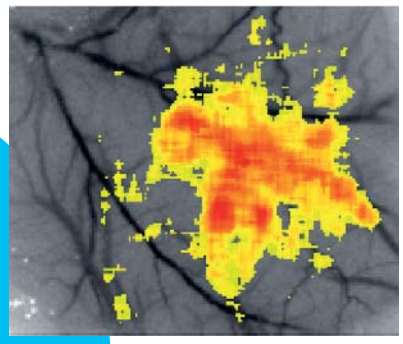
Turgut Durduran joined ICFO this January to set up a new research group in biophotonics research. Turgut's medical optics group will focus on the development of innovative tissue monitoring devices for preclinical and clinical studies.

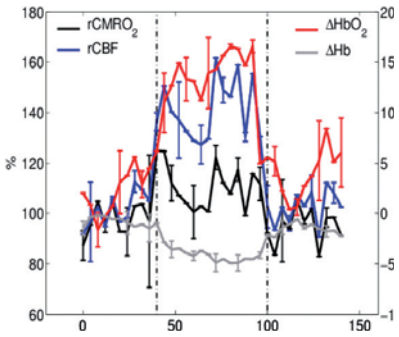
A native of Cyprus, Turgut set off for the United States when he was 17 to study physics at the University of Pennsylvania, in Philadelphia. As an undergraduate student in Arjun Yodh's lab, Turgut got involved in theoretical and experimental work that made it possible to monitor blood flow in deep tissues with laser light. He stayed on for a Ph.D. and developed non-invasive technologies for the measurement of blood flow and tissue oxygenation using diffuse optical imaging and spectroscopy. Then, as a postdoctoral researcher, Turgut was able to use the new instrumentation he had developed to acquire data from tissues in stroke, traumatic brain injury, and cancer patients. Eventually, during a three-year hospital-based faculty appointment, still at the University of Pennsylvania, Turgut worked directly at the interface of physics and medicine. "My particular interest was to turn this device into a bedside monitor" that would enable doctors to assess brain oxygenation in neurological patients so they may offer them better treatments. Altogether, the way his research topic--and his career--developed "is a very good example of translational research," Turgut says.

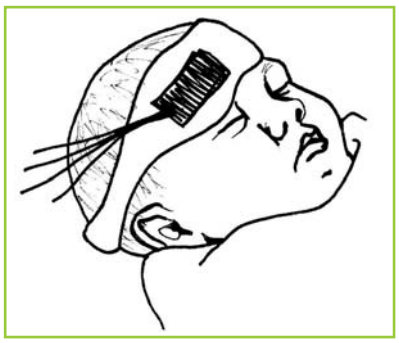
During his first year at ICFO, Turgut plans to work on improving some monitoring devices he's brought with him from Pennsylvania. "I hope that by the end of the summer this instrumentation will be used" in Barcelona, says Turgut, who has secured a collaboration with two local hospitals already. In the long term, Turgut aims to build a multidisciplinary team of computer scientists, medical physicists and engineers, and biologists to develop new technologies allowing the monitoring of tissues other than brain.

Turgut will also continue collaborating with the University of Pennsylvania, where he will hold an adjunct professor position during the transition period. And thanks to funding from the *Fundació Cellex Barcelona*, which also supports his new position at ICFO, another mission for Turgut will be to set up an exchange program between the University of Pennsylvania and ICFO.

Turgut Durduran has developed his theoretical and experimental work on blood flow monitoring into non-invasive, bedside monitoring devices







PERSPECTIVES

beyond ICFO

by Elisabeth Pain

Gajendra Pratap Singh, postdoctoral researcher at MIT

Gajendra Pratap Singh's natural curiosity and openness have brought him a long way. At 32, Gajendra has already explored several fields of research spanning mechanical engineering and biophotonics. Born in the Indian countryside, Gajendra now also works at the Massachusetts Institute of Technology (MIT) in the United States, following a stop-over in Europe. As he welcomed new challenges, a key steppingstone for Gajendra has been the 3 years and a half he spent at ICFO as a doctoral researcher. "It's not easy" to get accepted in one of the best engineering institutions in the world, but "ICFO prepared me very well for that," says Gajendra (who back in his ICFO days was affectionately called "GP").

Gajendra chose to study mechanical engineering at the G. B. Pant University of Agriculture and Technology in Pantnagar, India because it was one of the best subjects, and also because it offered good job opportunities. But by the time he earned his first degree, in 1999, the cloning of Dolly the sheep had made big news. "I was amazed" by that technical prowess, Gajendra recalls. So while most of his friends went for jobs in Indian software multinationals, Gajendra went to the University of Calicut about 3,000 km down south to study biotechnology.

Gajendra obtained his Master's degree in 2002 and soon after started looking for a Ph.D. project that would allow him to apply his engineering background to biotechnology. He got several offers from German and U.S. universities, but he chose to go to ICFO for the opportunity to work in biophotonics, a research field in which he saw still a lot to be done. "There are applications in biotechnology which are still governed by the techniques which were developed many years ago, and they aren't as fast as biophotonics can make them," he says. ICFO was also very helpful in speeding up the visa application process, which was another reason why Gajendra chose to come to Barcelona.

Gajendra did his Ph.D. in Dmitri Petrov's lab, working on trapping single cells with optical tweezers and analyzing them with Raman spectroscopy. A "Raman spectrum is like a fingerprint… We used Raman spectroscopy to detect biochemical reactions in a single cell," Gajendra explains. With few photonics facilities available in India at that time, initially Gajendra didn't know much about experimental photonics. But "because of his openness, his desire to know that as fast as possible, he started to understand these things," Dmitri says. Gajendra also had a knack for inventing new biological experiments, Dmitri adds, and he spent his days and nights working in the lab.

> His previous research at ICFO "was one of the main things that pushed me in," Gajendra says

At ICFO, Gajendra also learned how to work in an international environment. Together with former Ph.D. student Giovanni Volpe, Gajendra set up the Student Chapter, securing funding from the Optical Society of America for its first year of running. Bringing people with different backgrounds and perspectives together into a cohesive group proved a useful experience. All in all, "my Ph.D. was one of the best experiences of my life", he says.

Gajendra obtained his Ph.D., *summa cum laude*, in July 2006. He then took a teaching position at Florida Atlantic University in the United States. Six months later, he received an invitation for an interview at MIT. His previous research at ICFO "was one of the main things that pushed me in," Gajendra says. He was asked details about technologies used in commercial biophotonics instruments, "and I was like, 'yes I know it, I did it' in Dmitri Petrov's lab," he says. Gajendra joined the MIT's Laser Biomedical Research Center in February 2007. Since then, he's been working on developing new instruments for the non-invasive diagnosis of diabetes, vulnerable atherosclerotic plaque, and breast cancer using Raman spectroscopy.

Today Gajendra sees many similarities between ICFO and MIT. Both institutes are a "melting-pot… of bright people coming together and doing research," he says. Both also encourage "the exchange of knowledge among people. They always promote reaching out, talking with other labs." ICFO and MIT put emphasis on productivity and foster entrepreneurship too. MIT "is a great place to learn and to do cutting-edge research, and meet smart and creative people… In this respect, I feel it is almost like a larger form of ICFO," Gajendra says.

community pictures

The ICFO festive dinner held last December at the *Poble Espanyol* in Barcelona was a great occasion for ICFOnians to get to know each other better still while taking part in a character hunt, sharing a few drinks, playing games on the dance floor… and being quizzed about the very first issue of ICFO Spotlight.

ICFO festive dinner

THE LAST WORD

high profile

Professor Ignacio Cirac is Director of the Theory Division at the Max Planck Institute of Quantum Optics in Garching, Germany. Professor Cirac is also a Distinguished Invited Professor at ICFO, where he collaborates with Professors Antonio Acín and Maciej Lewenstein among others. Last October, Professor Cirac inaugurated the *Caixa Manresa* Chair program at ICFO, which aims to promote world-class research in quantum information science and technology

Elisabeth Pain talks with Professor Cirac about the way his research and scientific career have unfolded.

Q: How did you get into quantum physics?
A: As a kid I always wanted to be an architect, but in the end I changed my mind and decided to study something which looked a bit deeper into things. I hesitated between mathematics and physics, but then I thought that physics has probably more applications. Then, when I studied quantum mechanics for the first time, I liked it a lot and decided to go into that field.

Q: What is your research about, in a nutshell?
A: Quantum mechanics is a theory that tries to explain the microscopic world of atoms, molecules, electrons, and photons. These small particles behave in a very strange way. We try to use these strange phenomena to transmit information in a better and more secure way, and also to process information in order to make calculations which would otherwise be impossible.

Q: What do you find especially exciting about your research?
A: First of all, we deal with phenomena that are very esoteric and very difficult to imagine. Then, this field combines many fields of science. So there are not only theoretical physicists who work on that, but also chemists, mathematicians, computer scientists, and experimental physicists. And thirdly, this field combines the beauty of physics and its relation to the world with the more abstract world of mathematics.

Q: How do you expect the field to develop over the next few decades?
A: During the last 10-20 years, we have been able to enter a new world. And when you look at history, whenever this happened a new revolution in technology ensued that nobody could imagine at the time. The same thing is happening now. At the moment we know several systems in which in principle it's possible to build a quantum computer. But if you look further than computing, I am sure there will be many other applications.

Q: What is your most memorable moment in research so far?
A: In 1994, I listened to Artur Ekert explain what a quantum computer was. At that time it was not known how we could build one, nor whether it would be possible to build one even in principle. I started discussing this with people, and at some point we came up with an idea of how we may build a quantum computer. I was very happy because I knew it was an important issue.

Q: Any particularly tough times in your career?
A: The most difficult problems I had were during my Ph.D. I wanted to finish it but I didn't know whether I wanted to continue with that. But a visit to a group abroad led by Peter Zoller opened my eyes, and after that I was very determined to continue doing research in that field. That was a different environment. It was very open and very international. People were going to conferences and they were very excited about the work.

Q: You've received many prizes already, including the Prince of Asturias Award for Technical and Scientific Research and the Carl Zeiss Research Award and the BBVA Foundation Frontiers of Knowledge Award. What do these achievements mean to you?
A: When you work on something that you enjoy very much, and on top of that people recognize your work and give you such wonderful prizes, what else can you hope for? Also, it's not only a prize for a person but a prize for a community of people. There are many people working in those fields having ideas and participating who would also deserve these prizes. I feel like I am a representative of that community.

Q: In your view, what are the keys to scientific success?
A: It's a combination of several factors. I became very independent from the very beginning. I've always been collaborating but I was also participating in the ideas, reading on my own and suggesting things. Then, you also need to decide that you want to do something, and bet on that. Do it seriously, do it right, and do it in depth. Also try to be original. I was working on several projects, and some of the riskier ones became the most successful. But perhaps above all, it's important to be lucky and to be in the right place at the right time. I think I was. I was working very hard, but also it is a field that has developed very well.

Grand Opening of the Ignacio Cirac-*Caixa Manresa* Chair at ICFO last October

sudoku

easy

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difficult

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very difficult

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