THE CONSTANT YET EVER-CHANGING ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

In this age of globalization, the ICTP continues to stem the brain drain of physicists from developing nations while at the same time responding to new scientific challenges.

Juan G. Roederer

The early 1960s were very good years for science in the industrialized world. Both the decision-makers and the public shared a faith in the usefulness and importance of fundamental science, and there was unfaltering trust in the scientific community. Although the world was ideologically split into two camps, science was recognized by nearly everyone as an integral part of human culture and development. However, science did not fare as well in most developing countries, some of which had just gained their independence. The number of scientists active in research in such countries was small. As scientists emigrated to more developed nations, the resulting brain drain delivered serious blows to the scientific communities of those researchers, leaving deep scars in the intellectual fabric of their countries.

Abdus Salam, a Nobel Prize–winning Pakistani physicist, recognized that improving science locally would not be enough to stem the flight of fledgling scientists from developing countries. International mechanisms would be needed to allow scientists—especially those returning home after training abroad—to stay in touch with the world, to refresh their knowledge periodically, and to engage in international research collaborations. The time was right for the conception of an international center for theoretical physics. And Trieste, Italy, was the right place, located in the West, but at the doorstep to the Eastern bloc.

Salam's legacy

Salam, shown in figure 1, and Italian physicist Paolo Budinich founded the International Centre for Theoretical Physics (ICTP) in 1964 under the aegis of the International Atomic Energy Agency (IAEA). It was not to be just another international research institute, but a model organization with a triple purpose: promoting research in physics and mathematics in developing countries, in part by offering scientists training that could be applied in their home countries; serving as a forum in which scientists from all over the world could meet; and operating a first-class research facility. All three stated purposes reflect Salam's desire to confront the issues of isolation and brain drain. (See the article "The International Center for Theoretical Physics" by Abdus Salam in PHYSICS TODAY, March 1965, page 52.)

JUAN G. ROEDERER *is an emeritus professor of physics at the Geophysical Institute, University of Alaska–Fairbanks, and senior adviser to the Abdus Salam International Centre for Theoretical Physics.*

The ICTP's associate scheme, initiated in the same year the center was founded, deals directly with these issues. The program allows scientists coming from, and working in, developing countries to visit the ICTP three times during their six-year associateship for up to 90 days each time. The federation arrangements scheme is a complementary program. It enables affiliated institutions in developing countries to send junior scientists to meetings and workshops at the ICTP for up to 150 days on a cost-sharing basis.

The center also acts as an intermediary to provide libraries and laboratories with donated books, journals, and equipment as part of the ICTP/Third World Academy of Sciences donation program. The ICTP is now collaborating with many scientific societies to distribute a variety of science publications—in print and digital formats—to less developed countries. The three programs just described are designed to afford physicists from developing countries the opportunity to keep up with the rapid development of science, as is the office of external activities, which supports conferences, research activities, and a visiting scholar program in regions beyond the ICTP campus.

Today, with a permanent staff of about 130 employees, including scientists, technicians, and administrators, the ICTP maintains interactive links with scientific communities in about 170 countries and hosts up to 4000 scientists each year as short-term or long-term visitors. Since its creation, the ICTP has built a worldwide family of loyal alumni—tens of thousands of former associates, lecturers, and students, many of whom are now internationally recognized scientists, university leaders, research-council presidents, and even high-level politicians in their own countries.

Closer to home, the presence of the ICTP in Trieste has spawned local scientific organizations such as the International School for Advanced Studies (SISSA, funded by the Italian Ministry of Education and located on the campus of the ICTP) and several components of the complex of R&D establishments known collectively as the "Trieste Science System." The center is also host to the headquarters of several international organizations, most notably the Third World Academy of Sciences.

Adhering to Salam's vision, the ICTP became an institution of the highest academic standards at which young physicists from third world countries can find a second home where they are treated with dignity and respect. The ICTP affords them access to the necessities for practicing

FIGURE 1. ABDUS SALAM, Nobel laureate and founder of the International Centre for Theoretical Physics. The photo was taken in Bangladesh a few years before his death in 1996. In the March 1965 issue of PHYSICS TODAY, page 52, Salam wrote, "The Center's inception and its organization mark it as a new type of venture—an assay in collaboration among the East and the West and the smaller nations, an assay in collaboration for pure science organized under the aegis of the United Nations. The idea is the embodiment of the international ideal; it must succeed." Today we can assert: It did! (ICTP photo archives.)

modern science, such as a world-class library and computer support, and the opportunity to participate in the great adventure of expanding human knowledge.[1] (See figure 2 for an aerial view of the campus.) While the ICTP is focused on promoting science in the third world, many scientists from industrialized nations have also benefited and continue to benefit from its programs. As an example, during the past three years, some 900 physicists, mathematicians, economists, and biologists from the US have visited the ICTP as lecturers and guest investigators. These visits have led to many joint publications by ICTP investigators and US scientists.

Why theoretical physics?

People unfamiliar with the history and role of the ICTP may ask, Isn't theoretical physics the last thing a third world country would want to consider on its road to development? My answer is the following.

Research in theoretical physics does not demand a costly infrastructure. It gives young scientists early exposure to the great mysteries of the universe, stimulating their scientific imagination and making them feel they are participants in the great quest for knowledge. The study of theoretical physics trains the mind in scientific thinking and strategies of problem solving that scientists can later apply to any part of science. Theoretical physics is the glue that binds physics subdisciplines together and links them to mathematics. It is a key component of basic science, which is being seriously challenged in many parts of the world these days by people who are demanding more societal-good or economy-driven research. In short, the study of theoretical physics is in accord with the admonition from the late Argentine Nobel laureate Bernardo Houssay: "Before you can apply science, you must first *have* science!"

Starting from its original program in high-energy physics, the ICTP quickly extended its activities by including condensed matter physics in 1967 and mathematics in 1971. Later, the center incorporated subjects of more direct relevance to human society, such as studies of the structure and dynamics of Earth. As part of its training mission, the ICTP established laboratories to develop microprocessors and to study problems in aeronomy and radiopropagation relevant to third world countries. The center continues to expand under the direction of Miguel Virasoro, the distinguished Argentine theoretical physicist selected as the successor to Salam (see figure 3). Since Virasoro's appointment in 1995, the ICTP has created a new group on the physics of weather and climate and a new pilot program on mathematical modeling and simulation of complex realities that works at the intersection of applied mathematics and statistical physics. At the same time, the traditional sectors of high-energy physics, mathematics, and condensed matter physics have been strengthened to reemphasize the ICTP's historic message that a strong academic infrastructure in basic science is essential for any developing country.

High-energy physics and mathematics

In-house research has a clearly stated set of objectives, explained in the ICTP Long Range Plan.[2] Let me here convey a sense of why some of the research groups do what they do, rather than present a laundry list of recent achievements. I could never do justice to all: The publications speak for themselves.[3]

High-energy physics is, of course, Salam's old stomping ground, and it should be no wonder that this area is one for which the ICTP is best known. Today, the attempt to understand nature at both the smallest and largest scales, that is, the quest for a theory of quantum gravity (better yet, for a theory that unifies all the fundamental forces) stands at the cutting edge of scientific research. The challenge of understanding how the universe works lies at the heart of human culture, and with their black holes, quantum foam, and curled-up dimensions, current theories captivate the imagination of the informed public. Although the subject may seem esoteric as a research topic for a scientist from a developing country, it is a powerful magnet for attracting some of the brightest young graduates into collaborative work with researchers from advanced countries.

Under the direction of Iranian physicist Seifallah Randjbar-Daemi, the high-energy group conducts research in string theory and the phenomenology of particle physics. (Randjbar-Daemi and other group leaders are pictured together in figure 4.) One focus is on higher-

FIGURE 2. THE ICTP CAMPUS in Miramare near Trieste. The main building houses lecture rooms, scientific staff offices, a library with 120 000 holdings, the computer center, and the principal cafeteria. In the foreground is the Enrico Fermi Building with mainly administrative offices and the headquarters of the Third World Academy of Sciences. The white building on the left is the International School for Advanced Studies (SISSA). (ICTP photo archives.)

dimensional physics, which has a long history at the ICTP. Until the mid- to late 1990s, it was generally believed that the size of extra dimensions was set by the Planck length, approximately 1.6×10^{-33} cm, the length at which the quantum nature of the gravitational interaction should be taken into account. The minimum energy at which such small scales can be probed experimentally is of the (utterly hopeless to obtain) order 10^{19} GeV.

As early as 1983, however, Randjbar-Daemi, Salam, and John Strathdee anticipated that the extent of the extra dimensions could be far greater than the Planck length, and that the effects of these dimensions might already be seen at TeV energies.[4] During 1998–1999, work by Nima Arkani-Hamed (now at the University of California, Berkeley) and Gia Dvali (now at New York University), in collaboration with Savas Dimopoulos from Stanford University, opened a new line of research, which quickly turned into a major international project on higher-dimensional theories that include large extra dimensions.[5] Among other things, those authors argued that the observed value of Newton's gravitational constant is derivable from a higher-dimensional gravitational constant whose value is set by the electroweak scale. (See PHYSICS TODAY, September 2000, page 22.) The work on strings per se is mostly concentrated on the implications of duality symmetries in perturbative string theories and M-theory.

Another area of high-energy research at the ICTP, under Russian physicist Alexei Smirnov, involves a long-term collaboration with John Bahcall (Princeton University) and Plamen Krastev (University of Wisconsin). It mainly concerns the solution of the solar neutrino problem, that is, the question of why the flux of electron-type neutrinos from nuclear reactions in the Sun's core observed at Earth is smaller than what is predicted theoretically. The answer to this question may have fundamental implications for particle physics, astrophysics, and cosmology.[6] Various mechanisms for the neutrino flavor conversion recently seen at the Sudbury Neutrino Observatory (SNO) experiment (see PHYSICS TODAY, August 2001, page 13) have long been studied at the ICTP.

The practice of mathematics, like theoretical physics, is relatively inexpensive in terms of equipment and infrastructure. Thus, mathematical research allows a developing country with scarce financial resources to make a mark in science at the international level in a relatively short time and with little financial investment. The mathematics group at the ICTP, led until recently by the Indian mathematician Mudumbai Narasimhan, has adopted geometry as the core area of research, in view of its importance in mathematics and its role in physics. The center is now internationally recognized for its excellence in algebraic geometry, having made major contributions to the study of moduli spaces. These spaces parameterize objects of a given kind, for example, solutions of a differential equation; they arise naturally both in physics and mathematics.

The other areas pursued by the mathematics group are functional analysis and K-theory. K-theory originated from algebraic geometry and topology and has applications in other areas of mathematics and in physics. It could be viewed as a broad generalization of cohomology theory.

Condensed matter—pillar of technology

Condensed matter physics links the microscopic quantum domain with macroscopic properties of matter and has as its goal an understanding of the structure and behavior of solids, liquids, and amorphous substances. It has benefited greatly from the study of complexity, a burgeoning interdisciplinary endeavor that, in its highest expression, is related to the study of life itself. Continuing advances in information science and communications will rely heavily on new phenomena and principles derived from condensed matter research. Furthermore, new materials created as a result of this research, including those made of organic molecules, will continue to shape the way we live. Clearly, condensed matter physics has become one of the fundamental pillars of high technology, and expertise in it is of prime importance to all countries, advanced and developing alike.

Research by the condensed matter physics group, headed by Chinese physicist Yu Lu, includes studies of strongly correlated and disordered systems, computational condensed matter physics, statistical physics and complex systems, and more. The group's work has greatly benefited from a close collaboration with a group from SISSA, led by Erio Tosatti. The two groups have cooperated on joint projects of considerable technological relevance. For instance, using computer simulation aided by theory, Tosatti and coworkers in 1998 found that ultrathin metallic nanowires might show a novel structural transition, driven by decreasing radius, from a crystalline to noncrystalline state. In the noncrystalline state, the nanowire may exhibit icosahedral or, of special interest, helical configurations. This was verified experimentally in Japan in 2000.[7] Soon afterward, Tosatti and colleagues developed a full microscopic theory of the structure and properties of tip-suspended nanowires.[8]

Research in statistical physics and complex systems focuses on "phase transitions" in nondeterministic combinatorial problems, which are at the root of the theory of computational complexity. The models under study are simplified versions of real-world optimization problems, much as models of statistical physics are simplified constructs that capture the behavior of real materials. The theoretical framework of the research has applications in physics (disordered materials and out-of-equilibrium dynamics in complex systems), computer science (optimization and cryptography), bioinformation science, and game theory. A collaboration on computational complexity, initially involving Riccardo Zecchina of the ICTP, Scott Kirkpatrick of IBM, Bart Selman of Cornell, and Rémi Monasson of the Ecole Normale Supérieure in Paris,[9] is now highly interconnected, and involves several other institutions worldwide.

New research directions

Earlier I mentioned Virasoro's efforts to expand and update the ICTP's research. A good example is the newly created physics of weather and climate (PWC) group headed by Filippo Giorgi, an Italian physicist formerly at the National Center for Atmospheric Research in Boulder, Colorado. It makes a lot of sense to have such a group at the ICTP: The atmosphere is a complex, nonlinear system whose modeling presents many physical and mathematical challenges well suited to the talent available in-house. The PWC group uses limited-area atmospheric models for studies of climate change and has developed a widely used regional climate modeling system. As part of its commitment to the needs of developing countries, the group participates in the CHINA-MAP project, helping to create a coupled regional modeling system that includes atmospheric, chemical, aerosol, and agricultural components. CHINA-MAP is a collaboration among scientists at the ICTP, several US research institutions coordinated by the Georgia Institute of Technology, the Chinese Academy of Meteorological Sciences, and the Global Change Analysis, Research and Training Center for Temperate East Asia (START-TEA) in Beijing, China. The goal of CHINA-MAP is to elucidate the regional climatic and environmental effects of massive and rapidly increasing pollutant emissions by human activities over eastern Asia.

Another area of expertise of the PWC group is climate prediction on a seasonal timescale. The group is a participant in an international collaboration called PROMISE, sponsored by the European Union. The objectives of PROMISE are to assess the potential for climate prediction on a seasonal timescale, to analyze how such predictions can assist in the management of agriculture and water resources, and to estimate the impacts of anthropogenic climate change on tropical countries, in particular on crop productivity and the availability of water resources. The PROMISE collaboration includes a number of research centers from Brazil, China, India, Kenya, Niger, and the Philippines.

The group on structure and non-linear dynamics of the Earth (SAND), funded mostly by external grants and contracts from a number of Italian, European, and United Nations agencies, seeks to improve the understanding of earthquake mechanisms and the dynamics of seismicity, develop earthquake prediction techniques, and increase the accuracy of probabilistic seismic hazard assessments. The group is directed by Giuliano Panza of the University of Trieste and closely collaborates with the International Institute for Earthquake Prediction and Mathematical

FIGURE 3. MIGUEL VIRASORO, DIRECTOR OF THE ICTP, lecturing at the 1999 international summer school on statistical physics and probabilistic methods in computer science. Scientific staff members spend up to 50% of their time organizing courses and lecturing. This year, the ICTP is holding a total of 45 schools, conferences, and workshops. (ICTP photo archives.)

Geophysics of the Russian Academy of Sciences in Moscow.

The SAND group has explored new approaches for seismic risk mitigation based on three-dimensional modeling of terrestrial structure and earthquake sources and has developed a numerical model of seismicity and structural dynamics based on real fault geometry for the Apennines and Sicily in Italy. The group also has served as a lead organization for the international project "Realistic Modeling of Seismic Input for Megacities and Large Urban Areas," and recently led a team of Italian seismologists to the first-ever Indo–Italian workshop on seismic risk evaluation, held in Hyderabad, India.

Training labs

The microprocessor laboratory seems an anomaly as part of a theoretical physics center. Yet it plays an important complementary role by helping third world scientists develop skills they could apply in their own countries. The laboratory's main philosophy is that the most important signature of the computer revolution is no longer the routine manufacturing of microchips, but the design of microchips and the development of associated software for specific purposes of national importance. Designing integrated circuits and software, however, requires well-trained personnel available at home.

Under a formal agreement with the Italian Institute of Nuclear Physics, and led by Argentine physicist Alberto Colavita, the microprocessor laboratory developed a small, low-cost yet state-of-the-art R&D lab that offers third world scientists the opportunity to participate in advanced design projects. For example, the microprocessor laboratory pioneered the development of silicon-strip

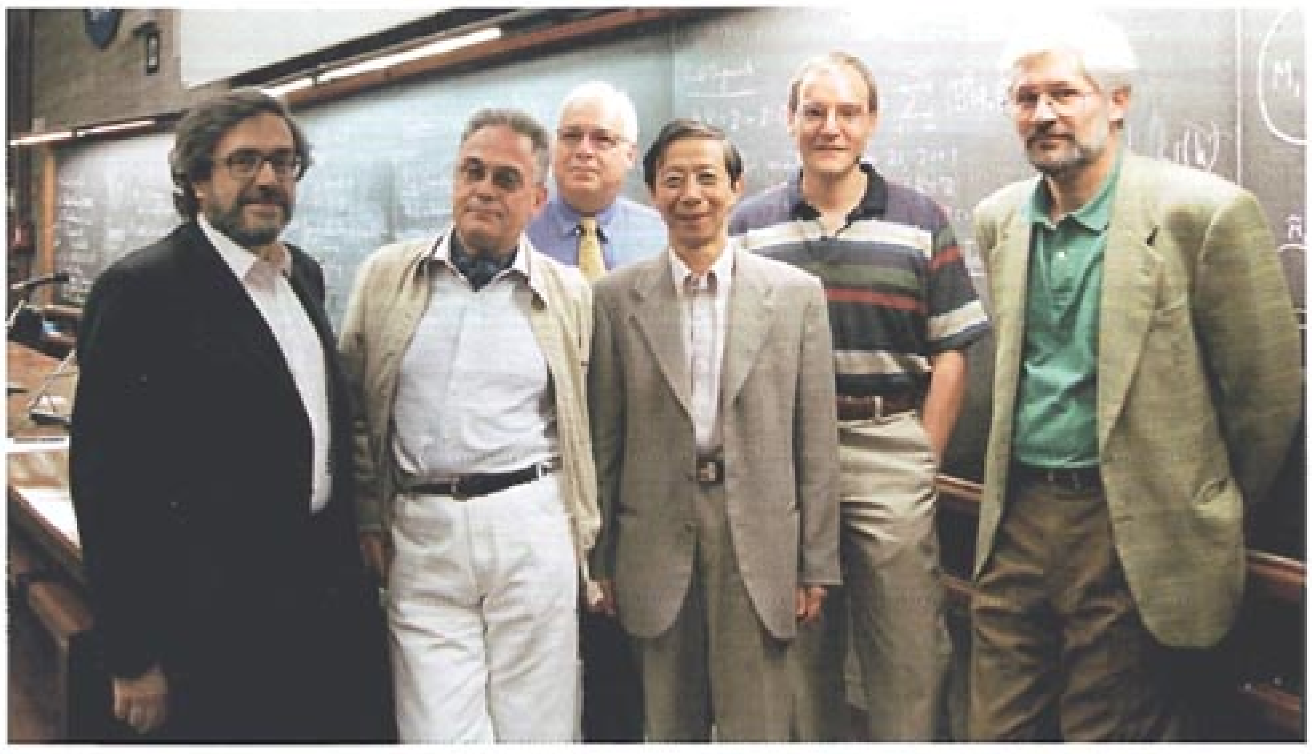

FIGURE 4. RESEARCH GROUP LEADERS at the ICTP. From left to right: Miguel Virasoro (ICTP director, now doubling as acting head of mathematics), Giuliano Panza (structure and non-linear dynamics of the Earth), Alberto Colavita (microprocessor lab), Yu Lu (condensed matter physics), Filippo Giorgi (physics of weather and climate), and Seifallah Randjbar-Daemi (high-energy physics). The groups' current research programs are summarized in the text. (ICTP photo archives.)

gamma-ray telescopes and designed a data-acquisition system for NASA balloon-borne cosmic-ray experiments. At present, the group is putting the final touches on a high-speed 5 Gbit/s data-acquisition system for the Ring Čerenkov detector in the hadron spectrometer of the international COMPASS collaboration at CERN.

Another training laboratory is the aeronomy and radiopropagation laboratory. The ARL deals with applied physics of the ionosphere, including "space weather" and its effects on humanmade systems. Because the investigation of the upper atmosphere and various practical applications require remote sensing of the ionosphere from the ground in many diverse geographical areas, there is a need for the participation of scientists from all over the world, especially from equatorial countries. One of ARL's objectives is to train such scientists. (See figure 5.) In addition, there are disadvantaged countries where high-frequency radio transmission is still the only affordable way to communicate in rural areas; the ARL helps scientists from those countries develop the necessary expertise to use the ionosphere's electromagnetic properties for their basic communications.

Not a university, but . . .

The ICTP is not a university. Nonetheless, as a matter of principle, it couples all of its research projects with training programs. Some of these programs address topics that do not correspond to in-house research, but are organized by ICTP scientists in collaboration with outside research groups. In a typical year, the ICTP organizes about 40 training activities and conferences. For example, the Stig Lundqvist Research Conferences, a series of workshops on strongly correlated electron systems, and many ICTP sponsored conferences and workshops on condensed matter physics, are recognized worldwide as top-level scientific meetings. These meetings have inspired condensed matter physicists of all ages, backgrounds, and nationalities, and have led to many new and substantive developments. During the cold war, ICTP conferences and schools offered one of the few opportunities for Western and Eastern bloc physicists to meet.

I have no intention of spelling out in detail the range of ICTP schools, conferences, and workshops; the yearly calendar of activities[10] does that. However, some of the interdisciplinary ones organized for 2001 are worthy of special mention. They are the summer colloquium on the physics of weather and climate: land–atmosphere interactions and the hydrological cycle; the college on neurophysics: evolution of intelligent behavior; the workshop on nuclear data for science and technology: accelerator-driven waste incineration; and the Adriatico conference on interaction and assembly of biological molecules.

The center created several formal programs to aid graduate students from developing countries. The ICTP diploma course was developed because many young visitors to the center have little opportunity at home of learning how to teach and how to conduct research. Established in 1991, the course provides advanced-level training to improve the teaching and research capabilities of talented students in high-energy physics, mathematics, and condensed matter physics.

Doctoral students in third world countries are often isolated, with limited library and computational facilities and precious few opportunities for scientific contacts on their research topics other than with their advisers. Recognizing the difficulties inherent in such isolation, the ICTP recently established a joint PhD program. This program offers doctoral students from universities in developing countries a chance to periodically visit advanced institutes (including the ICTP) in developed countries during the time they are working on their theses. The goal is to provide students with facilities and advice that they cannot obtain at their degree-granting home institutions.

The ICTP also offers international awards, including the ICTP Prize, which is given to outstanding physicists and mathematicians from developing countries, and the prestigious Dirac Medal.

A complex institution

The ICTP as an institution is a complex system. Consider, for example, the budget. The center reports to two intergovernmental organizations of the UN—UNESCO and the IAEA—but the lion's share of its annual income comes from the Italian government through a line-item appropriation in the national budget. For the 2001 calendar year, the Italian government appropriated about $15.8 million for the center, IAEA's contribution is $1.98 million, and UNESCO's is $507 000.

In addition, the ICTP will receive about $1.7 million in external grants and contracts during 2001. (It is interesting that the ICTP does not charge any overhead on external grants and contracts.) A steering committee, comprising one representative each from UNESCO, the IAEA, and the Italian government, with the ICTP director serving ex officio, sets policy guidelines and approves the budget, assisted by a scientific council presently chaired by Praveen Chaudhari of the US.

Administratively, financial control is entirely in the

FIGURE 5. STUDENTS FROM AFRICA AND LATIN AMERICA with Sandro Radicella (standing in the middle), head of the ICTP aeronomy and radiopropagation laboratory. (ICTP photo archives.)

hands of UNESCO, of which the ICTP is a so-called extra-budgetary initiative. This administrative categorization allows the center a great deal of fiscal autonomy and flexibility in its day-to-day operations, but all higher-level positions, for example those of senior scientists, are under the direct control of UNESCO. In addition, the general rules that the ICTP must follow in its personnel actions are set by UNESCO.

One gratifying consequence of UNESCO's financial control is that all salaries are exempt from Italian income tax. An unfortunate consequence is a mandatory retirement age of 62—an unfair limit for any productive scientist or effective science administrator! While that seems acceptable, even desirable, for the bureaucratic components of UNESCO, it is unconscionable, in my opinion, to apply such a limit at a scientific institution like the ICTP. The limit makes it extremely difficult to attract into leading positions top-level scientists of a mature age; recently, two of the center's most experienced group leaders had to take mandatory retirement, forced into accepting yearly contracts that do not include the usual benefits enjoyed by those with longer term appointments. In 2002, it will be the current director's turn to retire—and a search for his replacement is already under way.

The government of Italy provides about 85% of the regular budget, so it is both fair and strategically sound for the ICTP to pay special attention to its host and principal financial contributor. The center and its host country both benefit from their unique relationship. Many Italians are guests of the center and the ICTP manages and partially funds a program of training and research in Italian laboratories (TRIL) for students and postdocs from developing countries who want to work in experimental physics. The ICTP is part of the Trieste Science System and enjoys synergistic collaborations with the Elettra Synchrotron Laboratory, the University of Trieste's department of theoretical physics, and SISSA.

Beyond physics

While the fall of the Berlin Wall ended a period of east–west confrontation, north–south disparities have, in some cases, become more acute. In addition, a dramatic intensification of local conflicts has occurred. Is there a connection between the work of the ICTP and international efforts toward reducing global disparities and conflict? Virasoro argues,

> Science, both as an activity as well as a body of knowledge, continues to be an integral part of human culture representing its most universal components. Whoever visits the ICTP has the experience of its multi-ethnic people: Physicists from Pakistan, India, China, Vietnam, Algeria, Israel, [and] Palestine are all participating collegially in the same scientific activities. . . . The ICTP does not claim that it can help solve world conflicts but it does aim at de-emphasizing them by showing the possibility of constructive collaboration on one hand and the danger of oversimplifying reality on the other.[11]

It is in the national interest of every advanced country to ensure that scientifically and technologically informed and capable communities emerge in the third world. The long-term future of Earth may depend on it: As time progresses, political boundaries will undoubtedly remain, but information, goods, cultures, and people will increasingly intermingle—as will pollution, new diseases, and who knows what other potential disasters. One efficient way we can help the third world become scientifically developed is to support the mission of the ICTP. How can we do this? By keeping informed about ICTP activities and participating in its conferences; by directing students to appropriate ICTP programs; by informing private or public funding agencies about the center; and, if your country is a member of UNESCO, by sending a copy of this article to your UNESCO delegation!

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References

1. *ICTP Today, An Overview of ICTP Aims and Activities*, ICTP, Trieste (1999). The publication is available from the Public Information Office, Abdus Salam International Centre for Theoretical Physics, Strada Costiera 11, 34014 Trieste, Italy. The ICTP Web site is http://www.ictp.trieste.it.
2. *Toward a Long Range Plan 1999–2001*, ICTP, Trieste (1999).
3. See, for instance, the *2000 Annual Report*, ICTP, Trieste (2001).
4. S. Randjbar-Daemi, A. Salam, J. Strathdee, *Phys. Lett.* **124B**, 345 (1983).
5. N. Arkani-Hamed, S. Dimopoulos, G. Dvali, *Phys. Lett. B* **429**, 263 (1998).
6. J. N. Bahcall, P. I. Krastev, A. Yu. Smirnov, *Phys. Rev. D* **58**, 096016 (1998).
7. Y. Kondo, K. Takayanagi, *Science* **289**, 606 (2000).
8. E. Tosatti, S. Prestipino, S. Kostlmeier, A. Dal Corso, F. D. Di Tolla, *Science* **291**, 288 (2001).
9. R. Monasson, R. Zecchina, S. Kirkpatrick, B. Selman, L. Troyansky, *Nature* **400**, 133 (1999).
10. *ICTP Scientific Calendar*, ICTP, Trieste (2001), or consult the ICTP Web site given in ref. 1.
11. Ref. 2, p. 44.