



NEWS *from* ICTP



the
abdus salam
international centre for theoretical physics



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Entanglement and Encryption

Entanglement is something that you might want to avoid—except, of course, if you're a theoretical physicist. Austrian-born Erwin Schrödinger, who in 1933 shared the Nobel Prize with Paul Dirac, cited *Verschränkung* (German for entanglement) "as the most characteristic trait of quantum mechanics, the one characteristic that enforces its entire departure from classical line of thoughts."



GianCarlo Ghirardi

What is entanglement? It's a phenomenon in quantum mechanics by which an individual particle or system does not have a precise state of its own but exists only as a part of a larger composite system. In effect, the very possibility of considering a particle or system as possessing objective properties depends on its entanglement with another particle or system. In fact, in many instances the particle does not possess any property at all.

Here's an example. Consider a system composed of two distant and noninteracting photons, in an appropriately entangled state, moving in opposite directions. Now let's place polarizing filters in their path. Each photon has an equal probability of either passing through or being absorbed by the filter. In fact, according to quantum mechanics, it is impossible to know whether a photon will pass through or be absorbed by the filter. The individual events, simply put, are totally random.

Yet, Albert Einstein devised a situation that came to be known as the EPR paradox. He called attention to the fact that while it was impossible to know whether a single photon would pass or be absorbed by a filter (even more, that the situation forbids us to think that there is some feature

determining in advance the fate of a photon), paired photons subject to the same polarization tests always act in tandem—that is, they either both simultaneously pass through or both are simultaneously absorbed by the filters, a consequence of the two photons being entangled.

In more down-to-earth terms, what the world's greatest physicist implied by entanglement is a situation analogous to the following: Although when tossing a coin time and again you cannot predict whether the next coin toss will turn up heads or tails, if you toss two coins simultaneously, when entanglement occurs, either both coins turn up heads or both turn up tails. More importantly, when you know what took place for one of the coins you know what took place for the other despite the fact that they are far apart and in no way interacting.

That's exactly how photons behave when entangled—a situation that has subsequently taken on greater weight and reliability thanks to the studies of John Stewart Bell and the experiments of Alain Aspect.

Now here's one of the most intriguing aspects of this 'entangled' story. By allowing us to overcome difficulties related to the secure transfer of information and by spurring further advances in computer efficiency, the mind-bending abstraction inherent in studies of entanglement may prove to be of critical value to real-world technological improvements in cryptography and encryption, as well as in computer technology.

Specifically, relying on entanglement, we can devise a system by which scrambling and unscrambling digitized information is a task that both the senders and intended recipients can easily perform but which is impossible for others to intercept or decipher. In brief, we can devise a full-proof mechanism for exchanging secret information in cyberspace.

Relying on entanglement, moreover, could place us on the threshold of applying the counterintuitive principles of quantum mechanics to make an incredible jump in the efficiency of our computers.

Quantum mechanics meets quantum computers: a marriage that could propel the informatics revolution well beyond its existing horizons. □

For a more detailed account, please see "Entangled States Allow Radical Change," CERN Courier, March 2002, pp. 20-23.

Seven Years

As my seven-year tenure as director of the Abdus Salam International Centre for Theoretical Physics (ICTP) has come to a close, I would like to briefly reflect on the Centre's unique role in the promotion of global science, a role that I believe is unmatched by other institutions.

ICTP's success is derived from a simple yet difficult truth, one that I firmly believe drove Abdus Salam's thinking when he initially proposed the creation of a research and training centre for scientists from the developing world some more than four decades ago.

For Salam, ICTP was a place 'built by and for scientists.' Other institutions may focus on the need to develop scientific institutions in the South. Or, they may concentrate on the importance of creating effective scientific policies that link research excellence to problems of development. These are worthy endeavours that should not be ignored or undervalued.

But Salam designed ICTP to serve the needs and hopes of individuals in ways that would allow scientists from the South to freely pursue their dreams of becoming full-fledged members of the international scientific community.

That is why he insisted on providing them with the services that they would need so that they could concentrate solely on their work. That is why he hoped ICTP's facilities would be more than just adequate; indeed that they would be equal to those found in any other research institution in the North. That is why he devoted so much energy to attracting the world's best scientists to Trieste as conference organisers and lecturers. And that is why he spoke so often of creating an environment that would instill not just knowledge but dignity and confidence among those individuals in the South who chose science as their career.

He believed, like all of us who share his vision, that scientific talent exists everywhere and that, if given the proper environment in which to grow, all nations could contribute to its advancement and share in its bounty. Science, as Salam often said, is "the heritage of all humankind."

Salam also believed that science, which after all is based on the notion of discovery, must evolve as we learn more and more about the natural world in which we live. It is not surprising that in addition to his focus on high energy physics, mathematics and condensed matter physics, Salam during his tenure as director also launched research and training

activities in fields related to the physics of the environment, physics of the living state and laser physics.

Indeed it was Salam's expansive roadmap that has guided my journey over the past seven years. It helps to explain why we increased our funding levels for upgrading the facilities, library and the computer network; why we revamped such long-standing programmes as the associates and affiliates schemes to strengthen their emphasis on excellence and to ensure that younger scientists are well-represented. And that is why we moved into new but related fields—for example, the physics of weather and climate, statistical physics and complex systems and, most recently, ecological economics.



Miguel Virasoro

This ongoing journey has been made that much easier by the Italian government's additional contribution to the ICTP budget and, on behalf of scientists worldwide and especially those in the South, I would like to thank Italy for its generosity.

We have sought to use the money wisely and effectively and in a manner that is consistent with the principles that have guided the Centre since its inception. I hope that in the years ahead ICTP continues to serve as one of the world's most visible, effective and respected research and training institutions for individual scientists from the developing world. Their intelligence, skills and enthusiasm require only a nurturing environment to grow and prosper. □

Valuing Nature Through Science

"It is no accident that the words 'economy' and 'ecology' share the same linguistic roots. In Greek, *oikos* means home, suggesting that both disciplines have more in common than we think."

This insightful, yet simple, observation, recently made by Nobel Laureate Kenneth Arrow, professor emeritus at Stanford University (USA), serves as the guiding principle behind ICTP's newest hosted activity.

The subject is ecological economics. The programme, which was launched this spring, will continue until 2003. By then, those behind the project, including former ICTP director Miguel Virasoro, hope to find outside funding and a permanent home, perhaps in Trieste. If successful, they envision the creation of an International Institute of Ecology and Economics for Scholars from Developing Countries.

Ecological economics is not a new subject. In fact, its roots date back to the late 1960s and early 1970s when the environmental movement in the United States reached new levels of public support culminating with the celebration of the first Earth Day on 22 April 1970.

At the time, environmentalists were searching for more effective ways to protect the world's treasure trove of natural resources, which seemed to be under constant threat due to incessant population growth, higher consumption levels and never-ending industrial and commercial development.

Economists, meanwhile, were continuing their search for methodologies that would enable what they call 'externalities'—the hidden cost of maintaining clean air, water, and other common goods and services that we all depend on for our economic and social well-being—to be integrated into a nation's general accounting system.

The ultimate goals of this unusual marriage between

ecology and economics was, first, to obtain a true assessment of the cost of development over the long term and, second, to devise policy strategies that would take advantage of market forces to protect the environment.

"We've learned a lot over the past several decades," says Partha Dasgupta, Frank Ramsey professor of economics at Cambridge University, UK, "particularly as we've become increasingly sophisticated in the use of mathematics and statistical modelling in our efforts to decipher the driving forces behind human behaviour when it comes to the use and conservation of our natural resource base."

The problem is that much of the work originated and has continued to be done in the United States and Europe. Consequently, researchers have concentrated on resource issues of particular concern to rich countries. In fact, this multidisciplinary effort has too often focussed on what Dasgupta calls 'amenities'—for example, the economic value that may be derived from putting land aside for recreational parks or preserving farmland to enhance such lifestyle concerns as the desire for open space, pleasant vistas and even tranquillity in our noisy, frenetic world.

One persistent challenge has been how to determine the economic value of such concerns and then how to integrate that value into existing systems of national accounting. Another challenge has been to transfer or modify these research efforts to meaningfully address critical issues in the developing world.

Progress has taken place on both fronts. For example, Dasgupta notes that "the World Bank has recently published statistics on 'genuine investment' for almost all countries of the world in a volume entitled *World Development Indicators 2000*. Such efforts," he says, "have tried to incorporate assessments of economic growth with assessments of resource



Partha Dasgupta

depletion to come up with a true accounting of a nation's economic well-being."

Dasgupta admits that "these new accounting methodologies remain crude but it's important to remember that traditional methods of accounting also have had their shortcomings," not the least of which has been their failure to recognise the depletion of the natural resource base as a threat to long-term economic development.

"A person's spendable income can continue to rise," he notes, "even as he or she depletes his or her bank account. That, in effect, could be what is happening in many parts of the world when it comes to our natural capital." The hope is that increased applications of mathematics, statistics and game theory will help refine these efforts at 'eco-calculations' and make them even more valuable in the future.

"The developing world, at least until very recently, has been largely excluded from such studies," adds Karl-Göran Mäler, director, Beijer International Institute of Ecological Economics of the Royal Swedish Academy in Stockholm, Sweden. "That's a void we hope to help fill through our partnership with ICTP." Dasgupta and Mäler will guide the development of this activity over the next two years.

As part of the partnership, ICTP agreed to sponsor two workshops this spring: a Research Seminar on Property Rights Structures and Environmental Resource Management, held in South Africa, in late May 2002, and a Workshop on the Economics of Complex Spatial Models of Ecosystems, held in Namibia, in early June. Both activities were organised by the Beijer Institute. Each attracted a dozen or so researchers from the region in which it was held.

"Property rights," notes Mäler in describing his long-range expectations for the seminar in Durban, "provide important underpinnings for assessing the value of land. Yet, these rights differ from one country to the next. In Durban, we discussed the nature of property rights among the region's tribal chiefs to try to determine the impact such rights have on the value—and thus use—of both individually owned and communal land."

"The workshop in Namibia," observes Dasgupta, "had a different focus. Its intent was to lay the groundwork for eventually making economic valuations of such locally important ecosystems as range- and wet-lands. The inherent monetary value of such ecosystems, despite their importance to the economy, has been ignored when assessing the region's economic and social well-being—especially its long-term economic and social well-being."

"Our ultimate goal is to help local researchers acquire the tools that they need to make such assessments. These efforts not only present an academic challenge but could also have an important impact on economic and environmental policies throughout the region."

In describing how this new initiative fits into ICTP's mandate, Dasgupta notes that "for the developing world, ecological economics is a relatively new field of scholarly inquiry. It's a field that not only relies increasingly on mathematical and statistical tools that ICTP is well-versed in, but also promises to open new employment opportunities for those gifted in such areas."

Former ICTP director Virasoro sees the initiative even more broadly. "This effort," he declared in a ceremony marking the launching of the ecological economics initiative, held at the University of Trieste in May, "marks a natural progression of the Centre's efforts to build scientific capacity in the developing world."

"ICTP, created in 1964, remains the centerpiece of what has come to be called the Trieste System," Virasoro continued. That system now boasts a wide-range of international science institutions dedicated to the promotion of science in the South, including the Third World Academy of Sciences (TWAS), the International Centre for Genetic Engineering and Biotechnology (ICGEB), the International Centre for Science and High Technology (ICS) and, most recently, the InterAcademy Panel on International Issues (IAP). "Each of these institutions," he noted, "steered Trieste's broad science initiative in new directions and each brought applications of science to a broader audience."

"And that is the path we hope to continue on through this new initiative in ecological economics. If we are successful over the next several years, I envision a new institute that will play an important role in strengthening a system that has become synonymous with high-quality research and training for scientists from the developing world." □

For additional information about the Ecology-Economics initiative, please contact Karl-Göran Mäler, Beijer International Institute of Ecological Economics, Royal Swedish Academy, PO Box 50005, SE-104 05 Stockholm, Sweden, phone: +46 8 673 95 00; fax: +46 8 15 24 64; email: bejjer@bejjer.kva.se. The local contact is: eee@ictp.trieste.it.



Launching of the ecological economics initiative at the University of Trieste

Dirac Medal winner, John J. Hopfield, has brought his skills in physics to the world of neurobiology as part of a larger effort to better understand how the brain thinks.

Making Things Compute

Most scientists count themselves fortunate to acquire international status in just a single field during their careers. John J. Hopfield, leader of computational neurobiology and computing networks at Princeton University, USA, and winner of the ICTP Dirac Medal in 2001, has had the rare good fortune to distinguish himself in two fields.

In 1969, just nine years after earning a doctorate in physics from Cornell University, Hopfield received the Oliver E. Buckley Prize for his research on the emission and absorption of light by semiconductors, a topic of central importance for understanding how light-emitting diodes function. At the time he was honoured, the prize had been awarded to no less than nine scientists who had received (or subsequently would receive) the Nobel prize. At the age of 36, Hopfield seemed well on his way to an illustrious career in his chosen field.

But over the course of the next two years, Hopfield would switch his research focus from physics to biology, earning an international reputation for his pioneering applications of physics-related computational techniques to the emerging field of neurobiology.

It's the bifocal quality of Hopfield's career—his uncanny ability to envision and then apply techniques learned in his study of physics to problems in neurobiology—that led the committee members of the Dirac Medal to speak of Hopfield's "special and rare gift...to cross inter-disciplinary boundaries to discover new questions and propose answers that uncover the conceptual structure behind experimental facts."

"My mother and father were both physicists," explains Hopfield. "In fact, in the year I was born—1933—my father was helping to design a physics exhibition at the Century of Progress World's Fair in Chicago. I can't say I remember the exhibit, but my father's job at the Chicago world's fair shows that I was not the first person in my family to use training in physics in unusual ways." Hopfield made these remarks during a visit to Trieste this May to receive the Dirac Medal and present the Dirac Lecture.

"As a child in a household filled with physics," Hopfield notes, "it should come as no surprise to learn that I was fascinated by the physical world around me. But since the

time that I knew enough to pursue 'new' science, I have always been more interested in trying to understand things that were not understood at all rather than in exploring established areas of knowledge where unanswered questions, by definition, focus on higher level problems."

Although Hopfield's switch from condensed matter physics to biology may appear to be a radical new career path to

some, for him it represented a logical extension of the methodologies that he had been using in condensed matter physics.

"While I was intensely involved in my physics research," he says, "I noticed that many biologists were turning to quantitative measurements common in the study of physical structures. Put another way, biologists were trying to understand properties on the basis of structure—an approach that had long characterised the work of physicists."

Hopfield's breakthrough contribution to neurobiology is based upon his model of neural processing that offers keen insights into the vastly different mechanisms that the human brain and the digital computer use to compute information and make decisions. The Hopfield model, in

fact, demonstrates how qualitatively different computation in our brain and in a computer can be.

"The secret behind these differences," Hopfield notes, "lies in connectivity. In the human brain, each neuron makes 'synaptic' connections to thousands of other neurons in a vast and intricate network. In a computer, despite its complexity, each transistor is usually connected to only two or three other transistors. The human/computer 'connectivity divide' represents not just a quantitative difference but a fundamentally qualitative difference that affects the way in which decisions are made."

Hopfield is particularly interested in the way in which the human brain understands the world through its senses. "Every sensory system," he observes, "senses—or, put another way, makes sense of—the world by dividing it into objects. Our visual system does it, our auditory system does it, and our olfactory system does it. Working in tandem with our sensory systems, the brain's ability to separate and objectify the world is what makes the world coherent."



John J. Hopfield

"All of our sensory brain interactions involve complex physical structures and correlations," Hopfield notes, "but the visual system is particularly specialised and complicated."

Except for deciphering colours, the retina functions through a large number of identical receptor cells. "When the retina is exposed to light," he continues, "the pattern of excitation of the retinal cells is configured only when a given object is present (for example, a face). The pattern, however, also depends on the exact direction in which we are looking."

Consequently, the activity of a retinal cell is not only determined by *what* we are looking at but *how* we are looking at it—a situation that presents enormous complications for the study of visual pattern recognition.

By contrast, our sense of smell is based on having about 1000 different types of receptor cells, each harbouring a different response to any given odorant. As a result, in most circumstances, the most strongly driven receptor cells are determined solely by the object being smelled.

"Olfaction," Hopfield observes, "is one of the oldest and simplest senses. That has made it a logical place to pursue my neurobiology research and it explains why so much of my work has been based on studies of the olfactory system."

"The research challenge," he adds, "is particularly interesting in animals that use olfaction for remote sensing—for example, such carnivores as hyenas and bears that apply their sense of smell not only to identify and locate objects right in front of them but also objects that are not near-at-hand. Such remote sensing involves an assessment of the direction and force of the wind as well as an ability to distinguish the odour of the 'targeted' object from the background odours that are also present."

It's the nasal equivalent of being able to identify a distant sound by filtering out all of the noise in between. The ability of pigeons to find their way home over vast distances and the capacity of slugs to pinpoint their favourite food while sliming along in your garden provide excellent examples of such remote sensing capacities.

Hopfield recently discovered another organising factor in olfaction and, in the process, demonstrated a new principle explaining how the neural function takes advantage of the 'spiking' phenomenon (characteristic of interneural communication) in carrying out its computations. "My current research," he says, "focusses on how the brain's neural circuits produce such powerful and complex computations."

Hopfield acknowledges that understanding the biophysics of neurons is an enormously complicated task. How can we visualise—let alone begin to understand—the intricate web of biological and physical factors that is responsible for the way in which sensory information is presented to and then deciphered by the brain?

"Light and chemo-reception," he notes, "generate currents across a cell membrane by means of a cascade of physical and chemical events within a receptor cell. When information leaves the eye, nose or ear, it is represented as a sequence of action-potentials. Greater understanding of what turns action-potentials into objectified realities would shed enormous

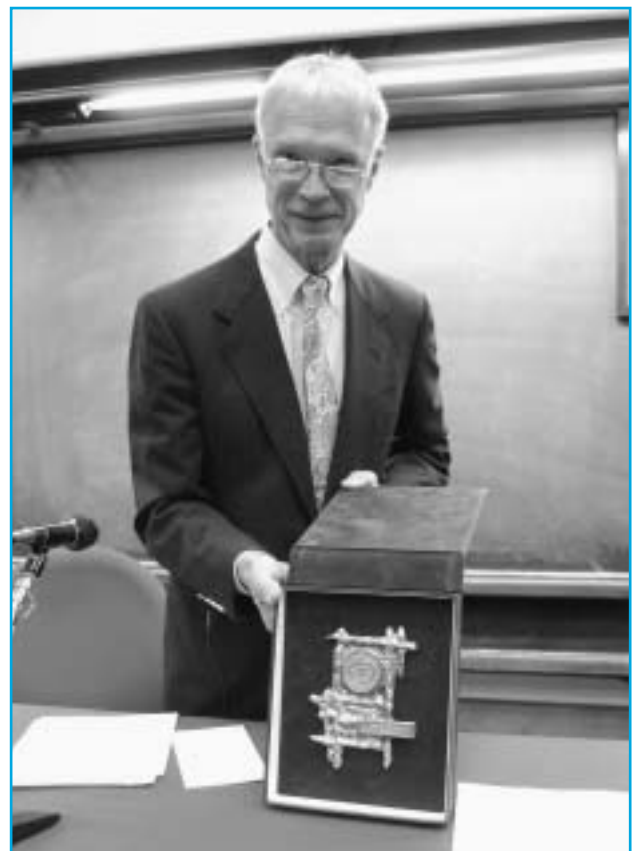
light on how the brain transforms sensory inputs into coherent information."

Hopfield believes that the 21st century will be the century of neurobiology much like the middle half of the 20th century was the century of the atom. "Researchers have been developing increasingly sophisticated techniques for understanding the basic mechanisms by which the brain computes, a process that has largely involved understanding the brain in computational terms."

"One of the most intriguing aspects of recent research," Hopfield notes, "has been the interaction—the intellectual back and forth—between trying to comprehend the workings of the brain and trying to develop brain-like computer programmes for useful application."

"As I mentioned before, the brain's intricate circuitry, driven by neurons linked together with huge synaptic connectivity, means that a brain functions differently than a computer. Nevertheless much of what the brain does can be described in terms of computation: associative memory, logic, inference, generating an appropriate sequence of locomotive commands, recognising a distinctive odour or judging the precise location of an object. All of these functions, at a fundamental level, require computation."

And that's where the application of computational tools, previously associated with physics to address unanswered questions in neurobiology, holds great promise. Such cross-disciplinary investigations, which serve as the centrepiece of Hopfield's current research, may offer an ideal strategy for better understanding how the human brain thinks. □



John J. Hopfield receiving the Dirac Medal

Hulme Appointed to Scientific Council

Mike Hulme, executive director of the Tyndall Centre for Climate Change Research in Norwich, UK, has been appointed to the ICTP Scientific Council. The Tyndall Centre is the main institute in the UK responsible for assessing climate change impacts and potential adaptation and mitigation strategies. The Centre, for example, is responsible for preparing the UK climate change report, the most comprehensive report on climate change in the nation. Before arriving at the Tyndall Centre, Hulme was a professor at the University of East Anglia, UK, where he headed the Climate Research Unit. His primary areas of research focus on climatology and climate change scenarios and impacts. Hulme has been a coordinating lead author



Mike Hulme

and member of the Intergovernmental Panel on Climate Change (IPCC) Working Group II, which examines climate change impacts and adaptation. He is also a participant in the European Climate Forum, a continent-wide initiative designed to discuss and analyse climate change issues of critical importance to Europe.

Giorgi on IPCC Bureau

Filippo Giorgi, head of the ICTP Physics of Weather and Climate group, has been elected one of six vice chairs of the Intergovernmental Panel on Climate Change (IPCC) Working Group I. As a representative from the European region, Giorgi is one of approximately 30 scientists from around the world elected to the bureau. The IPCC is divided into three working groups. Working Group I is responsible for examining the scientific basis of climate change; Working Group II focusses on impacts of climate change and adaptation; and Working Group III concentrates on mitigation. IPCC publications are recognised as the world's most authoritative research reports on global climate change issues. The panel's efforts have received international attention and its findings have helped shape public policies and perceptions related to climate change issues. The next round of IPCC reports are scheduled to be published in 2007.



Filippo Giorgi

TREL

ICTP has established a Training and Research in European Laboratories (TREL) Programme. **Daniele Treleani**, professor of physics at Trieste University and long-time ICTP consultant, will be responsible for the programme, which has been placed under the administrative umbrella of ICTP's Office of External Activities. The roots of this initiative reside in talks with Mohamed ElBaradei, director general of IAEA, who visited ICTP in September 1999, and Philippe Busquin, European Commissioner for Research and Technological Development, who visited in March 2001.

UNESCO Programme Specialist



Minella Alarcon and Daniele Treleani

Minella Alarcon, UNESCO programme specialist for physics and mathematics, visited ICTP from 23 to 26 April. She met with the heads of all research groups and programmes and toured the computing facilities and library. Alarcon was interested in laying the groundwork for future additional collaboration with ICTP.

ICTP at Albuquerque

ICTP served as the focal point of discussion at the 21 April session of the American Physical Society's annual meeting held in Albuquerque, New Mexico, USA. Former ICTP director **Miguel Virasoro** and **Boris Kayser**, visiting scientist at the Fermi National Laboratory Accelerator's Theory Group, Batavia, Illinois, USA, spoke on the role of ICTP in international science. **Pervez Hoodbhoy**, Quaid-i-Azam University, Islamabad, Pakistan, and **Arnulfo Zepeda**, Centro de Investigación y de Estudios Avanzados, Mexico City, Mexico, examined the role of ICTP in South Asia and Latin America respectively.

In Science

Fullerenes, soccer ball-like molecules formed by carbon atoms, may hold the key for understanding the behaviour of high temperature superconducting materials. A new theoretical model examining unconventional superconductivity in fullerenes was presented in the 28 June issue of *Science* in "Strong Correlated Superconductivity," an article written by a team of Italian physicists from the National Institute for the Physics of Matter (INFN) that included **Erio Tosatti**, ICTP's acting director and professor of physics at the International School for Advanced Studies (SISSA), and **Michele Fabrizio**, associate professor at SISSA and an ICTP consultant. Meanwhile, *Science Express*, the online edition of *Science*, has published a paper by ICTP staff scientist **Riccardo Zecchina**, along with **Marc Mézard**, University of Paris XI, and **Giorgio Parisi**, University of Rome *La Sapienza*, that proposes a new algorithmic strategy for 'hard problems' in computer science, computational biology, and the physics of disordered systems. The print version of the paper appeared in *Science* 297, 2 August 2002, pp. 812-815.

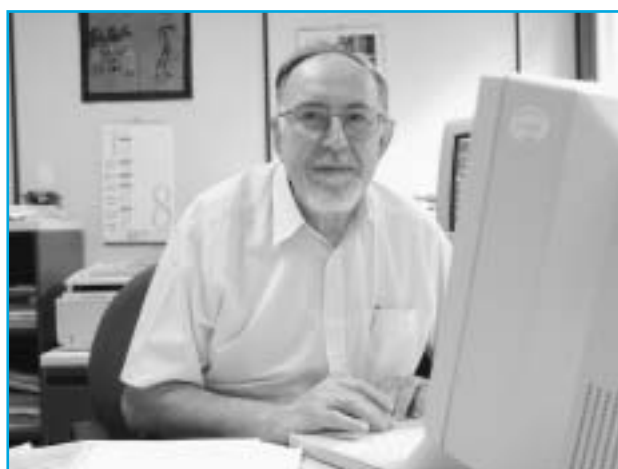
Cuba Honours Centre

Faheem Hussain, head of ICTP's Office of External Activities, attended a special ceremony at the University of Havana on 26 June commemorating the 40th anniversary of the university's physics degree programme. The Centre was honoured for the contribution it has made to the programme's development and success. ICTP and the university have worked closely together since the mid 1960s.



Faheem Hussain

Radicella Honoured



Sandro M. Radicella

Sandro M. Radicella, head of ICTP's Aeronomy and Radiopropagation Laboratory, has been awarded an honorary degree from the University of Bucharest in Romania in appreciation of his contributions to science and society. Radicella has played an instrumental role in the building of cost-effective radiocommunication networks in some of the South's poorest countries. His group is currently working on the Galileo project, a European Union initiative designed to establish an all-civilian system for satellite navigation. The project is expected to be operational by 2008.

De La Cruz and Altshuler

Two frequent visitors to ICTP have been elected to the US National Academy of Sciences. **Francisco de La Cruz**, researcher at *Centro Atómico Bariloche* and professor physics at *Instituto Balseiro*, Argentina, has been elected foreign associate for his contributions to the "phenomenology of traditional and new superconductors" and, in particular, "his studies of the physics of vortex matter in high-Tc superconductors." La Cruz has visited the Centre on numerous occasions, notably during the early 1990s when he served as director of the Experimental Workshop on High-Tc Superconductors and Related Activities. **Boris Altshuler**, professor of physics at Princeton University and fellow at the NEC Research Institute, USA, was elected a member for being "one of the founders of the theory of mesoscopic systems." Altshuler has participated in no less than 15 ICTP activities dating back to 1988 and has served as course director of the workshops on mesoscopic systems since 1998.



Boris Altshuler

SPRING COLLOQUIUM ON THE PHYSICS OF WEATHER AND CLIMATE: REGIONAL WEATHER PREDICTION MODELING AND PREDICTABILITY

8 - 19 April



Fedor Mesinger

Directors: F. Mesinger (National Centers for Environmental Protection, NCEP, Camp Springs, Maryland, USA), G. Kallos (University of Athens, Greece) and F. Giorgi (ICTP).

The Colloquium, which focussed on research issues aimed at understanding and advancing the predictive capabilities of regional weather prediction models, evolved around two activities: a Workshop on Design and Use of Regional Weather

Prediction Models (8 - 16 April) and a Conference on Current Efforts Toward Advancing the Skill of Regional Weather Prediction (17 - 19 April). The Workshop included lectures on regional weather prediction modeling and laboratory sessions in which students were taught how to install and operate the limited area weather prediction ETA model. The Conference explored the following topics: issues related to operations and data collection; numerical design; comparative benefits and limitations of local and regional models; and regional weather predictability.

WORKSHOP ON THEORETICAL ECOLOGY: NATURAL RESOURCE MANAGEMENT AND CONSERVATION BIOLOGY

22 April - 3 May

Directors: G.A. Canziani (*Universidad Nacional del Centro de la Provincia de Buenos Aires, Tandil, Argentina*), G.A. De Leo (*University of Parma, Italy*) and A. Dobson (*Princeton University, New Jersey, USA*).

The Workshop, one of a series of activities on mathematical ecology held at ICTP during the past 18 years, focussed on theoretical issues related to natural resource management. Examination of such issues has led to the emergence of such subfields as biocomplexity, bioeconomics, environmental economics and sustainability science. The Workshop addressed two main topics: natural resource management and conservation biology. Formal lectures were complemented by topic-oriented working-group sessions where participants were asked to develop strategies for examining problems in natural resource management of interest to developing countries. Topics included: population dynamics; fragmentation and persistence; and reserve network design. Analytical tools consisted of differential equations, linear algebra, and control and game theory. Mathematicians, ecologists, biologists, economists, and agricultural scientists were among those who participated.



Jon Rodriguez

SCHOOL OF SYNCHROTRON RADIATION AND APPLICATIONS

22 April - 24 May

Co-sponsor: Italian Synchrotron Light Society (SILS). **Directors:** M. Altarelli (*Sincrotrone Trieste S.p.A. and ICTP*), A. Craievich (*Universidade de São Paulo, Brazil*), C.S. Fadley (*University of California at Davis, USA*), A. Filipponi (*University of L'Aquila, Italy*) and H. Wiedemann (*Stanford University, California, USA*). *The School examined all aspects of synchrotron radiation research and experimentation, from machine physics, insertion devices and beamline design, to actual industrial and environmental applications. Emphasis was placed on practical training in accelerator technology, instrumentation, and the application of common experimental techniques. Visits to the Trieste synchrotron radiation laboratory, Elettra, were organised. Lecture topics included: accelerator physics and synchrotron radiation sources, beamline and monochromator design and applications of synchrotron radiation to physics, chemistry, materials science, surface science, engineering, geophysics, biophysics and the environment.*

THEMATIC INSTITUTE OF THE COMPLEX SYSTEMS NETWORK OF EXCELLENCE (EXYSTENCE) ON NETWORKS, DYNAMICS AND SOCIO-ECONOMICS

6 May - 1 June

Co-sponsor: European Commission (Brussels, Belgium). **Directors:** M. Marsili (*International School for Advanced Studies, SISSA, Trieste, Italy, and ICTP*) and G. Weisbuch (*Ecole Normale Supérieure, Paris, France*).

This was the inaugural meeting of the Thematic Institute of the European Commission's Network of Excellence (EXYSTENCE). Thematic Institutes are among several initiatives supported by EXYSTENCE to foster scientific collaboration. The concept is to have 15 to 25 invited scientists work together for extended (and possibly recurrent) periods at the same location. The Workshop on Economics and Heterogeneous Interacting Agents (30 May - 1 June) took place during this inaugural meeting (see p. 11).

WORKSHOP ON INDICATORS FOR SUSTAINABLE ENERGY DEVELOPMENT

13 - 17 May

Co-sponsor: International Atomic Energy Agency (IAEA, Vienna, Austria), in co-operation with the International Energy Agency (IEA, Paris, France), UN Statistics Division (New York, USA), UN Department of Economic and Social Affairs (New York, USA), and Eurostat (Statistical Office of the European Commission, Brussels, Belgium).

Director: I. Vera (IAEA). *The Workshop introduced participants to the Indicators of Sustainable Energy Development (ISED) package, developed by the IAEA. Participants discussed statistical procedures relevant to the introduction of ISED in national statistical and policy analysis efforts. They also reviewed proposals for applications of ISED to address policy concerns. A methodological approach and case study framework was examined to provide consistency and comparability in the development and implementation of country-specific ISED packages. Information was*

provided on methodological issues and collection procedures to ensure compliance with international standards for energy-related statistics. Participants—experts from IAEA member states, including those in developing countries, countries in transition, and countries of the OECD region—discussed procedures for demonstrating the applicability of the ISED package as a policy tool.

SCHOOL AND CONFERENCE ON PROBABILITY THEORY

13 - 31 May



School and Conference on Probability Theory

Directors: G. Lawler (Duke University, Durham, North Carolina, and Cornell University, Ithaca, New York State, USA), C.M. Newman (Courant Institute, New York, USA) and S.R.S. Varadhan (Courant Institute, New York, USA).

Local Organiser: C.E. Chidume (ICTP).

The School concentrated on three specific areas of probability: particle systems, combinatorics and random environment. Biological and physical systems can be modelled in terms of interacting particle systems. Scaling limits of large systems result in considerable simplification of the description of the systems as they evolve over time. The connection between probability and combinatorics is undergoing a revolution. Issues of conformal invariance of certain two-dimensional models, for example, are just beginning to be understood. Lecturers were researchers who have made significant contributions to the field.

SCHOOL AND CONFERENCE ON CHEMICAL SENSES: MOLECULES TO PERCEPTION

20 - 31 May



Visit at Illycaffè S.p.A.

Co-sponsors: International Centre for Genetic Engineering and Biotechnology (ICGEB, Trieste, Italy), International School for Advanced Studies (SISSA Trieste, Italy), International Brain Research Organization (IBRO, Paris, France),

Illycaffè S.p.A. (Trieste, Italy), and Olympus (Milan, Italy).

Directors: A. Menini (National Research Council, CNR, and SISSA, Trieste, Italy) and S. Firestein (Columbia University, New York, USA).

Local Organiser: A. Menini.

The School, led by internationally renowned researchers, examined the latest developments in the rapidly growing field of chemical senses. Participants learned about state-of-the-art research on olfactory and taste systems. The School, interdisciplinary in nature, involved such

topics as biophysics, information processing, genetics, molecular biology and electrophysiology. Principle areas of discussion included: molecular biology of odorant and taste receptors; genetics of olfaction and taste; cellular transduction in chemosensory neurons; neural circuits for encoding chemical stimuli; computational neurobiology of olfaction and taste; and psychophysics of chemosensory perception. Four main lectures each day were followed by periods of extended discussion and interaction among speakers and participants. Participants, moreover, were encouraged to present their own research.

WORKSHOP ON ECONOMICS WITH HETEROGENEOUS INTERACTING AGENTS (WEHIA 2002)

30 May - 1 June

Co-sponsor: EXYSTENCE Complex Systems Network of Excellence (www.complexityscience.org, funded by the European Commission, Brussels, Belgium).

Directors: M. Gallegati (University of Ancona, Italy), A. Kirman (Groupe de Recherche en Economie Quantitative d'Aix-Marseille, GREQAM, Marseille, France) and M. Marsili (International School for Advanced Studies, SISSA, Trieste, Italy, and ICTP).

Local Organiser: M. Marsili.

The economy is increasingly regarded as a complex system of interacting agents. Recent developments in this field have focussed on three main issues: (1) heterogeneity of agents in the economy; (2) ways in which agents interact; and (3) dynamic processes that govern the evolution of the individual. The Workshop consisted of presentations and discussions on the latest thinking on these issues.

INTRODUCTORY SCHOOL ON STRING THEORY

3 - 14 June

Directors: E. Gava (National Institute of Nuclear Physics, INFN, Trieste, Italy), K.S. Narain (ICTP) and S. Randjbar-Daemi (ICTP). The School, designed for beginners in the field, provided introductory lectures on string theory. Starting with discussions of the quantization of strings, their low energy effective theories and compactifications, the School went on to examine recent developments in such non-perturbative aspects of string theory as D-branes, string dualities and dualities between string theories and gauge theories. Topics included: bosonic and fermionic strings, heterotic string; supergravity actions and their classical solutions; toroidal and Calabi-Yau compactifications; D-branes and open strings; string dualities; and string theory/gauge theory duality.

EL NIÑO AND TROPICAL OCEAN-ATMOSPHERE INTERACTIONS

3 - 14 June

Directors: G. Philander (Princeton University, New Jersey, USA), D. Halpern (California Institute of Technology, Pasadena, California, USA) and F. Molteni (ICTP).

Local Organiser: F. Molteni.

The Workshop (3-10 June) introduced participants to tropical ocean-atmosphere interactions and such related phenomena as El Niño. Morning sessions were devoted to lectures, while afternoon sessions involved discussions of participant projects. The Conference (11-14 June) sought to synthesize the rapidly growing number of studies focussing on El Niño and related phenomena. Main topics included: the state of ocean-atmosphere interactions; the future of El Niño studies; and what remains to be learned about El Niño.

WORKSHOP ON CORRELATION EFFECTS IN ELECTRONIC STRUCTURE CALCULATIONS

17 - 21 June

Directors: V. Anisimov (Institute for Metal Physics, Ekaterinburg, Russian Federation), G. Kotliar (Rutgers University, Piscataway, New Jersey, USA) and G. Santoro (International School for Advanced Studies, SISSA, Trieste, Italy).

The Workshop introduced participants to the dynamical mean field method and examined how this method is used to investigate the properties of correlated materials. Morning lectures were followed by hands-on training sessions in the afternoon. The programme covered such topics as orbital based electronic structure methods; calculations of U 's; dynamical mean field equations and its solution via perturbative methods; and quantum Monte Carlo techniques. The activity concluded with a small conference.

JOINT ICTP-INFM SCHOOL AND WORKSHOP ON SPECTROSCOPIC INVESTIGATION OF THE COLLECTIVE DYNAMICS IN DISORDERED SYSTEMS

17 - 28 June

Co-sponsor: Italian National Institute for the Physics of Matter (INFM).

Directors: F. Barocchi (University of Florence, Italy), N. Binggeli (ICTP), G. Ruocco (University of Rome *La Sapienza*, Italy), F. Sacchetti (University of Perugia, Italy), and F. Sette (European Synchrotron Radiation Facility, ESRF, Grenoble, France).

The Workshop examined state-of-the-art experimental techniques used to study collective dynamics in disordered systems. The goal was to provide an overview of the problems inherent in different techniques and examine unanswered issues in the field. Lectures and seminars focussed, in part, on recent technical developments in the scattering spectroscopies commonly used to examine collective excitations in disordered systems. Topics included spectroscopic investigation of the collective dynamics in such disordered systems as colloids; quantum fluids; liquid metals; molecular, hydrogen-bonded and uncooled liquids; glass forming systems; and biological materials. Spectroscopic studies of off-equilibrium dynamics—for example, aging and related processes in disordered materials—were also discussed.

SUMMER SCHOOL ON ASTROPARTICLE PHYSICS AND COSMOLOGY

17 June - 5 July

Co-sponsors: International School for Advanced Studies (SISSA), and Italian National Institute for Nuclear Physics (INFN).

Directors: G. Dvali (New York University, USA), A. Pérez-Lorenzana (ICTP), G. Senjanovic (ICTP), G. Thompson (ICTP) and F. Vissani (INFN Gran Sasso Laboratories, Assergi, Italy).

The School examined such topics as dark matter and particle physics; finite temperature field theory; structure formation; nucleosynthesis; high energy cosmic rays; black holes and neutron stars; baryogenesis and leptogenesis; inflation; unification of particle forces and cosmology; and the physics and cosmology of large extra dimensions.



Georgi Dvali



Luciano Rezzolla

WORKSHOP ON MESOSCOPIC PHYSICS AND ELECTRON INTERACTION

24 June - 5 July

Directors: B. Altshuler (NEC Research Institute and Princeton University, Princeton, New Jersey, USA), C. Marcus (Harvard University, Cambridge, Massachusetts, USA) and V. Kravtsov (ICTP).

Accomplished theorists and experimentalists in the field were joined by young scientists to create an atmosphere that encouraged exchange and collaboration. To advance this goal even further, during the second week of the Workshop participants were given an opportunity to make presentations. The Workshop sought to enhance scientific understanding of the role of electron interaction in physics of mesoscopic systems. Issues discussed included the role of interaction and disorder in carbon nano-tubes; electron interaction in quantum dots; electron interaction and transport in two-dimensional systems; mesoscopic systems driven by time-dependent perturbations; and energy relaxation and low-temperature dephasing in mesoscopic systems.



PROFILE

Wesam El-Qadi, a computational expert from Palestine, describes the recent difficulties she encountered when travelling to Trieste for ICTP's School on Synchrotron Radiation and Applications.

Adventurous Journey

When coming to an ICTP research and training activity, most scientists board an aeroplane and arrive at the Centre the same—or the following—day. But computational physicist Wesam El-Qadi experienced a far more adventurous—and arduous—journey when she tried to leave her homeland in Palestine in late April to attend the Centre's School on Synchrotron Radiation and Applications in Trieste.

El-Qadi, who lives with her parents in Bethany, on the outskirts of Jerusalem, explains: "I learned about my acceptance to the school in March and made arrangements to depart from Tel Aviv airport on Sunday 21 April. That would have allowed me to arrive a day before the opening session on Monday, 22 April. Unfortunately, I could not get my visa in time and I missed my flight. Nothing has been easy during the current conflict between Israelis and Palestinians."

The following week, El-Qadi kept her plans for her trip to Trieste alive, first by avoiding Israeli military checkpoints on foot to obtain her visa in Jerusalem and then, accompanied by her father, by passing through a series of automobile checkpoints near the River Jordan, to get to Amman's airport. (Tel Aviv's airport had been closed to Palestinians.) There, she boarded a flight to Milan. A connecting flight brought her to Trieste.

On Monday, 27 April, El-Qadi attended her first lecture at the school—a week late but glad to finally be here.

El-Qadi received a bachelor of science degree in 1994 from Al-Quds University in East Jerusalem where she majored in physics, and a master of science degree in 2000 from Bowling Green State University in Ohio (USA), where she studied computational physics and quantum mechanics. Between her studies, El-Qadi taught high school in Jerusalem for one year and served as a teaching assistant at Al-Quds University for two years.

Her current field of interest focusses on entropy computations as they relate to quantum mechanics. "It's a highly theoretical field in which we try to calculate and theorise about the relationship between energy, mass and entropy among subatomic particles."

Throughout her university studies, El-Qadi has always worked within the broad field of computation. Her earlier research focussed on improving methodologies for calculating the distribution of air pressure and velocities in the human larynx as part of a larger effort to learn more about human speech and phonation—a subject no less difficult but somewhat less abstract than what she is doing now.

"The ICTP synchrotron school," she notes, "will hopefully provide me with additional understanding of the techniques that may be used to enhance my computational skills in a variety of fields, most notably in the field of entropy. That was my hope when I first applied to the school about a year ago. Now that I have participated in this activity, I'm glad that I did not abandon my efforts to come. ICTP's administrative staff appreciated my dilemma and did all they could to keep my options open as my circumstances and flight plans underwent constant change. If not for them and the help of my family, I would never have made it."

El-Qadi hopes to continue her studies and earn a Ph.D. in computational physics, perhaps at a university in Europe or the United States. Eventually, she hopes to explore career opportunities in her own region, especially after the Bessy I is relocated to Jordan as is currently planned under the Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME) project.

But for the immediate future, she is mostly concerned about living and working safely in Bethany, where she has resumed her work as a teaching assistant.

"The violence, tension, and daily disruptions and humiliations make it difficult—if not impossible—to have a normal life in Palestine. Thinking about tomorrow is a luxury when you face so many inescapable difficulties each day." □

Wesam El-Qadi

Korean Strings

Soo-Jong Rey, researcher at the Centre for Theoretical Physics of Seoul National University in Korea and recipient of the 2001 ICTP Prize in honour of Hans Bethe in the field of high energy physics, lectured on "Holographic View of Noncommutative Baryon" at the ICTP Prize award ceremony, which took place in the Centre's Main Lecture Hall on 21 March. Soo-Jong Rey has authored more than

90 papers in the field of string theory, cosmology and particle physics. Among his most noteworthy contributions are the discovery of string solitons and instantons, which have played a crucial role in enhancing scientific understanding of the non-perturbative dynamics of string theory. Such insights culminated in the discovery of various dualities in string theory in the mid-1990s. More recently, Soo-Jong Rey's research has examined the matrix theory formulation of the heterotic string.



ICTP on the Air

About four million Italians, tuning into the popular *Raiuno* science programme *Superquark* on Wednesday evening 26 June, had an opportunity to view a segment that featured **Tadele Adamtie Mengesha**, a young Ethiopian mathematician attending ICTP's Diploma Course. The segment not only told about Mengesha's recent experience in Trieste but also about his life growing up in Ethiopia, including his years of study at the University of Addis Ababa, where he earned his degree. Film footage for the segment was shot last March. Another television transmission on the Centre, featuring an extensive interview with former ICTP director **Miguel Virasoro**, was broadcast by Rai International at the end of May.



Fennessy Departs



John Fennessy (8th from left), ICTP director of administration since June 1998, has retired from the UN system after 26 years of service to assume the position of head of administration and finance, Organization for Security and Cooperation in Europe (OSCE), in Skopje, Macedonia. During his tenure, the ICTP Main Building and guesthouses underwent major refurbishing, including an unprecedented expansion of the Centre's lecture halls and an upgrading of the cafeterias. Fennessy also spearheaded the drive to hold Trieste's first UN Day at the Centre last fall. **Gallieno Denardo** has been appointed temporary ICTP director of administration. He assumed his duties on 1 July and will remain at the post until a permanent director is selected. Denardo, who has been associated with ICTP since the 1970s, served as long-time head of the Office of External Activities. He remains responsible for ICTP research and training activities related to lasers and optics.

Trieste: City of Science

Trieste Città della Scienza (Trieste City of Science), an elegant, fully illustrated book with concise but detailed texts on the scientific institutions that comprise the Trieste System, has been published by *Aps-Agenzia Promostampa*. A ceremony announcing the publication of the book took place at the corporate headquarters of Friulia S.p.A., Trieste, on 24 June. For additional information about the publication, contact sci_info@ictp.trieste.it.

Retirements

Ines Radatti (second from right in the photo under "Fennessy Departs"), who had been with the ICTP Publications Office since 1967 and had supervised the office for the past 20 years, retired from the Centre this June. **Bruna Marcuzzi**, who was in charge of housekeeping at the Centre's guesthouses for the past 19 years, also retired in June. Staff and scientists extend their warm thanks and well wishes to Ines and Bruna.



IN MEMORIAM



Victor Weisskopf, a renowned theoretical physicist who made important contributions to quantum mechanics in Germany in the 1920s and in the USA in the 1970s, died in Cambridge, Massachusetts, USA, on 21 April aged 94. Weisskopf was a member of the first ICTP Scientific Council. Born in Vienna, then the capital of the Austrian-Hungarian empire, Weisskopf served as a group leader of the Manhattan Project in the US during World War II. He witnessed the world's first atomic explosion in Alamogordo, New Mexico, in 1945. In the early 1960s, he served as Director General of CERN (the European Organization for Nuclear Research), based in Geneva, Switzerland.



Martino Rizzotti, professor of biology at the University of Padua, was Italy's most renowned Italian exobiologist. His research interests ranged from the chemistry of proteins to the evolution of early cells. Rizzotti died in Padua in March at the age of 55.

He attended and contributed to all six conferences on chemical evolution that have been organised at ICTP since 1992.

1 - 4 July

Workshop on Intrinsic Multiscale Structure and Dynamics in Complex Electronic Oxides

8 - 19 July

School and Conference on Spatiotemporal Chaos

8 - 26 July

School and Conference on Algebraic K-Theory and Its Applications (Dedicated to H. Bass on the occasion of his 70th birthday)

29 July - 2 August

Conference on Irreversible Quantum Dynamics

5 - 16 August

Trieste Workshop on Emergent Materials and Highly Correlated Electrons

19 - 22 August

Conference on the Science and Technology of Spin Transport in Nanostructures

26 August - 7 September

School on Statistical Physics, Probability Theory and Computational Complexity followed by Conference on Typical-Case Complexity, Randomness and Analysis of Search Algorithms

2 - 27 September

College of Medical Physics

9 - 27 September

School and Conference on Intersection Theory and Moduli

23 September - 4 October

School on Neutrino Physics and Astrophysics (NEUPAST)

30 September - 4 October

Second ICTP Conference on Detection and Modeling of Regional Climate Change

30 September - 12 October

6th Workshop on Three-Dimensional Modelling of Seismic Waves Generation, Propagation and Their Inversion



Throughout the year, the most up-to-date information on ICTP activities may be found on the World Wide Web and via e-mail. Here's how to find out what's going on.

ON THE WORLD WIDE WEB (WWW)

Our address is <http://www.ictp.trieste.it/>

The site includes detailed information on our research groups and activities, and a listing of our preprints, awards and job opportunities.

ON E-MAIL

(1) For Yearly Calendar of Scientific Activities

Create a new e-mail message and type

To: smr@ictp.trieste.it

Subject: get calendar 2003

Leave the body of the message blank. Send it.

Your e-mail will generate an automatic reply from the ICTP server containing the most updated version of the yearly Calendar.

(2) For Information on a Specific ICTP Activity

Each activity in the Calendar has its own 'smr' code number, which is located on the last line of each activity description. The 'smr' number will enable you to obtain more information—if available—on those activities you are interested in. To receive this more detailed information, create a new e-mail message and type the smr code number that you found on the calendar:

To: smr####@ictp.trieste.it

Under the e-mail's subject, type

Subject: get index

Leave the body of the message blank and send it.

You will receive an automatic reply listing all documentation available on that particular activity—the announcement or bulletin and, in most cases, a separate application form.

To receive the full text of the announcement and/or application form, you will need to send another e-mail message to the same smr code:

To: smr####@ictp.trieste.it

Subject: get announcement application_form

Again, leave the body of the message blank, and send it.

(3) For Information on All ICTP Activities

A free online service for the dissemination of information on all ICTP activities, programmes and related announcements is available via e-mail. To subscribe, create a new e-mail message and type:

To: courier-request@ictp.trieste.it

Leave the subject line empty.

In the body of the message type

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Any comments or suggestions on this service are most welcome. Please address them to pub_off@ictp.trieste.it.

NEWS from ICTP

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. Miguel Virasoro serves as the Centre's director.

News from ICTP is a quarterly publication designed to keep scientists and staff informed on past and future activities at ICTP and initiatives in their home countries. The text may be reproduced freely with due credit to the source.

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