ICTP 1964–2024

IAEA International Atomic Energy Agency

unesco United Nations Educational, Scientific and Cultural Organization

A Year in Review

Celebrating 60 years of science without borders

2024

The Abdus Salam
International Centre
for Theoretical Physics

2024:
A Year in Review

2024: A Year in Review
The Abdus Salam International Centre for Theoretical Physics

Compiled by the ICTP Public Information Office
Designed by 400 Communications

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Foreword

Important anniversaries are an occasion to reflect upon past achievements and think of new strategies for the future. In 2024, ICTP celebrated 60 years of its unique mission with a series of international, science-focussed events throughout the year, culminating in a one-day celebration in November.

That celebration was as much a nod to ICTP's six decades of indelible achievements as it was a staging for a future strategy that aims to put ICTP on a path to reaching its 100th anniversary and beyond.

ICTP's future must respond to new opportunities and realities while keeping true to the foundational inspiration from its creators Abdus Salam and Paolo Budinich. The three pillars on which ICTP was built are as strong and valid today as they were in 1964: excellence at the frontiers of science; global inclusion for scientific resources; and international cooperation through and for science.

With a view to the coming decades, ICTP's vision must take into account a delicate balancing act between emphasizing the unity of pure and applied science and the growing need to ensure equitable opportunities with new technologies. The modern Scientific Method now has computation as an important new pillar. There is a growing knowledge divide when it comes to the use of modern algorithms or tools like GPUs, Artificial Intelligence or quantum computing. ICTP considers it an obligation to find the means to make these critical resources for science globally available, ensuring global participation in technological revolutions.

ICTP's strategic plan for the coming years must focus on fostering international scientific communities, where a global approach is important to finding solutions. As a UN organization, ICTP has the mandate and convening power to hold multilateral, international meetings. Scientists need to overcome political barriers to collaborate with each other on scientific issues such as climate change which require a global response. ICTP is uniquely positioned to offer these opportunities. ICTP should help to create strong scientific communities in the Global South well versed in modern tools and climate modelling. This is an essential precondition for meaningful participation in decision-making of those most affected.

The Centre has already taken steps in this direction through the launch of its International Consortium for Scientific Computing (ICOMP), a global partnership to encourage open science, including open access to computational resources, open codes for high performance computing, and open weights of AI algorithms. A proposed International Consortium for Future Earth would create an effective scientific climate response with meaningful participation of the Global South.

Another initiative that ICTP is keen to develop is the International Science Alliance. During the anniversary year we had a number of impactful events around the world, including at the headquarters of our main sponsors UNESCO and IAEA. These events were aimed at highlighting the achievements and promise of ICTP and at building the ICTP community. We have been successful in forging new partnerships with countries like South Africa, Brazil, Vietnam, and Indonesia; with major foundations like the Arab Fund, the Kuwait Foundation for the Advancement of Sciences and the Simons Foundation; with scientific institutions like

CECAM and CINECA; and with corporations like IBM. These collaborations will greatly enhance our mission.

At the same time, as it builds upon its strong research foundation, ICTP needs to expand its resources and partnerships and improve its campus infrastructure. ICTP has been very successful in its advancement efforts during the past years towards this goal.

Thanks to generous funds for extraordinary maintenance from the Italian government, ICTP's main sponsor, the Centre is undertaking a major upgrade of its campus including offices, lecture halls and the Library. The Library space will be modernized and reconfigured and the book collection is being digitized thanks to generous donations from the well-wishers of ICTP.

A major grant from the Simons Foundation International will assist us to create a modern Science Complex. One natural destination for this complex would be the iconic Adriatico guesthouse which has been an integral part of the ICTP experience. Thousands of scientists from around the world who every year take part in ICTP's activities have benefitted from the residential facilities at the Adriatico, where more than 40% of our lectures and seminars take place. Some of the technical details are still being finalized.

We are very grateful to all our donors for their generous support and expect even greater success for our advancement efforts in 2025.

A major grant from the Simons Foundation International will assist us to create a modern Science Complex.

As it enters its sixth decade, ICTP continues to be a beacon of research excellence and science opportunity for all. Fulfilling our strategic plans in today's uncertain geopolitical climate will be challenging, but as the Centre has shown, facing those challenges through international collaborations and preparing future generations of scientists through open access to information and inclusive opportunities are some of the most effective ways to ensure a resilient future. It would not be an exaggeration to say that the survival of humanity depends on our ability to collaborate for science across geopolitical borders to address some of the major challenges that necessarily require a unified effort.

Atish Dabholkar
ICTP Director

ICTP Director Atish Dabholkar presenting his vision for ICTP's future at the 60th anniversary main celebration, 15 November 2024.
© Alberto Riccio Bergamas

ICTP at 60: A Celebration of Sustainable Science With a Look to the Future

Scientists, local and national dignitaries, and representatives from some of the world's most prominent science institutions paid their respects to ICTP at a day-long celebration for its 60th anniversary. Participants from 38 countries crossing 5 continents united to honour the Centre's rich history and to contemplate scenarios for the future.

The event gave an opportunity for ICTP to not only showcase the ongoing relevance of its mission but also to share a glimpse of its future directions. A series of panel discussions moderated by science journalists provided lively discussions about some of the most pressing global challenges, from equal access to scientific knowledge to balancing sustainability with growing energy needs, to convincing policymakers about the crucial importance of fundamental science.

ICTP Director Atish Dabholkar opened the celebrations by unveiling ambitious plans in his keynote address, with a view to the eventual 100th anniversary of ICTP in 2064. "Our vision for ICTP's future must respond to new opportunities and realities while keeping true to the foundational inspiration from ICTP's founders Abdus Salam and Paolo Budinich," said Dabholkar. Key points from his presentation can be found in the Foreword to this report.

Science Panels: "Physics is the queen of science"

Setting the stage for these discussions, and reflecting the core of ICTP's mission, the first panel focussed on how fundamental science is vital for the development of all societies, and the benefits of interdisciplinary research. Physics Nobel laureate David Gross and theoretical physicist Marc Mèzard – both of whom are on ICTP's Scientific Council – along with United Nations University Rector Tshilidzi Marwala provided keen insights and often light-hearted opinions on both topics.

On the importance of places like ICTP that do fundamental research, Gross started the discussion by quipping, "As a physicist, we know that physics is the queen of science, which is why institutes of theoretical physics have had such a large impact, not just on physics but on all the sciences." He added, "Theoretical physicists love nothing better than to get together and talk, and argue, and collaborate and compete. Theorists and mathematicians thrive in this kind of interaction." Institutes like ICTP have proved that this model of bringing researchers together is an incredibly successful model, Gross said. But ICTP, unlike other theoretical physics institutes like Kavli or IAS, has had this other aspect to it, this international effort, which is unmatched anywhere else, he continued.

From left: United Nations University Rector Tshilidzi Marwala, Nobel laureate David Gross and physics professor Marc Mèzard at a panel discussion on the importance of fundamental science. © Alberto Riccio Bergamas

This international aspect of ICTP, combined with the range of fields represented by its research, creates an environment ripe for cross-fertilization of ideas. When asked to comment on this, Marc Mèzard, a professor of theoretical physics at Università Bocconi, said, "I think the dynamics of scientific creativity is complicated; there are a lot of discoveries that come from the core of the disciplines, and there are others that come from the interactions between different fields. You have to combine these two." He continued, "Here at ICTP we have a model which works very well because of its relatively small size. It has a broad spectrum but also a strong unity. On top of that, it is a model with this incredible flux of people coming forth from various programmes."

The conversation turned to a potential collaborative role that UNU and ICTP can take to educate the next generation of scientists. "Education is changing, and we need to redefine what it actually means to be educated," said Tshilidzi Marwala. "I think the United Nations should be closer to universities and educational institutions, and this is what the UNU is trying to do. Why is that important? Knowledge has not yet been democratized. How much access to knowledge you get depends on where you are located. So the need for an international organization like the UNU to democratize knowledge becomes even more important," he said.

The Future of Computing and Quantum Sciences

A panel discussion on the Future of Scientific Computing and Quantum Science addressed the fundamental challenge of ensuring equal access to new technologies such as Artificial Intelligence, high-performance computing and recent advances in quantum computing. These new technologies are influencing the scientific process in several fields. The uniqueness of ICTP's mission to promote scientific excellence and collaboration between scientists from around the world gives it a key role in ensuring that the needs of scientific communities in less developed regions of the world are taken into account and addressed.

Urbasi Sinha, who heads the Quantum Information and Computing Laboratory at the Raman Research Institute in India, started the conversation with an overview of the current status of quantum research in India. "It is being talked about a lot, especially in the context of India's vision for 2047, the year it will celebrate 100 years of independence. The idea is that they want to become a developed nation by 2047. Technology development at a high level is important, and quantum is an important part of this program. Current initiatives are encouraging a move towards a digital economy, where quantum security and quantum cryptography will be important.

ICTP Diploma alumna Estelle Inack, now a researcher with the Perimeter Institute, was a panellist for a discussion on the future of scientific computing and quantum science. © Alberto Riccio Bergamas

India recently launched a national quantum initiative, one of the few countries in the world to have a quantum strategy."

The conversation turned to a discussion on the intersection of AI and quantum physics in solving real-world problems. Panellist Estelle Inack, a graduate of ICTP's Postgraduate Diploma Programme who went on to earn a PhD, is applying her knowledge of theoretical physics to the field of finance. Inack, who is now a researcher with the Perimeter Institute, has created the startup company yiyaniQ, which uses a neural network to get faster and more accurate derivative pricing calculations, one of finance's most difficult problems. "When I was doing my postdoc at Perimeter, we kind of combined this idea of stability and dealing with neural networks to create this method called variational classical and virtual quantum annealing. I saw the opportunity to actually solve real world problems; that's how we created my company. I decided to study finance," Inack explained.

From real-world applications, the audience heard about the role that major companies like IBM can play in international cooperation to ensure equal access to new technologies and knowledge.

Panellist Alessandro Curioni, Vice President of IBM Europe and Africa and Director of the IBM Research Lab in Zurich, sees equal access as an important result of ICTP's training mission combined with IBM's know-how. "We are talking today about AI and quantum computers, and these are going to be very powerful instruments that also the scientific community is going to use," he began, adding, "You could not have quantum computers without having quantum information theory and solid state physics, and you would not have these two things without quantum mechanics, and you would not have quantum mechanics without fundamental sciences. So, having institutions like ICTP that promote basic science, theory and physics is vital to push the next step and create these technologies that, if we do it in the right way, are going to benefit science and society. IBM has used open access to share its developments in quantum computing, to push the scientific community to use it, in an attempt to further accelerate the development of the technology."

He concluded, "This is why IBM is working with ICTP, to ensure that this skill development education and scientific development is done in a proper way."

The discussion concluded with the question of how to make quantum knowledge and applications globally available, and what ICTP's role could be. Sinha highlighted the growing importance and geopolitical tensions surrounding quantum technology, with countries restricting exports. She emphasized ICTP's unique role in fostering international cooperation as a neutral ground for scientific dialogue, through which quantum science could be accessible globally despite geographical and sanction challenges. "I think this is the beauty of ICTP. We can actually have people from countries come in and discuss which otherwise may be not very possible, sitting in our individual locations. It's like the Geneva of science," she said.

A panel discussion on Global Science for Climate and Energy included (from left) ICTP scientist Erika Coppola; IPCC scientist and University of Ghana professor Nana Ama Browne Klutse; former Acting Secretary General and Director of the Research Division of OPEC Adnan Shihab-Eldin; and Johannes Kepler University Linz professor Serdar Niyazi Sarıçiftçi.
© Roberto Barnabà

Climate and Energy

Panellists for the session on Global Science for Climate and Energy represented a broad spectrum of stakeholders. On the climate policy side was Nana Ama Browne Klutse, a climate scientist and professor at the University of Ghana, and Vice-Chair of the IPCC's Working Group I for the seventh assessment cycle. Adnan Shihab-Eldin shared his broad knowledge of energy systems as the former Acting Secretary General and Director of the Research Division of OPEC. Renewable energy was represented by Serdar Niyazi Sarıçiftçi, a professor of physical chemistry and solar energy expert at the Johannes Kepler University Linz.

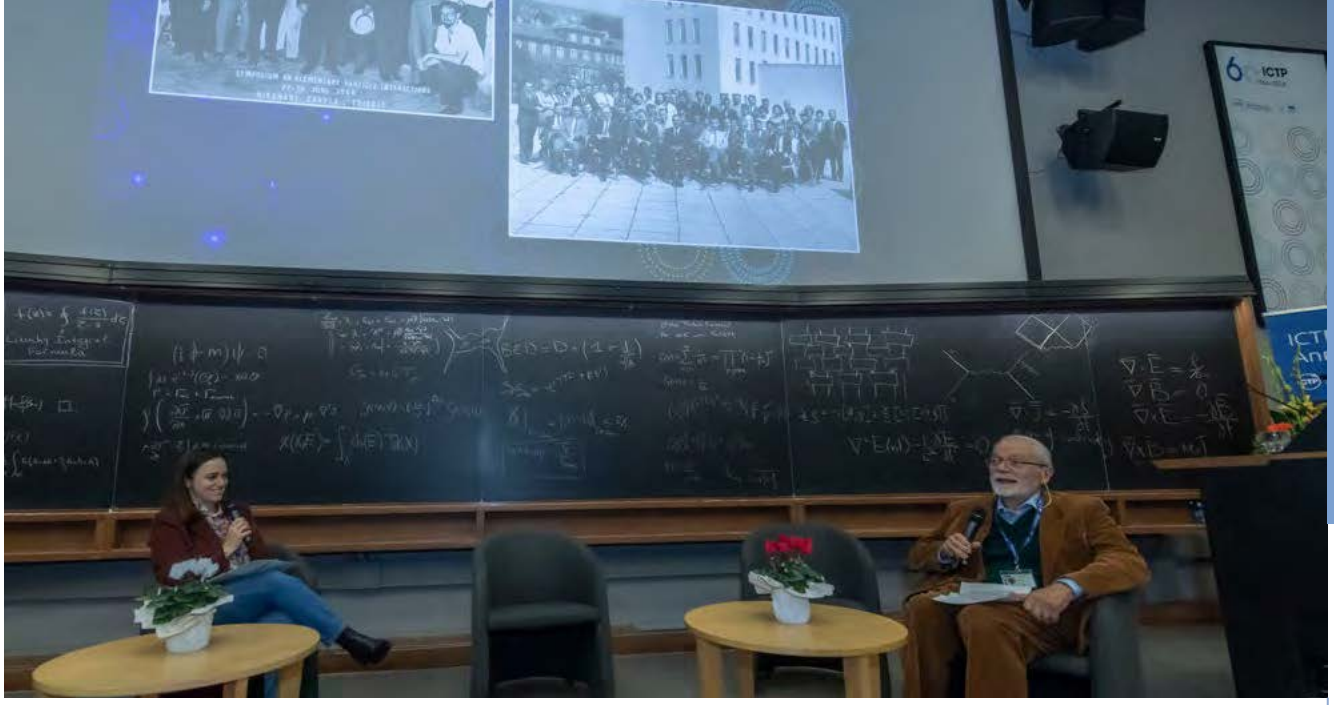
Panellists were tasked with addressing the contradictions between the actions needed to reduce the carbon footprint and the current increase in energy consumption. Reducing fossil fuel consumption is increasingly urgent, but any realistic attempt to mitigate the impact of climate change must take into account our growing energy needs, especially in the Global South, where a large part of the population still lacks access to electricity.

Addressing the main challenges in creating and implementing policies that address climate change, Klutse first emphasized that, from a scientist's viewpoint, there is an abundance of evidence showing that the climate is rapidly changing and that there is a need for urgent action. "The climate system is global, so one system or one process in one region affects the processes of climate in another region. We need to be concerned globally about the trends of events," she said. Klutse referred to the recent COP 29 meeting she had attended, where countries worked on agreements to cut emissions. "I believe that we have not been ambitious enough in these efforts, especially compared to the global efforts we had put together to fight the COVID 19 pandemic. We have the capacity to cut emissions as much as possible so that we don't get to the tipping point."

A possible pathway toward emissions reductions is to adopt decarbonization strategies, but how does the globe do this when the world's energy needs are so high? Adnan Shihab-Eldin offered a possible solution: "The first thing we need to do, and everybody has recognized that, is the low-lying fruit of energy efficiency technologies that have been tried and proven, especially in the North. That technology has to be shared more frequently with the South. Number two, we have to decarbonize using all possible low-carbon energy systems. We need to take knowledge that we are not equal in terms of our capacity, in terms of what we did to the environment, and what we need to move forward. Developing countries will need a lot of energy in the future, and if we don't make that recognition, we will not be able to reach our targets."

According to Serdar Niyazi Sarıçiftçi, many low-carbon energy technologies have been around for decades, but not well deployed. "The first solar heater panels have been on the market since 1890. It's one of the oldest technologies. And when I go to Africa and look around, I don't see any solar heaters on the roofs. The technology has been there for over 100 years, but people don't use it today. Combined with heat pumps, this would be the best, cheapest source of heat you can ever get in the South," he explained.

A panel on Collaborative Scientific Frontiers: ICTP Partnerships included panellists (from left) Caterina Petrillo, AREA Science Park, Trieste; Rolf Heuer, Wilhelm and Else Heraeus Foundation; Ricardo Galvão, National Council for Scientific and Technological Development, Brazil; Raïssa Malu Dinanga, Ministry for Education, Democratic Republic of the Congo; and moderator Ralf Kaiser, ICTP Head of Programmes.
© Alberto Riccio Bergamas



Former ICTP acting Director Erio Tosatti (right) discussed his memories of the early years of ICTP with ICTP researcher Agnese Bissi.
© Alberto Riccio Bergamas

Acknowledging ICTP's Roots

The day ended with a session honouring the spirit and leadership of ICTP's past directors as well as a first-hand account of the early days of the institute.

Salam family representative Aziza Rahman opened the session with a personal account of her father Abdus Salam's scientific voyage, his charisma and vision which eventually led to the establishment of ICTP. "This center, and the remarkable progress that it has made and is continuing to make, is a testament to this vision and to his belief that science is mankind's common heritage with a universal language, and all scientists, no matter their nationality or background, are entitled and deserve to have a place where they can come together to pursue – as my father said himself, 'be re-energised in' – their knowledge for the betterment of humanity," she said.

Salam's spirit lives on, especially in the steady and effective guidance of those Centre directors who have followed him. They include the late Miguel Virasoro, who led ICTP from 1995 to 2002, then Katepalli Sreenivasan, ICTP Director from 2003 to 2009, followed by Fernando Quevedo's directorship from 2009 to 2019. The latter two were honoured with ICTP 60th Anniversary Commemorative Awards.

The event ended with an informal, entertaining discussion between former ICTP acting Director Erio Tosatti and ICTP researcher Agnese Bissi, with Tosatti giving a first-hand account of the early years of the Centre, its most prominent research achievements, and important programme milestones.

ICTP 60th Anniversary Highlights

During 2024, ICTP celebrated its 60th anniversary by highlighting its chief scientific achievements as well as its profound impact on science development in disadvantaged countries. ICTP hosted celebration activities throughout the year related to its main fields of research and its mission, culminating in a one-day celebration held on 15 November 2024. Each anniversary event was thoroughly evaluated by ICTP according to the overall goals and objectives for the year, including the associated costs. Those analyses showed that the anniversary events were an overwhelming success, in terms of cost effectiveness, raising the awareness of ICTP's mission among local, national and international audiences, and extending the impact of ICTP to its global community. Those evaluations can be viewed at (https://www.ictp.it/home/ictps-60th-anniversary). The 60th anniversary activities are summarised here.

22 JANUARY

ICTP launched its 60th anniversary year of activities with a public lecture in its host city, Trieste. Held at the iconic Miramare Castle, the event featured a talk by Filippo Giorgi, international expert on climate change, member of the Intergovernmental Panel for Climate Change (IPCC) when it was awarded the Nobel Peace Prize in 2007, and former head of the ICTP Earth System Physics section. The talk was titled *Un Veliero della Conoscenza in Difesa del Pianeta* (A sailing ship of knowledge in defense of the planet).

Filippo Giorgi (second from right) at the special anniversary event held in the splendor of the Miramare castle.
© Roberto Barnabà

1 - 2 FEBRUARY

Applied mathematician Stéphane Mallat was the featured lecturer of ICTP's 2024 Salam Distinguished Lectures series. Under the theme "Learning Multiscale Energies from Data by Inverse Renormalisation", Mallat gave an overview of the deep connections between recent advances in data science and theoretical physics.

View on YouTube: https://www.youtube.com/playlist?list=PLoxv42WBtfCCzjE0a0s2oNJBP1kXzDaco

Applied mathematician Stéphane Mallat delivering ICTP's 2024 Salam Distinguished Lectures series.
© Alberto Riccio Bergamas

6 FEBRUARY

ICTP celebrated the 2024 International Day of Women and Girls in Science with a public event in partnership with Trieste's science institutes, providing an opportunity for the general public to come and meet some of the many women researchers who work in the institutions of the Trieste Science System.

ICTP's event to celebrate the 2024 International Day of Women and Girls in Science attracted participants representing all Trieste science institutes.
© Alberto Riccio Bergamas

18 - 20 FEBRUARY

ICTP's partner institute in Brazil, the ICTP-South American Institute for Fundamental Research (ICTP-SAIFR) celebrated its 12th anniversary with a number of scientific and public events at its headquarters in São Paulo, Brazil. Invited speakers included Physics Nobel Laureate David Gross, as well as ICTP Director Atish Dabholkar and ICTP physicist Rosario Fazio.

Atish Dabholkar with Nathan Berkovits, ICTP-SAIFR Director, at ICTP-SAIFR 12th Anniversary Symposium in São Paulo, Brazil.
© Celina Lerner/ICTP-SAIFR

ICTP 60TH ANNIVERSARY HIGHLIGHTS

10 APRIL

ICTP showcased its unique mission to member states of its UN partner, UNESCO, at a special session in Paris that was promoted by the Permanent Representation of Italy to UNESCO through a resolution approved by UNESCO's Executive Board. Some 200 people followed the celebrations from across the world, with about half of them attending in person.

ICTP Director Atish Dabholkar at the UNESCO event with ICTP alumnae Nana Geraldine Cabo Bizet, Lucía Mariel Arana Peña, Maha Hsouna, and Nana Klutse Brown.
© Cyril Bailleul

22 APRIL - 3 MAY

ICTP held two anniversary-related science events in Nepal and Macau, both of which focussed on technological innovation. In Nepal, the School on Parallel Programming and Parallel Architecture for High Performance Computing aimed to train early career scientists on tools and techniques to help them take full advantage of scientific computing for their research projects. In Macau, ICTP teamed up with the United Nations University Institute for a workshop on TinyML for Sustainable Development.

Participants of ICTP's School on Parallel Programming and Parallel Architecture for High Performance Computing, held in Nepal.

ICTP scientist Marco Zennaro (back row, right) with participants of the workshop on TinyML for Sustainable Development.

21 MAY

Harvard theoretical physicist and member of the ICTP scientific council Lisa Randall discussed her book “Knocking on Heaven's Door” in a public dialogue with Italian science journalist Barbara Gallavotti. The event was part of the Trieste science and literature festival Scienza e Virgola, and organized in collaboration with ICTP in honour of its 60th anniversary.

Lisa Randall (left) at the ICTP public event about her book “Knocking on Heaven's Door”.
© Roberto Barnabà

27 MAY

ICTP's international symposium on “The Future of Scientific Computing: a Global Perspective”, brought together leading scientists and technology experts from around the world to discuss the frontiers of scientific computing. The Symposium explored how Artificial Intelligence, high-performance computing, new hardware technologies, and recent advancements in quantum computing will impact the scientific process across different fields, including climate science, molecular chemistry, and materials science. Special emphasis was placed on the need for an inclusive approach that is able to address the needs of scientific communities working in the less developed regions of the world. https://www.ictp.it/news/2024/5/future-scientific-computing

Alessandro Curioni, Vice President of IBM Europe and Africa and Director of the IBM Research Lab in Zurich spoke at ICTP's international symposium on “The Future of Scientific Computing: a Global Perspective".
© Alberto Riccio Bergamas

ICTP 60TH ANNIVERSARY HIGHLIGHTS

1 - 3 JULY

Current associates gathered at ICTP, in Trieste and online, to celebrate the 60-year success of the Programme, which has impacted the lives and careers of thousands of scientists from across the globe. Some 45 associates took part in the event in person and about 100 connected online. The event highlighted the impact that the programme has had on the lives of many researchers over the years through the words and testimonies of past and current associates. The most recent video in the series “Science is our Common Language”, collecting the stories of eight current ICTP associates, was shown for the first time at the event.

View the video series, Science is our Common Language: https://www.youtube.com/playlist?list=PLoxv42WBtfCB9v0NLEkxCejDjIsMYMJWT

ICTP senior associate Elizabeth Gasparim at the Associate's 60th Anniversary celebration. © Roberto Barnabà

7 - 21 JULY

The ICTP co-sponsored African School of Fundamental Physics and Applications (ASP) took place at Cadi Ayyad University, Marrakesh, Morocco. The two-week school brought together 143 (50 online plus 93 in person) university-level students (about 50% of whom were women) from 28 countries to learn about nuclear and particle physics, astrophysics and cosmology, accelerator physics, high-performance computing, quantum information and more. For many students, the school marked the first time they encountered some of these topics.

Attendees of the ICTP co-sponsored African School of Fundamental Physics and Applications held in Morocco.

22 - 23 AUGUST

ICTP's International Symposium on Energy and Climate was one of two high-level anniversary events focussing on key sustainable development issues. Renowned speakers from some of the world's most important energy and climate organizations – including the Intergovernmental Panel on Climate Change (IPCC), Sustainable Energy for All (SEforALL), Clean Air Task Force (CATF) and the International Atomic Energy Agency (IAEA) – addressed the opportunities and scientific challenges that climate change presents to the energy sector.

Mark Howells, Climate Compatible Growth Programme, UK, was a keynote speaker at ICTP's International Symposium on Energy and Climate. © Roberto Barnabà

31 AUGUST - 1 SEPTEMBER

The Trieste Maker Faire was held in Trieste's Piazza Unita, providing a showcase for innovation and creativity of more than 150 "makers" in the Trieste region. ICTP is a co-organizer of the event, together with the Trieste Commune.

A view of the 2024 Trieste MakerFaire. © Filippo Blasetti

ICTP 60TH ANNIVERSARY HIGHLIGHTS

6 -17 NOVEMBER

In Havana, Cuba, ICTP's Quantitative Life Science section organised a Hands-On Quantitative Biology School. The two-week event aimed to expose biology and physics PhD students and postdocs to quantitative and interdisciplinary approaches in biology, with a combination of theoretical lectures and experiments. The school was one of several 2024 activities throughout the developing world branded as ICTP 60th anniversary events.

Students performing one of several research activities at the Hands-On Quantitative Biology School in Havana, Cuba.

15 NOVEMBER

At its 60th anniversary main celebration, ICTP launched its new promotional videos, "Igniting Discovery" and "Uniting Minds". The videos were part of a 60th anniversary communications campaign designed to showcase how ICTP's mission helps to build sustainable, resilient science throughout the world, especially in disadvantaged countries, giving these countries the boost they need to address and access rapid scientific and technological advances. Both videos can be viewed on ICTP's YouTube channel. View the videos at https://www.youtube.com/playlist?list=PLoxv42WBtfCCQynvMrPJAT_fT-bglH0vK

A behind-the-scene view of the documentary recording.
© Filippo Blasetti

29 - 30 NOVEMBER

Soon after its main 60th anniversary celebration on 15 November in Trieste, ICTP extended the festivities to its network of physicists and mathematicians in Vietnam. There, at the Vietnam Academy of Science and Technology's Institute of Mathematics in Hanoi, a two-day event titled 'ICTP and Vietnamese Science: Celebrating 60 Years of Collaborations and Building the Future' showcased the profound impact that ICTP has had on the development of physics and mathematics in Vietnam. The numbers say it all: more than 1,500 scientists from Vietnam have participated in conferences, workshops, training and educational programmes organised by ICTP.

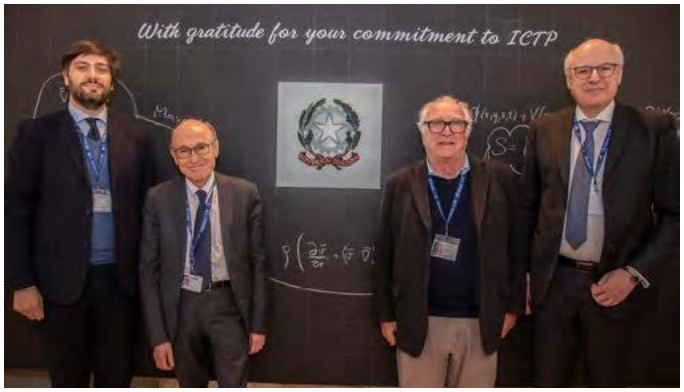
ICTP Director Atish Dabholkar (centre) with attendees of the ICTP 60th anniversary event in Vietnam.
© Marianna Tonutti

9 - 13 DECEDMBER

ICTP's final scientific activity of the year celebrating its 60th anniversary took place at its partner institute in Kigali, Rwanda. The African Biophysics School on Experimental and Computational Sciences (BISECS) introduced scientists at different stages of their careers to the most advanced computational and experimental methods in biophysics. The activity attracted about 25 participants from several different countries in the region, including Ghana, Tanzania, Chad, Nigeria, South Africa, Ethiopia, Cameroon, and Sudan.

Participants of the African Biophysics School on Experimental and Computational Sciences.

ICTP 60TH ANNIVERSARY HIGHLIGHTS



View ICTP's Flickr album for more photos from the November celebration.

ICTP Research

ICTP is widely regarded as an extraordinary environment for advancing knowledge in the physical and mathematical sciences, with a permanent faculty of distinguished scientists who conduct rigorous, world-class, curiosity-driven research in frontier and interdisciplinary science ranging from string theory, cosmology, and black holes to quantum computing, climate science, and quantitative life sciences.

They teach and mentor hundreds of students and young researchers every year, equipping them to go on to study, teach, and conduct research in the world's finest universities, and to contribute to the development of science in their home countries. Research at ICTP has been linked, directly or indirectly, to five Nobel prizes.

Today, ICTP supports cutting-edge research on wide-ranging topics in physical science and mathematics, organised under the following main groups: High Energy, Cosmology and Astroparticle Physics; Condensed Matter and Statistical Physics; Mathematics; Earth System Physics; Quantitative Life Sciences; and Science, Technology and Innovation. Read more about these research lines on the following pages.

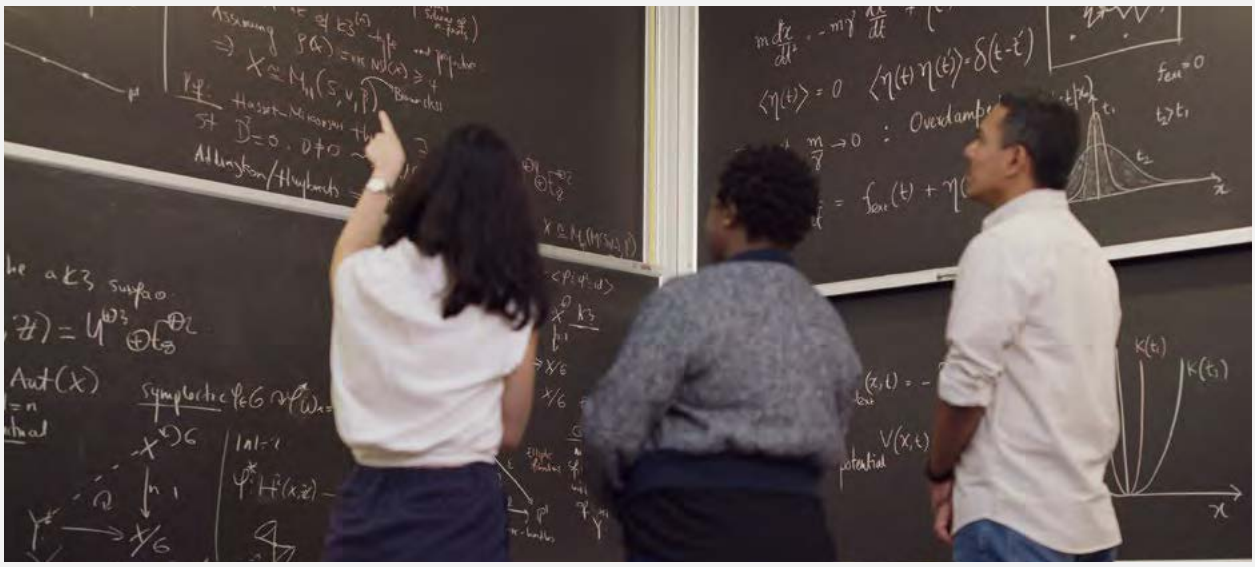
NUMBER OF ICTP RESEARCHERS

Staff, consultants, longterm visiting scientists, postdoctoral fellows

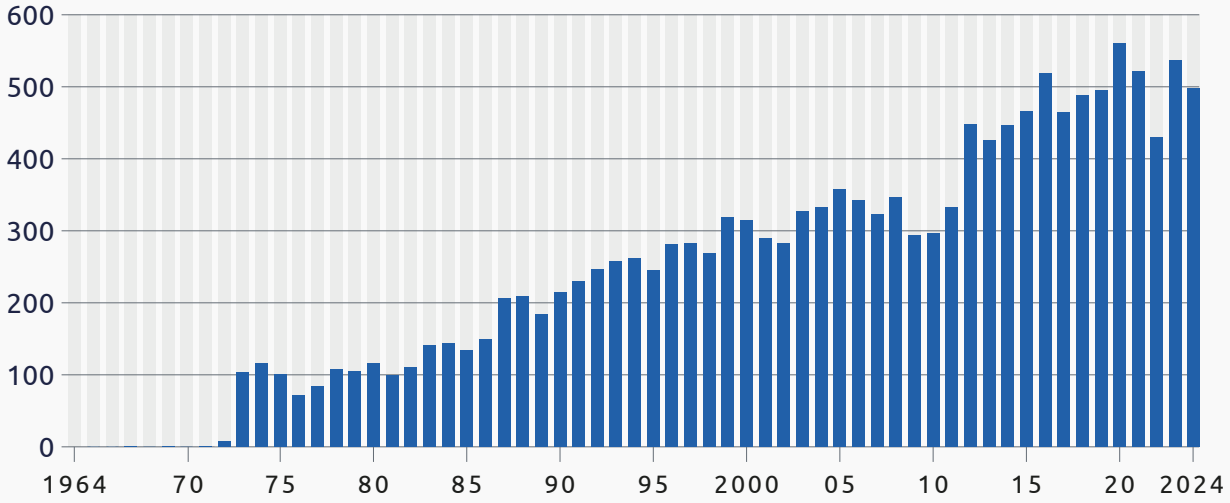
178

NUMBER OF COUNTRIES REPRESENTED BY ICTP RESEARCHERS

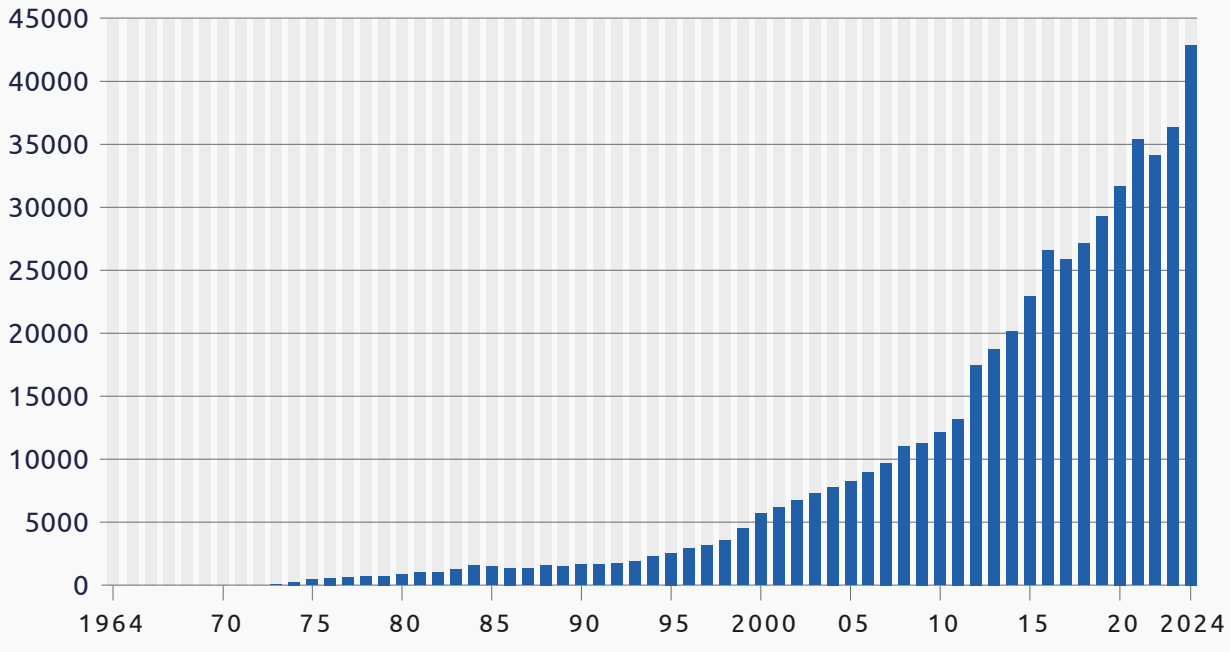
38



NUMBER OF ICTP PAPERS LISTED BY FINAL PUBLICATION YEAR



TOTAL NUMBER OF CITATIONS OF ICTP PAPERS



RESEARCH AREA:

High Energy, Cosmology and Astroparticle Physics (HECAP)

As a direct descendent of Abdus Salam's original research group at ICTP, the HECAP section tackles fundamental questions in physics to understand the basic laws governing the universe.

RESEARCH AREAS INCLUDE:

COSMOLOGY

New experimental results have driven fundamental changes in our understanding of the large-scale structure and evolution of the universe. HECAP cosmologists explore a variety of topics, such as dark energy, gravitational waves, black holes, and inflation.

PHENOMENOLOGY OF PARTICLE PHYSICS

HECAP researchers study the phenomenology of particle physics using an approach that combines modeling and data interpretation. Quantum Field Theory and experimental particle physics are bridged to investigate physics beyond the Standard Model, the phenomenology of high-energy colliders and precision experiments, dark matter, axions, neutrinos, and flavor physics.

STRING THEORY AND QUANTUM GRAVITY

String theory, which aims to unify general relativity and quantum mechanics, could be used to describe spacetime in extreme conditions, such as near a black hole or the Big Bang singularity, where quantum gravitational effects are significant. HECAP researchers study topological string theory and connections with new mathematics, the physics of quantum black holes, strongly coupled quantum field theories, string compactifications, and the fundamental principles of holographic correspondence.

EXPERIMENTAL PARTICLE PHYSICS

The joint HECAP/University of Udine ATLAS group collaborates with experimentalists working on CERN's Large Hadron Collider (LHC). HECAP researchers study the top quark and Higgs boson, and work on detector development, Monte Carlo simulation/validation, and computing performance.

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HECAP IN NUMBERS 2024

03
SCIENTIFIC ACTIVITIES ORGANISED AT ICTP

04
SCIENTIFIC ACTIVITIES ORGANISED ABROAD

46
SEMINARS ORGANISED

64
SHORT-TERM VISITORS

HECAP scientists study inflationary cosmology, black holes, physics beyond the Standard Model, general properties of Quantum Field Theory and string theory. Although HECAP has a mostly theoretical focus, with researchers using analytical methods to solve fundamental and sometimes purely mathematical problems, the ATLAS group at HECAP also collaborates with experimental scientists at CERN. This combination of experimental and theoretical groups in the section is key and it provides ongoing feedback between theory and experiments in the field.

HECAP researchers study the cosmological properties of axions, a compelling candidate for dark matter. Another topic is the derivation of general constraints imposed by the fundamental properties of quantum mechanics and special relativity. This line of research is generously supported by a prestigious ERC grant awarded to HECAP research scientist Joan Elias Mirò.

Highlight activities by the HECAP section in 2024 include the String-Math conference, organised jointly with the MATH section in Trieste, the African School of Fundamental Physics and Application, an ICTP 60th anniversary satellite event taking place in Marrakesh, Morocco, and the Conference on Topological Quantum Field Theory, held in Beijing, China.

HECAP also collaborates with the local community of high energy physicists and cosmologists. It plays an important role in the Institute for the Fundamental Physics of the Universe (IFPU) and in the Institute for Geometry and Physics (IGAP), a Trieste-based collaboration at the interface of physics and mathematics.

PUBLICATION HIGHLIGHTS

Gorghetto, M., Hardy, E., & Villadoro, G. (2024). More axion stars from strings. *Journal of High Energy Physics, 2024*(8). https://doi.org/10.1007/jhep08(2024)126

Gruzinov, A. & Mirbabayi, M. (2024). The Density of Relic Neutrinos Near the Surface of Earth. *arXiv:2403.03152*. https://doi.org/10.48550/arXiv.2403.03152

Creminelli, P., Janssen, O., Salehian, B., & Senatore, L. (2024). Positivity bounds on Electromagnetic Properties of Media. *Journal of High Energy Physics, 2024*(8). https://doi.org/10.1007/jhep08(2024)066

Gukov, S. & Putrov, P. (2024). On categorification of Stokes coefficients in Chern-Simons theory. *arXiv:2403.12128*. https://doi.org/10.48550/arXiv.2403.12128

Bissi, A., Donnay, L., & Valsesia, B. (2024). Logarithmic doublets in CCFT. *Journal of High Energy Physics, 2024*(12). https://doi.org/10.1007/jhep12(2024)031

RESEARCH AREA:

Condensed Matter and Statistical Physics (CMSP)

Research at CMSP spans various key areas of theoretical condensed matter physics, including nanostructure properties and many-body quantum systems; quantum information processing; computer simulations of fluids and solids using atomistic, molecular, and electronic structure-based methods; new material design for sustainable energy applications; and synchrotron radiation-related physics. Unsupervised Machine Learning methods are also applied to complex quantum systems at CMSP.

RESEARCH AREAS INCLUDE:

PHYSICS OF NANOSTRUCTURES

Nano-device development has a fundamental impact on modern technology, and both quantum coherence and strong interactions play a key role in these systems. CMSP researchers study the quantum transport of energy, charge, and mass, examining anomalous transport in quantum and classical low-dimensional systems, energy transport through impurities and nanostructures, and the fundamental properties of quantum heat engines.

EQUILIBRIUM AND NON-EQUILIBRIUM MANY-BODY QUANTUM SYSTEMS

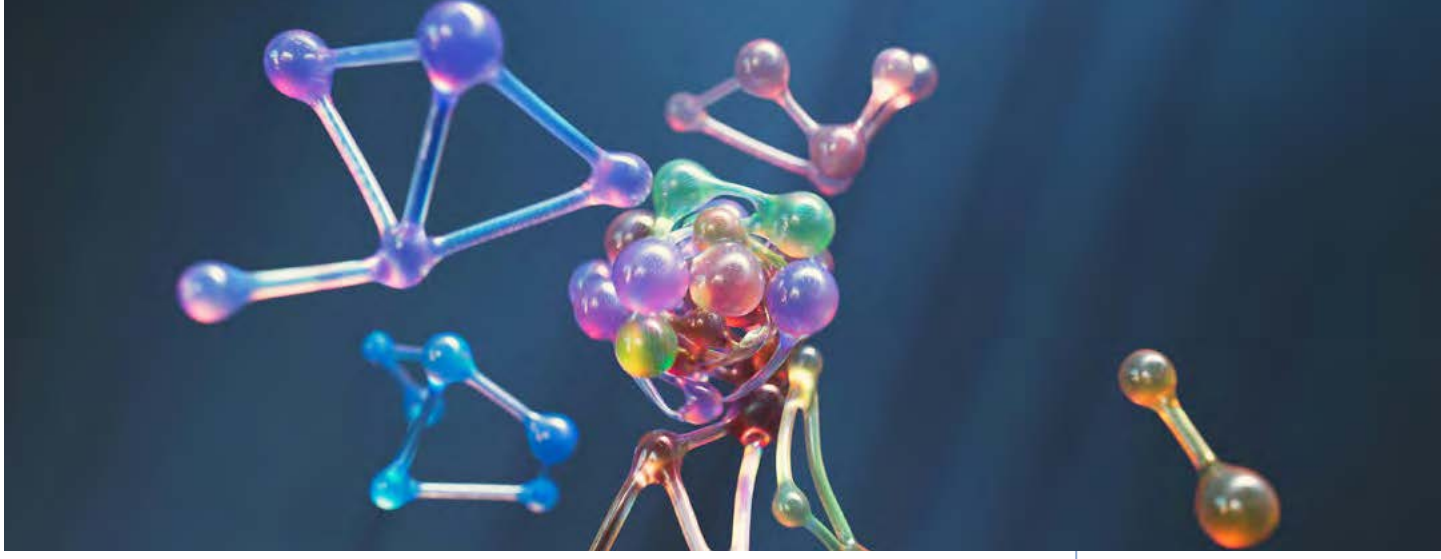
CMSP researchers investigate a wide spectrum of topics related to many-body quantum systems, such as superconductivity and magnetism in strongly-correlated systems, superfluids, cold atoms in optical lattices, localization in disordered systems, many-body physics and light, dynamics and relaxation in complex systems, quantum simulators, and quantum computing.

ATOMISTIC, MOLECULAR, AND ELECTRONIC STRUCTURE SIMULATIONS

A wide range of systems and phenomena may be studied in depth by modeling at the electronic structure, atomistic, and molecular levels. At CMSP, systems simulated using these approaches include multiferroic materials; nanostructures and nanostructured phases of graphene on metal; ultra-high-pressure systems; the development of polarizable force-fields for oxides; acid-base chemistry in water and interfaces; hydrogen-bond networks in biological systems; and the chemical physics of solvation.

MATERIALS FOR SUSTAINABLE ENERGY APPLICATIONS

Advanced functional materials are required for the efficient collection and storage of sustainable forms of energy. At CMSP, quantum mechanical modeling is combined with Machine Learning to investigate the physics and chemistry of material interfaces, which are key to the development of catalysis, new kinds of batteries, and solar cells.



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CMSP IN NUMBERS 2024

12 SCIENTIFIC ACTIVITIES ORGANISED AT ICTP

01 SCIENTIFIC ACTIVITIES ORGANISED ABROAD

77 SEMINARS ORGANISED

64 SHORT-TERM VISITORS

CMSP plays a pivotal role in the Sustainable Energy Initiative, which focuses on computational investigations into materials relevant for sustainable energy applications. Quantum atomistic simulations are employed to understand the behavior of various materials and processes.

CMSP is also home to scientists who perform theoretical research and training in condensed matter and applied physics topics that are experimentally investigated using synchrotron radiation (SR). There are close collaborations with experimentalists at the nearby SR source Elettra and other similar facilities.

CMSP researchers examine new methods and approaches to data science, with big data potentially opening new avenues of exploration in the field. Information theory tools and unsupervised Machine Learning are key to studying physical and biological systems, quantum information processing, and many-body systems. The group also works on functional material design, investigations of mesoscopic quantum systems and nanostructures, and approaches to forward the development of quantum technologies.

Specific projects developed by researchers at CMSP are supported by the European Research Council and the Italian National Recovery and Resilience Plan (PNNR).

PUBLICATION HIGHLIGHTS

Malosso, C., Manko, N., Izzo, M. G., Baroni, S., & Hassanali, A. (2024). Evidence of ferroelectric features in low-density supercooled water from ab initio deep neural-network simulations. *Proceedings of the National Academy of Sciences, 121*(32). https://doi.org/10.1073/pnas.2407295121

Mendes-Santos, T., Schmitt, M., Angelone, A., & Rodriguez, A. (2024). Wave-Function Network Description and Kolmogorov Complexity of Quantum Many-Body Systems. *Phys. Rev. X, 14*(2), 021029. https://doi.org/10.1103/PhysRevX.14.021029

Passarelli, G., Turkeshi, X., Russomanno, A., Lucignano, P., Schirò, M., & Fazio, R. (2024). Many-body dynamics in monitored atomic gases without postselection barrier. *Physical Review Letters, 132*(16). https://doi.org/10.1103/physrevlett.132.163401

Li, Z., & Scandolo, S. (2024). Competing phases of iron at Earth's core conditions from deep-learning-aided *ab-initio* simulations. *Geophysical Research Letters, 51*(19). https://doi.org/10.1029/2024gl110357

Li, Y.-B., Si, R., Wen, B., Wei, X.-L., Seriani, N., Yin, W.-J., & Gebauer, R. (2024). The role of water molecules on polaron behavior at rutile (110) surface: A constrained density functional theory study. *The Journal of Physical Chemistry Letters, 15*(4), 1019–1027. https://doi.org/10.1021/acs.jpclett.3c02855

Nguyen, T. K., Nguyen, H. Q., & Kiselev, M. N. (2024). Thermoelectric transport across a tunnel contact between two charge Kondo circuits: Beyond Perturbation theory. *Physical Review B, 109*(11). https://doi.org/10.1103/physrevb.109.115139

RESEARCH AREA:

Mathematics (MATH)

The MATH section covers a broad range of traditional themes in mathematics, such as algebraic geometry; harmonic analysis and PDEs; dynamical systems and ergodic theory; differential geometry, topology and geometric analysis, with a focus on general relativity and condensed matter physics; and both algebraic and analytic number theories.

RESEARCH AREAS INCLUDE:

HARMONIC ANALYSIS AND ANALYTIC NUMBER THEORY

Harmonic analysis is used to study various oscillatory phenomena in nature, while analytic number theory involves the analysis of structures related to integer numbers. MATH researchers explore a range of themes that lie at the interface between these two fields.

HIGH-DIMENSIONAL STATISTICS, INFERENCE AND THEORY OF MACHINE LEARNING

MATH and QLS researchers investigate fundamental questions related to inference and learning efficiency, data requirements, and performance. Their mathematically rigorous approach is often rooted in statistical physics combined with information theory, random matrix theory, high-dimensional statistics, and the mathematical physics of spin glasses.

DIFFERENTIAL GEOMETRY AND GEOMETRIC ANALYSIS

Differential geometry is the mathematical theory describing the curvature of spaces with arbitrary dimension. MATH researchers combine techniques from the calculus of variations, PDEs, and algebraic geometry to investigate various aspects of differential geometry, and their connection to general relativity, cosmology, and condensed matter physics.

DYNAMICAL SYSTEMS AND ERGODIC THEORY

MATH researchers use (smooth) ergodic theory, which combines ideas from analysis, topology, geometry, and probability theory, to understand and explain the phenomena of unpredictability and chaos in dynamical deterministic systems, and their statistical properties.

ALGEBRAIC GEOMETRY

Algebraic geometry is closely linked to algebra, complex analysis, differential geometry, topology, number theory, and mathematical physics, and utilizes their methods and results. MATH researchers in this field focus on moduli spaces: algebraic varieties that parametrize interesting objects in algebraic geometry, such as curves, vector bundles, and sheaves on varieties.

MATHEMATICAL PHYSICS

MATH researchers explore mathematical concepts that are closely related to theoretical physics. Quantum field theory and string theory are mines for non-trivial mathematical conjectures and constructions such as topological quantum field theory, which incorporates topological invariants of manifolds and embeddings into convenient algebraic structures.

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MATH IN NUMBERS 2024

07
SCIENTIFIC ACTIVITIES ORGANISED AT ICTP

03
SCIENTIFIC ACTIVITIES ORGANISED ABROAD

32
SEMINARS ORGANISED

50
SHORT-TERM VISITORS

In 2024 the MATH section organised a series of activities across the world, and particularly in Uganda, Cuba, China and Vietnam, as well as in Trieste. Fundamental themes were combined with the most recent applications, particularly exploring the connections between math and Artificial Intelligence and theoretical physics, including quantum field theory and string theory, between number theory and physics, geometry and its applications, dynamical systems and algebraic geometry.

While continuing to strengthen its ties with the International Mathematical Union (IMU), the Centre International de Mathématiques Pures et Appliquées (CIMPA) and the Istituto Nazionale di Alta Matematica (INdAM), the MATH section formalized new collaboration agreements with several scientific institutions in China and Vietnam.

In 2024, MATH researchers obtained relations between analytic properties of Witten-Reshetikhin-Turaev 3-manifold invariants and Fukaya category of certain associated symplectic manifolds. They also studied different types of Fourier optimization problems. In algebraic and differential geometry, MATH researchers continued work on generalizations of Vafa-Witten invariants. Semi-orthogonal decomposition of the derived categories of Quot schemes were also proven and used to calculate the cohomology of interesting tautological vector bundles over the Quot scheme.

MATH researchers also studied foliations by constant mean curvature hypersurfaces of some natural negatively curved manifolds and verified the Riemannian Penrose inequality for them. In the area of Machine Learning, MATH researchers proved that, in some strongly overparametrized regime, deep neural networks are equivalent to simple linear methods.

PUBLICATION HIGHLIGHTS

Camilli, F., Tieplova, D., & Barbier, J. (2024). Fundamental limits of overparametrized shallow neural networks for supervised learning. *arXiv:2307.05635*. https://arxiv.org/pdf/2307.05635.

Arezzo, C., Li, C., & Loi, A. (2024). Gromov-Hausdorff limits and Holomorphic isometries. *Mathematics Research Letters*. Accepted in January 2024, awaiting publication.

Coates, D., & Luzzatto, S. (2024). Persistent non-statistical dynamics in one-dimensional maps. *Communications in Mathematical Physics, 405*(4). https://doi.org/10.1007/s00220-024-04957-0

Gukov, S. & Putrov, P. (2024). On categorification of Stokes coefficients in Chern-Simons theory. *arXiv:2403.12128*. https://arxiv.org/abs/2403.12128

Marian, A. & Negut, A. (2024). Derived categories of Quot schemes on smooth curves and tautological bundles. *arXiv:2411.08695*. https://doi.org/10.48550/arXiv.2411.08695

RESEARCH AREA:

Earth System Physics (ESP)

The ESP section encompasses a range of research topics related to the solid (lithosphere) and fluid (atmosphere and oceans) components of the Earth system.

The solid-Earth geophysics research line investigates how continents deform and the way earthquake faults behave in a time span of interest to the society. Global atmospheric and ocean models are used to study large-scale climate variability and change, whereas high-resolution regional models provide local scale climate information. ESP also studies the impact of anthropogenic climate change on water cycle, humans, ecosystems and vector-borne diseases.

RESEARCH AREAS INCLUDE:

SOLID EARTH GEOPHYSICS

ESP researchers use seismology, space geodesy, tectonics, and numerical experiments to conduct large-scale modelling of faults and cracks in the Earth's crust; examining active earthquake and volcanic regions, the physics of transient deformation, and earthquake hazard.

AI FOR CLIMATE APPLICATIONS

ESP researchers use AI-based climate emulators to complement their dynamical modelling and reach kilometre-scale climate projections.

CLIMATE APPLICATIONS

ESP applies analog methods to understand the contribution of anthropogenic climate change to the recent exacerbation of extreme climate events all over the world. Dynamical and statistical modelling techniques are employed to assess the socio-economic impact of climate variability and change on human resources such as energy, water, and health. The ESP-developed VECTRI dynamical model is employed to describe malaria transmission, and determine its response to climate variability. ESP scientists use the CHyM hydrological model, coupled with the regional climate models, to describe the hydrological conditions of the river basins in a changing climate.

EARTH SYSTEM MODELING

A suite of Earth system models are developed to represent the key processes that determine the Earth's climate, such as atmospheric and ocean circulation, and land surface processes. ESP researchers use tools such as recent evolutions of the regional climate model RegCM, the intermediate complexity global model SPEEDY and the global ocean model MOM5 to understand our climate, its natural variability, and its response to anthropogenic forcing.

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ESP IN NUMBERS 2024

08
SCIENTIFIC ACTIVITIES ORGANISED AT ICTP

15
SHORT-TERM VISITORS

The new regional climate model version RegCM5 is now available for climate projections over all land regions of the world within the newly started CORDEX-CORE task force to contribute to the upcoming Seventh Assessment Report of the Intergovernmental Panel for Climate Change (IPCC). Very high resolution, kilometer-scale, climate projections are performed in several regions of the world to study climate hazards and extremes.

Ocean and coupled models are used for the study of tipping elements of the Earth system, such as ice sheets and the global ocean circulation, with implications for sea level rise, heat and carbon uptake and changes in weather patterns.

A 2024 paper from ESP identified a new source of predictability for the South African monsoon. An Indian Ocean Precipitation Dipole (IOPD) provides predictability of the South African monsoon with up to 5-month lead time. ESP researchers also presented a new stochastic reaction-diffusion model for the tropics, which is able to simulate aggregated and random convective states.

PUBLICATION HIGHLIGHTS

Dong, C., Noyelle, R., Messori, G., Gualandi, A., Fery, L., Yiou, P., Vrac, M., D'Andrea, F., Camargo, S. J., Coppola, E., Balsamo, G., Chen, C., Faranda, D., & Mengaldo, G. (2024). Indo-Pacific regional extremes aggravated by changes in tropical weather patterns. *Nature Geoscience, 17*(10), 979–986. https://doi.org/10.1038/s41561-024-01537-8

Prigent, A., & Farneti, R. (2024). An assessment of Equatorial Atlantic interannual variability in Ocean Model Intercomparison Project (OMIP) simulations. *Ocean Science, 20*(4), 1067–1086. https://doi.org/10.5194/os-20-1067-2024

Tompkins, A. M., Casallas, A., & De Vera, M. V. (2025). Drivers of mesoscale convective aggregation and spatial humidity variability in the tropical Western Pacific. *Npj Climate and Atmospheric Science, 8*(1). https://doi.org/10.1038/s41612-024-00848-2

Horan, M. F., Kucharski, F., & Ashfaq, M. (2024). Seasonal variability and predictability of monsoon precipitation in Southern Africa. *Environmental Research Letters, 19*(3), 034010. https://doi.org/10.1088/1748-9326/ad2737

RESEARCH AREA:

Quantitative Life Sciences (QLS)

The QLS section focuses on problems at the interface between statistical physics, biology, ecology, economics, neuroscience, information theory and Artificial Intelligence.

RESEARCH AREAS INCLUDE:

QUANTITATIVE ECOLOGY AND EVOLUTION

QLS researchers investigate how many species can coexist in highly-diverse communities, and the processes determining their dynamics and their evolution, with a main focus on microbial ecology. This research line aims at building a robust quantitative phenomenology from observational and experimental data and integrating it with mathematical theory.

EFFICIENCY OF NEURAL COMPUTATION

QLS researchers use statistical physics and theoretical Machine Learning to study how computation emerges from the complex dynamics of neural systems. Data-driven models are built to describe neural population dynamics using large-scale recordings of behaving animals performing tasks.

STOCHASTIC THERMODYNAMICS

Nonequilibrium fluctuations in microscopic systems are studied at QLS using stochastic thermodynamics, and a combination of theory, numerical simulation, and experimental data analysis. QLS scientists investigate the relevance of the martingale theory of stochastic thermodynamics to biological, soft-matter, condensed and active matter systems, with applications extending to finance and game theory.

EMERGENT COLLECTIVE BEHAVIOUR IN INTERACTING AGENT SYSTEMS

Statistical mechanics-based methods are used to explore economical phenomena such as loss of transparency in financial transformations and the unintended consequences of technological innovation, with particular emphasis on problems relevant to the human dimension of sustainable development.

PHYSICS OF BEHAVIOUR AND SENSING

QLS researchers study decision-making in several model systems such as chemotaxis in bacteria and cancer cells, olfactory search, and flight. Statistical physics, information theory, computer science, and biology are used to form an algorithmic understanding of animal search behaviour and decision-making guided by sensory information.

HIGH-DIMENSIONAL STATISTICS, INFERENCE, AND THEORY OF MACHINE LEARNING

QLS researchers study inference and learning efficiency using a quantitative approach based on statistical physics, addressing questions about the impact of data structure and the required amount of data on performance. An information-theoretic quantitative measure of relevance is employed to address fundamental questions such as the difference between learning and understanding and the emergence of abstraction in deep neural networks.

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QLS IN NUMBERS 2024

06
SCIENTIFIC ACTIVITIES ORGANISED AT ICTP

03
SCIENTIFIC ACTIVITIES ORGANISED ABROAD

15
SEMINARS ORGANISED

46
SHORT-TERM VISITORS

In addition to these research activities, in 2024 scientists in the QLS section organised several trainings – schools and conferences that took place both in Trieste and across the world. The Hands-On Quantitative Biology School in Havana, organized by ICTP as part of its 60th anniversary celebrations, exposed PhD students and postdocs from diverse backgrounds to interdisciplinary approaches in biology through theoretical lectures and hands-on experiments. Students had the opportunity to investigate microbial growth, biofluids, and bioacoustics, thus gaining first-hand experience in applying the methods and approaches of physics to life sciences.

The school on Information, Noise and Physics of Life organised by QLS in Niš, Serbia, featured frontier fundamental and applied topics in statistical physics, including nonequilibrium thermodynamics, active matter, information theory, and machine learning.

The Laboratory on Quantitative Sustainability workshop on Limits of Collective Agency took place in Trieste and gathered scholars studying complex systems in a variety of disciplines including sociology, political science, ecology, artificial intelligence, neuroscience and theoretical physics. The aim was to promote research on the limits to sustainability related to human agency, by identifying specific questions that can be tackled in a quantitative manner.

PUBLICATION HIGHLIGHTS

Shoemaker, W. R., & Grilli, J. (2024). Investigating macroecological patterns in coarse-grained microbial communities using the stochastic logistic model of growth. *eLife, 12*. https://doi.org/10.7554/elife.89650.3

Roldán, É. (2024). Thermodynamic probes of life. *Science, 383*(6686), 952–953. https://doi.org/10.1126/science.adn9799

Barbier, J., Camilli, F., Ko, J., & Okajima, K. (2024). On the phase diagram of extensive-rank symmetric matrix denoising beyond rotational invariance. *arXiv.2411.01974*. https://doi.org/10.48550/arXiv.2411.01974

Xie, R., & Marsili, M. (2024). A simple probabilistic neural network for Machine Understanding. *Journal of Statistical Mechanics: Theory and Experiment, 2024*(2), 023403. https://doi.org/10.1088/1742-5468/ad0a8c

Celani, A., & Panizon, E. (2024). Olfactory search. *Target Search Problems,* 711–732. https://doi.org/10.1007/978-3-031-67802-8_30

RESEARCH AREA:

Science, Technology and Innovation (STI)

STI researchers find technological solutions to scientific and societal problems that impact humanity, through both in-house laboratory work and collaborations with UN agencies and international organizations.

The STI Unit has a broad scope, encompassing research in wireless communication and sustainable AI on embedded devices; advanced instrumentation for sensors, optics, nuclear and particle physics applications, and supercomputing; and ionospheric physics, modelling, and space weather.

RESEARCH AREAS INCLUDE:

WIRELESS ICT AND INTERNET OF THINGS

STI researchers design Internet of Things (IoT) technology to collect data from remote and inaccessible regions. Advanced embedded AI solutions are created to address both scientific and societal challenges.

IONOSPHERIC PHYSICS, MODELLING AND SPACE WEATHER

STI researchers investigate the near-Earth plasma environment, advance the understanding of ionospheric physics, and develop ionospheric electron density models. Particular focus is placed on space weather phenomena and their impact on the performance of technological systems, such as the Global Navigation Satellite Systems (GNSS). Special emphasis is given to ionospheric monitoring, primarily through the analysis of total electron content data.

ADVANCED SCIENTIFIC INSTRUMENTATION

STI researchers develop advanced scientific instrumentation and methods for particle physics experiments, nuclear applications, supercomputing, and multidisciplinary experimental research, including projects on cultural heritage and optics.

DIGITAL FABRICATION AND SCIENCE DISSEMINATION

The STI Unit's Scientific FabLab (SciFabLab) features cutting-edge manufacturing equipment for digital fabrication and rapid prototyping, operating within the global FabLab network. The laboratory is accessible to ICTP researchers and the public for projects focused on science, education, and sustainable development. Additionally, the SciFabLab engages in science outreach through laboratory tours and events like the Maker Faire Trieste.

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STI IN NUMBERS 2024

03
SCIENTIFIC ACTIVITIES ORGANISED AT ICTP

05
SCIENTIFIC ACTIVITIES ORGANISED ABROAD

01
SEMINAR ORGANISED

15
SHORT-TERM VISITORS

Development of sustainable equipment is a key theme at the STI Unit: STI researchers design low-cost devices, easily exportable to developing countries.

The Marconi Lab researchers specialise in Tiny Machine Learning (TinyML), a small, energy-efficient, and low-cost technology for the implementation of applied Artificial Intelligence. A network of more than 60 universities in developing countries are part of the TinyML Academic Network led by ICTP with the goal of developing sustainable AI solutions.

During 2024, the STI unit's SciFabLab focused on research and training activities on the use of digital technologies for science and education, on developing science exhibits, and on designing and prototyping devices for the implementation of scientific experiments.

Researchers at the Multidisciplinary Lab (MLab) have been developing the data processing system for the multichannel ECAL2 detector to be used in the proton radius measurement of the AMBER experiment at CERN, in ongoing collaboration with INFN. In continued partnership with the IAEA's Nuclear Science and Instrumentation Laboratory, they are also working on a mixed-radiation monitoring system based on Machine Learning and low size, weight, and power devices, as well as an X-ray fluorescence for cultural heritage studies. The team also collaborates with the University of Trieste to develop a cluster of systems-on-chip for reconfigurable computing.

The ionospheric modeling team at STI has been actively engaged in expanding the network of low-cost GNSS receivers developed by the group. This initiative aims to strengthen Africa's capacity in space weather and ionospheric monitoring, enhancing data collection and analysis for scientific research and technological applications.

In 2024 members of STI organized nine SMR activities, including workshops and conferences in Macau, Brazil, Kenya, South Africa, and Qatar.

PUBLICATION HIGHLIGHTS

Imran, M. A., Zennaro, M., Popoola, O. R., Chiaraviglio, L., Zhang, H., Manzoni, P., van de Beek, J., Stewart, R., Arij Cox, M., Leonel Mendes, L., & Pietrosemoli, E. (2024). Exploring the boundaries of connected systems: Communications for hard-to-reach areas and extreme conditions. *Proceedings of the IEEE, 112*(7), 912–945. https://doi.org/10.1109/jproc.2024.3402265

Morales, I. R., Soledad Molina, R., Bogovac, M., Jovalekic, N., Liz Crespo, M., Kanaki, K., Ramponi, G., & Carrato, S. (2024). Gamma/neutron online discrimination based on machine learning with CLYC detectors. *IEEE Transactions on Nuclear Science, 71*(12), 2602–2614. https://doi.org/10.1109/tns.2024.3498321

Fior, G., Fonda, C., & Canessa, E. (2024). Hands-on STEM learning experiences using digital technologies. Submitted on 09 September 2024 to the *International Journal of STEM Education.*

Azpilicueta, F., & Nava, B. (2024). Study of the weddell sea anomaly using novel satellite altimeter TEC Maps. *Journal of Geophysical Research: Space Physics, 129*(10). https://doi.org/10.1029/2024ja032457

ICTP Global

Science is a powerful driving force in the success of any nation, contributing to its economic well-being and the individual fulfilment of its people. Many countries, however, do not have the infrastructure or educational provision to support the growth of science and technology and to keep pace with the developed world. Technology unsupported by science simply does not take hold or flourish. It is not enough to have the know-how; countries also need the know-why. ICTP is committed to addressing and eliminating those inequalities.

ICTP's reach and impact is global. The Centre's four regional centres of excellence in Brazil, China, Mexico and Rwanda bring ICTP's unique blend of high-quality physics and mathematics education and high-level science meetings closer to scientists everywhere. Our Physics Without Frontiers programme spreads the joy and wonder of physics to students in science- and technology-lagging countries, helping to build the next generation of scientists.

ICTP also builds scientific capacity through programmes coordinated by its External Activities Unit. These include support for scientific meetings, research networks, visiting scholars, and collaborative agreements with universities in developing countries. The latter, which ICTP considers 'affiliated centres', receive ICTP support for their postgraduate programmes in physics or mathematics, and are encouraged to enrol staff and students in ICTP programmes.

ICTP regional centres of excellence

MEXICO:

The Meso-American Institute for Sciences (MAIS) was established in collaboration with the Universidad Autónoma de Chiapas (UNACH) as a regional headquarters of ICTP in Mexico, Central America and the Caribbean.

BRAZIL:

The ICTP South American Institute for Fundamental Research (ICTP-SAIFR) is a regional centre for theoretical physics created in collaboration with the State University of Sao Paulo (UNESP) and the Sao Paulo Research Funding Agency (FAPESP).

04	ICTP Partner Institutes	ICTP
17	ICTP Schools, Workshops and Conferences (outside of Trieste)	S
05	ICTP-EAU Affiliated Centres	C
05	ICTP-EAU Networks	N
13	ICTP-EAU Scientific Meetings	M
31	Physics Without Frontiers Activities	P

RWANDA:

Inaugurated in 2018, the East African Institute of Fundamental Research (EAIFR), based at the University of Rwanda's Kigali campus, offers an important educational and research hub for the region and for Africa.

CHINA:

In Beijing, the International Center for Theoretical Physics-Asia Pacific (ICTP-AP) is hosted at the University of the Chinese Academy of Sciences (UCAS) and provides opportunities for advanced training, research and education in theoretical physics and related interdisciplinary areas.

ICTP: A Hub for Global Scientific Activities

ICTP's work at the very frontiers of research makes it a destination of choice for leading physicists and mathematicians from all over the world. Each year, ICTP brings together thousands of world-leading and early career scientists from more than 150 countries to participate in advanced workshops and conferences that explore topics at the cutting edge of physics and mathematics. This rich intellectual atmosphere is enhanced by resources such as our Library – one of Europe's finest research libraries – our high-performance computing facilities, and residential and community facilities that promote informal social and intellectual interactions where ideas are discussed over meals or coffee.

Over the years, more than 100 Nobel laureates, 20 Fields medallists, and members of our distinguished Scientific Council have spent time at ICTP, offering unparalleled opportunities for the brightest minds in the world, whether established or early-career scientists, to learn from each other.

ICTP also reaches directly into the developing world. Our four partner institutes in Brazil, China, Rwanda, and Mexico give scientists in those countries access to our networks, expertise, and convening power and have flourishing research and training programmes of their own and in collaboration with ICTP.

ICTP has been the anchor of the "Trieste Science System" – a network of institutes including the International School for Advanced Studies (SISSA), Elettra Synchrotron Facility, and the University of Trieste – which offers even broader opportunities for collaboration within a short distance of our campus.

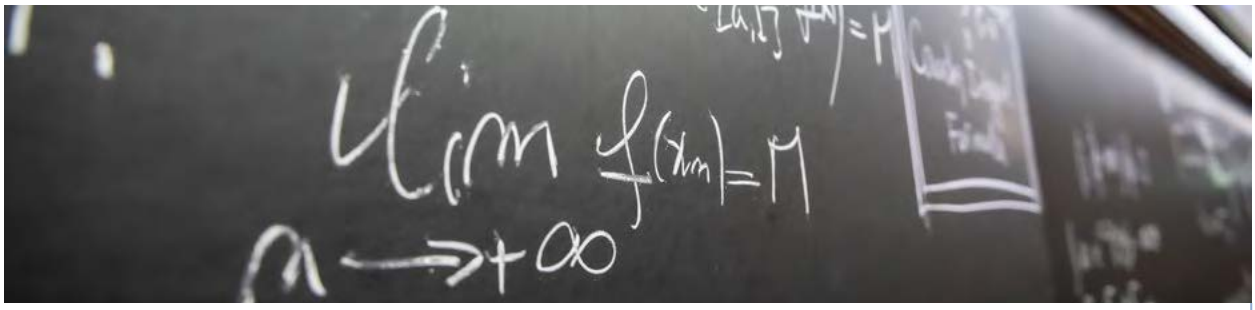
ICTP ACTIVITIES IN NUMBERS, 2024

5317
PARTICIPANTS, INCLUDING THOSE WHO PARTICIPATED REMOTELY

144
NATIONS REPRESENTED

58
CONFERENCES, SCHOOLS AND WORKSHOPS

32%
OF PARTICIPANTS WERE WOMEN



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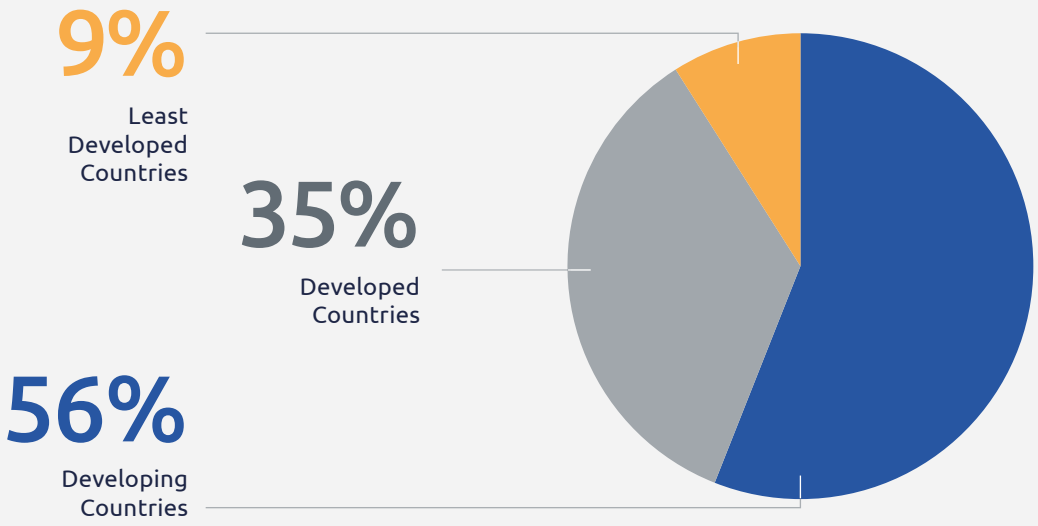
DEVELOPING STATUS OF PARTICIPANTS' COUNTRIES, 2024



Higher Education and Career Development

Educational Programmes

Scientists at all stages of their careers can advance their knowledge in physics and mathematics through ICTP's education and training programmes. These include pre-PhD programmes that help prepare students for the rigors of doctorate study. The Centre offers a number of masters and PhD degree programmes jointly with Italian and European universities. Scientists who want to maintain their connection to ICTP can participate in the Centre's Associates Scheme, which supports sabbatical visits over a period of several years.

Postgraduate Diploma Programme: Supporting its mission to promote advanced scientific research in developing countries, ICTP offers a Postgraduate Diploma Programme that prepares talented students for PhD studies. The intense, one-year course of study is competitive: from about 180 applicants to each of the five regular Diploma programmes, only 10 students are admitted in each. All 50 are given full support, covering airfare and living costs. The focus is especially on those developing countries for which high-quality advanced scientific training is less accessible. In the 2024-2025 course that began in September 2024, the students came from Algeria, Bangladesh, Cameroon, Colombia, Cuba, Ecuador, Egypt, Ethiopia, Ghana, Indonesia, Jordan, Kenya, Lebanon, Lesotho, Madagascar, Mexico, Morocco, Nepal, Nigeria, Oman, Pakistan, Palestine, Peru, Sudan, Syria, Thailand, Uganda, Uzbekistan, Vietnam, and Zambia.

After obtaining the ICTP Diploma, most students go on to do a PhD in Europe or North America; or return to jobs as college teachers, or register for PhD in their home countries. In the 2023-2024 batch of 42 students who received their Postgraduate Diplomas, the MSc/PhD placements included the Ludwig Maximilian University of Munich, the University of Göttingen, the University of Colorado Boulder and Tohoku University, among others.

ICTP EDUCATION IN 2024

153
STUDENTS ENROLLED IN MASTERS, PHD, DIPLOMA AND STEP PROGRAMMES

60
COUNTRIES REPRESENTED (INCLUDING 13 LEAST-DEVELOPED COUNTRIES)

Masters' Programmes: ICTP, in collaboration with local universities, offers study opportunities to scientists from the developing world, helping them attain master's and doctoral degrees in physics and mathematics. Thanks to these collaborations, students from disadvantaged countries can pursue masters degrees in the following programmes:

- *Master of Advanced Studies in Medical Physics:* a two-year advanced training programme run jointly by the ICTP and the University of Trieste designed to provide young, promising graduates of physics or related fields (mainly from developing countries) with postgraduate theoretical and clinical training so that candidates may be recognised as clinical medical physicists in their home countries.

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The programme comprises a year of basic and advanced courses (taught in English) prepared with the assistance of experts from the ICTP, the University of Trieste, the International Atomic Energy Agency (IAEA) and appointed external advisors. This is followed by a year of professional clinical training in a medical physics department of an Italian hospital in the programme's training network.

The MMP is co-sponsored by the IAEA, and is supported by the International Organisation for Medical Physics (IOMP), the European Federation of Organizations in Medical Physics (EFOMP), the Italian Association of Medical Physics (AIFM), in collaboration with Trieste University Hospital. The Master's Programme is accredited by the International Organisation for Medical Physics (IOMP). In 2024, 20 students (8 female and 12 male) from 16 different countries were enrolled in the 2024-2025 academic year, while 17 students (7 female and 10 male) graduated from the programme.

- *Master in High Performance Computing:* an innovative degree programme that prepares students for exciting careers in the fast-growing field of high performance computing (HPC). Set in the stimulating research environment of ICTP and SISSA, the programme combines lectures with hands-on and applied projects to prepare future HPC specialists for academia and industry. Courses are delivered by an international faculty composed by local HPC experts complemented by international well-renowned experts in the field. Practical HPC experience allows students to work side-by-side with scientific groups and/or stimulating industrial environments. In 2024, 8 students (1 female and 7 male) from Algeria, Brazil, Colombia, Guatemala, India, Mexico, Philippines, and Syria were registered in the MHPC with the ICTP Fellowship, while 7 students (3 female and 4 male) graduated.
- In addition, ICTP offers a limited number of scholarships to students from developing countries selected to follow the training track in Condensed Matter Physics of the International Master in Physics of Complex Systems, offered through an international consortium of universities. Each scholarship includes a travel grant, insurance and tuition fees. In 2024, one female student from Lebanon was funded by ICTP.

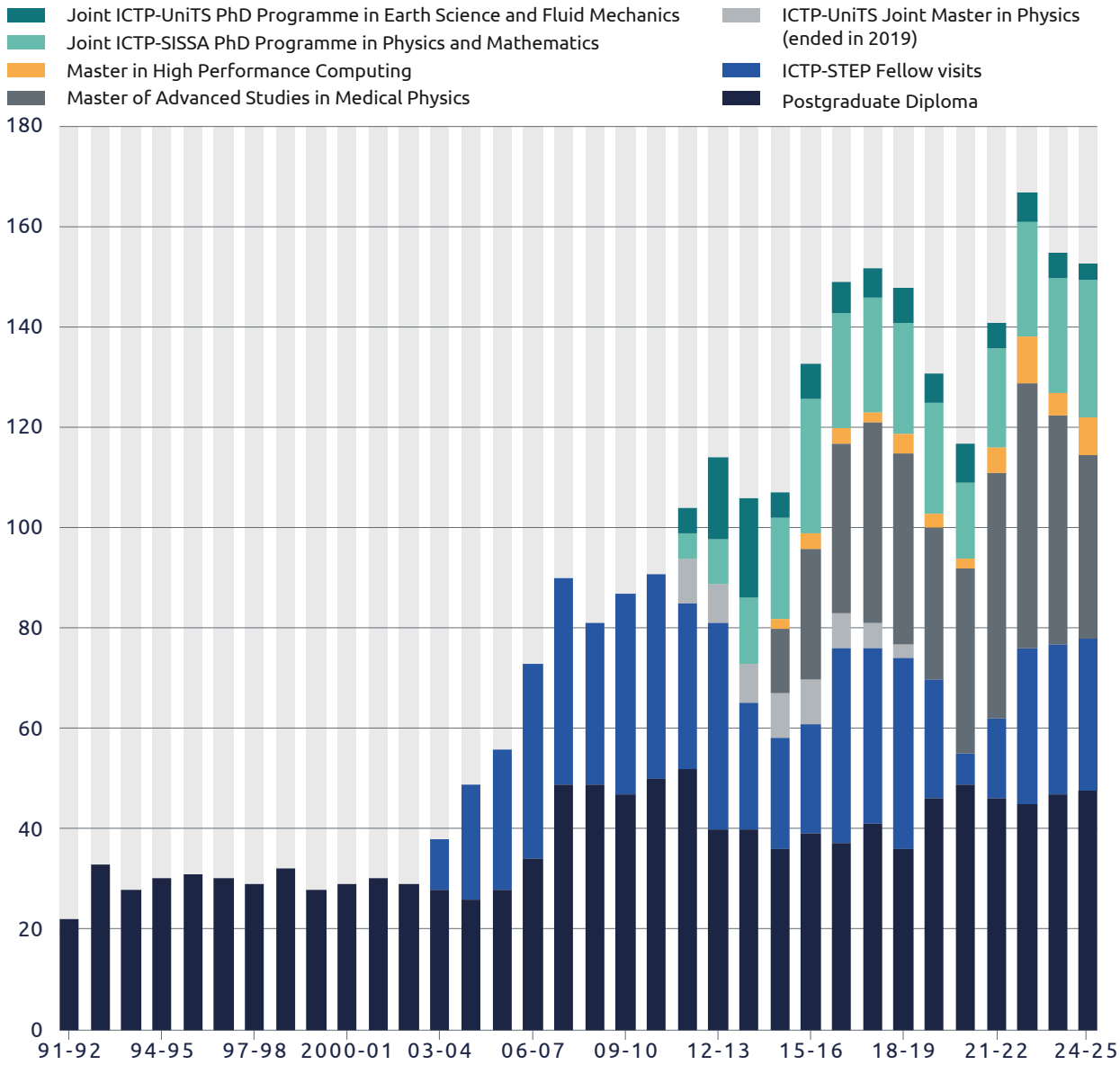
PhD and Sandwich Programmes: ICTP, in collaboration with local universities, offers study opportunities and fellowships to scientists from the developing world, helping them attain master's and doctoral degrees in physics and mathematics. Thanks to these collaborations, students from disadvantaged countries can pursue doctoral degrees in the following programmes:

- *Physics PhD Programme, University of Trieste:* ICTP offers a scholarship for students from developing countries who want to do research in areas of interest to ICTP to enroll in this PhD programme. In 2024, 2 female students from Rwanda and Tunisia were enrolled in the programme with an ICTP scholarship, while one student graduated from the programme.
- *Joint ICTP/SISSA PhD Programme in Physics and Mathematics:* ICTP partners with SISSA to offer students who have successfully completed ICTP's Postgraduate Diploma Programme the opportunity to enroll in a PhD programme in Trieste. The Programme offers courses in: applied mathematics, mathematical analysis, geometry, mathematical physics; astroparticle physics, astrophysics; elementary particles; physics and chemistry of biological systems; statistical physics; condensed matter theory and numerical simulation. During 2024, 26 students (5 female and 21 male) from 16 countries were enrolled in this PhD programme; 5 students graduated in 2024.

- *Joint PhD Programme, Earth Science, Fluid-Dynamics, and Mathematics. Interactions and Methods:* Co-sponsored by ICTP, the University of Trieste and the Italian National Institute of Oceanography and Experimental Geophysics (OGS), this programme aims at the interdisciplinary training of students in the field of the Earth system science, with special attention to the interactions between Earth science, fluid-dynamics and applied mathematics, as well as to the interplay of methodological aspects, modeling and applications. In 2024, 3 students (2 female and 1 male) from Bangladesh, Brazil and Ghana were enrolled in the Programme.
- *PhD Programme, Industrial and Information Engineering, University of Trieste*: ICTP provides fellowships to students from developing countries to enroll in this programme that prepares researchers in design methods, theoretical analysis, soft-computing and advanced experimentation. During 2024, one student from Guatemala was enrolled in the programme with an ICTP fellowship. Also during 2024, another student from the same country graduated from the programme.

In addition, through its **Sandwich Training Educational Programme** (STEP), ICTP and its UN partner, the International Atomic Energy Agency (IAEA), offer fellowships to PhD students from developing countries in the fields of physics, mathematics and related fields. PhD students study at their home universities but have the financial support to visit ICTP or a collaborating institute for a three- to six-month stay each year for up to three successive years. Fellows work on their PhD theses with their advisors at their home institutes and co-advisors at the hosting institutes. Their PhD is awarded at their home institutes. During 2024, 30 fellows (15 female and 15 male) from 19 countries participated in the STEP programme.

TREND IN ICTP PROGRAMMES AND ENROLLMENT, 1991-2024



Career Development Programmes

ICTP takes a holistic approach to nurturing the careers of scientists by helping them at all stages of their careers. In addition to its educational programmes, the Centre provides sabbatical, postdoctoral and laboratory opportunities through the following schemes.

Associates Programme: ICTP's Associates Programme enables individual scientists at different stages of their careers to maintain long-term formal contacts with ICTP's stimulating and active scientific environment. Researchers who hold a PhD and are working in developing countries are eligible for the programme. The programme supports regular visits to ICTP, where ICTP Associates have the opportunity to remain in touch with the experts and also with the most modern aspects of their scientific fields. To a large extent, this helps to eliminate the brain-drain in their home countries and the sense of isolation.

ICTP Associates are active scientists in their countries, and they are expected to play a major role in the process of building their scientific communities, enhancing physics and mathematics education at all levels, and planning research projects related to the specific needs of their region. During 2024, 123 Associates (34 female and 89 male) from 41 countries visited ICTP.

Postdoctoral Opportunities: ICTP Postdoctoral Fellowships are intended for young scientists or mathematicians with a strong research record. Fellows must have completed a PhD in a related field prior to the start of their fellowship. The fellowships typically have a two-year duration with a possible extension for a further period of 12 months. The starting date can be negotiated. Preference is given to candidates who will benefit most from the time spent at ICTP in pursuit of their own research, using the ICTP facilities and participating in ICTP activities, and who will interact with local scientists and visitors and will contribute to the intellectual vitality of the Centre. In 2024, ICTP supported 77 postdoctoral students (22 female and 55 male) from 26 countries.

Laboratory Opportunities: Access to modern, well-equipped research laboratories is crucial for scientists working in the developing world. ICTP helps by supporting visits to its on-site laboratories as well as to those located elsewhere in Trieste and throughout Italy. Laboratory programmes include ICTP's Training and Research in Italian Laboratories (TRIL), which offers scientists from developing countries the opportunity to undertake training and research in an Italian laboratory in different branches of the physical sciences. In 2024, 73 scientists (35 female and 38 male) from 31 countries participated in the TRIL programme.

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Further laboratory opportunities are available through the ICTP-Elettra Users Programme, offering access to Trieste's Elettra synchrotron radiation facility for scientists from developing countries who work in those countries. Support includes a limited number of grants to cover travel and living expenses of individuals and small groups who participate in the beamtime at Elettra. During 2024, 31 scientists (15 female and 16 male) from 5 countries benefited from the Elettra Users Programme.

ICTP cooperates with its UN partner, the IAEA, in placing scientists from developing countries in Italian laboratories. In 2024, this IAEA Fellowship Training and Scientific Visits Programme placed 44 researchers (15 female and 29 male) from 22 countries in 20 hospitals and research institutes around Italy.

In addition, ICTP has partnered with the American Physical Society (APS), the European Physical Society (EPS), and the APS Forum on Early Career Scientists (FECS) to support research visits to laboratories in Europe (excluding Italy) and North America, or to a more advanced developing country. In 2024, this APS-EPS-ICTP Travel Award Fellowship Programme supported 3 female scientists from Cuba, Nigeria and Palestine.

CAREER DEVELOPMENT IN 2024

230

SCIENTISTS ENGAGED IN CAREER DEVELOPMENT PROGRAMMES: ASSOCIATES, TRIL, ELETTRA AND ATAP

52

COUNTRIES REPRESENTED (INCLUDING 11 LEAST-DEVELOPED COUNTRIES)

Science Outreach

ICTP has a long tradition of scientific capacity building in developing countries. Over the last few decades, ICTP has supported numerous activities throughout the developing world, including training programmes, networks, and the establishment of affiliated centres.

Activities are initiated by scientists and scientific institutions in the developing world and are carried out at sites located within the region. The purpose is threefold:

- To initiate, stimulate or make applicable research and training in the fields of physics and/or mathematics related to locally available resources or local problems of specific relevance to the development of the region.
- To form and strengthen national and regional communities and research groups by supporting institutions or national societies for physicists and mathematicians at all levels.
- To enhance physics and mathematics teaching.

ICTP achieves these goals through a number of science outreach programmes:

External Activities Unit: ICTP supports research and training activities of physicists and mathematicians living and working in developing countries, primarily by providing assistance for regional activities. Such support complements the training and research that is provided to developing-country scientists at ICTP. The goal is to boost the scientific level of individuals, groups or institutes in developing countries to an international level through North-South collaboration, and to stimulate networking of scientists in the developing regions to reach a critical mass of researchers through South-South collaboration. Assistance is coordinated by ICTP's External Activities Unit, through which ICTP directly supports postgraduate courses and students as well as early career scientists in Affiliated Centres, research group networks, scientific meetings, and visiting scholars and consultants. In 2024, ICTP's External Activities Unit funded 5 Affiliated Centres, 5 Scientific Networks and 13 Scientific Meetings, involving a total of 46 countries from Africa, Asia, Europe and Latin America.

The number of scientists supported in EAU programmes in 2024 included:

- 12 students (3 female and 9 male) from Algeria, Bangladesh, Cameroon, India, Morocco, Nigeria, Pakistan and Saudi Arabia, at ICTP Affiliated Centres.
- 5 scientists from Australia, Germany, Italy and the Netherlands were visiting scholars and consultants in Asian and Latin American institutes.
- 10 scientists (2 female and 8 male) from Cameroon, Egypt, Kenya, Italy, Mexico and USA visited advanced light sources (AdLS) through the LAAAMP FAST Teams Visits to Advanced Light Sources programme.

Participants of a PWF course on Advanced Quantum Mechanics, June 3-14, Université Joseph KI-ZERBO (UJKZ), Ouagadougou, Burkina Faso.
© Jacques Napon

- 12 researchers (5 female and 7 male) from Argentina, Brazil, Cameroon, India, Iran, Morocco, Nigeria, Pakistan, Thailand and Türkiye, benefited from the fellowship and collaborated with colleagues from European institutes through the CIMPA-ICTP Research in Pairs Fellowships.
- 2 scientists (1 female and 1 male) from Congo and Kenya visited universities in Germany and France through the ASESMANET-EU programme.
- 14 researchers (4 female and 10 male), from Argentina, Brazil, Bulgaria, Croatia, Iran, Romania, Serbia, Türkiye and USA, attended diverse conferences and training programmes during 2024 in Greece, Nigeria and Switzerland under the Individual Scientist Grant programme.

Physics Without Frontiers: Physics Without Frontiers (PWF) targets the far reaches of the developing world to inspire and engage undergraduate and master's physics students. The programme embarks on physics roadshows, run by working groups comprising volunteer young PhD students and postdocs who visit university physics or maths departments in a developing country to give one-day, intensive masterclasses to undergraduate and master's students. The outreach is extended to high school students, the general public and policy makers via events throughout a country. In 2024, PWF organised 30 different activities, including a roadshow, 12 courses, schools and workshops, and more than 15 on-line events, with a total of 971 in-person and 733 remote participants, from 33 countries across Africa, Asia and Latin American. PWF also brings high-level master's courses to universities that lack such courses. In 2024, PWF taught courses in Iran, instructing a total of 3 master's students.

2024 Timeline

January

2024 SPIRIT OF ABDUS SALAM AWARDEES

Three people were named as the 2024 Spirit of Abdus Salam Awardees for their longterm dedication to the Centre's scientific excellence and social well-being. The recipients are: Rosanna Sain, who worked for 44 years for the Trieste science community, first as a secretary to ICTP co-founder Paolo Budinich at the Istituto di Fisica Teorica and then for ICTP; Luciano Maiani, the chairperson of the ICTP Scientific Council from 2011 to 2022; and Fabio Zwirner, the representative of the Italian Government on the ICTP Steering Committee, as well as its chair, from 2014 to 2022.

2024 Spirit of Abdus Salam awardees Rosanna Sain, Luciano Maiani and Fabio Zwirner.

March

MASTER IN HIGH PERFORMANCE COMPUTING (MHPC) PROGRAMME CELEBRATED ITS 10TH ANNIVERSARY

The Master in High Performance Computing (MHPC) programme celebrated its 10th anniversary in 2024. The programme, run jointly with SISSA, prepares students for careers in the fast-growing field of high performance computing. Since its founding in 2014, 109 students have graduated from the programme; about one third of them come from developing countries and were selected and funded by ICTP. Over the years, the Centre has supported the enrolment of 29 students from 18 technology lagging countries, nearly all of whom have found a relevant job, either in academia or in industry, after completing the degree programme.

May

MIGUEL VIRASORO VISITING INTERNATIONAL CHAIR

Subir Sachdev, Herchel Smith Professor of Physics at Harvard University, is the first holder of the Miguel Virasoro Visiting International Chair, which ICTP launched in 2024. The Chair is hosted in ICTP's Condensed Matter and Statistical Physics section.

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NEW PRIZE FOR ARTIFICIAL INTELLIGENCE RESEARCH

ICTP announced a new prize for Artificial Intelligence research, sponsored by IBM. Alessandro Curioni, Vice President of IBM Research Europe and Africa, announced IBM's intent to sponsor the prize for five years – until the end of 2029. The sponsorship initiative is aligned with IBM's efforts with the AI Alliance, a global organisation launched in December 2023 by IBM and Meta, which ICTP has also joined. The first prize winner will be announced in 2025.

Alessandro Curioni, Vice President of IBM Research Europe and Africa.
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ICTP COLLOQUIUM

"Hyper-diversity and Negative Frequency-dependent Interactions in Host-pathogen Systems"

Mercedes Pascual,
New York University

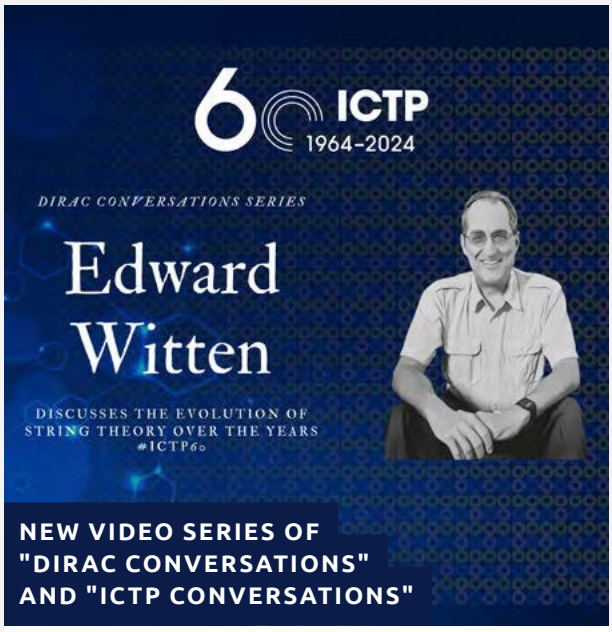
View the talk online at:
https://www.youtube.com/watch?v=7Er8u7QiyFk&list=PLoxv42WBtfCC7q3kIL-87bJaaRrdu7d4y&index=3

Sandro Scandolo, ICTP Senior Coordinator of Research, welcomes the launch of ICOMP at the International Symposium for Scientific Computing.
© Alberto Riccio Bergamas

INTERNATIONAL CONSORTIUM FOR SCIENTIFIC COMPUTING (ICOMP)

ICTP launched a new initiative to promote open access to scientific computing resources and the education and training needed to take full advantage of their capabilities. The International Consortium for Scientific Computing (ICOMP) was announced during ICTP's International Symposium on the Future of Scientific Computing: A Global Perspective, a 60th anniversary event that attracted leading scientists and technology experts from around the world to discuss the frontiers of scientific computing.

May



NEW VIDEO SERIES OF "DIRAC CONVERSATIONS" AND "ICTP CONVERSATIONS"

ICTP launched a new video series of "Dirac Conversations" and "ICTP Conversations", interviews conducted by ICTP Director Atish Dabholkar (sometimes accompanied by members of the Centre's faculty) with Dirac medallists and other prominent physicists and mathematicians and posted on the Centre's YouTube channel.

GENDER EQUALITY ACTION PLAN

ICTP took an important step to address gender balance and work-life issues at the Centre by releasing a Gender Equality Action Plan (GEAP). The GEAP formally acknowledges gender equality and intersectionality as key objectives and fundamental values of ICTP as a UNESCO research and educational institution. The document is in line with ICTP's Strategic Plan, which acknowledges action for gender equality as one of the Centre's key strategic pillars. Read the plan at https://www.ictp.it/sites/default/files/attachments/ICTP_GEAP_2024_1.pdf

ICTP Director Atish Dabholkar and CECAM Director Andrea Cavalli sign the agreement between the two institutions in Lausanne. © CECAM

ACCESS TO EUROPEAN HIGH PERFORMANCE COMPUTING

A new agreement signed by ICTP and the Centre Européen de Calcul Atomique et Moléculaire (CECAM) will facilitate access to European high performance computing (HPC) resources for scientists and research teams in Africa who apply scientific computing to do research in atomic and molecular physics, materials science, chemistry and biology.

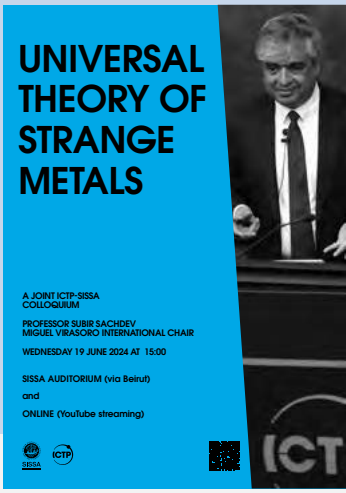
June

ICTP/SISSA JOINT COLLOQUIUM

"Universal Theory of Strange Metals"

Subir Sachdev,
Harvard University

View the talk online at: https://www.youtube.com/watch?v=Ac5tUs433tc



July

NEW AGREEMENT

An agreement of scientific collaboration between Brazilian scientists and ICTP researchers in climate modelling, scientific computing and other fields was signed during a ceremony in Brazil's capital, Brasilia, attended by Brazil President Luiz Inácio Lula da Silva, Italian President Sergio Mattarella, ICTP Director Atish Dabholkar and Luciana Santos, Brazil's Minister of Science, Technology and Innovation.

© Ministry of Science, Technology and Innovation (Brazil)

VISIT BY AN AFRICAN UNION DELEGATION LED BY MOHAMED BELHOCINE

ICTP hosted a visit by an African Union delegation led by Mohamed Belhocine, Commissioner of the African Union's Education, Science, Technology and Innovation (ESTI) Programme. An agreement was signed to strengthen cooperation through a series of concrete projects, including an effort to facilitate access to knowledge and resources for scientific computing in the African continent, as part of ICTP's International Consortium for Scientific Computing (ICOMP). The two organisations also committed to strengthen exchanges between ICTP and the Pan-African University, and between the Pan-African Institute and ICTP's partner centre in Rwanda, the East-African Institute for Fundamental Research, as well as enhance capacity in Africa towards the creation of an African synchrotron.

ICTP Director Atish Dabholkar (right) and Mohamed Belhocine, Commissioner of the African Union's Education, Science, Technology and Innovation (ESTI) Programme sign agreement between the African Union and ICTP.
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GLOBAL SCIENCE PORTAL

ICTP launched its Global Science Portal, an online community hub where former and current ICTP scientists across the world can meet to form connections and collaborations, develop meaningful international and local networks and support each other's professional development. The Portal will provide members of the ICTP community with a place to easily connect with others in their field or geographic region, discover and post opportunities such as mentoring, studentships, grants, jobs and courses, catch up on news from ICTP, search for other researchers, share career and scientific updates, message other users, and engage in forum discussions. Visit the Portal at https://ictp.global/

August

POSTGRADUATE DIPLOMA PROGRAMME

An unforgettable year of scientific and personal growth concluded for the 42 students of ICTP's 2023 - 2024 Postgraduate Diploma Programme. The young scientists successfully completed an intense 12 months of physics and mathematics studies and received their diplomas at a graduation ceremony held on 28 August. This year's graduates came from 25 countries; 38% were female. More than half will continue their studies at the master's or PhD level at universities in Europe and the United States. A special prize funded by and named for long-time friends and supporters of ICTP, Qaisar and Monika Shafi, was awarded to Diploma graduates Anis Bousclet and Cristopher Erazo Vallejos.

© Roberto Barnabà

MEET SOME OF THE 2024 DIPLOMA PROGRAMME GRADUATES:

ANIS BOUSCLET

Algeria

Diploma in Mathematics; admitted to PhD programme at SISSA

© Roberto Barnabà

"In the past, I often felt that my interest in mathematics wasn't valued and that people around me didn't care about what I wanted to do. Here at ICTP things are different. I feel valued, and I feel that I belong. In addition to being very good researchers, the professors in the Diploma Programme really care about us, they are there to answer our questions and are supportive of our plans for the future. The level of the courses is very high, also thanks to the tutors, who give us very interesting exercises to do."

CRISTOPHER ERAZO

Ecuador

Diploma in Quantitative Life Sciences; admitted to PhD in theoretical and computational neuroscience at SISSA

© Roberto Barnabà

"The Programme is quite intense, but somehow it also aims to get you involved in the research lifestyle. It didn't feel like being at a university class, but more like being part of a research community, where people meet and discuss about science. That has been very empowering for me, and it has helped me to understand that research is what I like. Now I know that one day I would like to have a job in academia."

ARWA AL RASHDI

Oman

Diploma in Earth System Physics

"One of my passions is to help people understand what is going on with climate change and how what we do has an impact, because we are all affected by climate change and knowledge is empowering."

© Filippo Blasetti

2024 TIMELINE

JUAN CASTELLANOS

Colombia

Diploma in Condensed Matter Physics; accepted to a master's degree programme at the University of Stuttgart and the Max Planck Institute for Solid State Research

© Roberto Barnabà

"My goal is to learn as much theory as I can, and once I know enough, I will be able to start looking at the possible applications, and even try experiments. I see myself as a future research leader. There is much that I want to accomplish!"

SALIM DAVILA

Venezuela

Diploma in High Energy, Cosmology and Astroparticle Physics; accepted to a master's degree programme at the Ludwig Maximilian University (LMU), in Munich

© Roberto Barnabà

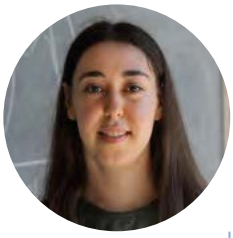
"Coming here was a very big change in my life. I left everything – my family, my friends, my pets. At the beginning, during the first month, I admit I felt a bit lost, but at ICTP I found a group of friends and I am very happy to be here. Here you meet people from all over the world, I think this is what makes ICTP so special."

JANA FAKHER EDDINE

Lebanon

Diploma in Condensed Matter Physics; accepted to a PhD programme at SISSA

"The professors at ICTP really care about us. They do not expect that we are perfect students, but they want to make sure that we get the most out of the programme and learn as much as possible."



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ICTP ANNOUNCES 2024 DIRAC MEDALLISTS

ICTP awarded its 2024 Dirac Medal to four physicists who have made pioneering contributions to the understanding of quantum entropy in gravity and quantum field theory.

The winners are:

- Horacio Casini, National Scientific and Technical Council (CONICET) and Bariloche Atomic Centre, Argentina
- Marina Huerta, National Scientific and Technical Council (CONICET) and Bariloche Atomic Centre, Argentina
- Shinsei Ryu, Princeton University, United States
- Tadashi Takayanagi, Kyoto University, Japan

The award cites "their insights on quantum entropy in quantum gravity and quantum field theories".

August

2024 RAMANUJAN PRIZE

ICTP and the International Mathematical Union (IMU) awarded the 2024 Ramanujan Prize for young mathematicians from developing countries to Ruochuan Liu of Peking University, China, for his fundamental contributions to p-adic Hodge theory. Liu is a professor at the Beijing International Center for Mathematical Research (BICMR) at Peking University.

Ruochuan Liu, recipient of the 2024 Ramanujan Prize.
© Roberto Barnabà

September

ICTP COLLOQUIUM

"The Bizarre One-dimensional Quantum Physics"

Thierry Giamarchi, University of Geneva

View the colloquium at https://www.youtube.com/watch?v=amxWUu0q7lI

2024 WALTER KOHN PRIZE

ICTP and the Quantum ESPRESSO Foundation awarded their 2024 Walter Kohn Prize to Rafael Gonzalez Hernandez, a professor at the Universidad del Norte, Colombia, for his ground-breaking work in uncovering the physics and properties of altermagnetism, an unconventional magnetic state of matter, and for his ab initio predictions of related effects in real materials.

Rafael Gonzalez Hernandez, recipient of the 2024 Walter Kohn Prize.
© Alberto Riccio Bergamas

November

UNESCO EVALUATION OF ICTP

ICTP's UN partner UNESCO released the results of its 12-year evaluation of ICTP programmes. The results showed that ICTP's mission and foundational principles of excellence, inclusion, and international cooperation remain highly relevant to the needs of developing countries, addressing the persistent North-South capacity gap and new technological challenges and opportunities. The full evaluation report is here: https://unesdoc.unesco.org/ark:/48223/pf0000391782.locale=en

IAEA EVENT

The IAEA hosted a side event to its Ministerial Conference on Nuclear Science, Technology and Applications and the Technical Cooperation, highlighting the impact of ICTP in promoting global scientific collaboration and knowledge exchange, with a focus on the projects that the Centre carries out with the IAEA. The side event was promoted by the Permanent Mission of Italy to the international organizations in Vienna.

Ambassador Debora Lepre, Italy's Permanent Representative to the International Organizations in Vienna, Najat Mokhtar, Deputy Director-General and Head of the Department of Nuclear Sciences and Applications at the IAEA, and ICTP Director Atish Dabholkar at the IAEA event.
© Permanent Mission of Italy to the international organizations in Vienna.

December

2024 ICTP PRIZE

ICTP awarded its 2024 ICTP Prize to two researchers who, although in different fields, exhibit notable creativity in their work. Ranjan Laha, an assistant professor at the Indian Institute of Science, Bengaluru, India, received the prize for his outstanding and wide-ranging work in theoretical particle astrophysics and cosmology. Enzo Tagliazucchi, professor of computational neuroscience at the University of Buenos Aires and principal researcher at the Latin American Brain Institute at Santiago, Chile, shared the prize for his significant insights in human cognition and consciousness based on general theoretical principles, validated on empirical data from neural recordings according to the established standards of cognitive neuroscience.

Recipients of the ICTP Prize 2024: Ranjan Laha (left) and Enzo Tagliazucchi.

ICTP's 2024 graduation ceremony for its Masters in Medical Physics programme.
© Alberto Riccio Bergamas

MASTER OF ADVANCED STUDIES IN MEDICAL PHYSICS PROGRAMME

ICTP held a graduation ceremony for students who successfully completed its Master of Advanced Studies in Medical Physics programme. The ceremony also marked the 10-year anniversary of the programme. Launched in 2014, the MMP has so far opened the way to a successful career path for nearly 200 physicists from 72 countries spanning 5 different continents. Of these, approximately 48% are from Africa, 22% from Asia, 21% from Latin America, 8% from Europe, and 1% from Oceania; more than 30% are women. This year 17 students from 13 different countries completed the two-year programme; a record 41% of this year's graduates were women.

Governance

ICTP operates under a tripartite agreement between the Italian Government, the International Atomic Energy Agency (IAEA), and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Each party has a representative on the Centre's Steering Committee, which sets general guidelines for the Centre's activities, determines budgeting levels, and considers proposals from the Director for the programme, work plans, financial plans, and budget.

ICTP also has a Scientific Council that comprises distinguished specialists in disciplines relevant to the Centre's activities who represent a broad geographical range. The Council advises ICTP on its programmes of activities, taking into consideration major academic, scientific, educational and cultural trends relevant to the Centre's objectives.

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Professor, Department of Theoretical Physics, University of Padua

IAEA:
Najat Mokhtar
Deputy Director General, Department of Nuclear Sciences and Applications

UNESCO:
Lidia Arthur Brito, Assistant Director-General, Natural Sciences Sector

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The University of Chicago, U.S.A.

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Enrico Fermi Distinguished Service Professor, Department of Physics, Enrico Fermi Institute, U.S.A.

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Professor Matias Zaldarriaga
Institute for Advanced Study, Princeton, U.S.A

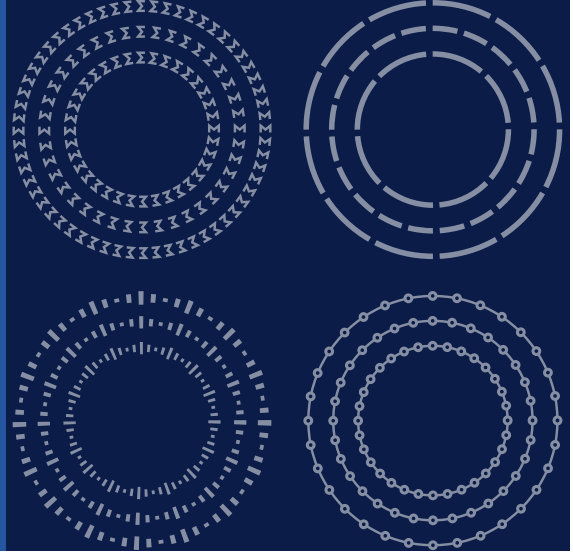
Professor Peter Zoller
University of Innsbruck, Institute for Theoretical Physics, and IQOQI, Austrian Academy Of Sciences, Austria

ICTP Scientific Council members actively engage with the ICTP community during their annual meeting in Trieste. In this photo, Council members (from left) Jeffrey Harvey, Sara Solla, Lisa Randall and Peter Zoller having an informal discussion with ICTP Postgraduate Diploma students in the Centre's Budinich Lecture Hall.

ICTP's Associates Programme enables individual scientists from the Global South at different stages of their careers to maintain long-term formal contacts with ICTP's stimulating and active scientific environment. The Programme supports regular visits to ICTP, where associates have the opportunity to remain in touch with the experts and also with the most modern aspects of their scientific fields. In the photo, ICTP Scientific Council members Carolina Vera, Giulia Galli, and Nobel Laureates David Gross and Giorgio Parisi meet with a group of associates whose visits to ICTP coincided with the May Scientific Council meeting.

Supporters

ICTP would like to express its deep gratitude to all who supported us in 2024.



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Italian Ministry of Foreign Affairs, MAECI, Italy

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Redesigning the ICTP Library: A Model for Success Based on a Public-Private Partnership

Of all the buildings in academia, the library has always occupied a special place: a highly curated repository of both existing knowledge and speculative thinking in areas of central importance to human knowledge.

The ICTP Library has traditionally been home to a vast collection of both journals and books. It is a magnet for both faculty and visiting scholars, a place where they can soak in the vast treasure trove contained in the many miles of carefully organized pearls of wisdom.

The current library had two major challenges in fulfilling its central role in ICTP's research and educational missions:

1. The building was in significant need of updating its basic infrastructure, including the heating, air conditioning, and electrical systems.
2. In the digital era, many of the books and journals are now available online. There is a demonstrated need to make these materials instantly available to the scholars, no matter where they are in the world.

Addressing these two vital needs also created an opportunity: to re-imagine the modern-day library at ICTP, envisaged as a place for scholars to congregate and collaborate both in-person and remotely. Flexible spaces could be used in solitude, as well as for small and large in-person and virtual meetings at short notice.

The re-design and upgrade of ICTP's library, requiring a significant commitment of time and resources, is well underway thanks to a unique public-private partnership.

The Government of Italy has provided significant funding for the infrastructure work related to the project, including demolition, heating, air conditioning, and electrical systems. This represents around half the project costs.

Ashvin B. Chhabra, President and Chief Investment Officer of New York-based Euclidean Capital, and Daniela Bonafede-Chhabra, a community volunteer in Princeton, made a significant donation to ICTP to fund the redesign of its library.

The first phase was a digitization project, generously funded by an anonymous donor. It has allowed the library to digitize a large selection of materials that will now be made available to the global ICTP community for download into their own libraries in perpetuity. This, along with the decommissioning of rarely utilized books and journals, has provided for significantly more useable space.

The second phase of the project and the broader redesign proposal includes the selection of a design firm experienced with the highest industry standards for library redesigns. This phase has been generously funded through a significant donation by Ashvin B. Chhabra and Daniela Bonafede-Chhabra, private donors who have in recent years become an important part of the ICTP community.

"Libraries are some of the very first places where each of us could pursue our quest for knowledge"

Ashvin chairs ICTP's Development Advisory Board, which was set up to work with the ICTP Director and staff towards realizing some of ICTP's strategic developmental initiatives. An important part of this Advisory Board's initiative is to broaden the ICTP community throughout the world, and to expand its reach with individual and organizational donors.

Dr. Chhabra is President and Chief Investment Officer of Euclidean Capital– a New York based family office which was founded by the mathematician, financier and philanthropist James H. Simons (1937-2024). Ashvin, grew up in New Delhi, received his PhD from Yale in non-linear dynamics (chaos theory) and first visited ICTP as a graduate student, where he attended ICTP's summer school on chaos.

Dr. Bonafede-Chhabra is a community volunteer in Princeton, with a focus on promoting equality of opportunity, starting with her local community. She helps advocate for and build affordable rental homes and leads McCarter Theater's board to support the development of bold new work and access to it by everyone in the community. She grew up in Italy, received a BS in biology from Caltech and a PhD in neurobiology from Yale University.

In addition to the generous financial support, Ashvin and Daniela have met with Advancement and Library staff, reviewing project plans. They have also helped organize and hosted fund raisers and community get-togethers in Princeton and New York City, helping make connections with other donors on this and other significant initiatives for ICTP.

"The global democratizing of scientific knowledge and research is what compels us to support ICTP's mission," stated the Chhabras while also explaining why the Library renovation project spoke to them specifically.

"Libraries are some of the very first places where each of us (a girl in a small town in Italy and a boy in one of the largest capitals of the East) could pursue our quest for knowledge, so it made immediate sense to support the Library reimagining at ICTP."

Ashvin and Daniela also recommend that those thinking about donating to ICTP don't just plan on philanthropic estate provisions but "start building your legacy now, donate at any level and enjoy seeing what you can help build in this world."

The Chhabras do much more for ICTP than just financial support. They attended the 60th Anniversary celebrations in Trieste and have hosted events in the U.S., introducing ICTP to an expanding network of supporters because they "strongly believe in the power of many to change the world together."

To join Ashvin and Daniela in supporting ICTP generally or for a specific project, contact the Institute Advancement Office at advancement@ictp.it.

An architectural rendering of ICTP's renovated Library space.
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ICTP wouldn't be where it is today without the profound dedication of its staff, both scientific and administrative, who have kept the spirit of Abdus Salam alive these 6 decades and who made the 60th anniversary year a resounding success!
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