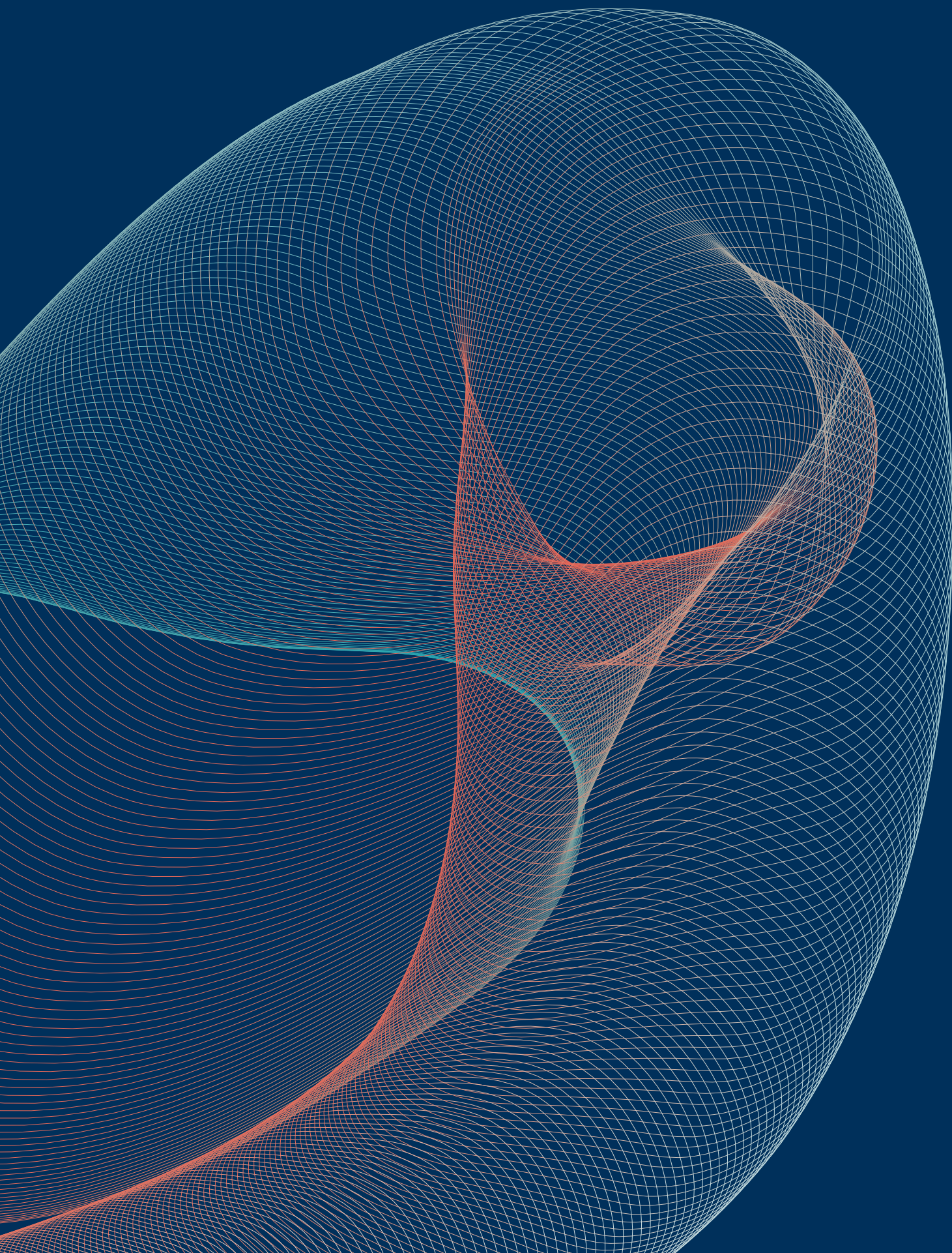


News from  
ICTP 143



## Contents

- 04 Science with a Smile: An Interview with Sir Michael Berry**
- 06 ICTP Scientist Wins Prestigious Research Award from Search Engine Giant**
- 07 Research Highlights**
- 08 ICTP Honoring Research Excellence**
- 10 Nurturing Future Scientists**
- 12 Outreach Activities**
- 14 Awards and Achievements**



## Science with a Smile

### In lectures and in person, Sir Michael Berry's wit and wisdom shine through

In January 2017, Sir Michael Berry—self-described “dreamer and scribbler, of mathematics, mostly”—delivered a set of talks on superoscillations and wave physics for ICTP’s annual Salam Distinguished Lecture Series. His presentations had their fair share of mathematics, but also included many of Berry’s “scribbles”, colorful graphics generated from equations describing wave intensities.

“I like physics that you can see, natural phenomena,” admits Berry, during an interview held between his Salam lectures. Indeed, Berry has a name for his art—“eyemath”—that has evolved from the blackboards of Bristol University, UK, where he has been lecturing and drawing formulas for more than 50 years.

“A lot of time in physics you deal with mathematics that you just can’t work out only using formulas,” explains Berry. “When you make pictures, you can see into the math. This helps us to understand the content of the mathematics, and it helps communicate with colleagues and with people who are not scientists.”

In the interview, as well as behind the lectern, Berry exudes warmth and friendliness, along with a keen sense of humor. During his first Salam Distinguished lecture he relates how, after thinking for years about a paradox presented to him by Yakir Aharonov, he has the epiphany that he had sensed the ideas behind the paradox years before it was presented to him.

“I have a name for these moments of sudden understanding,” he quips, “It is my contribution to elementary particle physics: what is the elementary particle of sudden understanding? It’s the clariton! In an instant, something becomes clear.” The flip side to that, Berry jokes, are the anti-claritons, that often come and annihilate the claritons.

It was a search for clarity that led Sir Michael to physics and mathematics in the first place. As a child, he was fascinated with astronomy, a gateway field for many future physicists. “I came to realize that underneath the astronomy was physics and maths. I studied physics at university, but found I was really clueless about the mathematics; somehow, though, it came naturally,” Berry explains. He adds, humbly, “It was a long time before I dared to admit that I was a physicist.”

Berry says he was honoured that ICTP invited him to deliver the Salam Distinguished Lecture Series, which is held every year on or near the ICTP founder’s 29 January. Although Berry never collaborated scientifically with Abdus Salam, he did meet him on several occasions, including in 1995 when Berry came to ICTP to receive its Dirac Medal.

Sir Michael holds great admiration for Salam, not only for his science but also for his humanitarian side. “He is a good example

of the fact that science crosses national and cultural borders, which is the whole message of ICTP,” says Berry, adding, “Whether you come from Asia or Africa, when you talk about physics, it is the same, and that’s a lovely thing. Because it is about nature, about the underlying concepts that make the natural world what it is, and that is really independent of us. It doesn’t depend on which culture we come from. Salam exemplified that.” Berry was also impressed by Salam’s impressive record for creating science institutes: “He was a mover and a shaker, he made things happen.”

Science’s culture-blindness has perhaps contributed to a curious protocol for scientific dialogue. Berry notes, “We’ve learned a strange trick as a community: how to disagree without being disagreeable. You can go to a scientific meeting and disagree with a presentation, but it is not hostile, it is a productive form of disagreement. I think this is something the world needs.”

One is left with the impression from his frequently lighthearted presentation style that Berry thinks the world also needs levity; or, in the case of his work with Nobel Laureate Andrey Geim, levitation. The two shared the 2000 Ig Nobel Prize in Physics for their flying frog experiment, which, while amusing on the surface, demonstrated some serious scientific principles about magnetism. Berry and Geim saw the award as an opportunity to educate the public about science. In a press release they issued on acceptance of the prize, they said, “We are pleased to accept the Ig prize because we have always considered it a duty to make physics more understandable and bring it closer to nonscientists.”

The two end their release with the statement, “Let there be more science with a smile”. For Berry, this philosophy underpins his science. “It’s what I do most of the time, so why not enjoy it?”

## Google Grant

### ICTP scientist wins prestigious research award from search engine giant



ICTP condensed matter physicist Antonello Scardicchio has been awarded a Google Faculty Research Award for work related to quantum computing. The US\$72,000 in seed funding will be used to support graduate students and postdoctoral associates working in his group.

Quantum computing has the potential to revolutionize the speed and efficiency of computers because of the way it processes information: as quantum bits, or qubits. Unlike classic computers, where information is stored as bits and each bit is either zero or one, quantum computing's qubits are made of quantum particles that can exist in a superposition of both values at the same time. This could allow quantum computers to process information millions of times faster than today's supercomputers.

The algorithms used in quantum computing presumably are faster than algorithms used on classical computers because they take advantage of the speed offered by interference of matter waves, a peculiar quantum phenomenon. To confirm the performance superiority of quantum algorithms would help to define which problems can benefit significantly from using a quantum computer instead of a classical one. This is what Scardicchio's research aims to do, using techniques developed in statistical mechanics and condensed matter, in particular the analysis of differences of quantum and classical dynamics. By understanding in which situations quantum interference can speed up the dynamics and in which ones, instead, the interference hinders the dynamics (a phenomenon known as localization), one can give guidelines for the design of quantum algorithms to exploit the first and avoid as much as possible the second.

"It is certainly an honor to receive such an award, in particular since this recognizes the practical importance of our theoretical investigations," says Scardicchio.

The award builds upon Scardicchio's past research on spin glasses, or disordered magnets whose atoms are not aligned in a regular pattern. "Eventually, I realized that the physics of quantum spin glasses is actually connected with how you build a quantum computer," he explains, adding, "Phenomena that occur in quantum spin glasses have a bearing on the performance of quantum algorithms." The work attracted Google's interest, and in particular that of their Quantum Artificial Intelligence group, which is actively working on building a quantum computing device.

"Quantum computation, when effectively implemented, will change the way we do theoretical condensed matter, and in general our ability to treat quantum many-body systems," says Scardicchio. He adds that simulations are an invaluable tool for condensed matter physicists, and being able to simulate quantum systems in an effective way will make researchers able to test and confirm or discard quickly new ideas and conjectures.

Google Faculty Research Awards are highly competitive; only 15% of applicants receive funding after going through a rigorous review process.

## ICTP Research Highlights

### ICTP co-author among *Physics World's* Top 10 Breakthroughs in 2016



credit: IQOQI/Harald Ritsch

Research to which an ICTP scientist contributed has been chosen by *Physics World* magazine as one of the top ten physics breakthroughs of the year for 2016.

ICTP scientist Marcello Dalmonte, the Ludwig Boltzmann Senior Postdoctoral Fellow in the Centre's Condensed Matter and Statistical Physics section, co-authored a paper with his colleagues at the University of Innsbruck, on "Real-time dynamics of lattice gauge theories with a few-qubit quantum computer". The paper, which was published in *Nature* in June 2016 ([doi:10.1038/nature18318](https://doi.org/10.1038/nature18318)), describes a digital quantum simulation of a gauge theory, simulating the emergence of particle-antiparticle pairs using trapped ions as quantum hardware. Quantum computing represents a promising way for scientists to go beyond the power of high performance computing to simulate particle interactions, by exploiting the peculiar rules of quantum mechanics to process information in ways that are impossible on a standard computer. This combined theory/experiment effort represents the first demonstration of a key building block in this direction, paving the way towards the observation of particle physics phenomena in atomic quantum simulation experiments.

Dalmonte started his fellowship at ICTP in September 2016.

### Climate prediction and malaria outbreaks

Predicting the spread and outbreaks of malaria is a complicated affair: malaria-causing parasites are spread through mosquito bites, and mosquitoes need water to breed and multiply. As a result, public health experts take a detailed interest in the weather: more rain can lead to more mosquitos, resulting in more malaria cases.

But scientists are finding that this relationship is not so simple: some intense rain events can flush mosquito larvae out of breeding sites and reduce malaria risk. The amount of rain, but also the rate of rain, the soil composition, and the topography all affect the resultant pools and puddles available as mosquito bedding grounds. ICTP climatologist Adrian Tompkins and his collaborators have worked to integrate all these factors, and more, into a model of how malaria spreads and infects people.

The model, known as VECTRI, helps predict malaria outbreaks and is now shared as free, open-source software for scientists and health ministries worldwide. "Not many climatologists are involved in this kind of application yet," says Tompkins, who specializes in sub-seasonal predictions, adding, "There are a lot of nuances in predicting malaria that the latest seasonal forecast and climate models can help fill in."

Those improved prediction abilities would allow doctors and officials to better prepare for epidemics. With more lead time from seasonal predictions, malaria nets can be distributed or teams organized to treat rural habitations with insecticidal sprays, and more staff and medical supplies can be readied for an influx of cases.

To date, VECTRI has been downloaded over 50 times worldwide, used today by research groups and in the near future, health ministries. All of these groups can use Tompkins' model because of its open-source designation; sharing the work to be built on and applied is a natural extension of ICTP's mission to help opening doors for developing-country scientists.

# ICTP Honoring Research Excellence

## String theorist awarded ICTP Prize 2016



ICTP has awarded its 2016 ICTP Prize to Aninda Sinha of the Center for High Energy Physics, Indian Institute of Science, Bangalore, India.

Sinha is a string theorist whose work crosses multiple disciplines, from quantum field theory to condensed matter physics. He is particularly known for a number of inventive contributions to the application of the holographic connection between theories of gravity and strongly coupled condensed matter physics. In recent years his publications have covered aspects of the holographic correspondence between gauge theory and gravity, its applications to aspects of fluid dynamics and connections with black hole dynamics and entanglement entropy.

Sinha's ICTP Prize cites his "key contributions to aspects of quantum field theory using the AdS/CFT correspondence. In particular, the development of holographic c-theorems for strongly coupled theories which led to the first c-theorem in odd-dimensions, an important breakthrough in the study of hydrodynamic properties of strongly coupled systems with holographic duals, of the holographic entanglement entropy and in the conformal bootstrap program".

Created in 1982, the ICTP Prize recognizes young scientists (under 40) from developing countries who work and live in those countries and who have made outstanding and original contributions to physics.

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 2016 ICTP Prize honors Nobel Laureate Kenneth G. Wilson, a theoretical physicist who pioneered the application of computational field theory methods to critical phenomena and elementary particle problems, and a friend of ICTP.

## ICO/ICTP Prize recipient reflects passion for light and outreach



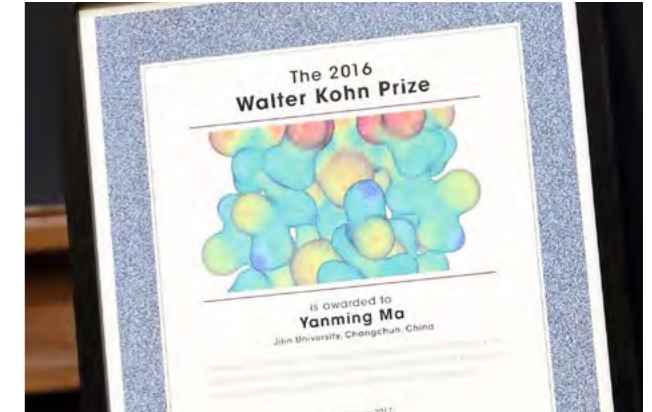
Goutam Kumar Samanta of the Physical Research Laboratory in Ahmedabad, India, is the recipient of the 2017 ICO/ICTP Gallieno Denardo Award.

The prize was announced 21 February by ICTP and the International Commission for Optics (ICO) during their annual Winter College on Optics. It recognizes Samanta's significant contributions to the field of nonlinear optics, lasers and quantum optics, as well as his efforts in popularizing science among school students in India.

Samanta says a fascination with light attracted him to the field of photonics and optics. As a physics student, he gravitated toward the study of lasers. His research interests include structured laser beams, nonlinear generation of structure beams, optical parametric oscillators, and development of entangled photon source with high brightness.

At India's Physical Research Laboratory, Samanta's research group is looking at the orbital angular momentum of light at the single photon level and its use in quantum optics. The work involves structuring a laser beam and studying its nonlinear effects, and generating entangled photons with high brightness, useful for quantum optics experiments. "Entangled photons are the basic ingredient for many quantum optical experiments not only for the fundamental research, but also for a variety of applications in real world quantum communications and quantum computing, for example long distance and satellite communications," Samanta explains.

## First Walter Kohn Prize honors Chinese researcher



The first Walter Kohn Prize for quantum-mechanical materials and molecular modeling was presented to Yanming Ma, a young researcher from Jilin University in Changchun, China. The prize recognizes his development of efficient methods for the determination of crystal structures based on density-functional theory and for the prediction of novel phases of materials under high pressure.

Yanming Ma is a rising star in the quantum-mechanical materials modeling world. "Professor Ma's research is having a tremendous impact in this field," says Stefano Baroni, professor in the Condensed Matter section at SISSA and director of the Quantum ESPRESSO Foundation, a co-sponsor of the prize. "His work has applications as diverse as the design of functional materials—superconductive, superhard, or thermoelectric materials—and the stability of matter at extreme conditions," Baroni continues. "Not only has Professor Ma authored countless publications, he is also the main developer of an open source software package (nicknamed CALYPSO), thus making his methodology available to a broad scientific audience."

"One of the hardest problems in physics, chemistry or materials science is to predict the atomic arrangement—the crystal structure of a material—with no prior knowledge apart from the chemical composition," says Shobhana Narasimhan, a member of the Walter Kohn Prize selection committee and Professor of Theoretical Sciences and Dean of Academic Affairs at the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore. "Yanming Ma has developed new methods that are a significant step forward in achieving this difficult task. Over the last few years, his work has featured noteworthy examples of many different aspects of computational materials science: developing novel algorithms, performing virtual experiments, and the in silico design of materials with useful properties."

The Walter Kohn Prize honors a great founder of the field of materials modeling. Walter Kohn became a leading condensed matter physicist after escaping Nazi Germany in the 1930s for the US. He won a Nobel Prize in Chemistry in 1998 for the creation of density functional theory, or DFT.

"One of the hardest problems in physics, chemistry or materials science is to predict the atomic arrangement—the crystal structure of a material—with no prior knowledge apart from the chemical composition"

—Shobhana Narasimhan

## Nurturing Future Scientists



### Medical Physics Success New graduates join growing numbers of medical physicists trained at ICTP

The students came to ICTP from all corners of the earth—Latin America, Eastern Europe, Northern Africa, the Middle East—two years ago, full of ambition as they embarked on a course of study leading to a master's degree in medical physics.

On 13 December 2016, the 13 students achieved their goal, earning degrees in the joint ICTP-University of Trieste Masters in Medical Physics Program (MMP). They now have the knowledge and technical skills needed to forge safer, more efficient medical radiation treatment in the developing world.

The graduates have spent the last two years enrolled in the world's only medical physics masters program devoted to scientists from developing countries. ICTP, with its decades of experience supporting sustainable science in less advantaged parts of the world, launched the degree program three years ago with academic backing from the University of Trieste. In addition, ICTP received invaluable, ongoing support from its UN partner, the International Atomic Energy Agency, whose experts actively participate as course lecturers and curriculum developers. The IAEA also provides fellowships to many of the students.

"The Joint Master in Medical Physics program was developed in response to demand from developing countries," said ICTP Director Fernando Quevedo in remarks at the ceremony. "It represents a logical extension of the long history of medical physics training activities ICTP has organized with the IAEA, and is one of the most successful initiatives we have started in the past few years," he stated.

University of Trieste Rector Maurizio Fermeglia highlighted the added benefit to developing countries of a highly trained force of medical physicists. "This field will be crucial in tackling growing problems associated with an aging population and environmental changes, issues that will disproportionately affect the developing world," he explained.

At only three years old, the MMP program has already attracted international honors, reflecting the high regard with which the program is held. In June 2016, the American Cancer Society offered to provide two scholarships worth 60,000 Euro to help train students from Africa. The money supports an international initiative to assist Ethiopia in expanding the number of cancer centers in the country--bringing treatment closer to the population--and provide long-term training of cancer specialists.

Another recent MMP program achievement is its accreditation by the International Organization for Medical Physics (IOMP), the premier medical physics organization that fosters educational and professional development and promotes quality medical services for patients.



### Second MHPC Class Graduates High Performance Computing students receive Master's

The joint ICTP-SISSA program granting a Master's in High Performance Computing graduated its second-ever class, during a ceremony in February 2017. Thirteen students received their diplomas after a year and a half of intense studies and thesis preparation.

Course coordinator and ICTP scientist Ralph Gebauer proudly highlighted the geographical diversity of the graduating students, who hailed from Italy, Ghana, Pakistan, Colombia, Costa Rica, Germany, India, Cuba, Mexico, and the Philippines. In addition, there were three women in the graduating class this year, helping to fight the heavily skewed gender ratio in the field of high performance computing.

Graduate Marlon Esteban Brenes Navarro won the prize for the best thesis, delivering a talk on his project, 'Massively parallel implementation and approaches to simulate dynamics of 1D quantum interacting systems using Krylov subspace techniques.' Nicola Mazari, a professor at the École Polytechnique Fédérale de Lausanne in Switzerland, gave the keynote talk, entitled, 'Computational materials science enters a new age.' He offered some career advice to the MHPC graduates, stressing that

intelligence alone is not a guarantee for a successful career. Instead, Marzari urged the students to focus on hard work, drive, vision, and creativity.

"This is a very proud moment for us," said ICTP director Fernando Quevedo in his opening remarks and welcome. Gebauer is doubly proud that every member of the first class of MHPC students have jobs, as do the majority of this graduating class. Congratulations to the graduates, and best of luck on your next step!

# Outreach Activities

## ICTP-SAIFR celebrates 5th anniversary

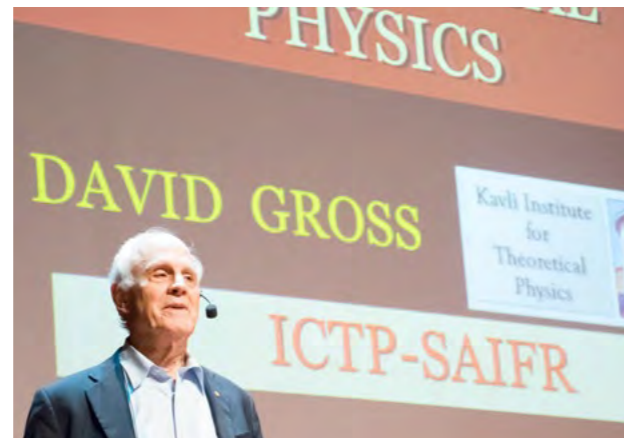
Over one thousand physicists and two thousand graduate students have traveled to São Paulo in the past five years, all drawn to the bustling theoretical physics institute there. The South American Institute for Fundamental Research, known as ICTP-SAIFR, is an international research center and ICTP partner institute. It recently celebrated its fifth anniversary, and hopes to expand and continue its busy calendar of research, training, and outreach activities.

ICTP-SAIFR was the first of ICTP's partner institutions, independent research centers modeled after ICTP, with a similar program of schools, conferences, and visiting scientist programs. ICTP-SAIFR was started with scientific and administrative help from ICTP staff, and extensive support and collaboration from São Paulo State University (UNESP) and the São Paulo Research Funding Agency (FAPESP). Situated on the campus of the Instituto de Física Teórica (IFT) at UNESP, ICTP-SAIFR has made a name for itself in physics, acting as an international meeting point and conference center.

Nathan Berkovits, the director of ICTP-SAIFR, oversees a research staff of five scientists and a regular rotation of post-doctoral fellows. With the help of four administrative staff, SAIFR organizes and hosts hundreds of seminars, as well as over 75 schools, workshops, and conferences. "Our scientific calendar is open to including activities on almost anything related to theoretical physics," says Berkovits. "It varies with what our scientists are interested in and what our 60 Associate scientists from around South America propose." Recent activities have covered gravity and string theory, relativistic astrophysics, particle physics, mathematical biology, and pathogen dynamics.

Running these high-level scientific activities is one of the main successes of ICTP-SAIFR over the past five years, reflects Berkovits. "We are fortunate to have hired great faculty, who do high-quality research," he says, highlighting the support that both FAPESP and The Simons Foundation have provided to fund competitive positions for talented young scientists. The ICTP-SAIFR faculty contributed to a recent citation of its host UNESP by the journal Nature, for the university's sharp increase in quality research output. Nature pointed to UNESP's strength in physics, which is reinforced by the quality work coming from ICTP-SAIFR's scientists.

Joint activities with other institutes around the world help maintain the flow of high-level, international physicists. In addition to the partnership with ICTP, SAIFR enjoys a fruitful collaboration with the Perimeter Institute in Canada that has yielded more resources for another one of ICTP-SAIFR's facets, outreach. ICTP-SAIFR professor Pedro Vieira, who holds a joint appointment with Perimeter, has leveraged that partnership to expand outreach in São Paulo. Materials prepared for high school physics teachers by Perimeter, workshops for high school



Renowned physicist David Gross was a featured speaker at ICTP-SAIFR's fifth anniversary celebration

students, science social hours, and public lectures have all helped ICTP-SAIFR excite the next generation of physicists.

ICTP-SAIFR's success is encouraging for its scientists and for physicists throughout South America, as the institute hopes to gradually expand over the next several years. Berkovits hopes ICTP-SAIFR will be able to hire several more permanent faculty, as well as become more competitive and attractive for top talent. "We'd like to become the best theoretical physics institute in South America, one of the top in the world," Berkovits says. "I would love to see someone from our institute be the first Latin-American physicist to win a Nobel Prize." With the current trajectory, that goal may not be far off for the vibrant ICTP-SAIFR.

## Promoting equality in science: ICTP celebrates International Day of Women and Girls in Science



Why are there still fewer women than men in science? The reasons are many, ranging from the challenge of balancing family life and career to a lack of childcare support and role models.

Putting a spotlight on the challenges and opportunities for women scientists, ICTP hosted an exhibit and social media activities to support the United Nations' International Day of Women and Girls in Science. The event was co-organized by The World Academy of Sciences (TWAS) and the Organization for Women in Science for the Developing World (OWSD).

Members of the ICTP community were invited to view displays about women in science. ICTP's Marie Curie Library staff were there with a selection of related books.

## Physics Without Frontiers in South America: Venezuela and Colombia host joint program



ICTP's Physics Without Frontiers program has been on the road since 2008, bringing high-energy physics masterclasses and courses to inspire and engage students in developing countries. In October 2016, a joint program in Venezuela and Colombia was organized to both explore high energy physics with students and to strengthen connections between institutions in the two countries. The virtual research and learning community of CEVALE2VE was also highlighted, as a network created to stimulate and widen the physics postgraduate education and research in Venezuela and Colombia, as well as to create links with European and North American institutions.

You can view a photo essay about the program on our blog, thanks to the local PWF team: [blog.ictp.it/wp/](http://blog.ictp.it/wp/)

# Awards and Achievements

Theoretical physicists **Joseph Polchinski**, **Andrew Strominger**, and **Cumrun Vafa** have won the 2017 Breakthrough Prize in Fundamental Physics for “transformative advances in quantum field theory, string theory, and quantum gravity”.

The three are already well known to the ICTP community: all are recipients of ICTP’s top physics prize, the Dirac Medal. ICTP congratulates them on their success.

The family of ICTP founder and Nobel Laureate Abdus Salam announced the winners of the 2017 Spirit of Abdus Salam Award on 29 January, Abdus Salam’s birthday. The award recognizes those who, like Salam himself, have worked tirelessly to promote the development of science and technology in disadvantaged parts of the world:

- **Imrana Ashraf Zahid**, ICO/ICTP Prize winner (2004) and regular tutor at ICTP’s annual Winter College on Optics, and who, in Pakistan, has promoted the education of young women by organizing hands-on, scientific activities;
- **Daniel Gómez**, a long-time ICTP Associate who actively promotes learning and scientific collaboration in his home country, Argentina;
- **Giancarlo Ghirardi**, who has been associated with ICTP for many years, as a researcher, a professor, and as the head of its Associate and Federation Schemes, which provides important opportunities for scientists from developing countries;
- **Muhammad Iqbal**, who first came to ICTP in 1993 to help take care of Abdus Salam, and who is recognized by many ICTP visitors as the competent, friendly multimedia assistant always present in the Budinich Lecture Hall to ensure that ICTP’s presentation equipment functions properly.

ICTP Associate **Meysam Nassiri**, a mathematics professor at the Institute for Research in Fundamental Sciences, Iran, has been selected to deliver an invited lecture at the upcoming International Congress of Mathematicians, to be held in 2018 in Rio de Janeiro, Brazil. Speaking at ICM is of great importance and prestige in the mathematics community; ICM speakers are commonly regarded as the current and/or future leaders of mathematics.

Junior Associate **Fadipe-Joseph Olubunmi** has been appointed ambassador, International Mathematical Union Committee for Women in Mathematics. She is the only appointed ambassador for Nigeria.

Former ICTP postdoctoral fellow **Rachel Lowe** has won a prestigious 5 year royal society Dorothy Hodgkin Fellowship from the Royal Society. Lowe is modelling the impact of global environmental change on vector-borne disease risk. While at ICTP, she worked with Adrian Tompkins in ICTP’s Earth System Physics section.



Joseph Polchinski



Imrana Ashraf Zahid



Andrew Strominger



Giancarlo Ghirardi



Cumrun Vafa



Muhammad Iqbal

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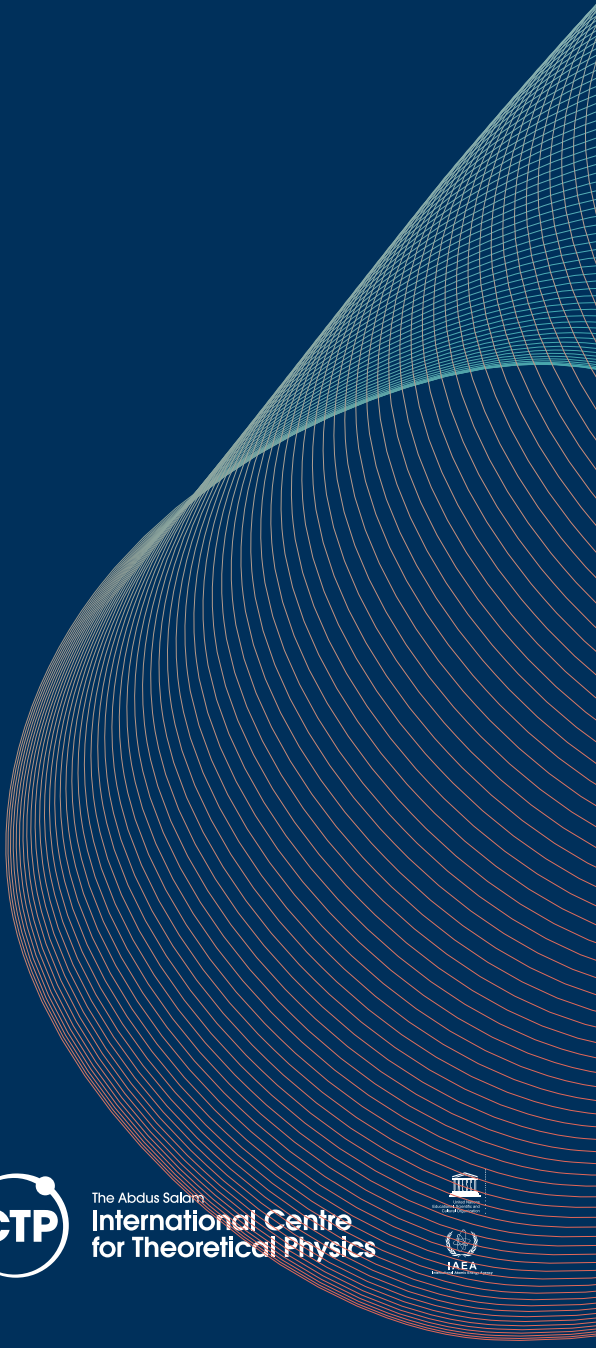
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