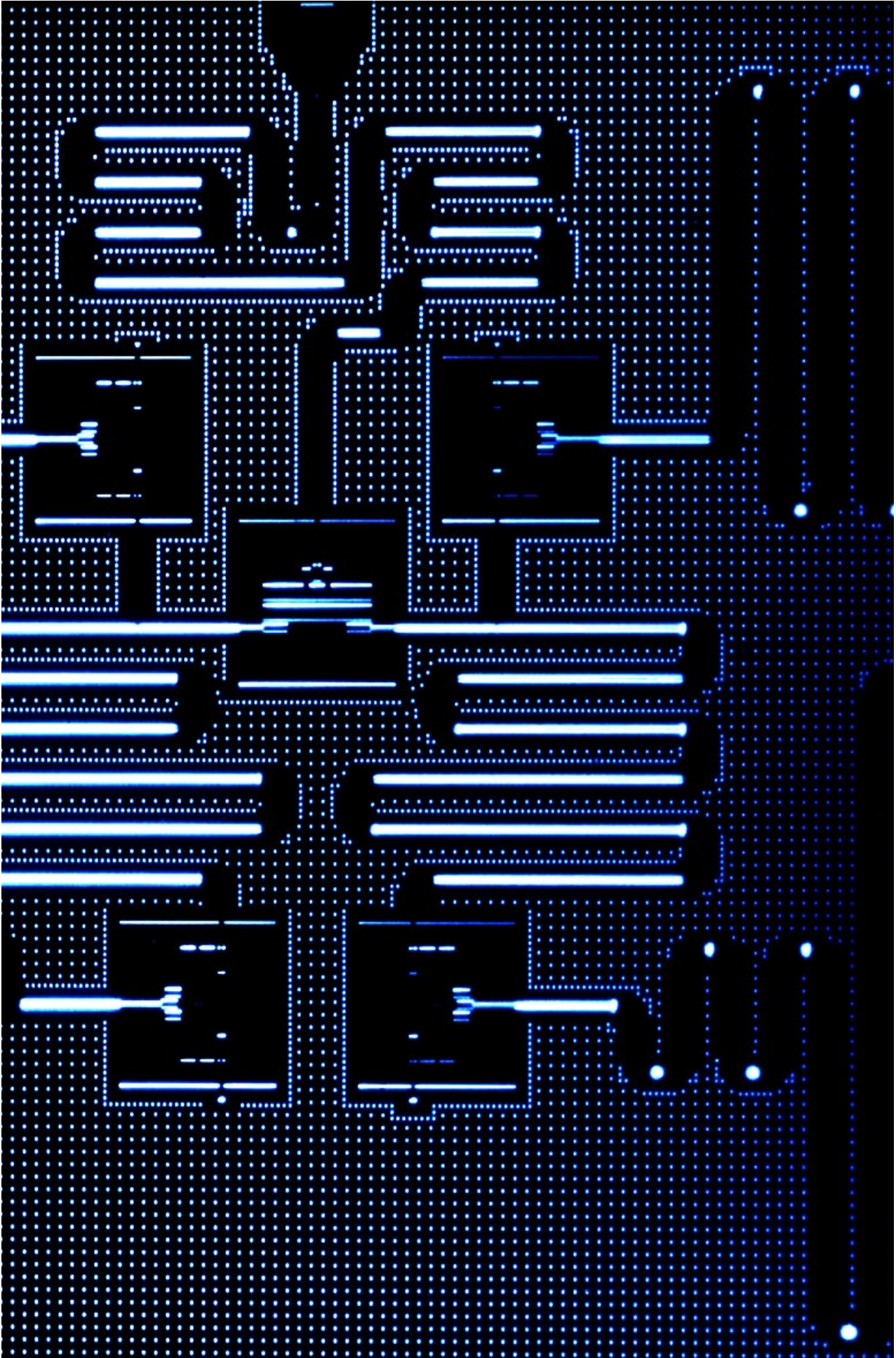


News from
ICTP 144

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2017 ICTP Dirac Medallists Announced

Three share prize for building foundations of quantum information science

ICTP has awarded its 2017 Dirac Medal and Prize to Charles H. Bennett (IBM T. J. Watson Research Center), David Deutsch (University of Oxford) and Peter W. Shor (Massachusetts Institute of Technology) for their pioneering work in applying the fundamental concepts of quantum mechanics to basic problems in computation and communication, thereby bringing together the fields of quantum mechanics, computer science and information, creating the field of quantum information science.

Today, quantum information science is a large and intense field of research, both theoretical and experimental. It relies on the remarkable ways that quantum mechanics differs from the classical mechanics that describes much of our everyday world. Conventional information science involves data in the form of bits, each of which must have a definite value of zero or one. Quantum information science uses the quantum bit, or qubit, which may exist in a quantum superposition that includes values of zero and one simultaneously. Superpositions of two or more qubits may exhibit a further property called entanglement, in which the qubits' values are correlated in ways that defy classical intuition. The three medallists for 2017 each made key contributions in uncovering how the uniquely quantum characteristics of qubits may be exploited to process and transmit data, thus launching the field of quantum information science.

Charles Bennett is an intellectual leader in quantum information science. Four decades ago, he independently invented and carefully analyzed what is now known as reversible classical computation, proving that classical computation can in principle be performed without consumption of energy. In some respects, reversible classical computation is a forerunner of quantum computation, which necessarily involves reversibility and must minimize stray dissipation. With Gilles Brassard (University of Montreal), Bennett invented quantum cryptography, where two distant parties share a secret encryption key, with security from eavesdroppers guaranteed by the basic quantum limitations on measurements of incompatible observables. Bennett and collaborators also introduced quantum teleportation, whereby entanglement and classical signals are used to transfer quantum states. He and coworkers proved that a quantity called the von Neumann entropy is the proper measure of entanglement for pure systems, an early result in the quantification of entanglement, which continues to be an active area of research.

David Deutsch is one of the founding fathers of quantum computing. He introduced the notion of a quantum Turing machine that would operate on arbitrary superpositions of states (that is, on qubits), the concept of the quantum logic gate and quantum circuit, as well as the network model of quantum computations. He showed that all possible operations on a quantum computer could be generated by combining sequences of a single kind of three-qubit logic gate. (Later, Bennett, Shor and coworkers showed that sequences of one-qubit gates and one



simple type of reversible classical two-bit gates sufficed.) Working alone and with Richard Jozsa (University of Cambridge), Deutsch proposed the first quantum algorithms, known as the Deutsch and the Deutsch-Jozsa algorithms, showing that quantum computation could solve certain problems faster than any known classical computer algorithm.

Peter Shor boosted the field of quantum computation by designing efficient quantum algorithms for factoring large numbers and computing discrete logarithms, each of which can be used to break classical encryption schemes. He thus proved that a quantum computer could solve a useful, hard computational problem exponentially faster than any known classical computer algorithm. Shor also introduced quantum error-correcting codes and fault-tolerant quantum computation, which are schemes for coping with the effects of stray interactions (noise) disturbing qubits. Without robust quantum error correction, large-scale quantum computation could be stymied by the extreme sensitivity of quantum states to noise. Instead, the theory of quantum error correction is now a well-established branch of quantum information science, and the difficult path to developing large-scale quantum computers appears open.

ICTP's Dirac Medal, first awarded in 1985, is given in honor of P.A.M. Dirac, one of the greatest physicists of the 20th century and a staunch friend of the Centre. It is awarded annually on Dirac's birthday, 8 August, to scientists who have made significant contributions to theoretical physics. An award ceremony, during which the three winners will present lectures on their work, will take place in 2018.

—Graham Collins

Class of 2017, ICTP Postgraduate Diploma Programme

Ceremony and celebration



In August, ICTP celebrated the graduation of the 34 students enrolled in its Postgraduate Diploma Programme. The ceremony capped a year of intense study that will propel many of the students on to doctoral studies at universities throughout the world. The graduates not only sharpened their study skills: coming from 19 different countries, they also benefitted from the multicultural environment that thrives at ICTP.

ICTP's Postgraduate Diploma Programme is designed to assist students from developing countries who are interested in further study in physics or mathematics. It helps fill in any past gaps in their education, expose students to many different subfields, and prepare them to competitively apply to any PhD programme in the world.

Of the 34 graduating students, four were singled out as the top students of their respective programmes:

- Mary Madelynn Nayga (Philippines) studied condensed matter physics and will go to Dresden, Germany for a PhD at the Max Planck Research School for Chemistry and Physics of Quantum Materials;
- Jan Tristram Aparejado Acuña (Philippines) studied high energy physics and will start a PhD at SISSA this fall;
- Sumiya Baasandorj (Mongolia) studied mathematics and will go to Korea to start a PhD at Seoul National University;
- John Keith Velazquez Magali (Philippines) studied Earth system physics and will begin a PhD at the University of Lyon in November.

Students appreciated their ICTP professors and the skills passed on. "I was excited and worried when I learned I was accepted to this program, feeling I had many gaps I had to fill. I have learned to ask many questions and not just accept things at face value," says Adu Offei Danso, a condensed matter physics student. "All our professors made a great job in teaching us such a complex material," says Roshan Chamba, who studied high energy physics.

Many of the graduates admit that they will miss ICTP's unique international environment, as well as its host city of Trieste. "Trieste is a very good place for ICTP, and for studies," says Michael Baidu, another Earth system physics student. "It's peaceful and calm, the sea is right there. Unlike other cities, there's very few distractions." Rafael A. Martínez Márquez, who studied mathematics, said "One year ago, we arrived in Trieste, with many dreams, shy, and far from our families. We are still a little shy, but now we have a new family, made of people from different countries."

Diploma Graduates 2017: PhD Destinations

ICTP / SISSA PhD Programme (4), Trieste, Italy

SISSA (2), Trieste, Italy

Max Planck Institute, Dresden, Germany

Houston University, Houston, United States

Seoul National University, Seoul, South Korea

Ruhr University Bochum, Bochum, Germany

Université Côte d'Azur (2), Nice, France

University Daejeon, Daejeon, South Korea

Instituto de Astrofísica de Canarias, La Laguna, Canary Islands

Kings College London, London, United Kingdom

Université Grenoble Alpes, Grenoble, France

GFZ German Research Centre for Geosciences, Berlin, Germany

ENS Lyon, Lyon, France

Bologna University, Bologna, Italy

Open University, Milton Keynes, United Kingdom

ICTP in Asia-Pacific

New agreement opens way for physics partner institute in China



ICTP Director Fernando Quevedo (third from left) with UNESCO Director-General Irina Bokova (center) and Chinese Academy of Sciences President Chun-Li Bai (center) at signing of agreement to establish ICTP-AP

China will soon be home to an international theoretical physics institute modelled after ICTP. An agreement signed on 13 May between the Chinese Academy of Sciences and one of ICTP's UN supporters, UNESCO, paves the way for the opening of ICTP-Asia Pacific (ICTP-AP) as a UNESCO Category 2 institute, as well as an ICTP partner institute, to be based at the University of the Chinese Academy of Sciences (UCAS) in Beijing.

ICTP-Asia Pacific will provide opportunities for advanced training, research and education in theoretical physics and related interdisciplinary areas. It will also be an international hub for high-level conferences, schools and workshops, playing an important role in building sustainable science in the Asia Pacific region.

The agreement, which was signed by CAS President Chun-Li Bai and UNESCO Director-General Irina Bokova, came on the eve of China's Belt and Road Forum for International Cooperation in Beijing, an economic and development initiative attended by 29 foreign heads of state along with heads of international organizations.

Underscoring the importance of ICTP-AP, Bai Chunli said at the signing, "No issue on the Sustainable Development Goals agenda can be solved without science." Irina Bokova echoed his sentiments, stating that the establishment of ICTP-AP will be a good opportunity to promote scientific development and South-South cooperation, as basic science is key to the United Nations 2030 development plan.

ICTP Director Fernando Quevedo witnessed the signing, along with Yue-Liang Wu, Vice President of UCAS, and Dian-Wen Cao, Vice Director of the Bureau of International Cooperation, CAS. "This is a landmark event for the future of ICTP activities in Asia," says Quevedo, adding, "China's dynamic scientific development combined with the strong international component of ICTP make this partnership ideal to further promote scientific excellence worldwide."

ICTP-AP will be China's first UNESCO Category 2 basic science center. It will develop outreach activities in cooperation with national and international institutions, providing an international forum and enhancing collaborative networks among scientists from different countries in and out of the region.

The new institute in China joins similar ICTP initiatives in Brazil, Mexico and Rwanda. ICTP aims to bring its unique blend of high-quality physics and mathematics education and high-level science meetings closer to scientists everywhere.

Ramanujan Prize Winner Announced

2017 award goes to
Brazilian mathematician



ICTP, along with the Department of Science and Technology, India and the International Mathematical Union (IMU), have awarded the 2017 Ramanujan Prize for Young Mathematicians from Developing Countries to Eduardo Teixeira of the Federal University of Ceará, Brazil.

The prize is in recognition of Teixeira's outstanding work in Analysis and Partial Differential Equations (PDE), building on his early work on existence and regularity results for free boundary problems. He then introduced an original approach to the regularity of degenerate elliptic equations, which consists in viewing the set of critical points of a solution as a free boundary, leading to the solution of several outstanding open problems.

Teixeira collected his prize during the 2017 Ramanujan Prize ceremony, held at ICTP on 12 October.

In addition to his mathematical achievements, Teixeira was cited for his determined pursuit of high-level research at his home institution in northeast Brazil, where over the last decade he has founded and directed one of the major research groups in nonlinear PDEs in Latin America.

The selection committee consisted of Idris Assani (University of North Carolina at Chapel Hill), Rajendra Bhatia (Indian Statistical Institute), Alicia Dickenstein (University of Buenos Aires and vice president, IMU), Stefano Luzzatto (ICTP and chair, Ramanujan Prize selection committee), and Van Vu (Yale University).

The Ramanujan Prize is awarded annually to a researcher from a developing country who is less than 45 years of age on 31 December of the year of the award, and who has conducted outstanding research in a developing country. Researchers working in any branch of the mathematical sciences are eligible.

ICTP Prize 2017 Announced

Award goes to Argentinian
neuroscientist

ICTP has awarded its 2017 ICTP Prize to Emilio Kropff, a neuroscientist from Argentina affiliated with that country's National Scientific and Technical Research Council's (CONICET) Instituto de Investigaciones Bioquímicas de Buenos Aires (IIBBA), Leloir Institute.

The ICTP Prize recognizes Kropff's outstanding contributions to neuroscience. His works address several aspects of memory and spatial cognition, combining both experimental and theoretical approaches. His theoretical work shows how the hexagonal geometry of spatial maps encoded in grid cells—the positioning system of the brain—can emerge from self-organization in networks of neurons. He participated in the experimental discovery of entorhinal border cells. Most importantly, Kropff discovered speed cells in the entorhinal cortex, neurons that encode a high-precision measurement of speed. Their discovery was crucial, as it provided the missing link in our understanding of how path integration, a mechanism contributing to spatial orientation based on self-motion rather than sensory cues, is implemented in the brains of rats.

ICTP published an article about Kropff's work in 2015. He is an ICTP Associate working with the Centre's Quantitative Life Sciences section. The ICTP Prize will be given to Kropff at a ceremony to be held at ICTP in June 2018.

Each year, the ICTP Prize is given in honor of a scientist who has made outstanding contributions to the field in which the prize is given. The 2017 ICTP Prize honors Daniel J. Amit, a theoretical physicist who pioneered statistical mechanics approaches to neural networks and was one of the founding fathers of modern theoretical and computational neuroscience.

Standard Model Milestone

Steven Weinberg's livestreamed lecture marks 50 years since seminal paper



Photo credit: Matt Valentine

On Tuesday 17 October at 16:30, physicist Steven Weinberg gave a lecture that was livestreamed to ICTP and the world to mark the 50th anniversary of his 1967 paper, "A Model of Leptons". In his lecture, titled "Reminiscences of the Standard Model", Weinberg described the path that led him to the electroweak theory of Salam and himself, and what happened afterwards.

A recording of the livestream is available on ICTP's YouTube page.

Weinberg's paper, in which he presented his work on the unification of weak and electromagnetic interactions, played a seminal role in the development of the Standard Model of particle physics. Together with ICTP founder Abdus Salam and Sheldon Glashow, Weinberg won the 1979 Nobel Prize in Physics for contributions to the theory of the unified weak and electromagnetic interaction between elementary particles.

Weinberg's research has extended over many areas of theoretical physics, especially in the theory of elementary particles and in cosmology. In recent years, he has been concerned with the fundamentals of quantum mechanics, and in particular whether any viable generalization of quantum mechanics is possible. He has also returned to his concern with cosmology, working with Raphael Flauger on a new project: to evaluate the effects of intervening matter on gravitational radiation from distant sources, such as gravitational waves from coalescing black holes discovered by the LIGO observatory and from quantum fluctuations in the early universe.

SESAME Center Inaugurated

ICTP helps celebrate science for peace



Building scientific capacity in the developing world is one of ICTP's main missions, and so it is fitting that ICTP has long been involved in the creation of the first synchrotron light source research facility in the Middle East. ICTP's founder Abdus Salam proposed the idea for such a regional scientific center back in 1983, hoping that scientific cooperation could pave the way for future peace, growth, and collaboration between Middle Eastern countries. Now his hopes have come to fruition: the Synchrotron-Light for Experimental Science and Applications in the Middle East, known as SESAME, was officially inaugurated on 16 May 2017.

Photos from the ceremony and surrounding events can be found on ICTP's Flickr account.

SESAME is run by an independent intergovernmental organization, a coalition of scientists from eight governments, some of which have long histories of not talking to each other. Representatives from Cyprus, Turkey, Israel, Iran, Pakistan, Egypt, Jordan, and the Palestinian Authority have committed their support via funding and other resources since the project was launched officially in 1999. Jordan, as the only country that had diplomatic relations with all members at that time, contributed the facility site in Allan. This sort of cross-border scientific endeavor is partially modelled on CERN, which was founded after World War II to foster cooperation between countries and rebuild scientific networks. Like CERN, SESAME aims to use science as a common language for its culturally diverse coalition.

SESAME will start with two beamlines: the x-ray absorption/fluorescence spectroscopy beamline and the infrared spectromicroscopy beamline. These two beamlines were built first to cater to some of the scientific needs of the region; the x-ray absorption beamline will be particularly useful for environmental and materials science, and the infrared beamline will have applications in biology, medicine, as well as materials science.

Research Highlights

Simple Microswimmers Behaving Smartly

Tiny microorganisms usually seem helpless, but these microscopic creatures have survival strategies of their own, and ICTP physicist Antonio Celani is modelling these strategies to inform the engineering of artificial micro- and nano-swimmers, devices that could eventually be put to work delivering drugs or assessing machinery, as versatile tiny robots.

Reference: Flow navigation by smart microswimmers via reinforcement learning. *Physical Review Letters*, doi: 10.1103/PhysRevLett.118.158004

Controlling the Kondo Cloud

The spins of electrons often interact with each other, and one of these interactions, the Kondo effect, changes how electrons travel and behave, an effect scientists would like to be able to manipulate. Recent work by a team including ICTP physicist Oleg Brovko provides a valuable proof-of-principle of Kondo effect control.

Reference: Potential energy-driven spin manipulation via a controllable hydrogen ligand, *Science Advances*, doi: 10.1126/sciadv.1602060

Climate Connections

A recent modeling paper from ICTP climatologist Fred Kucharski and ICTP Associate Cheng Sun has uncovered an unexpectedly strong connection between decades-long climate patterns in the Atlantic Ocean and sea surface temperatures in the Western Tropical Pacific.

Reference: Western tropical Pacific multidecadal variability forced by the Atlantic multidecadal oscillation. *Nature Communications*, doi:10.1038/ncomms15998

New Frontiers of Nano-Manipulation

A deep understanding and the full control of matter at the nanoscale can help to improve many technology and industry sectors. In particular, nanoscale transport and manipulation are crucial aspects for a whole new generation of technological devices, which led ICTP physicist Erio Tosatti and colleagues to study how to move a gold nano-cluster on top of a suspended graphene membrane, with no need to touch it.

Reference: Ballistic thermophoresis of adsorbates on free-standing graphene. *Proceedings of the National Academy of Sciences of the United States of America*, doi: 10.1073/pnas.1708098114

Mountain Meltdown

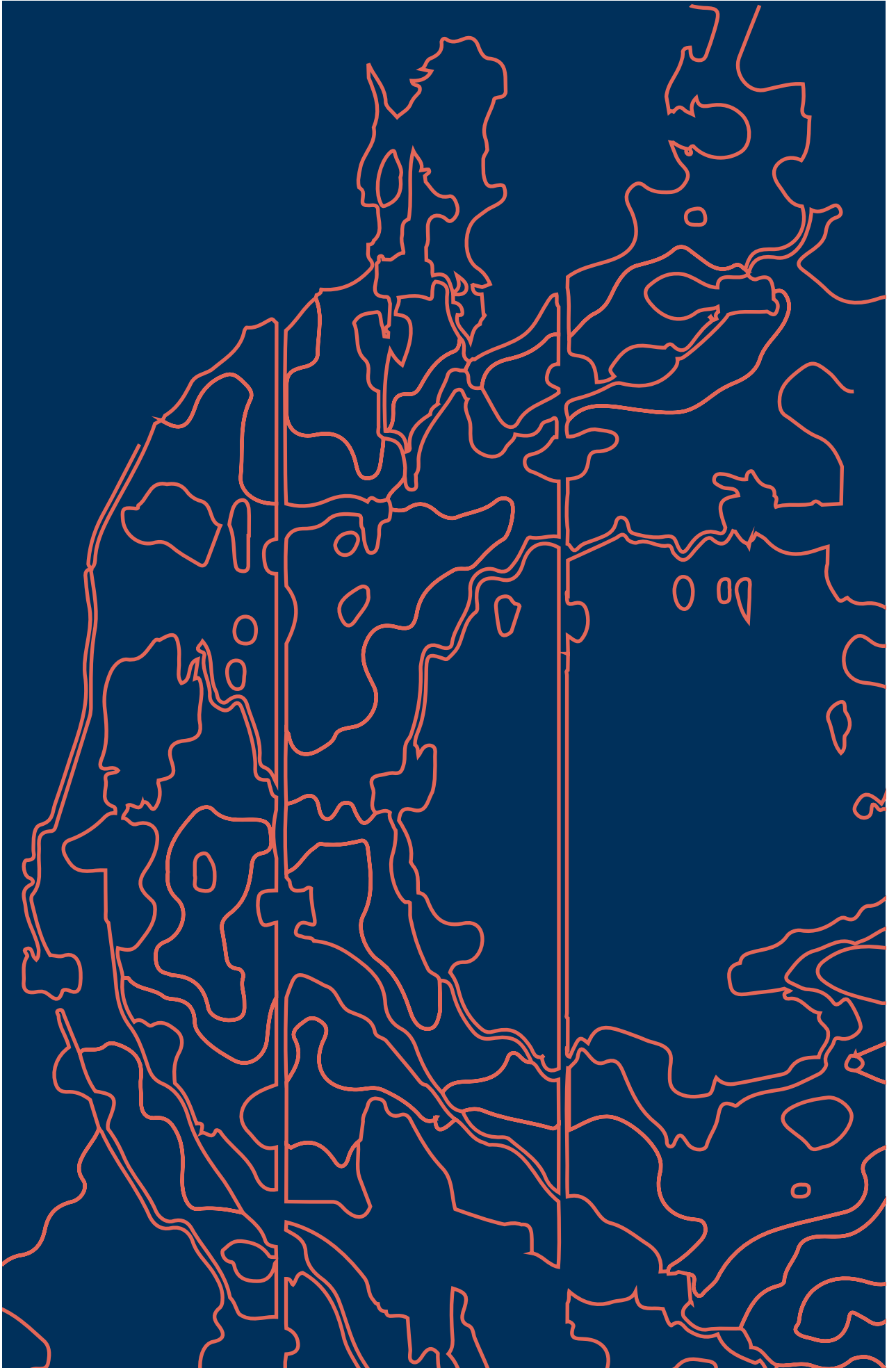
Summer heat can be stressful, but winter heat waves can be just as alarming: ICTP climatologist Filippo Giorgi and colleagues have published a report on a surprising high temperature anomaly in the Alps in 2015, where for the first time in hundreds of years, the surface mean temperature at high elevations remained high for an entire month, thanks to thermal inversion.

Reference: Unprecedented heat wave in December 2015 and potential for winter glacier ablation in the eastern Alps. *Scientific Reports*, doi:10.1038/s41598-017-07415-1

(Synchrotron) light shed on ancient fossils

Using X-ray microtomography, ICTP researchers Claudio Tuniz and Federico Bernardini have recently shed light on the life and death of an Upper Paleolithic fetus, examining teeth minutely to understand what a mummified mother and fetus went through and died of more than 28,000 years ago.

Reference: Virtual histological assessment of the prenatal life history and age at death of the Upper Paleolithic fetus from Ostuni (Italy) *Scientific Reports*, doi:10.1038/s41598-017-09773-2



Awards and Achievements

Filippo Giorgi, head of ICTP's Earth System Physics section, has been awarded the prestigious Alexander von Humboldt Medal by the European Geosciences Union (EGU). The medal recognizes scientists of exceptional international standing whose research benefits developing countries. Giorgi is an international expert in climate modeling and climate change research. He pioneered the field of regional climate modeling and leads an ICTP team that develops and maintains the RegCM regional climate model system. He has contributed to all five reports of the Intergovernmental Panel on Climate Change (IPCC), which won the Nobel Peace Prize in 2007.

ICTP Associate **Omololu Akin-Ojo** has been appointed as director of ICTP's new partner institute in Rwanda, the ICTP-East African Institute for Fundamental Research (ICTP-EAIFR). Akin-Ojo, a condensed matter physicist from Nigeria, will lead the new institute as it enters its most crucial phase: hiring full-time researchers and recruiting students for its masters and doctoral programmes in physics and mathematics. Akin-Ojo earned a master's degree in physics from the University of Ibadan, Nigeria, and a PhD in physics from the University of Delaware, USA. He has years of teaching and research experience, most recently as a senior lecturer at the University of Ibadan. ICTP-EAIFR is scheduled to open in 2018.

Ermanno Pietrosevoli, a researcher at ICTP's Telecommunications/ICT for Development Lab since 2010, has devoted years trying to make the world a more digitally connected place for all. For his "significant contributions to providing Internet access by means of affordable wireless technologies and the training efforts to empower communities and organizations", he has now joined the elite ranks of inductees into the Internet Hall of Fame. This recognition programme and virtual museum, launched in 2012 by the Internet Society, celebrates individuals whose extraordinary contributions have made the Internet, its worldwide availability and use, possible.

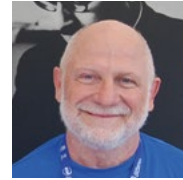
Three physicists with close ties to ICTP—**William Bialek, Subir Sachdev, and Peter Zoller**—are among the winners of the American Physical Society's annual, prestigious awards. Bialek was honored with the Max Delbruck Prize in Biological Physics "for the application of general theoretical principles of physics and information theory to help understand and predict how biological systems function across a variety of scales, from molecules and cells, to brains and animals collectives". Sachdev was awarded the Lars Onsager Prize "for his seminal contributions to the theory of quantum phase transitions, quantum magnetism, and fractionalized spin liquids, and for his leadership in the physics community". Bialek and Sachdev are members of ICTP's Scientific Council, the Centre's governing body. Zoller won the Norman F. Ramsey Prize in Atomic, Molecular and Optical Physics, and in Precision Tests of Fundamental Laws and Symmetries "for his pioneering theoretical work on quantum computation, communication, and simulation with trapped ions, atoms, and molecules." Zoller is a recipient of one of ICTP's highest honors, the Dirac Medal, which he won in 2006.



Filippo Giorgi



Omololu Akin-Ojo



Ermanno Pietrosevoli



William Bialek



Subir Sachdev



Peter Zoller

ICTP Scientific Council member and Dirac Medallist **Michele Parrinello** has won the 2017 Dreyfus Prize in the Chemical Sciences, conferred this year in Theoretical and Computational Chemistry. The international prize, awarded biennially, consists of \$250,000, a medal, and a citation. Parrinello, the first recipient from outside the United States, is honored for his groundbreaking developments of molecular dynamics simulation methodology and associated landmark studies of chemical, material, and biomolecular systems.

The European Research Council (ERC) has recently announced the awarding of its Starting Grants to 406 early-career researchers throughout Europe. Among them are two ICTP-based young researchers: **Marcello Dalmonte** and **John Gould**, both working at the cutting-edge of fundamental science, studying physical properties of quantum systems.

A paper written by ICTP Senior Associate **Humberto Cabrera** in collaboration with Nova Gorica University, titled “Optimized frequency dependent photothermal beam deflection spectroscopy” (doi:10.1088/1612-2011/13/12/125701), was selected by the international journals *Laser Physics* and *Laser Physics Letters* as one of the year’s best papers for 2016. Cabrera is affiliated with the Venezuelan Institute for Scientific Research (Instituto Venezolano de Investigaciones Cientificas).

Phillibert Nang, ICTP associate and head of the Research Laboratory of Mathematics in Libreville (Gabon), has been awarded the African Mathematics Millennium Science Initiative (AMMSI)—Phillip Griffiths Prize 2017. Established in 2016, the Prize is given to African mathematicians living in Africa for their outstanding contribution to mathematics and its applications or to the promotion of it. Nang was cited for the “impact of his work on a wide range of areas of mathematics, as well as for his notable contributions to mathematical development in his home country of Gabon”. Nang was awarded ICTP’s Ramanujan Prize in 2011.

Former ICTP STEP student **Melessew Nigussie** has received the American Geophysical Union’s (AGU) 2017 Africa Award for Research Excellence in Space Science. The award is given annually to early career scientists from Africa who have completed significant work that shows the focus and promise of making outstanding contributions to research in space science. Nigussie is a researcher at Bahir Dar University’s Washera Geospace and Radar Science Laboratory in Ethiopia.

Several mathematicians with close ties to ICTP have been invited to deliver main lectures at the 2018 International Congress of Mathematicians (ICM), to be held in Rio de Janeiro, Brazil. Speaking at the ICM is of great importance and prestige in the mathematics community, and ICM speakers are commonly regarded as the current and future leaders of their mathematics fields. The ICTP-affiliated speakers include ICTP Associates **Moustapha Fall**, **Meysam Nassiri**, and **Carolina Araujo**, as well as Visiting Scientist **Meng Chen**.



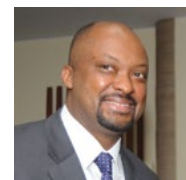
Michele Parrinello



Marcello Dalmonte & John Gould



Humberto Cabrera



Phillibert Nang

In Memoriam

Francis Allotey

One of Africa's most eminent scientists, Francis Allotey played a key role in the scientific direction of ICTP as a long-time member of its Scientific Council. He credited his early love of reading, especially biographies of renowned scientists such as Newton, Einstein and Galileo, for his eventual career as a successful physicist. "I decided that I would also be a great scientist to learn more about the workings of the cosmos and to contribute to its understanding," he wrote in "One Hundred Reasons to be a Scientist", a book of essays by notable physicists published by ICTP.

Abdourahamane Konaré

Abdourahamane Konaré had a close working relationship with ICTP, from the early years of the inception of the Physics of Weather and Climate group, which later became the Earth System Physics section (ESP). He was an ICTP Associate in the early 2000s, and many of his scientific studies into the weather and climate of West Africa were co-authored with members of ESP. Konaré collaborated with ICTP to organize a number of workshops and training events in the region, and a number of his students also visited ICTP and participated in its activities.

Narendra Kumar

An eminent Indian theoretical condensed matter physicist and native of Madhya Pradesh, Narendra Kumar was a long-time professor and chairman of physics and mathematics at the prestigious Indian Institute of Science in Bangalore, later also directing the Raman Research Institute. His ties with ICTP have been probably the strongest, most regular and fruitful among all scientists from the Indian subcontinent. He was an ICTP Senior Associate, as well as a Fellow of The World Academy of Sciences.

Maryam Mirzakhani

Maryam Mirzakhani was the first woman to win the Fields Medal, the most prestigious prize in mathematics, for her work in the dynamics of geometry of Riemann surfaces and their moduli spaces. She was a visiting mathematician and conference attendee at ICTP before moving to Harvard to complete her PhD in 1999, and from there her career took off. Mirzakhani was due to visit ICTP again as a conference organizer in 2016, but cancelled at the last minute. ICTP will greatly miss the opportunity to have her visit again, and mourns the passing of such a pioneering mathematician.

Elias Burstein

Elias Burstein had been an important solid state experimental physicist, working in optical properties of semiconductors (the Burstein shift), surface enhanced Raman scattering, tunneling in solids, and a rich collection of other subjects. He played an important role in establishing ICTP's Condensed Matter and Statistical Physics section in the 1980s.



Francis Allotey

ICTP on the web: www.ictp.it

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The Abdus Salam International Centre for Theoretical Physics (ICTP) is administered by two United Nations agencies—the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Atomic Energy Agency (IAEA)—under an agreement with the Government of Italy.

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