The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

ICTP in Nigeria

P-2 ICTP has a long tradition of scientific capacity building in Africa. Over the last few decades, ICTP has supported numerous educational, training and networking activities throughout the continent. The most recent activity took place in Nigeria, at the invitation of the country's National Assembly • • •

Downsize Me

P-9 It's a small, small world in the realm of nanoscience. ICTP researchers are studying the diverse and mysterious nature of the field, looking at practical applications, and sharing their knowledge with students in the developing world • • •

Destination Laboratorio

CENTREFOLD Through ICTP's Training and Research in Italian Laboratories programme, hundreds of scientists from developing countries have gained valuable, hands-on research experience on topics ranging from atomic and molecular physics to non-conventional energy sources. Their presence enriches their Italian hosts as well as their home countries • • •

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ICTP in Nigeria

DELEGATION OFFERS SCIENCE AND TECHNOLOGY ADVICE TO NATIONAL ASSEMBLY

ICTP's long experience with science and technology for developing countries took centre stage at an awareness workshop hosted by the National Assembly of Nigeria, and formed the basis for an agreement between the two for ongoing science and technology cooperation.

The country had invited an ICTP delegation to inform Parliamentarians of trends in science and technology, in an effort to strengthen Nigeria's capacity in these areas and to provide the background needed to formulate science and technology policies.

"The Nigerian National Assembly needs more knowledge of science and technology in order to create effective policies, and that is what motivated us to form an agreement with ICTP," said Honourable Usman Bayero Nafada, deputy speaker of the Nigerian House of Representatives.

NIGERIA

At a two-day event held in Nigeria's capital, Abuja, ICTP scientists representing several areas of physics, mathematics and technology spoke on themes ranging from science policy to climate change. ICTP Director Fernando Quevedo initiated the first day of discussions with a talk on "Creating World Class Scientific Institutions and Centres of Excellence". He was followed by several members of ICTP's scientific staff, including Matteo Marsili and

+ ICTP Director Fernando Quevedo and other Centre researchers at a high-level meeting in Nigeria

+ Clement Onime (centre) reviewing NASS technology

Sandro Scandolo of the Condensed Matter and Statistical Physics section, Filippo Giorgi of the Earth System Physics section, Sandro Radicella of the Aeronomy and Radiopropagation Laboratory, and former Mathematics section researcher Charles Chidume, who is currently acting president of the African University of Science and Technology (AUST), all of whom spoke of their research in terms of its importance to development. Clement Onime of ICTP's Information and Communication Technology Section spoke of high performance cluster computing.

"ICTP's core mission is to foster the growth of physics and mathematics in developing countries, and we are pleased to be able to share our experience with Nigeria, a country eager to develop its capacity in these areas as well as in technology," said Director Quevedo.

The ICTP-Nigeria agreement, which was signed on 7 May, will ensure continued contact between the two in the form of awareness workshops and exchange activities in order to assist Nigeria in reaching its capacity development goals.

ICTP and Nigeria have a number of collaborative programmes already in place, such as a PhD programme in mathematics at the University of Nigeria, a planned MSc programme in high performance computing at AUST, and an agreement with the National Universities Commission of Nigeria to develop scientific capacity in Nigerian universities. In 2009, 92 scientists from Nigeria visited ICTP in Trieste for research and training opportunities.

Key recommendations emerging from the awareness workshop included that Nigeria provide adequate funding of scientific research, improvement of education at all levels and substantial support to universities for basic science and engineering, and that centres of excellence be created to promote and enhance research in science and technology and to contain brain drain.

High-tech help

ICTP experts review Nigerian National Assembly IT infrastructure

Demonstrating its commitment to narrowing the digital divide, ICTP sent two of its information and communication technology experts, Clement Onime and Carlo Fonda, to review the current state of information technology at the Nigerian National Assembly (NASS).

The visit was a prelude to the "Awareness Workshop on Science and Technology for Related Committees of the National Assembly of Nigeria," where a delegation of ICTP scientists shared their knowledge and expertise with NASS parliamentarians. Nigeria is eager to improve its science and technology capacity and has turned to ICTP for assistance.

During the five-day visit, Onime and Fonda conducted a detailed technical analysis of the NASS IT infrastructure, focussing on the local area network, the wireless network infrastructure and the internet connectivity. The visit ended with the team making recommendations to the NASS Clerk aimed at improving the quality of service, the overall capacity and the scalability of the IT infrastructure.

ICTP Announces **Dirac Medallists** for 2010

AWARD CITES WORK ON FUNDAMENTAL FORCE OF NATURE

Italian physicist Nicola Cabibbo (University of Rome "La Sapienza", Italy) and Indian-American physicist Ennackal Chandy George Sudarshan (University of Texas, Austin, Texas, USA) have been awarded ICTP's Dirac Medal and Prize for 2010.

The award recognizes their fundamental contributions to the understanding of weak interactions and other aspects of theoretical physics. The weak interaction is one of the four fundamental forces of nature, along with strong interaction, electromagnetism, and gravity. It is crucial to the structure of our universe, as it, among other things, causes the fusion that makes the sun burn.

DIRAC MEDALS 2010

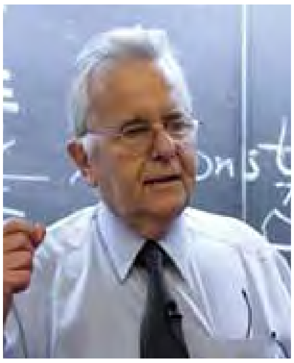
Cabibbo was notified of the award on 8 August, a week before his death on 16 August in Rome (see page 27 for memoriam). Cabibbo was cited for his important contributions to theoretical physics including the recognition of the significance of mixing in weak interactions, which has established the existence of a new class of physical constants, whose first example is the Cabibbo angle. This angle determines the mixing of strange quarks with non-strange quarks and has been measured experimentally. With the discovery of a third family of quarks and leptons, quark mixing led to the understanding of the phenomenon of CP violation. Cabibbo was chair of ICTP's Scientific Council.

Sudarshan's important contributions to theoretical physics include the discovery (with Robert Marshak) of the V-A theory of weak interactions, which opened the way to the full description of the unified electroweak theory. He has also made innovative discoveries in the field of quantum optics, including the optical equivalence theorem, which provides the foundation upon which the investigations of the manifestly quantum or non-classical character of the electromagnetic field are based.

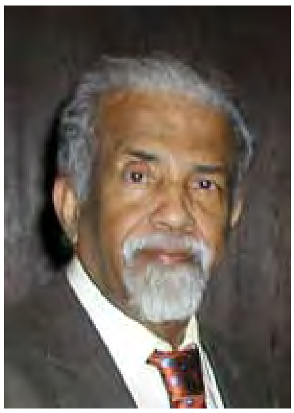
In announcing the winners, ICTP Director Fernando Quevedo said, "I am very pleased by the decision of the Dirac Medal selection panel for this year's medallists. Cabibbo and Sudarshan have played major roles in advancing our understanding of what is now called the standard model of particle physics, in addition to making many other important contributions to theoretical physics. It is a recognition that is long overdue. Furthermore, both have had strong links to the developing world, reflecting the spirit of ICTP's mission."

ICTP's Dirac Medal is given in honour of P.A.M. Dirac, one of the greatest physicists of the 20th century and a staunch friend of the Centre. It is awarded annually on Dirac's birthday, 8 August, to scientists who have made significant contributions to physics. The Medallists also receive a prize of US$5,000.

For additional information about the Dirac Medal and a complete list of previous winners, see http://prizes.ictp.it/Dirac.



+ Nicola Cabibbo (above) and E.C. George Sudarshan



Molecular Dynamics

ROBERTO CAR, DIRAC CO-MEDALLIST FOR 2009, REFLECTS ON DEVELOPMENT OF SIMULATION MODEL

At a formal ceremony held in May 2010, ICTP presented its 2009 Dirac Medal to Roberto Car of Princeton University, USA, and Michele Parrinello of the Swiss Federal Institute of Technology (ETH Zurich). The Medal recognizes their revolutionary "molecular dynamics" numerical simulation method that allows scientists and laypeople alike to visualize atoms in motion during physical and chemical processes.

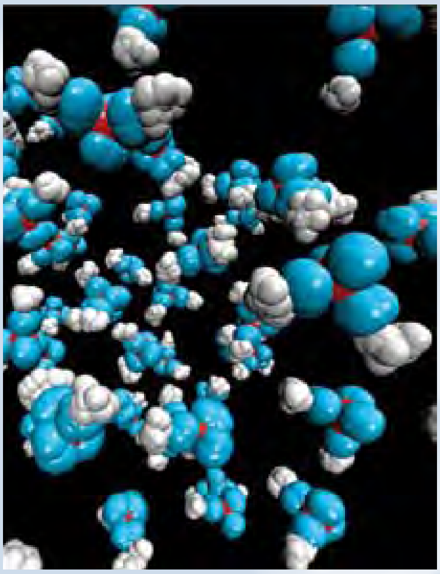
Car and Parrinello published a paper on their method in the November 1985 issue of the journal *Physical Review Letters*; the paper now ranks sixth among the journal's top cited articles, with a total of 5,027 citations. The work created a new paradigm, now an indispensable tool of every computational condensed matter physicist, chemist, and even biologist.

ATOM SIMULATION

News from ICTP talked with Car about the evolution of the method and its impact on multidisciplinary science, among other aspects.

What motivated you to develop the Car-Parrinello model? What were you trying to accomplish with the model?

The landscape in condensed matter physics was quite different back then. Semiconductor physics was a very hot topic, density functional theory was just establishing itself as a predictive tool for the ground state electronic structure of materials (it could predict the relative stability of crystalline structures and the phonon vibration frequencies), and molecular dynamics simulations were proving very powerful in computational statistical mechanics but were restricted to simple inter-atomic potentials, such as the Lennard-Jones potential.



Empirical potentials had limited transferability and had to be tuned in each specific case. Michele had a background in statistical mechanics and had just come back to Trieste from the Argonne National Laboratory in the US, where he collaborated with Anees Rahman, one of the pioneers of molecular dynamics. I had a background in electronic structure theory and had just moved to SISSA from IBM's Thomas J. Watson Research Center in the US, where I worked in a group headed by Sokrates T. Pantelides, a leader in the field of defects in semiconductors.

It was clear to the two of us that if one could extract the inter-atomic potential directly from the electronic ground state within density functional theory one would have accomplished something important. But how? The hurdles seemed insurmountable. A new electronic structure optimization would have to be done at each molecular dynamics step and at least several thousands of those steps were needed, while electronic structure optimizations could only be done for a few atomic configurations on relatively small supercells using state-of-the-art approaches of the time. Without fear, and perhaps even with naive optimism, Michele and I joined forces and came up with what appeared immediately as a radically new way of looking at the problem:

a unified molecular dynamics approach to deal with both electronic and molecular dynamics aspects.

Not surprisingly, our first application was to the semiconductor silicon, of which we could model the liquid state and generate an amorphous structure by melt quenching without the need for empirically adjusted potentials. It was quite amazing to watch how atomistic and electronic structures changed in a correlated fashion as the system amorphized.

These were also the first self-consistent electronic structure calculations of a disordered system at a time when exploiting crystalline symmetry was crucial to make calculations feasible. Our simulations led to novel insight on the role played by the local chemistry, i.e. the electronic structure, in determining the order at short and intermediate range in disordered materials.

What was the computing environment like when you worked at ICTP/ SISSA?

Only old people like us know what it was like working with computers in those days. At the beginning, we did not even have TV screens; the output was emitted from a teletype machine. Michele and I came back from the US with huge stacks of cards and large magnetic tapes. I had learned to use TV terminals at IBM but in Trieste I was back to cards and punching machines. The computer centre was on one side of the ICTP entrance hall and Alvise Nobile was the man in charge. He was very helpful. We had access to a Gould computer, which was anything but user friendly. It was relatively fast, though, and compared well with significantly costlier and friendlier IBM computers.

+ The old Computer Room, ICTP, 1985

The development of the method took place mostly on the Gould and was essentially completed in the spring of 1985 after a major breakthrough in the winter of the same year. Michele and I spent the summer of 1985 visiting IBM. We are still grateful for the hospitality of Sok Pantelides, who gave us complete freedom to work at our project, even if at the time this could not be applied yet to semiconductor defects. Sok and Art Williams, who was the head of the electronic structure theory group at Watson, gave us generous time on the best computers available, in addition to participating in good physics discussions with us. Our paper was submitted to *Physical Review Letters* in August 1985 while we were still at IBM. It contained the word "Lagrangian" which was changed by the editor to "Lagrangean".

After submitting this short method paper we were ready to tackle liquid silicon. At IBM we had included accurate pseudopotentials in our code and performed extensive tests on a 16-atom cell. Back in Trieste, the computing environment had improved dramatically. CINECA, the Italian Supercomputer Center in Bologna, had acquired a Cray-1S, the best number-crunching machine of the time. CINECA gave us generous access to the Cray supercomputer, and ICTP/SISSA had a dedicated connection, which at the beginning was still teletype-based, but soon TV screens became available. Thanks to CINECA and ICTP/SISSA, we could perform the first "realistic" ab-initio molecular dynamics simulation of liquid silicon on a 56-atom cell.

What difference did the presence of ICTP make to the development of your work?

ICTP was very supportive from the very beginning. The Miramare campus in 1985 consisted just of the ICTP building. SISSA and the Department of Theoretical Physics of the University of Trieste were both hosted there, which was indeed overcrowded with people sharing every available bit of space. Scientifically the place was very lively and a great group of condensed matter theorists was being assembled thanks to the initiative and leadership of Mario Tosi and Erio Tosatti. This was facilitated by the absence of boundaries between the three institutions. The presence of ICTP, SISSA and the University of Trieste in the same physical space made possible what would have been otherwise extremely difficult, if not outright impossible, in a regular Italian physics university department. Among many other things, ICTP contributed with a world premier scientific library, excellent administrative support, hosting capabilities, and unlimited flexibility on the Italian scale to support scientific visits and exchanges. The scientific atmosphere was excellent and the stimulating discussions we had with many colleagues helped a lot in the development of our model. I recall in particular discussions with Stefano Baroni, Alfonso Baldereschi and Erio Tosatti. Other people included Annabella Selloni and Paolo Carnevali, who were in Rome at the time, but were also often visiting Trieste. Several other people could be added to this list.

The atmosphere at ICTP made us feel as if we were actively involved in a much broader international scientific network. Seminars, schools and colleges and scientific meetings covering a broad range of disciplines were going on almost at all times. Famous physicists could be met like Walter Kohn, Norman March, and John Ziman, to name just a few condensed matter physicists. Another famous condensed matter physicist, Stig Lundqvist, was at ICTP almost permanently.

How has the model contributed to our understanding of materials at the microscopic scale?

The model gave us unprecedented insight on the deep connection between ground state electronic structure and atomistic structure and dynamics in a large class of material systems. It allowed scientists to interpret experiments and to predict the behaviour of condensed matter at extreme temperature and pressure conditions, as one encounters for instance in the interior of the Earth or of other planets. In these conditions, experiments are difficult and it is especially rewarding that several ab-initio molecular dynamics predictions could be subsequently confirmed by experiment.

The model also led to better understanding of associated liquids like water. In this context I mention two issues in particular: one, cooperative effects leading to molecular polarization, essential for the dielectric properties, were found to be larger than what was typically assumed; two, the microscopic structure of defects associated to proton excess/deficiency could be predicted together with the very fleeting character of these defect complexes due to proton exchanges among neighbouring molecules in the liquid.

These predictions agreed with experiments. However, the simulations did not always produce results in agreement with experiments. Theoretical failures are, in my opinion, as important as successes and sometimes even more so, because they reveal deficiencies of the underlying physical model—in this case, most likely deficiencies of the adopted density functional approximations. While the mapping between ground-state energy and electron density, which is at the basis of density functional theory, is exact, drastic approximations regarding exchange and correlation effects need to be adopted to make the theory of practical use. In the 1980s I thought that the simplest approximation, the local density approximation, could work well in most circumstances if correlation effects among the electrons are weak. In retrospect this would have been rather surprising because real materials are not at all microscopically homogeneous. The failure of the local density approximation was evident to us as soon as we tried to model liquid water. Luckily a large effort to improve on the local density approximation was already underway in a community encompassing both physicists and chemists. In this area some of the most significant contributions were made indeed by chemists. By providing a testing ground of systems well beyond simple molecules in gas phase, our model impacted these developments.

What do you think will be the major future impacts, and potential breakthroughs, that the ab-initio simulation method you pioneered might make possible, not just in materials physics, but also in chemistry and in life sciences?

Areas in which the ab-initio simulation method is likely to have a significant impact include nanoscience, physical chemistry and combinations of these two disciplines. The ability to predict structures, when disorder is present and under both equilibrium and non-equilibrium thermodynamic conditions, is very important in nanoscience. Water is the most important liquid for chemistry applications and our approach can describe, in principle, liquid-solid interfaces, solvation effects and chemical reactions in solution. All

+ Roberto Car

these systems and processes play a crucial role in chemistry. Thus chemistry is a very broad area of application, broader in effect than materials science.

The future will be largely interdisciplinary. Physics, chemistry and materials science are all important to the development of new materials and processes for energy applications, such as solar cells, batteries, photochemical cells, etc. As one starts investigating these systems, limitations of currently adopted physical models become apparent, including limitations of the density functional theory approximations, and limitations of the basic molecular dynamics approach when dealing with processes that occur very infrequently on the time scale of atomistic dynamics. These difficulties are greatly amplified in molecular biology. At the microscopic scale, relevant processes in this field involve macromolecules in solution, catalytic reactions, and chemical transfer of information among different macromolecules. Chemical processes at the molecular scale are essential to understand the working of biological systems. Processes such as bond rearrangement, molecular recognition and breaking and forming of bonds are all governed by quantum mechanics and should therefore be amenable to ab-initio molecular dynamics simulation. Thus one may expect that the life sciences should be a major potential area of future impact for ab-initio methodologies.

There are, however, major limitations to overcome. Some limitations are associated to the size and time scales of the relevant processes but these barriers are gradually becoming less severe with the development of novel computer architectures and of new algorithms that improve spatial and temporal resolution of the simulations. Some basic difficulties remain. On the one hand, biological processes are truly multiscale processes on the energy scale of the basic interactions. The balance between covalent bonds, ionic effects, hydrogen bonds and dispersion interactions must be described correctly. This poses a very severe challenge to density functional approximations. On the other hand, the sheer complexity of systems with several mutually interacting parts means that experiments under controlled physical conditions, like in the case for instance of surface physics under ultrahigh vacuum conditions, are not possible. This challenges direct comparison of theory and experiment in many circumstances.

In your view, how important will it be to highlight and to spread ab-initio simulations to the community of developing country scientists through the development of research strengths within ICTP?

ICTP is playing an invaluable role to help the development of science and to foster scientific education in the developing countries. Ab-initio simulation is just a particular scientific methodology, which should not be emphasized at the expense of other computational, theoretical and experimental methodologies.
I can see at least three reasons for highlighting and spreading ab-initio simulations within the community of scientists from developing countries: (i) the interdisciplinary character of the ab-initio approach that encompasses physics, chemistry and materials science, (ii) the increasing accessibility of computational resources all over the world, and (iii) the important role of visualization made possible by ab-initio simulations that gives us insight on the behavior of electrons and nuclei in materials, nanostructures and biomolecules. In simulation-based research (as in all other research endeavors), maintaining high scientific standards is very important. In this respect ICTP can play a key role in disseminating science and science education. To fulfil this goal, the development of research strengths in this domain at ICTP is crucial.

Downsize Me

NANOSCALE RESEARCH

ICTP RESEARCH INVESTIGATES HOW MATTER "MISBEHAVES" AT THE NANOSCALE

The year was 1959 and the man of the hour was the enigmatic Richard Feynman. In the now-famous talk titled "There's Plenty of Room at the Bottom," he said: "Why can't we write the entire 24 volumes of the *Encyclopædia Britannica* on the head of a pin?" Feynman had set the pace for advances in nanotechnology at a time when the atom had not even been viewed under a microscope!

Simply put, nanoscience is the study of matter on an atomic and molecular scale. It mostly deals with structures of the size 100 nanometres or smaller and involves developing materials or devices within that size. Nanotechnology is very diverse and has applications in many fields such as high energy physics, solid state physics, computing, medicine, as well as commercial applications in the cosmetics and food industry.

In modern times, 'the smaller the better' is a popular mantra. From the smallest and most high-tech computers to the slimmest memory sticks that hold 500GB of data but are half the size of your little finger, multiple functions are compressed to the smallest scales.

But it isn't always easy to miniaturize things. The properties of materials change drastically as you look at them on a smaller scale. At the nanoscale, a substance may melt at a lower temperature. It is more prone to entropy as there is more surface than body, and its properties of adhesion and conductivity change. A wire does not behave in the same way at the scale of a few nanometres as it does at the normal width. Something as seemingly fundamental as Ohm's law is not valid at the nanoscale.

Great advances in technology such as the scanning tunnelling microscope and later the atomic force microscope have brought a deeper understanding of these phenomena. Scientists in the Condensed Matter and Statistical Physics section of ICTP have been looking into different aspects of physics at the nanoscale.

Surface embrace

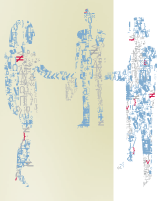
Conductivity of metals, surface interactions and friction at the nanoscale are of keen interest to ICTP researcher Erio Tosatti, who has had numerous papers published on the topics.

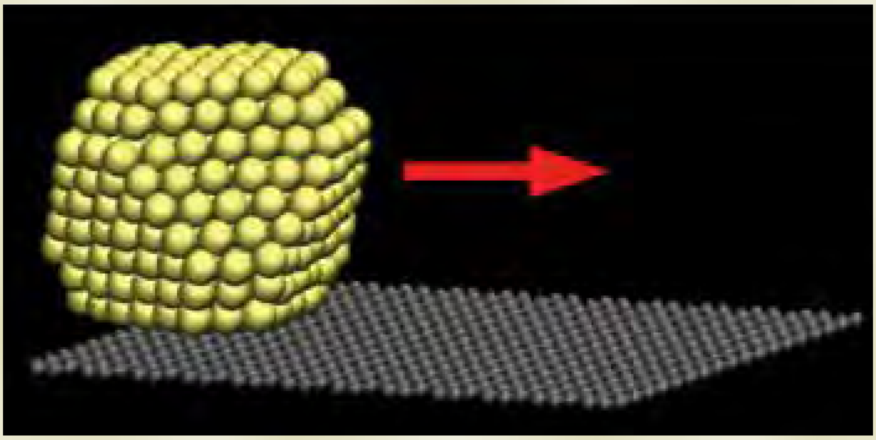
Tosatti's interest in metal conductivity has led to his study of the physics of nano-contacts. "The physics of nano-contacts is amusing and amazing in many ways; you can never make two nano-contacts that are identical. While they may have similar properties, they all vary," says Tosatti. A way to investigate these contacts is to study the passage of electrical current through them. But once more, the nano world lives by its own rules and even the most basic properties of electricity, such as Ohm's law, are not valid at the scale of a nano-contact.

Tosatti clarifies that the electron mean free path is much larger than the nano-contact. The contact is one nanometre and as the mean free path is much longer, electrons can cross the contact without hitting anything. At this point the conduction becomes 'ballistic' (i.e. a smooth flow of charge or energy carrying particles over relatively long distances in a material). "The end result is that the conductance of nano-contacts is completely determined by quantum mechanics. This was rather unexpected," says Tosatti.

Tosatti and his colleagues at ICTP and SISSA also do considerable research on nanofriction. At the nanoscale, the amount of surface far exceeds the bulk body and so the role of contact adhesion and friction becomes paramount.

Although the dynamics of friction





+ Simulated gold cluster on graphite substrate

are well understood from a physical viewpoint, the intricacies of what actually causes friction have not been resolved, according to Tosatti. He says that computer simulations can advance a physical understanding of friction, boosting existing technology and applications. "If one was able to take a step forward in this area, it would be big progress. There is a huge waste of energy and material in industry due to friction. I think people underestimate when they say 5% of energy is wasted in friction," he says.

In a recent paper published in July in the online version of *Nature Materials*, Tosatti and his co-authors looked at different regimes of nanofriction by simulating a system of gold clusters on graphite substrates. Gold clusters on graphite are known to be thermally mobile even at room temperature, and make an ideal test case as they diffuse over graphite's slippery surface. The paper, titled "Ballistic Nanofriction", concluded that two distinct regimes are seen in nanofriction, with a co-relation of diffusion and friction seen in the slow drift and an anti-correlation seen in the fast drift. The effect of temperature on each is the opposite. Experiments are now called for to test these predictions, and characterize ballistic friction.

"Who knows," says Tosatti, "this understanding might even come of use when humans will have to take to rockets and cross atmospheres at high speed while migrating to other planets."

Graphene keen

CMSP researcher Markus Müller has been looking at the myriad of interesting properties displayed by graphene. Graphene, essentially a nano structure, is a one-atom-thick planar sheet of carbon atoms with sp2 bonding, in a distinctive honeycomb crystal lattice. It derives its name from graphite, which consists of many graphene sheets stacked together. The carbon-carbon bond length of graphene is approximately 0.142 nanometers.

So what is so interesting about graphene and why is Müller studying it? Graphene is still a relatively new substance and shows many promising possibilities. It is a good contender to replace current silicon-based technology in the future. But graphene displays a number of seemingly unconventional properties.

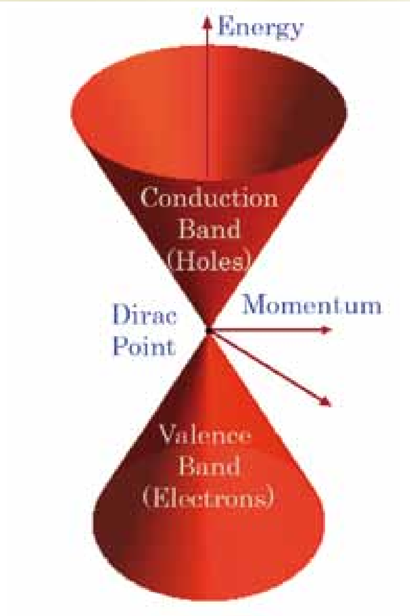
The first of these is that graphene is not completely a conductor or an insulator. It can be considered a metal from the point of view that within the atom, it goes from occupied to empty states; but it has fewer occupied states than one would expect in an insulator. So, it is a semi-metal. It is a bad conductor for a metal, but quite good for a semi-metal.

The second interesting feature is that graphene has a Dirac point: that is, a single point at which the valence band and the conductance band meet. This makes graphene act like a high-energy substance and makes it an excellent lab system to study high energy particles. It resembles the relativistic quark-gluon plasma that is said to have dominated our universe in the early days of its formation. Responses to electric fields or thermal gradients for graphene look essentially the same as those in an ultra-relativistic plasma of charged particles, the type seen in collider physics.

"I have been inspired by this and I am trying to figure out the physical consequences that you might see when you measure something of graphene that looks like the fascinating quark-gluon plasma," says Müller.

Another interesting property, he explains, is that because such a small number of states are filled with electrons, Coulomb interactions—that is, electron-electron interactions—are strong. For most metals, if any particle is added to the metal, a 'screening cloud' of electrons form around it to hide the presence of the extra particle. So, interaction of that particle with something far away is normally weak. But for that to occur requires a large number of electrons to be present. If the electrons are not present, no screening occurs and so the effect of the particle is felt even at a long distance. This makes interactions a lot more prominent than in a normal metal. This is true for graphene in vacuum, not in a substrate, as the substrate could provide the extra electrons. “This kind of strong interaction is always interesting because it tells you that you have more collective behaviour,” Müller explains. “If one particle talks to another one, then they do something together. Just one particle alone is considered boring!”

All of these properties make



+ The Dirac point of graphene where the filled and empty bands meet

graphene an exceedingly interesting substance to study. But yet another interesting property, which has applications in technology, is still being explored: when graphene is at finite temperatures, some electrons go from lower energy to higher energy states and make ‘holes’ as they occupy the higher states. So, one sees a gas of particles and anti-particles that are strongly interacting. It was imperative to see how much this trait influences graphene’s conductivity and viscosity.

While studying viscosity, metals are not generally considered, as in most cases their viscosity co-efficients are very large and essentially unobservable. This is because standard metals have a large Fermi surface, instead of just a point. “But an analogy of graphene with the quark-gluon plasma and high energy physics suggests the viscosity of graphene should be particularly small and somehow must be realized at the smallest possible limit,” says Müller. In recent years, people have discovered that liquids cannot have such low viscosity coefficients as previously thought. But, physicists studying black holes and string theory conjectured that there is some minimal viscosity ratio for highly relativistic strongly coupled structures. This ratio gives the state of turbulence of the liquid if you drive the system.

The ratio tells us that the more strongly coupled a liquid is, the lower viscosity it has. This launched a search for liquids with particularly low values of viscosity, and on the radar were cold atoms and graphene. Graphene, a simple system with a relatively low viscosity ratio, is a good candidate for an ideal fluid.

Add to all of the above the fact that graphene has high mobility, is relatively ‘clean’ as well as easy to dope, then graphene is a very interesting substance. Researchers in the field will have a lot to look forward to in the coming years.

Energize me

Another application of nano-sized physics is to produce more flexible ways to harvest energy from the sun. The traditional, silicon-based solar cells that appear on rooftops use an old technology developed in the 1960s. They are expensive and may eventually be replaced by solar cells derived from nanoscience research, says Ralph Gebauer, an ICTP physicist. That research, combined with organic dyes derived from grapes or tomatoes, may someday help society to harness sunlight. Gebauer’s computer simulations work toward this end.

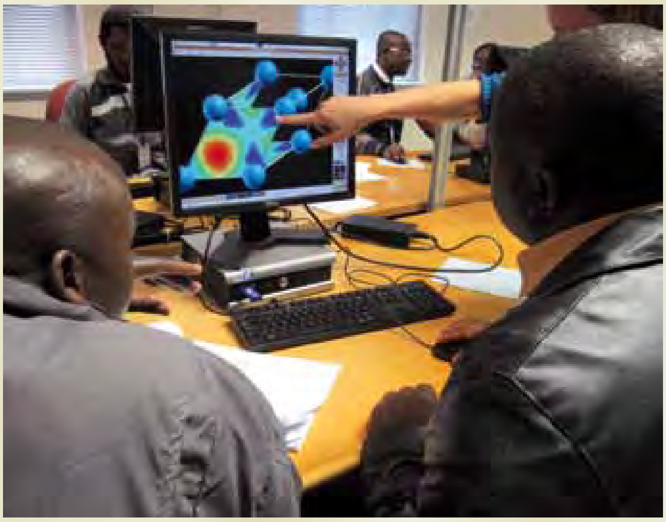
Commercial nanoscience-based solar cells already exist. They are embedded in tinted windows that help power lights in buildings. They line backpacks that let hikers recharge their cellphones. Such materials have enormous potential but many unresolved problems: their efficiencies are lower than those of traditional technologies. They also degrade in as little as two to three years.

Gebauer performs computer simulations of the electronic and structural properties of novel materials to guide experimentalists. Moreover, he has collaborated with others at ICTP to train researchers in developing countries to perform these calculations. The work is catching on in regions that receive abundant sunlight. In 2010, Gebauer and colleagues interfaced with an experimental group in Addis Ababa, Ethiopia, to hold a school on computational and materials science that featured applications for solar energy.

“We had some of the most famous experts in this field from the Europe and the United States,” Gebauer says. Ninety participants arrived from all parts of Ethiopia, Nigeria and South Africa. News of the school piqued the curiosity of the Ethiopian government and prompted an interested phone call to the organizers from the minister of science and technology.

Critical mass

Along with the school in Addis Ababa, Gebauer and colleagues at ICTP have organized a series of workshops in developing countries on computational nanoscience.



+ School participants learn computational nanoscience in Africa

Describing the properties of a novel material—its strength, optical spectrum, electron transport properties—can be done relatively cheaply with computers. What's more, junior researchers all over the world are familiar with computers and enjoy using them as a tool, says ICTP physicist Sandro Scandolo, one of the organizers.

Six years ago Scandolo, Gebauer, and Tosatti teamed up with their international colleagues to run schools on computational nanoscience in China, India, Nigeria, and South Africa. They have taught young researchers how to code and to use pre-packaged software. The students learned to set up and maintain computer clusters to solve their own research questions. They acquired a taste of what systems, nanoscale and beyond, could be pursued with these techniques. The team is now embarking on a string of five schools that will be held at different locations in Africa every two years.

"When you are organizing activities at ICTP, you can invite one or two scientists from a given group in a given country," Scandolo says. "We thought that by going there, we could be much more effective in convincing the local community to start as a group, to build a critical mass."

Among other things, the students learn how to use Quantum Espresso, a free suite of programs for modelling materials at the nanoscale. The software stretches limited computational resources by treating nuclei as classical objects and using approximations to describe the quantum mechanical behaviour of large systems of electrons. Scandolo, Gebauer, and many European and American collaborators developed the code over decades. Last year the group published an article summarizing the method and asked users to cite it in any resulting publications.

"It's already been cited around 150 times," Scandolo says. "I expect it will have a thousand citations quite soon."

The citations cluster in places where Scandolo and others organized schools. One of the schools, held in 2006 in Bangalore, India, resulted in a publication with all the participants as authors. The organizers selected a problem that required several independent calculations and distributed these among the students.

"If you squeeze carbon dioxide, you can turn it into structures that are similar to quartz," Scandolo says. Currently the solid is only stable at high pressures and reverts to molecular carbon dioxide under normal conditions. If the material could be engineered to remain solid at ambient pressure, it would be a lighter and stronger alternative for quartz. In hopes of finding a way to stabilize it, the students computationally tested different ways to dope the solid with silicon.

The work was instructive though none of the tested arrangements turned out to be stable at ambient pressure. Scandolo views it as a successful experiment in "parallel human computing."

"We merged everything together and discussed the results," he says. "Then we wrote the paper all together."

Efforts like these may help scientists become more visible in their home countries, Scandolo says.

"The governments are rich enough," Scandolo says. "Money is not the real issue. It's more to educate people, to help scientists convince their own policy makers to invest more in science and science education."

Early **Warning**

MALARIA PROJECT

ICTP MALARIA PROJECT ADDRESSES CLIMATE-HEALTH INTERACTIONS

ICTP is taking part in a newly-launched, major international, European Union-funded project to help fight malaria and other vector-borne illnesses by developing and deploying an early warning system for disease outbreaks in Africa.

The €3 million project, titled "Quantified Weather and Climate Impacts on Health in Developing Countries (QWeCI)", unites climate experts with health professionals to develop a computer model of climate and disease interactions that will aim to provide reliable forecasts of epidemic disease outbreaks. The forecasts would allow health workers and planners to react in a timely manner to reduce the severity of the outbreaks.

"The QWeCI project hopes to provide predictions of malaria several months ahead of current methods, giving countries affected by outbreaks ample time to implement disease-fighting strategies," said ICTP scientist Adrian Tompkins of the Centre's Earth System Physics section, who co-designed the project with the University of Liverpool.

Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected mosquitoes. It causes nearly one million deaths a year, mostly among African children. Climate plays a key role in how vector-borne diseases such as malaria and Rift Valley fever develop. The research aims to develop a better understanding of how climate change in Africa, including extreme events like droughts and floods, affects these vector-borne diseases.

Combining state-of-the-art models for climate and diseases, the EU project will develop an integrated decision support system that can present monthly, seasonal and decadal climate-health interactions to national health planners. "The system would be the cornerstone for health early-warning systems," said Tompkins.

An important and unique component of the project will be a pilot study in Malawi that will use a low-cost, wireless network developed by ICTP's Aeronomy and Radiopropagation Laboratory (ARPL), headed by Sandro Radicella, to collect and disseminate malaria outbreak information between remote health clinics and a central hospital. "QWeCI is the first project that will test the potential of this technology to centrally monitor disease and infection rates, as well as to disseminate health forecasts," said Radicella.

Research partners include:

- ICTP
- University of Liverpool (UK)
- Centre de Suivi Ecologique (Senegal)
- Consejo Superior de Investigaciones Científicas (Spain)
- European Centre for Medium-Range Weather Forecasts (UK)
- Fundació Privada Institut Català de Ciències del Clima (Spain)
- International Livestock Research Institute (Kenya)
- Institut Pasteur de Dakar (Senegal)
- Kwame Nkrumah University of Science and Technology (Ghana)
- Université Cheikh Anta Diop de Dakar (Senegal)
- University of Malawi (Polytechnic & College of Medicine)
- Universität zu Köln (Germany)
- University of Pretoria (South Africa).

Destination Laboratorio

TRIL PROVIDES FUNDING FOR SCIENTISTS TO SPEND UP TO A YEAR AT ITALIAN RESEARCH LABORATORIES

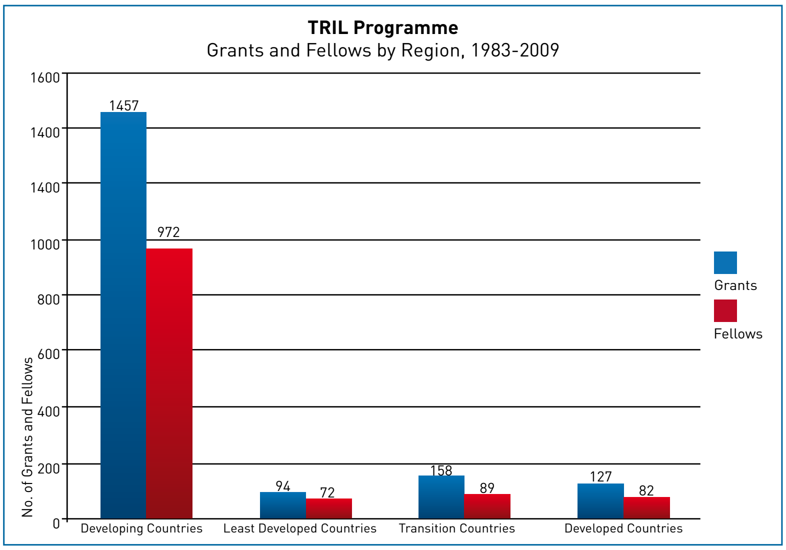
Since 1983, hundreds of researchers from developing countries have come to Italy for training in experimental physics, thanks to the ICTP Training and Research in Italian Laboratories programme (TRIL). The fellows focus on physics problems in condensed matter, energy, technology, the environment, or the living state.

"Experimental training is not a simple thing," says Daniele Treleani, the head of the TRIL programme. TRIL introduces scientists to top-notch facilities. From several months up to a year, they learn skills that can only be acquired through long-term active research. "It's really something valuable we are offering to people."

More than 1,200 fellows have now gained experimental fluency, made international connections and served as catalysts for research in their home countries. For instance, former TRIL fellow Teketel Yohannes Anshebo now leads a world-class research group at the University of Addis Ababa, Ethiopia, Treleani says. In May Anshebo co-directed the ICTP School in Addis Ababa on nanoscience for solar energy conversion.

TRIL

TRIL researchers and their homelands are not the only ones to benefit from the programme. The fellows have made valuable contributions to Italian science, appearing as authors of roughly 3,000 scientific articles during their training. This fact was not lost on their host institutions: The 400 participating laboratories have sponsored many of the fellows and have contributed more than 50% of the TRIL budget. The programme works hand-in-hand with laboratories to select roughly 70 fellows each year.



Some of the researchers strengthen Italy's links with developing countries while working abroad. One former TRIL fellow, Ivan Kostadinov, is now a researcher at ISAC-CNR in Bologna. He is leading an effort to build an environmental-monitoring station in the Accra Tema region of Ghana. The project originated when Samuel Sackey of Cape Coast University in Ghana visited ISAC on a TRIL fellowship (see next page). Now Sackey is again at ISAC to learn how to use the instrument, which was assembled by Kostadinov and his colleagues at ISAC. The station is slated to open in early 2011.

Physicists in developing countries face a number of problems, Treleani says, and TRIL does not try to provide whole-scale solutions. "We try to find some good cases that are worth helping," says Treleani. "The fundamental feature of ICTP is investing in people. That is the best investment."

The Abdus Salam
International Centre for Theoretical Physics

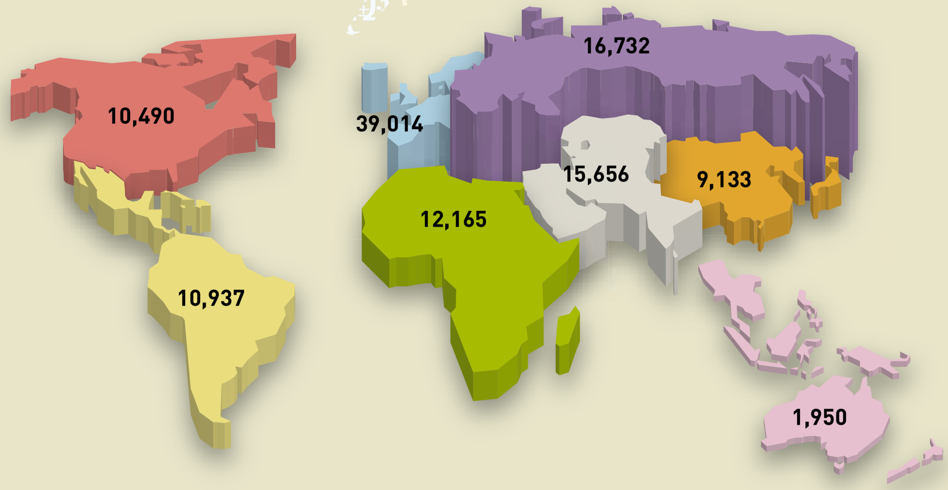
United Nations Educational, Scientific and Cultural Organization

IAEA
International Atomic Energy Agency

ICTP in Numbers 2009

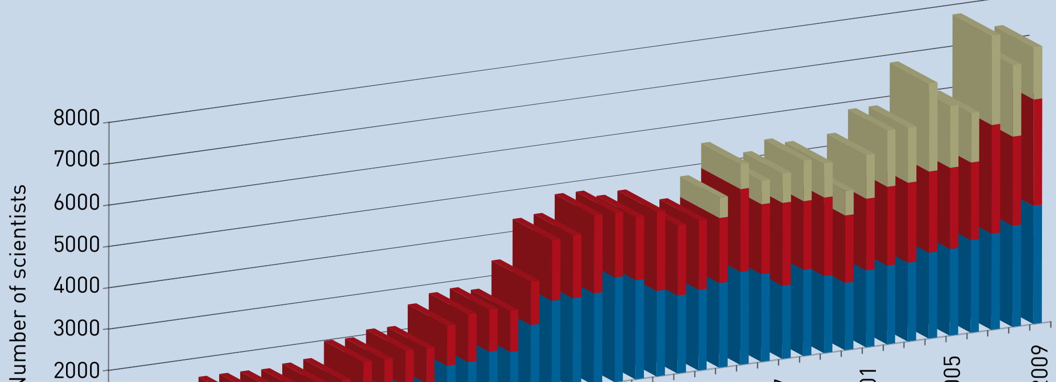
Where our visitors come from (1970-2009)

Since its inception, ICTP has received more than 116,000 visits from scientists representing 184 countries. About half of the scientists have come from the developing world, particularly India, China, Brazil, Argentina and Egypt. Least developed countries (LDCs) with the highest number of visitors include Bangladesh, Sudan, Ethiopia, Senegal and Nepal.

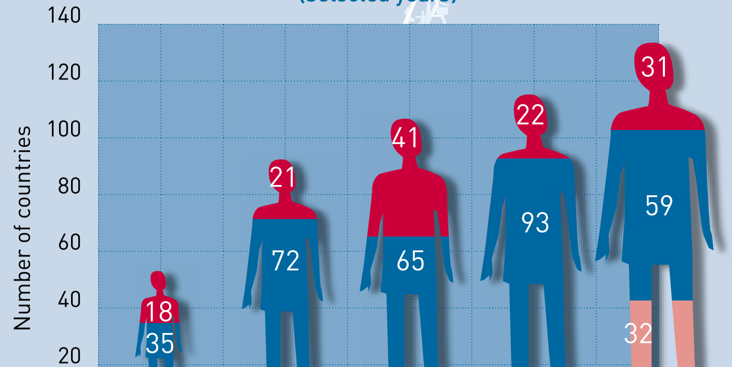


Trend of ICTP visitors by region, 1964-2009

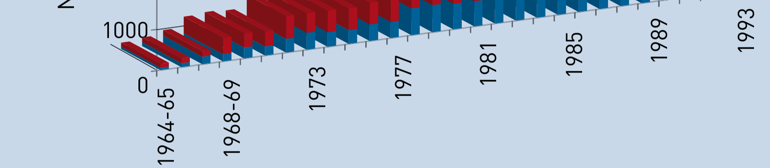
Number of Scientific Visitors, 1964-2009

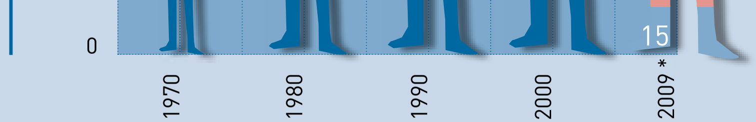


Number of Countries Represented
(selected years)



* As of 2008, countries are further categorized





as LDCs and transition countries

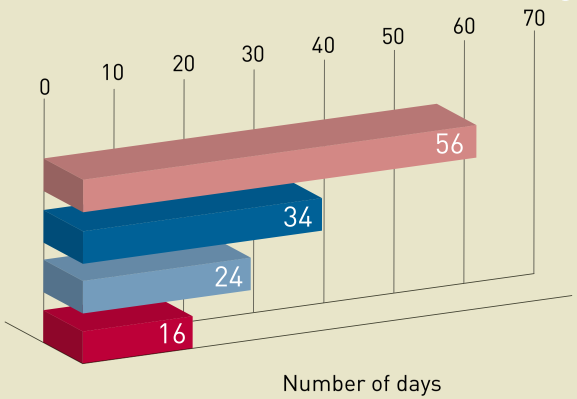
- Developing countries *
- Developed countries
- "Hosted activities"

* Includes Least Developed Countries (LDCs) and transition countries

In 1964, ICTP had 154 visitors from 40 countries. In 2009, it received 6,972 visitors from 137 countries. About 5,050 participated in ICTP regular scientific activities and 1,922 participated in activities organized by other institutions but hosted by ICTP. Forty-seven percent of the visitors came from developed countries while the remaining 53% came from developing countries, LDCs and transition countries.

Duration of visits

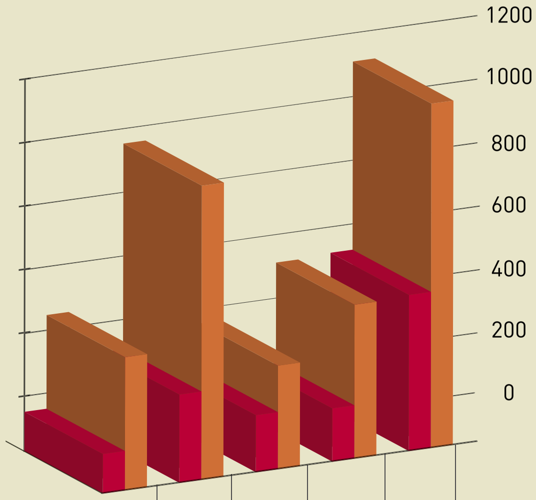
Of the 5,050 total short- and long -term visitors to ICTP in 2009, the average length of stay for ICTP visitors coming from LDCs, developing countries and transition countries was 56, 34 and 24 days respectively. Overall, the time spent by visitors from these regions represents 70% of the total. Visitors from developed countries spent an average 16 days at ICTP.



- LDCs
- Developing countries
- Transition countries
- Developed countries

ICTP training activities

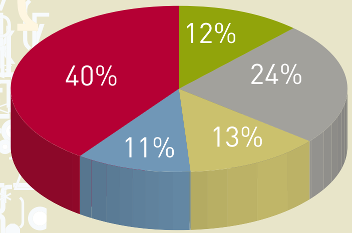
In 2009, ICTP organized 58 training activities related to its five main areas of research: High Energy, Cosmology and Astroparticle Physics (**HECAP**); Condensed Matter and Statistical Physics (**CMSP**); Mathematics (**Math**); Earth System Physics (**ESP**); and Applied Physics (**AP**). In total, ICTP provided 1,323 months of training to 3,412 course participants for an average length of stay of 12 days. In addition, 10 regional training activities were organized by ICTP and held in Africa, Asia, Europe and Latin America.



	HECAP	CMSP	Math	ESP	AP
Person-months	135	294	196	182	517
Participants	440	970	351	515	1136

Gender statistics

Globally, women account for slightly more than one quarter of researchers. Over the past nine years, the number of women participating in ICTP activities has increased steadily and now stands at 20 percent of the total number of visitors. In 2009, 128 female scientists came from Africa, 262 from Asia, 139 from Latin America, 122 from transition countries, and 424 from developed regions.



Region of Origin, Female Scientists at ICTP

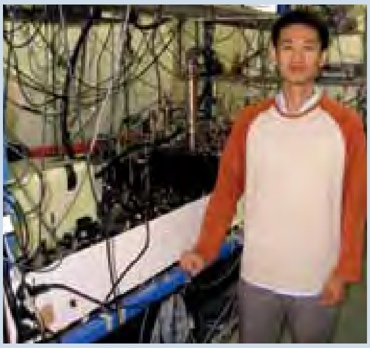
- Africa
- Asia
- Latin America
- Transition countries
- Developed countries

In their own words...

Sora Abdalah came to TRIL from the High Institute of Telecommunications, AlSalihiyah, Baghdad, Iraq. She is currently working with Tito Arecchi and Riccardo Meucci at the National Institute of Applied Optics in Florence.

"Many people (one of them my husband) encouraged me to contact this programme. They were right. I was surprised at the beginning because I got the TRIL support simply.

"I am doing research in laser nonlinear dynamics to simulate neural cells, in order to understand how we can make an artificial neural system using lasers and optoelectronic devices."



Wang Fu Yuan joined TRIL after completing his PhD at the Key Laboratory of Quantum Information at the University of Science and Technology in China. He is pursuing his training with Guglielmo Tino at the University of Florence.

"My current project involves measuring local gravity, which is similar to what Galileo did 400 years ago. The difference between Galileo's experiment and mine is I use cold atoms instead of a ball.

"After I got my PhD, I was looking for a postdoc position around the world. Finally, I contacted the advisor with whom I am working now. He told me he could employ me through the TRIL Programme. I have to say that I learned a lot during this year in my host lab."

Assefa Tadesse Abebaw, originally from Ethiopia, works under the supervision of Maria Peressi at the Department of Physics of the University of Trieste and collaborates with Fulvio Parmigiani at the Elettra Synchrotron Light Laboratory. He studies high temperature superconductors (cuprates) using time-resolved spectroscopy.

"My impression of TRIL is huge. A student like me from a rural part of Africa gets a quality education and meets people from different parts of the world, which brings me one step closer to the career that I want to achieve.

"Apart from academics, the benefit of this programme is that by studying and working with native students there is also a chance to learn the culture of Italy."

Samuel Sackey became a TRIL fellow after working at the University of Cape Coast in Ghana. He joined the team of Giorgio Giovanelli at ISAC in Bologna.

"Through this programme I have been trained in the use and operation of a Differential Optical Absorption Spectroscopy system. One of such systems has been donated and currently installed and outfitted in a heavy industrial area in Tema, Ghana. With this system we are now able to achieve real-time measurements of atmospheric pollutants like NO_2, SO_2 and O_3 that play important roles in the chemical dynamics of the atmosphere.

"After a brief interaction with Daniele Treleani, I was surprised and impressed at his level of dedication and commitment to my training programme. A similar level of dedication is exhibited by the head of my host laboratory, Giorgio Giovanelli, and his dedicated team of researchers."

Climate
Past and Present

ICTP PRIZE WINNER MARCELO BARREIRO DISCUSSES EARTH'S CLIMATE HISTORY

Marcelo Barreiro, a young climate scientist from Uruguay whose research interests range from paleoclimates to ocean-atmosphere interactions, was honoured at a ceremony at ICTP in June as the recipient of the 2009 ICTP Prize.

"I am humbled by the receipt of this prize. I first visited ICTP 10 years ago, thanks to funding from the Centre, which makes it easy for scientists from developing countries to visit Trieste," said Barreiro.

Barreiro, who is an associate professor and head of the Atmospheric Sciences Unit, School of Sciences, Universidad de la República in Uruguay, won the ICTP Prize in recognition of his "contributions in the field of tropical Atlantic variability, and the exploration of dynamical mechanisms to explain the paleoclimatic record in the last few million years". The results of his investigations have important implications for seasonal forecasting and the climate change debate.

ICTP PRIZE

Barreiro has been a speaker at ICTP training activities in the field of the physics of weather and climate since 2005. While he was in Trieste to collect his award, *News from ICTP* spoke to him about his climate research.

How can the study of past climates be useful for current and future climate studies?

In order to know what is going to happen in the future, you need to know what other kinds of climate the Earth can support. The only way to do so is to look at past records.

Looking at past climate is also particularly important for testing models, because in order to use climate models to make projections for future climate you need to see if the models can produce something besides the present climate. Past climate is perfect for that.

The mid-Pliocene (about 3 million years ago) is particularly interesting, because the geographical distribution of the continents was the same as now, the estimates of CO_2 concentrations were very similar to current levels, and it is thought of as a potential analogue for future climate at the end of the 21st century. Thus, understanding how the Pliocene climate came about may give clues about the evolution of the present climate.

You list as a research interest the role of the oceans in past climates. What were the ocean circulations doing in the past?

We don't really know yet, and that is one reason to study past climates. For example, during the Pliocene, what did the tropical circulation look like? In the mid-Pliocene, the equatorial cold tongue in the Pacific was absent (the so-called 'permanent El Niño' state), which means that the tropical circulation was much different than today's. How can you sustain a world like this? That is the question we are trying to address. The thermohaline circulation has definitely changed over time: it has been weaker and stronger during glacial and interglacial climates, but we still don't know if the changes are a consequence or a cause of climate change. It is likely that changes in the atmosphere caused changes in the ocean circulation, which in turn influenced the atmosphere.

Is there the possibility of a 'permanent El Niño' as a future climate scenario? What would be the causes and its consequences?

Again, this is where a study of past climates can help with future climates.

Due to what we know about ocean currents during the mid-Pliocene, there was possibly a permanent El Niño. However, IPCC models cannot reproduce these conditions, so the idea of a permanent El Niño is still controversial.

How can seasonal forecasting be improved, and what are the limits of its predictability?

Seasonal predictions would be improved if we could go beyond the El Niño view. There has been a lot of research on El Niño in the past 20 years: there are buoy systems monitoring the equatorial Pacific, and there is something like that in the Atlantic and Indian Oceans too, but the focus has been largely on the Pacific.

We need better monitoring of the tropical Atlantic and Indian Oceans, because we have found that for the countries bordering the tropical Atlantic, the El Niño signal is moderated by what the tropical Atlantic does, so, depending on the state of the tropical Atlantic, the El Niño effect on the climate can be large or small. We need to have a model that takes into account predictions for the tropical Pacific as well as the tropical Atlantic and Indian Oceans.

In the Pacific, climate is really dominated by one thing: El Niño. In the tropical Atlantic and Indian Oceans there are many processes going on at the same time, and that makes predictions for these areas much more complicated.

There is a limit to climate predictability. The variability of, say, precipitation can be considered as coming from two sources: one is the forcing by the tropical oceans—a predictable part—and another is the internal atmosphere variability, which is the part that cannot be predicted beyond a 10-day time scale. So if internal atmosphere variability is too large, it is hard to predict much on seasonal time scales. But for a location like Uruguay, the influence of El Niño can be a good thing, because it allows us to have some predictive power. If there were no El Niño, the predictability of the climate in many regions of the world would suffer a lot. We would still have the signal from the other tropical oceans but they are smaller. So, El Niño helps in predictions. As I said before, however, it is not enough to consider El Niño in order to make successful seasonal climate predictions.

What advice can you give to scientists from developing countries where limited opportunities/research infrastructure may prevent them from contributing significantly to solutions of important problems?

I would encourage them to take as many opportunities as the world can offer. If you are a student and are offered an opportunity to go somewhere, go! But then come back! Likely, it is in your own country where you can make the largest contribution.

I returned after eight years away from Uruguay. However, I understand why people might not want to go back; returning depends very much on the conditions in your country. The one thing that makes it easier today is that collaboration is much easier than before. So, if you go out to the developed world and then return to your home country, you are probably going to maintain your ties at home and away. You definitely can continue to work on important problems if you continue to collaborate with people outside.

The main issue is not necessarily collaborating with the developed world to solve problems, but to develop a critical mass of people working on them. They can be from your own country or from outside. Doing it alone these days is very difficult. In developing countries, there are usually very few people in the same research area as you are, so you really need to go beyond your borders and collaborate with people of the region or wherever they are. That, to me, is the only requirement for working on an important problem.

Lastly, one must not forget that the importance of a problem depends very much on where you are. Thus, the important problems for the developed world may not be the same as for developing countries.

Walking in the Mathematical Garden

ERNESTO LUPERCIO RECEIVES THE 2009 RAMANUJAN PRIZE

Days before his fortieth birthday, Ernesto Lupercio arrived at ICTP to accept the 2009 Ramanujan Prize for Young Mathematicians from Developing Countries. The gregarious and energetic researcher is known for his outstanding contributions to mathematical physics, geometry, and algebraic topology, and for cultivating mathematics in Mexico. He is a researcher at the Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional in Mexico City (CINVESTAV).

"I have enormous respect for the other winners of the Ramanujan Prize and could not have possibly imagined something like this happening to me," Lupercio says. "This is also a prize for Mexican mathematics, which has come a long way since its inception."

RAMANUJAN PRIZE

Lupercio names dozens of colleagues from all over the world who have influenced his work and has a notable talent for starting collaborations.

"He is really making a difference in the Mexican mathematics community," says José Seade, a mathematician at the Universidad Nacional Autónoma de Mexico in Cuernavaca, Mexico, who is currently visiting ICTP. "He has changed the face of mathematics in our country."

Like many researchers from developing countries, Lupercio earned his doctorate abroad, at Stanford University in 1997. He was a postdoctoral fellow at the Max-Planck-Institut für Mathematik in Bonn, Germany, and then continued his professional career in the United States. But he returned to Mexico in 2003 for a position at CINVESTAV.

"We are at a breaking point in Mexican mathematics, where a student can do serious PhD work here in Mexico without having to leave the country," Lupercio says. "I have several students graduating in the next four months and I believe their thesis work is as good as that from Stanford or Berkeley."

Lupercio's research revolves around the properties of spaces. Among other accomplishments, he helped lay the foundations of the theory of gerbes over orbifolds. His recent work with young mathematicians introduced the concept of loop orbifolds. The research incorporates ideas of leading theorists such as Edward Witten, Dennis Sullivan, and Maxim Kontsevich, according to Seade.

Lupercio's work interacts with diverse subjects from quantum field theory and string theory to economics. He finds it deeply meaningful that mathematics has implications for the physical world.

"We humans somehow are lucky enough to walk in the mathematical garden and look at these objects," Lupercio says. He says he feels astonished that "the walk in the mathematical garden has anything to do with a walk in physical reality."

Yet advances in mathematics do often drive technological progress and benefit society. This link should not go unnoticed by the governments of developing countries, says Seade, adding that funding for mathematics is still scarce in many places. The US$15,000 component of the Ramanujan Prize can be a vital contribution toward research.

Cosmic Cultures

ICTP CO-HOSTS ROMANIAN "CARPATHIAN SUMMER SCHOOL OF PHYSICS 2010"

"We are all made of star stuff"— Carl Sagan

The above aphorism applies well to the recent Carpathian Summer School of Physics 2010 "From Nuclei to Stars," held in Romania. The school was conducted collectively by the Cyclotron Institute, Texas A&M University, National Institute for Physics and Nuclear Engineering, "Horia Hulubei" Foundation, and ICTP-Romania, a regional centre of ICTP, from 20 June until 3 July.

The range of topics for this summer school was carefully chosen, giving considerable thought to the fields of science most practiced in Romania and covered at ICTP. Physicist Alexei Smirnov from ICTP's High Energy, Cosmology and Astroparticle Physics section was one of the directors of the school, who, along with the other directors, set up a way to meld the variety of topics that the workshop covered, ranging from nuclear physics and particle physics to astrophysics and cosmology. Both the theoretical and experimental aspects were covered during the two-week school.

CARPATHIAN SCHOOL

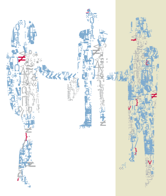
The profile of the course underwent a considerable revision this year, with week one at a basic level and week two at an advanced level. The first week saw 2-4 hour lectures being held to familiarize young researchers to various vistas in the field. During the second week, 50 experts from all over the world lectured at a much more advanced level, drawing on the topics introduced the previous week. Smirnov himself conducted two introductory lectures on the basics of neutrino properties and their propagation. The organizers also brought together a number of top level experts in the fields of solar neutrinos, solar nuclear reactions, nucleosynthesis and the life-cycle of stars covering the spectrum of the "From Nuclei to Stars" banner. Preliminary experimental results from numerous experiments and facilities were discussed; for example first results from detectors like the IceCube Neutrino Observatory were examined.

Two special features of this school included a one-day workshop conducted during the second week that covered the future of large-scale structures in Europe like the LAGUNA detectors, as well as a round-table outreach session that discussed the highly engaging topic of "Science and Society—Do (All) Countries Need Science?" This was attended by some government science representatives as well as the local press. Ways and means of developing science in Romania and catalyzing further participation in European science ventures were debated. Participants agreed that levels of research and technical and financial capabilities differ, so even people from the developing world must be given a chance.

Capability and scientific literacy have no geographical boundaries. "Things are changing. We have big science experiments now, like the Large Hadron Collider at CERN, unlike the table top experiments of the past," says Smirnov, adding, "Science is an element of culture. People who do research should promote science as it is the way to civilized progress."

Smirnov recalls that toward the end of the debate, a student came up to the speakers and showed them some simulations that he ran, of cascading neutrino particles for the area where they were seated during the talk!

About 70 students and 50 researchers attended the conference over the two weeks. The students were pleased with the chance to mingle with the best of the best from their chosen field.



Research News Briefs

BUSINESS 101

ICTP promoting technology transfer in developing countries

ICTP is helping physicists and engineers from developing countries to commercialize their scientific inventions.

The Centre hosted a workshop from 3 to 7 May on "Entrepreneurship for Physicists and Engineers from Developing Countries".

"Scientists working in universities and scientific institutions in the West are well-versed in technology transfer techniques, but their colleagues in the developing world lack the knowledge to bring their inventions to the market," said workshop organizer Joseph Niemela of ICTP.

RESEARCH

Niemela explained that the workshop introduced these scientists and engineers to the process of innovation, generation and protection of intellectual property, technology transfer and commercialization of inventions. From financing to marketing, participants learned the basic skills they need to create a business plan and how to sell that plan to potential investors.

A panel of experts at the workshop provided valuable feedback on the participants' plans, bringing them one step closer to entering the marketplace. The workshop included a trip to Trieste's Area Science Park, where participants heard testimonials from several start-up companies there •

NORTH AFRICA EARTHQUAKE HAZARDS

ICTP workshop trains young scientists in quake monitoring, assessment techniques

ICTP's recent Algerian workshop on earthquake hazards got off to a shaky start, according to organizer Abdelkrim Aoudia of the Centre's Earth System Physics section.

"A 5.2 earthquake struck during our opening talks," said Aoudia, explaining that the temblor occurred in the south of the country but could be felt in Algiers, where ICTP sponsored the conference on "Geophysics, Geodesy and Tectonics of the North Africa Plate Boundary for Better Earthquake and Tsunami Hazard Assessments".

Aoudia said that the coincidental quake, which killed two people (non-conference participants), was centred in an area of Algeria for which researchers have no geophysical data, making it impossible for the country to predict or prepare for earthquakes in that region. "That was the main point of our workshop: to highlight the importance of using satellite data and computer models as tools to assess the risks of seismic and tsunami hazards," explained Aoudia.

Countries in northern Africa sit on the boundary of the African tectonic plate and are at high risk of not only earthquakes but also tsunamis. Indeed, in the past few decades northern Africa has experienced unprecedented seismic activity, prompting scientists and local communities to focus attention on geo-hazards in the region. "All major cities in northern Africa are built on a major thrust fault that has a strong potential for a magnitude 7.5 earthquake, even stronger than the 7.0 one that struck Haiti," said Aoudia, adding that the loss of life in these cities could be in the hundreds of thousands.

ICTP is helping north African countries by training young scientists in the physics of earthquakes, faults and tsunamis, as well as in techniques to analyze satellite data and use computer modelling to assess hazards. The ICTP workshop, which ran from 15 to 21 May, offered educational lessons and hands-on training. Also conducted was an international conference addressing research related to the North Africa boundary, ranging from basic research to applied and pragmatic solutions.

"The purpose of the workshop was to train young scientists in estimating the probability of an earthquake occurrence in a given time period, as well as in intensity and area of impact," said Aoudia. He said the nearly 200 conference participants also discussed early warning systems for tsunamis and the need to educate the public on how to respond to hazard warnings.

In addition to organizing conferences on the topic, ICTP is establishing an African PhD programme in geo-hazards, to be based at Addis Ababa University, as a successful outcome of an earlier workshop that focussed on geo-hazards in east Africa. The objectives of the PhD programme are to provide specialized high-level doctoral training to African candidates and others, with international standards in the fields of seismology, volcanology and geochemistry.

ICTP plans to have a workshop on the Haiti earthquake in January 2011 •

SATELLITE NAVIGATION FOR AFRICA

Annual workshop for developing countries now in second year

ICTP's "Second Workshop on Satellite Navigation Science and Technology for Africa" took place from 6 to 23 April in Trieste.

Over the course of their training, the students—who represent 18 different countries—were taught by international experts in global navigation satellite systems (GNSS) on topics ranging from global positioning systems to navigation and robotics.

For the latter topic, participants built Lego Mindstorm robots "as a prelude to learning about autonomous navigation," said Patricia Doherty of Boston College, who co-directed the workshop with ICTP's Sandro Radicella. Doherty explained, "Participants will take the robot kits back to their home countries and donate them to elementary and high school students."

The workshop also included sessions on space weather and ionospheric research in an effort to initiate space science research programmes in African universities, and support existing groups in the field.

Global navigation satellite systems provide an enabling technology that can make major contributions to economic growth and societal betterment worldwide. "The educational programme of the workshop, as in 2009, prepares a future workforce knowledgeable of GNSS that can sustain this revolutionizing science and technology in Africa," said Radicella •

ASTROPHYSICS IN *NATURE*

Former ICTP Diploma student is 1st author of *Nature* paper

An analysis of more than 70,000 galaxies by University of California, Berkeley, University of Zurich and Princeton University physicists demonstrates that the universe—at least up to a distance of 3.5 billion light years from Earth—plays by the rules set out 95 years ago by Albert Einstein in his General Theory of Relativity.

The research was published in the 11 March issue of the journal *Nature*, and former ICTP Diploma student Reinabelle Reyes (now a Princeton University graduate student) is the first author. Among the other authors is Uros Seljak, an astrophysics professor at the University of California, Berkeley who was a scientist with ICTP's High Energy Physics section from 2004 until 2006.

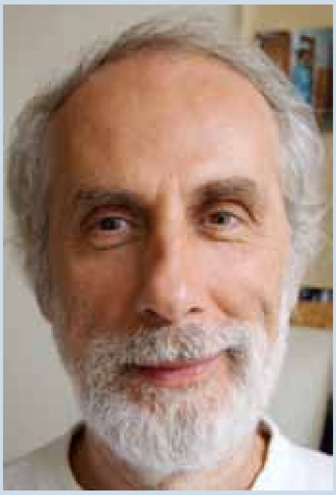
By calculating the clustering of these galaxies and analyzing their velocities and distortion from intervening material, the researchers have shown that Einstein's theory explains the nearby universe better than alternative theories of gravity. One major implication of the new study is that the existence of dark matter is the most likely explanation for the observation that galaxies and galaxy clusters move as if under the influence of some unseen mass, in addition to the stars astronomers observe.

The title of the paper is "Confirmation of general relativity on large scales from weak lensing and galaxy velocities"

ICTP SCIENTIST HONOURED

Particle physics festival celebrates Goran Senjanovic

A four-day conference titled "A Look from the Past into the Future of Particle Physics: GoranFest" was held in June in Split, Croatia, to celebrate ICTP high energy physicist Goran Senjanovic's 60th birthday. Under the motto "The Joy of Making Physics", the conference aimed at highlighting Senjanovic's outstanding contributions to physics, taking the occasion for a wider view on the status of particle physics and looking to its future.



Some of the most eminent names in high energy physics, such as G. Dvali, R.N. Mohapatra, K.S. Babu, S. Barr, T. Han, A. Romanino, and F. Vissani participated in the meeting, along with well known physicists from around the world, such as C.S. Aulakh from India, I. Picek from Croatia, B. Bajc and S. Fajfer from Slovenia, T.C. Yuan from Taiwan, T. Schwetz from Germany, C.S. Lim from Japan, and S. Gninenko from Russia. Together with a number of international young scientists, they created a healthy atmosphere of lively discussions and heated debates. Topics included left-right symmetry, neutrino mass, Grand Unification, supersymmetry, the origin of CP violation, and lepton number and flavor violation. Their contributions are available on the conference website at www.sissa.it/goranfest.

In the 35 years of his career, Goran Senjanovic has been a leading figure in theoretical ideas that go beyond the currently accepted theory of elementary particles and their forces. Senjanovic is a co-inventor of the 'seesaw' mechanism, which explains why neutrinos should have masses, and why they are so tiny. He is also well known for his pioneering work on left-right symmetric models, which provide an explanation for the maximal parity violation of the Standard Model. His papers with Rabi Mohapatra on this subject are considered a milestone, having achieved thousands of citations, and in recent years one of them became the most cited paper by the Hep-ph arXiv.

Senjanovic is also a prominent figure in the field of Grand Unified Theories, and has served as its spokesperson over the years. In 1981, together with William Marciano, he wrote a now-famous paper in which unification was shown to be a natural effect of the existence of supersymmetry and predicted that for unification to take place, the top quark mass had to be near to its now known value, contrary to the conventional wisdom of that era. His other notable achievements include his work with W.Y. Keung that suggested a possibility for observing lepton number violation at colliders, today a paradigm for such processes at the Large Hadron Collider at CERN.

Over his lifetime of service, he has mentored a large number of students. Especially noteworthy is his contribution in identifying and mentoring young talents from the developing world through his work at ICTP, developing them towards successful scientific careers.

The GoranFest was hosted by the University of Split and held at Palazzo Milesi, a Renaissance palace in the historical centre of Split, home to the Croatian Academy of Sciences and Arts

ICTP News Briefs

ICTP AFTER 45

ICTP to host anniversary event

For more than 45 years, ICTP has provided scientists from developing countries with opportunities to conduct research and to study the latest advances in physics and mathematics.

With its new leadership, and in light of rapid economic and technological developments taking place worldwide, the Centre is poised to update its strategic vision for the decades ahead. While its core mission—to support excellence in science, paying special attention to the needs of developing countries—will remain, ICTP recognizes the need to evolve in order to meet the challenges of a rapidly changing, international scientific landscape.

ICTP will examine its new mandate during a three-day conference titled “ICTP after 45: Science and Development for a Changing World”. The event, scheduled for 8 to 10 November, will gather prominent scientists and policymakers together to discuss the following:

- The future of fundamental science (with presentations by ICTP Dirac Medallists and other prominent scientists)
- The role of basic science in the developing world
- How to foster the advancement of science within a new geopolitical framework (with a focus on emerging and least-developed countries)

NEWS

ICTP Director Fernando Quevedo will present highlights of ICTP’s new, five-year strategic plan •

NEW SCIENTIFIC COUNCIL MEMBERS

Science strategists join ICTP governing body

The ICTP Scientific Council has welcomed eight new members, all renowned in their fields, to replace six who have left its ranks. Joining the council are theoretical physicist Edouard Brezin of the Laboratoire de Physique Theorique de l’ENS; environmental engineer Elfatih A. B. Eltahir of the Massachusetts Institute of Technology; theoretical physicist Renata Kallosh of Stanford University; theoretical physicist Juan M. Maldacena of the Institute for Advanced Study in Princeton; mathematician M.S. Narasimhan of the TIFR Centre for Applicable Mathematics; computational scientist Michele Parrinello of ETH Zurich; theoretical physicist Valeri A. Rubakov of the Russian Academy of Sciences Institute for Nuclear Research; and mathematician Gang Tian of Princeton University •

INDIAN STRING THEORIST RECEIVES 2010 ICTP PRIZE

TIFR scientist recognized for work on string and field theories

ICTP has awarded its 2010 ICTP Prize to Shiraz Minwalla, a string theorist at the Tata Institute of Fundamental Research (TIFR) in Mumbai, India.

The ICTP Prize recognizes Minwalla's influential work in string theory, which attempts to provide a unified and consistent description of the fundamental structure of the universe, based on the idea that particles are made of vibrating strings.

As a researcher and faculty member at Harvard University, the Indian Institute of Technology (IIT) and, most recently, TIFR, Minwalla has won numerous fellowships and awards, including an Alfred P. Sloan Fellowship, a National Science Foundation Presidential Career Fellowship, and a Swarnajayanti Fellowship from the Government of India. His papers have generated numerous citations. In 2008 he taught a course on "Fluid Dynamics from Gravity" at ICTP; that same year, Minwalla was elected as a Young Affiliate of The Academy of Sciences for the Developing World (TWAS).

Minwalla received a PhD in physics from Princeton University, and a master's in physics from IIT.

ICTP's Scientific Council created the ICTP Prize in 1982. It recognizes young scientists (under 40) from developing countries who work and live in those countries and who have made outstanding and original contributions in physics or mathematics. The Prize includes a sculpture, a certificate and a cash award of €3,000.

The 2010 ICTP Prize is named in honour of Nicola Cabibbo, one of the greatest theoretical high energy physicists. Cabibbo was a key player in ICTP since its early days and was chair of the ICTP Scientific Council.

To view the full citation of Minwalla's award, as well as a list of past winners, please see prizes.ictp.it/Prize •

ICTP BUILDING DEDICATION

Trieste institutes celebrate joint purchase of MLab building

The building that is home to ICTP's Multidisciplinary Laboratory (MLab) was formally dedicated on 2 March in a ceremony attended by top representatives of Trieste's research and educational institutes, as well as local and regional officials.

The building, which was owned by the Municipality of Trieste and originally housed a primary school, was recently purchased by the University of Trieste, with financial assistance from ICTP, the Fondazione CRTrieste, and the Consorzio per la Fisica di Trieste. Prior to the purchase, the Consorzio had rented the building from the Municipality and had ICTP, INFN and SISSA (International School for Advanced Studies) sharing the space. The Consorzio played an important role in negotiations for the purchase.

"The new purchase ensures that the building will remain a facility devoted to science," said Consorzio President GianCarlo Ghirardi in remarks during the ceremony.

ICTP's MLab hosts activities that promote interdisciplinary experiments and applied physics. The Laboratory collaborates with local as well as international research institutes in offering hands-on education for scientists from developing countries. Laboratories based here include:

- ICTP-Italian National Institute of Nuclear Physics (INFN) Microprocessor Laboratory
- Plasma Focus Laboratory
- Imaging Laboratory
- Accelerator Mass Spectrometry

For more details about the MLab, please visit mlab.ictp.it •

COLLOQUIUM SERIES

New lectures promote interdisciplinary physics

ICTP has inaugurated a new colloquium series that aims to increase interaction between its research groups as well as expose doctoral students to the Centre's rich array of physics and mathematics activities.

"The idea for the colloquia came out of a brainstorming session amongst ICTP scientists," explained Director Fernando Quevedo in opening remarks during the premier lecture, which was held on 11 March. ICTP scientists from each of the Centre's research areas will participate as speakers. "We hope the talks will inspire cross-discipline research. The colloquia also are meant to be an educational tool for ICTP's Diploma students," said Quevedo.

Quevedo, a theoretical particle physicist with wide-ranging research interests in string theory, phenomenology and cosmology, presented the first colloquium, titled "String Theory and the Real World?"

Future colloquia will be held once a month. ICTP's Antonello Scardicchio of the Condensed Matter section and Bobby Acharya of the High Energy section are the series' organizers •

ICTP IN SPACE

European Space Agency adopts Centre's ionospheric model

The European Space Agency (ESA) has added ICTP's ionospheric modelling system NeQuick 2 to its Space Environment Information System (SPENVIS), making the model widely available to space engineers and scientists.

Spacecraft experience numerous problems as a result of encounters with the space environment. SPENVIS is an internet-based, user-friendly interface to models of the space environment and its effects, including cosmic rays, natural radiation belts, solar energetic particles, plasmas, gases, and micro-particles.

NEWS

NeQuick 2, a computer model developed by ICTP's Aeronomy and Radiopropagation Laboratory in collaboration with the Institute for Geophysics, Astrophysics and Meteorology of the University of Graz in Austria, provides 3D views of electron density in the Earth's ionosphere.

NeQuick 2 is particularly suitable for the trans-ionospheric propagation of radiowaves and has been recommended by the International Telecommunication Union for the assessment of ionospheric effects in global navigation satellite systems (GNSS) and telecommunication satellite operations.

NeQuick also has been adopted by the Galileo satellite programme to be used for ionospheric corrections in range measurements. The Galileo programme is Europe's initiative for a state-of-the-art GNSS, providing a highly accurate, guaranteed global positioning service under civilian control •

ICTP AND NUCLEAR SECURITY

Centre, IAEA to establish school of nuclear security for developing countries

ICTP and its UN partner the International Atomic Energy Agency (IAEA) have announced plans to hold an "International School on Nuclear Security" at the Centre's Trieste campus next year.

The announcement comes on the heels of US President Obama's Nuclear Summit, where a number of nations pledged their support to strengthen global nuclear security. Italy, ICTP's chief sponsor, included the Trieste school amongst its nuclear security action plans.

The ICTP-IAEA International School on Nuclear Security will train nuclear personnel from developing countries, providing them with the knowledge they need to meet obligations under the international nuclear security legal framework. Participants will learn how to identify and remedy threats against nuclear security by using radiation detection strategies and advanced isotopic analysis. They will also learn how to respond to incidents involving nuclear and other radioactive material.

"Nuclear security experts and scientists can play an essential role in fostering national nuclear security cultures and creating awareness of the need for nuclear security at the national level," said ICTP Director Fernando Quevedo.

ICTP actively supports a number of educational activities geared towards building competence in developing countries. It currently hosts several IAEA schools, such as the School of Nuclear Knowledge Management, which has been successfully conducted at ICTP for the past six years.

ICTP's Assistant Director Claudio Tuniz, who organizes the joint ICTP/IAEA schools, explained that the new International School on Nuclear Security will complement these efforts, but will be more focussed in scope and geared towards building competence in nuclear security in developing countries. "Cooperation between the IAEA and ICTP in this subject area will break new ground and will hopefully form the base for future developments," he said •

ICTP HIGHLIGHTS OF 2009

Report summarizing Centre achievements now available

ICTP's *Summary of Activities 2009*, a report highlighting important milestones and achievements reached during 2009, is now available. Once again, users can choose from two different formats to view the document:

- Online PDF
- Paper copy (contact the Public Information Office at pio@ictp.it for delivery).

A more detailed, *Full Technical Report*, is available on a CD attached to the printed annual report, or as an online PDF.

To download the reports, go to:

http://pio.ictp.it/words/annual-report-archive/annualreport.html •

WEBCASTING GRANT ANNOUNCED

Support provided for educational webcasting in developing countries

ICTP's Science Dissemination Unit (SDU) congratulates the winners of its first grant programme "International Academic Webcasting Grant for Developing Countries Using openEyA". The grants support the automated production of on-line scientific content (via "webinars") and e-learning and distance education (via web lectures).

The grant is meant to contribute to capacity building and development by implementing academic webcasting using openEyA. The grantees have agreed to publish recorded lectures on the web and distribute them freely in digital form for educational purposes.

The four winners, selected from a total of 100 grant submissions, received a complete set of the openEyA recording system (worth about €650), including all necessary hardware and software.

The four grantees are:

- E-Learning Unit, Institute of Adult and Continuing Education, Makerere University, Uganda
- Department of Atmospheric and Oceanic Sciences, School of Sciences, University of Buenos Aires, Argentina
- Department of Mathematics, University of Valparaiso, Chile
- Department for Open Distance Learning, University of Bucharest, Romania

For more details about openEyA, visit the website at www.openeya.org •

ICTP ON FACEBOOK

Official Centre fan page goes online

Don't lose touch with the Centre! The official Facebook Fan Page of ICTP is now operational. Visit us on Facebook at "ICTP Official Fan Page" to receive updates on workshops, symposia and other events. See what's happening at the frontiers of theoretical physics and mathematics. See who is visiting us in beautiful Trieste. Participate in discussions with fans, visitors, staff, and alumni. Ask questions. Post photos. Tell your friends •

IN MEMORIAM

Nicola Cabibbo

1935 - 2010

As *News from ICTP* was going to press, we received the sad news that Scientific Council Chair Nicola Cabibbo had died on 16 August. A leading theoretical physicist at the University of Rome "La Sapienza", Cabibbo was actively involved with ICTP for many years, presenting at conferences and helping with the Centre's strategy as the Italian government's representative to ICTP, a member of the ICTP Scientific Council since 1997, and then as its chair since 2006.

ICTP Director Fernando Quevedo, who had contacted Cabibbo on 8 August to personally notify him of the Dirac award, said that the news had come as a pleasant surprise to Cabibbo. "He was very happy to receive the award and to share it with George Sudarshan," said Quevedo, adding that for both winners the award was recognition long overdue.

News from ICTP will publish a detailed memoriam about Cabibbo in its next edition •

Jan S. Nilsson

1932 - 2010

Jan S. Nilsson was head of ICTP's Office of External Activities from 1985 to 1988, and a former member of the Centre's Scientific Council from 1996 to 2003. He attended the first workshop at Miramare, Trieste that preceded the founding of ICTP in 1964. He was an associate fellow of The Academy of Sciences for the Developing World (TWAS), as well as president of the International Union of Pure and Applied Physics (IUPAP).

One of Sweden's leading physicists, Nilsson was a professor of mathematical physics at Chalmers University of Technology, the dean of the Faculty of Mathematics at the University of Gothenburg, and for six years rector at the same university.

In addition, Nilsson was president of the board of directors of the Wallenberg Foundation, which is Sweden's largest private funding agency for research and advanced scientific equipment •

UPCOMING SCIENTIFIC ACTIVITIES

For more details, visit the ICTP web page: http://calendar.ictp.it/2010/

11-15 October
Conference on Molecular Aspects of Cell Biology: A Perspective from Computational Physics

18-27 October
Advanced School on Complexity, Adaptation and Emergence in Marine Ecosystems

18-29 October
International Advanced School on Space Weather Modelling and Applications

2-5 November
Workshop on Mobile Science: Sensing, Computing and Dissemination

8-10 November
ICTP After 45: Science and Development for a Changing World

8-12 November
Joint ICTP-IAEA Workshop on Nuclear Data for Science and Technology: Analytical Applications

8-26 November
Joint ICTP-IAEA School of Nuclear Energy Management

15-21 November
School and Workshop on D-brane Instantons, Wall Crossing and Microstate Counting

15-26 November
Joint ICTP-IAEA Workshop on Dense Magnetized Plasma and Plasma Diagnostics

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