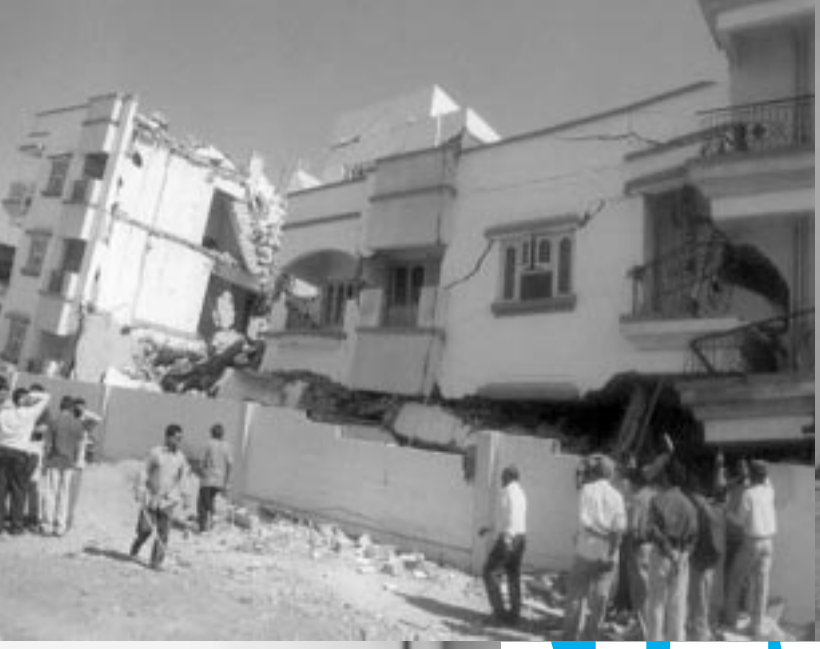

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#96

Alessandro Vespignani
ICTP Staff Associate

WHAT'S NEW

Alessandro Vespignani and his colleague Romualdo Pastor-Satorras have conducted a detailed statistical study of the behaviour of computer viruses. Their findings may surprise you.

Cyber-Virus

While the increasing use of the internet allows for the global exchange of electronic information (everything from the transfer of brief e-mail messages to large data files), it also encourages the spread of computer viruses. In fact, computer viruses have been invading the digital community for more than a decade. Just one recent example illustrates how troublesome they can be. The "iloveyou" bug, which struck in May 2000, is estimated to have cost the world nearly US$7 billion in damages and downtime.

Viruses, as we all know, are not confined to the world of computers. Indeed the word, which refers to something "poisonous, noxious, deadly or pernicious," historically has been associated with the world of living matter. Biological viruses, which can quickly multiply within the living cell of a host, are medically defined as "infective agents consisting of nucleid acid molecules covered in a protein coat."

Computer scientists have adopted the term 'virus' from biologists and medical researchers to describe 'infective agents' in the world of electronic communications largely because the behaviour of 'e-viruses' seems to parallel the behaviour of 'b-viruses.' Both require a host, both have a protective 'coating,' and both spread quickly.

Therefore it should come as no surprise that when my colleague Romualdo Pastor-Satorras from the Polytechnic University of Catalonia in Barcelona, Spain, and I began to study computer viruses one year ago, we chose to rely on epidemiological techniques and models borrowed from the biological world. Since then, we have analysed the statistical incidence of more than 800 computer viruses. Based on this research, we have estimated that the average lifetime of a computer virus ranges from one to two years. A few sturdy viruses can live three years or longer.

Our research suggests that the amount of time a computer antivirus is available as an antidote—usually no more than two or three weeks after a virus has been identified—is no match for the longevity of a virus itself. As a result, our research also suggests that all computer viruses not only have a good chance to pervade the global communications network (after all, widespread application of antiviral agents usually does not begin for two or three days after the virus starts to spread), but that a virus is also likely to continue to infect computers long after users think that the agent has been purged. In the case of digital viruses, such long-standing persistence could be considered the equivalent of endemic states.

One of the key principles in the world of biological epidemiology, used in the development of models designed to analyse the spread of viral diseases, is that there are only a few highly infectious diseases and that most of these diseases spread and then die out quickly with the application of effective antiviruses. A second key principle of the world of biological epidemiology is that there is a threshold below which a given virus cannot produce a major epidemic.

Our research indicates that such principles, while critical to the development of epidemiological models, may not apply to the world of computers. The reason is that these principles fail to account for the internet's complex connectivity properties, which constitute a prime element of the environment in which digital viruses spread. Connections between computers on the internet, in fact, are characterised by enormous fluctuations based on intricate structures that must be included in all theoretical and experimental studies of digital epidemics.

That's why we have devised a numerical model of virus-spreading that explicitly takes into account the internet's complex interwoven fabric. By simulating numerically the evolution of epidemic outbreaks on the internet, we have developed a theoretical construct of virus-spreading among computers. Strikingly, we find that the internet lacks an 'epidemic threshold.' In other words, the global electronic network is prone to the spreading and persistence of infections whatever level of 'virulence' the virus may possess.

Such findings not only offer new fundamental insights into how computer viruses spread, but they also provide a theoretical model for the study of optimal immunisation of the global network. The latter could ultimately help us contain viruses that have wreaked such fear and loathing among computer users across the globe. ¤

For a scientific analysis of this research, see Romualdo Pastor-Satorras and Alessandro Vespignani, Physical Review Letters *86 (2 April 2001), p. 3200. News articles about their research have appeared in* New Scientist *(4 November 2000),* Diario, *Spain (28 February 2001),* Nature "Science Update" *(9 March 2001), and* USA Today *(27 March 2001).*

Faheem Hussain
Coordinator, ICTP High Energy Diploma Course
Head, ICTP Office of External Activities

COMMENTARY

Egyptian science, once an enduring pillar of this ancient civilisation, shows promising signs of rebirth.

Among the Pyramids

Cairo, the political and cultural heartland of the Arab world, served as the venue for the Cairo International Conference on High Energy Physics, which took place in January.

Two former ICTP Diploma students, Shaaban Khalil (1991-1992) and Elsayed Lashin (1992-1993), were instrumental in organising the conference, and funding from ICTP's Office of External Activities (OEA) covered travel and lodging expenses for many participants from the developing world. Additional money from the US National Science Foundation helped to make the conference an international event. In all, some 60 physicists from around the world attended.

The conference was the first of its kind to be held in Egypt. Although science in Egypt has faced hard times for a very long time, for several millennia during ancient times the country was at the centre of scientific discovery.

Egypt, in fact, is home to one of the world's oldest civilisations—the place where humankind made its first great leaps forward in science and technology. According to scholars, Egypt and Babylon informed and inspired the ancient civilization of Greece, which most intellectuals view as one of the pillars of modern science. Meanwhile, Giza's 5000-year-old pyramids, which required precise knowledge of geometry and engineering, serve as a lasting symbol of ancient Egypt's scientific and technological skill.

The golden age of Egyptian science, centered in Cairo, took place between the 20th and 15th centuries before the birth of Christ. Nearly a thousand years later, following the conquest of Egypt by Alexander the Great, the city named in honour of this fierce warrior and world conqueror became a renowned centre of learning with the construction of a museum and library unprecedented in size and scope for their time. Euclid lived and worked in Alexandria, as did Erastothenes of Cyrene, the first scientist to accurately measure the Earth's circumference, and Apollonios of Perga, who wrote the first textbook on conics. Astronomical studies in Alexandria were equally remarkable. For example, Aristarchos, the Copernicus of antiquity, proposed a heliocentric cosmological system 1800 years before Copernicus.

Egypt's golden age of science is not about to return but recent developments suggest that the long dark days for science in Egypt may finally be coming to an end. Indeed a reasonable level of research in nuclear physics, laser physics and spectroscopy has taken place in Egypt over the past two decades. But the same cannot be said for particle physics. While physicists and, more generally, scientists suffer from the usual litany of problems afflicting researchers in the developing world (limited access to journals and books, inadequate laboratory equipment, and suffocating bureaucratic rules and regulations), there is now a level of knowledge, commitment and even enthusiasm, especially among younger physicists, that suggest progress will be made despite the obstacles standing in the way.

The coordinated efforts of ICTP's Diploma Programme and Office of External Activities deserve some of the credit for the promising signs that surround the state of particle physics in Egypt. The nation's young and talented physicists would be the first to tell you that ICTP's 'support stream' from post-undergraduate education through the first years of their careers has been instrumental in their efforts to turn their dreams into reality. But at the same time much of the credit must go to the perseverance of the scientists themselves. Shaaban Khalil, for example, first presented his proposal to hold an international conference on high energy physics in Cairo several years ago. Thwarted time and again by a lack of funding and bureaucratic indifference, he refused to be discouraged and finally triumphed when most observers thought he would fail.

Slowly but steadily a critical mass of Egyptian-born particle physicists are earning advanced degrees, and slowly but steadily they are choosing to return to their home country after completing their education abroad. As these researchers become better known in the global physics community, they are attracting the attention of their university deans and presidents at home. Such notice often leads to additional funding and additional funding opens the door to more productive research.

If current trends continue, Egypt, once the home of Euclid, could soon have its own centre for theoretical physics. And if such a centre is built, the International Conference on High Energy Physics, held in Cairo in January, will surely be cited as one of the major reasons why.¤

Filippo Giorgi
Head, ICTP Physics of Weather and Climate Group

ICTP scientist Filippo Giorgi examines the current state of knowledge on climate change and the importance of the issue to the developing world.

Climate Change in the Developing World

The Intergovernmental Panel on Climate Change (IPCC), which was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Development Programme (UNDP), recently issued its *Third Assessment Report on the Science of Climate Change*. Scientists and policymakers worldwide view this 1000-page monograph as the most authoritative assessment of the current state of knowledge on issues related to global climate change.

The report, which contains a number of important conclusions, was approved by more than 100 nations attending the IPCC Plenary Meeting of Working Group 1, held in Shanghai, China, between 17-20 January.

The first and most significant conclusion is that, on a global scale, the Earth's surface warmed by about 0.6°C in the 20th century. Moreover, new and more convincing evidence shows that most of the warming over the past 50 years can be attributed to human activities associated with fossil fuel combustion. Such activities have resulted in widespread emissions of greenhouse gases, most notably carbon dioxide.

Other key conclusions in the IPCC report also present a picture of a warming world. These conclusions, based on state-of-the-art scientific research and analyses, include irrefutable evidence of widespread persistent retreat of glaciers, snow cover and ice sheets, as well as a relentless rise in sea levels.

In short, more than ever, the global scientific community now agrees that continued emissions of greenhouse gases as a consequence of human activities will significantly modify the Earth's climate in the coming decades.

For example, projections of climatic changes due to anthropogenic activities suggest a possible warming by the latter decades of the 21st century of between 1.4°C and 5.8°C. That's a projected rate of warming unprecedented in the known history of the Earth's climate. Sea levels, moreover, are expected to rise by 0.09 to 0.88 meters, which would place many coastal areas at risk. In addition to reductions in the size of glaciers, sea ice and snow cover, the IPCC report anticipates increases in precipitation intensity, changes in regional precipitation patterns, and widespread mid-continental summer drying of the soil.

How will these climate modifications affect human societies? This is a critical question because climatic changes can have dramatic impact on a broad range of fundamental human activities, including agricultural production, water and energy management, human health, coastal development, fishing and recreation. Climate change can also affect natural ecosystems, such as coral reefs and mountain habitats. In addition, the frequency and intensity of such extreme, often catastrophic, weather events as hurricanes, floods and droughts are expected to rise significantly in many regions as a result of global climate change.

An island coastline of the Maldives now (left) and five years ago (right) offers dramatic evidence of the effect of rising seas

For all these reasons, it is clear that the issue of climate change cannot be ignored by the public or private sectors either in the developed or developing world. While manufacturing practices and consumption patterns in countries in the North over the past century and a half may be largely responsible for the problem, future issues related to climate change are likely to prove particularly difficult for developing countries.

Why is this so? Because countries in the South, many of which are located in tropical regions, will be most vulnerable to possible changes in climatic patterns. In addition, they do not have sufficient resources or expertise to deal with these problems.

For example, scientists estimate that a sea level rise of the order of half a meter would endanger more than 15 million people living in coastal areas of Bangladesh. Large sea level rise would also place many small ocean islands—for instance, Antigua, Fiji, the Maldives and Tonga—at risk. Increases in surface temperature and associated soil drying, moreover, could reduce agricultural productivity in many already food-insecure sub-Saharan African countries, where irrigation is not widely used and water supplies are critically dependent on precipitation patterns. Atmospheric warming may also lead to the spread of vector-borne diseases, most noticeably malaria, in many of the world's tropical zones.

The bottom line is this: While global change is a problem that has been created mostly by industrialised nations, its consequences are likely to be most keenly experienced in developing nations. Yet, despite growing recognition among experts and policymakers that developing countries are the most vulnerable to projected changes in climate, global-change research sorely lags in most of these countries (except for several emerging developing countries, including China, Brazil and India). For example, of the several hundred authors and contributors to the assessment report, only 10 to 15 percent come from developing countries.

What are the reasons for the developing world's lack of participation in what may be the largest global research enterprise ever undertaken? Lack of adequate infrastructures is certainly one. State-of-the-art climate research requires access to powerful computing resources that are generally lacking in developing countries.

Lack of research and training is another. While a long-standing tradition of research and training in mathematics and theoretical physics can be found in many developing countries, research and training in more recent fields like climate research are generally not very advanced. In fact, in many countries, it is even difficult to find university-level courses in basic meteorology and climatology. The reality is that there are many prominent scientists from developing countries in atmospheric physics and dynamics but most reside and work in the United States or Europe.

Given the situation, it is important that developing countries develop their own indigenous know-how on climate change and related impacts through research and training programs. Without their own team of experts, the delicate position of these countries concerning global change issues will be based on information provided by outside scientists. Such information may not always be relevant to the climate change challenges faced by developing nations.

That could be a problem not just for the South but for the North as well. A critical global environmental issue such as climate change, after all, requires a truly global response. Stated more directly and ominously, meaningful participation from the developing world is essential if meaningful solutions to the problems associated with climate change are to be found.¤

A summary of the Third Assessment Report on the Science of Climate Change *may be found at www.ipcc.ch.*

GROUP ACTIVITIES

The ICTP Physics of Weather and Climate group, established in 1998, has focussed its research and training activities on the development and testing of limited area climate models and the refinement and verification of a simplified atmospheric general circulation model. Issues related to seasonal predictability, climate-chemistry aerosol interactions, uncertainties in regional climate change predictions, interannual and interdecadal climate variability in the 20th century, and the predictability of Asian monsoon circulation have shaped its research agenda. The group maintains and distributes two models, the RegCM and Eta, for scientists, particularly those from the developing world, who are interested in limited area modeling; maintains several datasets that are made available to outside researchers, especially those from the developing world; and participates in the European Union's (EU) PROMISE programme on natural and anthropogenic climate change in tropical regions. ICTP climate-related training activities in 2001 include a Summer Colloquium on Land-Atmospheric Interactions and the Hydrological Cycle and a two-part advanced Course on Climate Change in the Mediterranean Region. The group has developed strong partnerships with, among others, the Chinese Academy of Sciences, the European Centre for Medium-Range Weather Forecasts (ECMWF), and the US National Center for Atmospheric Research (NCAR). For additional information about the ICTP Physics of Weather and Climate Group, please see the group's homepage at www.ictp.trieste/~pwc.

Under the umbrella of the SAND group, Indian and Italian scientists have joined efforts to examine one of the world's most destructive forces: earthquakes.

Seismic Changes... One Step at a Time

In the early morning hours of 26 November 1997, two moderate earthquakes, the first 5.7 in magnitude and the second 6.1, rattled the Italian hill provinces of Umbria and Marche, located in central Italy about 150 kilometers northeast of Rome. The event marked the first of a series of earthquakes that would continue to rumble across the region for the next six weeks—not only disrupting one of Italy's most picturesque areas but also fraying the nerves of the more than 100,000 people who live there. Ten deaths and US$10 million in damages would mark the earthquake's toll. Yet the world's most enduring image of this tragedy would be the collapsed roof of the Basilica of Saint Francis of Assisi, which left a heap of rubble on the church floor containing jagged puzzle pieces of one of the Western world's great artistic treasures: 13th century frescoes by the famed artist Giotto.

On 26 January 2001, a much stronger earthquake, 7.6 in magnitude, struck the Indian state of Gujarat in the northeast corner of the world's second most populous nation. The earthquake, which took place on the Indian national holiday of Republic Day, was felt throughout northwestern India, western Nepal and much of Pakistan. As the Indian government sought to cope with the catastrophe, it was soon evident that this earthquake would be the worst natural disaster in India since the nation had achieved independence in 1949. More than 20,000 people died, 165,000 were injured, and hundreds of thousands more left homeless. Experts estimate the recovery and reconstruction efforts will cost more than US$5 billion.

"We tend to think of earthquakes as unusual events—and thank goodness they are not everyday occurrences," says Giuliano Panza, head of the Structure and Non-Linear Dynamics of the Earth (SAND) group, which is an ICTP hosted activity. "But earthquakes are much more common than most people realise. For example, between the 1997 earthquake in Umbria/Marche and the 2001 earthquake in Gujarat, we experienced 16 major seismological events worldwide, including earthquakes in Afghanistan, Turkey, Colombia and Taiwan." And since the earthquake in India less than six months ago, in February a major earthquake in El Salvador killed at least 1100 people and left more than 1 million people homeless in that poor Central American country, and in March a moderate earthquake in Japan caused millions of dollars in damages. As Panza notes, "it's part of the human condition to be crushed and buried by earthquakes."

As Panza also points out, earthquakes may be "global phenomena but their severity and impact are often determined by local and regional conditions." For this reason, he says, "modelling may be an effective strategy for assessing both the prospects for a seismological event and the potential dangers likely to be experienced if an earthquake of a certain magnitude were to strike."

For the past decade, Panza, with the help of Abdelkrim Aoudia and other colleagues associated with the SAND group and the University of Trieste's Department of Earth Sciences, has developed and refined scenario-based models that have enabled scientists to better understand the anticipated behaviour of the Earth in such seismically active regions as central Italy and northwest India. "In effect," Panza notes, "the models help us envision what may happen without waiting for an earthquake to occur."

"Over time, we have acquired a great deal of knowledge about the Earth's geology," adds Aoudia, "that can be put to good use together with theoretical insights concerning the Earth's dynamical behaviour." Marrying observed data to theoretical constructs, and then testing the conclusions against the Earth's complex movements during a seismological event, has helped the SAND group to draw increasingly more reliable pictures of what may occur during future earthquakes. The goal of the seismological modelling process is not much different than what climatologists and meteorologists are doing with increasing confidence in projecting future changes in climate and weather.

Panza and his colleagues recently brought their modelling expertise to India as part of the first-ever Indo-Italian Workshop on Seismic Risk Evaluations, held in Hyderabad, 6-9 March 2001. He was accompanied by Aoudia and a number of other scientists from ICTP and the University of Trieste and other Italian research institutions. Those traveling to India with Panza included Roberto Sabadin, University of Milan; Fabrizio Mollaioli, University of Rome; Peter Suhadolc and Fabio Romanelli, University of Trieste; Giacomo Di Pasquale, National Seismic Survey; and Leonello Serva, Italian National Environmental Protection Agency.

The Italian contingent was joined by a group of some 30 Indian scientists, including seismologists, geologists and geotechnical engineers. Among those in attendance were Vinod Gaur, scientist emeritus, Centre for Mathematical Modelling and Computer Simulation (CMMACS), Bangalore, who is one of the true pioneers in seismology research in

his home country, and Harsh Gupta, former director of the National Geophysical Research Institute (NGRI) and presently secretary to the government of India in the Department of Ocean Development.

"Modelling methodologies served as the organising principle of the workshop," explains Aoudia, "but on a more general level we discussed such topics as the development of seismological observational networks and geo-databases, the underlying principles and goals of hazard assessments, and the current state of research on seismic microzonation and seismic vulnerability."

"The Indo-Italian workshop had been conceived and planned under the protocol of cooperation between the two countries," says Satish Bhatia, deputy director and head, Earthquake Hazard Assessment Group at NGRI. "The schedule, in fact, was finalised in early January 2001. However, the earthquake later that month in Gujarat made the workshop an even more timely event."

Bhatia also says that "overall India has a reasonably good number of well-trained and experienced seismologists but their numbers need to be expanded and their training strengthened to address the full range of seismological and emergency management issues that our nation face."

"After a brief initial period of shock and disbelief," he notes, "the rescue and recovery efforts in the area struck by the earthquake in Gujarat proved to be the most effective in the history of such emergencies in our country. While the scope of devastation and despair cannot be understated, the government, with the help of local grassroots organisations and other national as well as some international agencies, made an extraordinary effort in dealing with such a devastating situation."

The nation's risk management and mitigation efforts will receive another boost later this year when an Earthquake Risk Evaluation Centre (EREC), which has been in the planning stages for some time, becomes operational.

"The institution," Bhatia says, "is designed to be a centre of excellence in all phases of seismological research. For example, researchers will conduct state-of-the-art studies of earthquake-prone areas and develop seismic hazard and vulnerability maps based on the most up-to-date information and techniques."

The Indo-Italian workshop not only gave participants an opportunity to learn more about each other's work but also provided a platform for developing future joint activities. Three topics selected to receive special attention from the emerging Indo-Italian seismological network are:

- *Microzonation* of selected cities in India, coordinated by the Geological Survey of India and the University of Trieste's Department of Earth Sciences.
- Site-specific *seismic hazard assessment in megacities* using the most advanced modelling techniques, coordinated by the National Geophysical Research Institute (NGRI), Hyderabad, and the University of Trieste's Department of Earth Sciences.
- Estimation of *vulnerability and seismic risk assessment for megacities* of high hazard, coordinated by the Building Materials Technology Promotion Centre (BMTPC), Delhi, and the University of Rome *La Sapienza*.

Each of these activities, which will involve an exchange of visits among scientists in Italy and India, will include the direct participation of the SAND group. The effort is expected to get off the ground sometime next year and a report on the progress that has been made as a result of these cooperative research ventures will be presented at the International Geological Congress in Florence, Italy, in 2004.

As Panza observes: "We no longer have to wait for an earthquake to take place and then measure the ground motion to assess its impact. We can now use geological and geophysical data to model seismograms based on theoretical insights and assessments."

That's the goal both Indian and Italian scientists hope to advance in the years ahead as they work together to better understand the awesome physical forces responsible for violent shifts in the Earth's crust.

For additional information about the Indo-Italian network and, more generally, the SAND group, please contact panza@ictp.trieste.it or browse the group's homepage at www.ictp.trieste.it/sand.

Indo-Italian Workshop on Seismic Risk Evaluations

DATELINE

Math Money

The ICTP Mathematics Group has received a US$27,000 grant from the European Commission (EC) and a US$23,000 grant from the US National Science Foundation (NSF) to fund the cost of participation of young European and American scientists, respectively, in the Centre's School on High-Dimensional Manifold Topology. The School will be held in Trieste from 21 May to 8 June. Meanwhile, Brazil's National Research Council (CNPq) will increase its annual grant to the ICTP Mathematics Group from US$40,000 to US$50,000. The funds will be used to cover the cost of participation for Brazilian scientists in the ICTP School on Dynamical Systems (30 July to 17 August) and other Centre-based activities in mathematics and physics.

Call for Proposals

ICTP has issued a call for proposals from the scientific community for the organisation of schools, workshops and conferences in all fields of theoretical physics and mathematics as well as in subjects outside of those fields that make extensive use of the tools of physics and mathematics. The latter include weather and climate research, nuclear data and applications, mathematics of economics and computer science. For more detailed information, please contact proposals@ictp.trieste.it.

Nuclear Matters

Francesco Calogero, professor of physics at the University of Rome *La Sapienza*, spoke in the ICTP Main Lecture Hall on 26 February on issues related to nuclear weapons development and control. Calogero serves as Chairman of the Pugwash Council (1997-2002). Pugwash received the Nobel Prize for Peace in 1995. In his lecture, Calogero noted that the number of nuclear warheads has declined from a peak of 70,000 in 1986 to about 30,000 today.

Francesco Calogero

EU Commissioner

Philippe Busquin, the European Union's (EU) Commissioner for Research, visited ICTP on 16 February as part of a one-day tour of scientific institutions in Trieste. The Commissioner met with ICTP director Miguel Virasoro and members of ICTP's research groups to discuss ways that the EU and ICTP could work together to promote scientific cooperation between developing countries and Europe. Two areas of particular interest to the Commissioner were the ICTP Training and Research in Italian Laboratories (TRIL) programme and the Centre's involvement in the EU's PROMISE programme, which focusses on the predictability and variability of monsoons and the agricultural and hydrological impacts of climate change.

ICTP director Miguel Virasoro welcomes Philippe Busquin (right)

Sky Gazing

The ozone hole over Antarctica could heal in some 50 years, according to an international panel of scientists chaired by Alan O'Neill, director of the Centre for Global Atmospheric Modelling, University of Reading, UK. The recent announcement strongly suggests that the global effort to reduce the use of chlorofluorocarbons (CFCs), launched in 1987, is succeeding.

Two of the scientists who made major contributions to the understanding of the processes that influence the atmosphere's ozone content visited ICTP during the past few months: Dutch-born Paul J. Crutzen and American-born F. Sherwood Rowland. In 1995, they shared the Nobel Prize for chemistry with Mario J. Molina (also from the United States) for their pioneering work in atmospheric chemistry, particularly concerning the formation and depletion of ozone.

Crutzen recently stepped down as director of the Max Planck Institute for Chemistry in Mainz, Germany, and now serves as co-chief scientist of INDOEX, the Indian Ocean Experiment that since 1995 has been collecting data from satellites, aircraft, balloons, ships and island stations to provide information about the complex influence of aerosol cooling on global warming. INDOEX is supported by universities and national laboratories from the United States, Europe and the Indian Ocean region.

INDOEX's activities were the main topic of discussion at the special seminar on "The Importance of the Tropics in Atmospheric Chemistry and How It Is Impacted by Human Activities,"

Paul J. Crutzen

F. Sherwood Rowland

which Crutzen delivered at ICTP on 25 October 2000. In 1970, Crutzen showed that nitrogen oxides react catalitically with ozone, thus accelerating the rate of reduction of the ozone content in the atmosphere. During the same period, he pointed out the possible threat to the ozone layer created by civil supersonic aircraft because of the releasing of nitrogen oxides in the middle of the ozone layer at altitudes of 20 kilometres.

F. Sherwood Rowland, who is the foreign affairs chairperson of the US National Academy of Sciences, attended the first meeting of the InterAcademy Panel's (IAP) Executive Committee that took place at ICTP at the end of January (see page 14). With colleagues from the University of California at Irvine, Rowland is now analysing the air in some 25 megacities worldwide to identify the sources of urban pollution.

"We also hope to use this data," explains F. Sherwood Rowland, "to study the effects of rising levels of carbon dioxide on climate change. The Earth's temperature has increased by about 0.7°C since 1880, due in part to the release of carbon dioxide during industrial activities. For the near future, I put no great trust in solar or wind energy. But we may be able to 'imprison' carbon dioxide in underground cavities or beneath the seas. Research on such potential mitigation strategies are already taking place in Norway, for instance."

John Casti

Would-Be Worlds

John Casti, of the University of Vienna (Austria) and the Santa Fe Institute (USA), presented a public lecture at the ICTP Main Lecture Hall on 29 March focussing on the 'would-be' behaviour of complex systems ranging from traffic patterns to stock markets to rainforests. Casti contends that high-powered computers now give us the ability to create surrogate versions of real complex systems—artificial worlds, if you will—that are analogous to the more familiar laboratories that have been used by physicists, biologists and chemists for centuries to understand the workings of matter and nature. The difference is that these new computerised laboratories allow us to explore the informational rather than the material structure of systems. The result, according to Casti, is that for the first time in history we may now be in the position to realistically think about the creation of a theory of complex systems.

REPORT ON REPORTS

STRINGS 2001, Mumbai, India

5 - 10 January

Co-sponsors: Clay Mathematical Institute (Cambridge, Massachusetts, USA) and Tata Institute of Fundamental Research (TIFR, Mumbai, India).

Directors: A. Dabholkar (TIFR), S. Mukhi (TIFR), K.S. Narain (ICTP), G. Thompson (ICTP) and S. Wadia (TIFR).

The Conference, held at Tata Institute of Fundamental Research in Mumbai, attracted 300 physicists from around the world specialising in string theory. Some 45 speakers made presentations. This marked the first time that this annual event was held outside of the United States or Europe. Previous locations included Los Angeles, Amsterdam, Santa Barbara, Potsdam (Berlin), and Ann Arbor (Michigan, USA). A special programme following the conference featured talks by David Gross, Stephen Hawking and Edward Witten.

Left to right: David Gross, Edward Witten and Stephen Hawking in Mumbai

TENTH INTERNATIONAL WORKSHOP ON COMPUTATIONAL CONDENSED MATTER PHYSICS: TOTAL ENERGY AND FORCE METHODS

11 - 13 January

Co-sponsors: International School for Advanced Studies (SISSA) and Department of Theoretical Physics of the University of Trieste.

Directors: S. de Gironcoli (SISSA), R. Needs (Cavendish Laboratory, University of Cambridge, UK) and K. Terakura (Joint Research Centre for Atom Technology, National Institute for Advanced Interdisciplinary Research, JRCAT-NIAIR, Tsukuba, Japan).

The Workshop, the latest in a series that began in Oxford in 1983, was devoted to recent advances in computational condensed matter physics. Topics included: density-functional molecular dynamics; large-scale electronic structure calculations; linear-scaling methods; density-functional theory beyond local-density approximation; quantum Monte Carlo; many-body techniques; empirical tight-binding and effective medium theory; applications to transition states and rates; chemical reactions in condensed phases; non-equilibrium and non-adiabatic processes; electron dynamics and excited states; catalysis; geophysics; magnetism; nanoscience; surfaces and other low-dimensional systems; phase transitions; and polarisation, fields and currents.

SOUTHERN AFRICA REGIONAL MODELLING WORKSHOP, Cape Town, South Africa

22 January - 2 February

Co-sponsor: International Institute for Theoretical and Applied Physics (IITAP, at Iowa State University, Ames, Iowa, USA), with the endorsement of the South African Society for Atmospheric Sciences (SASAS).

Directors: B. Hewitson (University of Cape Town, South Africa), W. Gutowski (IITAP), F. Giorgi (ICTP), and A. Adedoyin (University of Botswana, Gaborone, Botswana).

The Workshop consisted of lectures on climate models (including talks concerning model structures and implementation) interlaced with hands-on sessions that drew on regional climate models. The objectives were to build capacities in regional climate modelling among scientists in southern Africa nations; improve their understand of regional climate models; help them gain greater appreciation for the general features of Africa's climate; and provide them with the know-how to initialise, run, archive and analyse regional model simulations.

TRIESTE MEETING OF EUROPEAN PROJECT COST 271

24 - 27 January

Project Chairman: B. Zolesi (Italian National Institute of Geophysics).

Local Organiser: S. Radicella (ICTP).

This marked the first Management Committee meeting of COST (Cooperation in Science and Technology) Action 271 on "Effects of the Upper Atmosphere on Terrestrial and Earth-Space Communications," a European Commission programme. The meeting was attended by about 50 European experts. Sandro M. Radicella, head of ICTP's Aeronomy and Radiopropagation Laboratory, was elected co-chair of Working Group 4 : Space Plasma Effects on Earth-Space and Satellite-to-Satellite Communications.

SCHOOL ON DIGITAL AND MULTIMEDIA COMMUNICATIONS USING TERRESTRIAL AND SATELLITE RADIO LINKS

12 February - 2 March

Co-sponsor: International Union of Radio Science (URSI, Gent, Belgium).

Directors: S.M. Radicella (ICTP) and R. Struzak (Radio Regulation Board of the International Telecommunication Union, ITU, Geneva, Switzerland).

School on Digital and Multimedia Communications Using Terrestrial and Satellite Radio Links

The School, a follow-up to three previous schools on the use of radio for digital communications, included lectures and laboratory work on computer networking and radio techniques for digital communications. Lectures, which were complemented by case studies presented by participants, covered the following topics: modern communication potential and needs in developing countries; the information society and global information infrastructure; access to spectrum/orbit resources and principles of spectrum management; radio interference, electromagnetic compatibility, and coordination of radio links; Earth-to-Earth and Earth-to-space radiopropagation issues related to broadband systems; satellite-based and terrestrial-based broadband radiocommunication systems. Laboratory work, which used digital communications facilities available at ICTP, simulated the planning and implementation of a campus multimedia computer network using radio links.

WINTER SCHOOL ON LASER SPECTROSCOPY AND APPLICATIONS

19 February - 2 March

Co-sponsors: International Centre for Science and High Technology of the United Nations Industrial Development Organization (ICS-UNIDO, Trieste, Italy).

Directors: W. Demtröder *(Universität Kaiserslautern, Germany)* and M. Inguscio (*Università di Firenze*, Florence, Italy).

Local Organiser: G. Denardo (ICTP and University of Trieste).

The School, which introduced scientists to basic modern spectroscopy through lectures, group discussions and laboratory demonstrations, provided the background needed to follow the most advanced literature. Topics included basic instrumentation of modern spectroscopy; techniques in absorption-, emission-, doppler-free, and time-resolved spectroscopy; recent developments in laser spectroscopy (including optical cooling, atomic interferometers and atomic lasers); applications of spectroscopy in chemistry, biology, medicine and environmental science; and VUV, soft x-ray and photo-electron spectroscopy.

Massimo Inguscio

INTERNATIONAL SCHOOL ON CRYSTAL GROWTH OF MATERIALS FOR ENERGY PRODUCTION AND ENERGY-SAVING APPLICATIONS

5 - 10 March

Co-sponsors: International Union of Crystallography (IUCr), Crystal Growth Section of the Italian Crystallographic Association (SCC-AIC) and Italian Group for the Structure of Matter of the National Research Council (GNSM-CNR), in cooperation with the Italian National Institute for the Physics of Matter (INFM).

Directors: R. Fornari (Institute of Special Materials for Electronics and Magnetism, MASPEC, Parma, Italy).

The School, which included lectures by 16 international experts, focussed on the preparation and characterisation of materials to be used in energy production and energy storage applications. The curriculum was designed for young master and Ph.D. students working in fields of material science.

ADVANCED COURSE: CLIMATE CHANGE IN THE MEDITERRANEAN REGION - PART I: PHYSICAL ASPECTS

12 - 16 March

Co-sponsors: European Project RICAMARE (with funding from the European Commission/Director-General for Science, Research and Development and START programmes).

Directors: G. Begni (MEDIAS, Toulouse, France) and F. Giorgi (ICTP).

Tutorial lectures focussed on the following topics: physical principles of climate change; main climate-driving forces in the Mediterranean region; representation of climate variability in General Circulation Models (GCMs); effects of greenhouse gas concentrations on climate and vegetation (including the impact on deforestation and afforestation); and the origin and impact of aerosols in the Mediterranean. The Course was designed primarily for scientists and graduate students working in the areas of atmospheric physics and chemistry, climatology, chemistry, physics and mathematics.

COLLEGE ON SOIL PHYSICS

12 March - 6 April

Directors: D. Gabriels (Department of Soil Management and Soil Care, Gent University, Belgium), D. Nielsen (Department of Land, Air and Water Resources, University of California, Davis, USA), I. Pla Sentis (*Facultad de Agronomía, Universidad Central de Venezuela*, Maracay, Venezuela, and *Departamento de Medi Ambient i Ciencies del Sol, Universitat de Lleida*, Lleida, Spain) and E. Skidmore (U.S. Department of Agriculture, Manhattan, Kansas, USA).

Local Organiser: GC. Ghirardi (University of Trieste and ICTP).

The College, intended for students and professionals with backgrounds in physics, mathematics, soils, engineering, agricultural and environmental science, examined the state of knowledge of soil physical properties and processes. The aim was to provide participants with the intellectual tools they need to address agronomic, engineering and environmental challenges related to drainage, irrigation, erosion, fertilisation and pollution. The College paid special attention to practical applications, instrumentation and measurement techniques, and the modelling of physical processes. Topics discussed included soil (genesis, pedotransfer functions, intrinsic and temporal properties, and property measurements); soil-water-plant relationships (infiltration, drainage, evaporation, and water balance); erosion processes (physics, measurement, prediction, and control); solute transport (leaching, soil salinity, pollution and remediation); and spatial processes (geostatistics, applied time series, GIS, and monitoring technology).

Saw-Wai Hla

PROFILE

Saw-Wai Hla recently garnered worldwide publicity for uncovering a technique that enables scientists to study chemical reactions molecule by molecule.

Ultimate Reactions

Former ICTP Diploma student Saw-Wai Hla, currently a researcher at the Free University in Berlin, Germany, is an accomplished young scientist whose pathbreaking work with scanning tunnelling microscopes has been discussed in virtually every major scientific publication. He is also an accomplished musician who once earned a living playing bass guitar in a 'boy band' that produced three albums and made a dozen appearances on national television in his native country of Myanmar (formerly Burma) in southeast Asia.

Hla fervently believes that the talents and skills accounting for his success as a musician are the same ones that he has put to good use in his scientific endeavours.

"In science as in music," Hla explains, "it's not enough to master the techniques. You must know how to handle the instruments. You must also have an emotional attachment to your work."

"In music that means not just having the ability to play the correct notes and chords but *the feeling* to play those notes and chords in ways that touch and move your audience. In science that means not just having the ability to master your laboratory instruments but having an innate feeling of how to take your research in uncharted directions."

Hla describes how this feeling helped him take the well-known analytical power of scanning tunnelling microscopes to new heights by using the tip of the microscope to 'tease' single molecules through a complicated chemical process known as the Ullman reaction.

The Ullman reaction, which has been part of the tool kit of chemical laboratories for more than a century, creates multi-ring polymers by blending countless reacting molecules in large copper-laced vessels that provide the catalyst for the reaction. Hla and his colleagues at the Free University in Berlin miniaturised the process by using electron flows from the tip of the microscope to break and then rejoin molecules one at a time. A process, previously characterised by a blur of chemical activity, was reduced to a step-by-step procedure that allows scientists to visualise the reaction as it's unfolding.

This breakthrough, which could effectively allow scientists to probe the most intimate details of chemical reactions molecule by molecule, also opens up the possibility of building human-made molecules in the future. "We are not there yet," says Hla, "but the discovery certainly makes a monomolecular construction process a possibility." If such a bottom-up molecular construction technique becomes a reality, it could have an enormous impact on atomic-scale chemistry and nanoscience and nanotechnology.

Chemical and Engineering News, the flagship publication of the American Chemical Society, billed Hla's "atom by atom reaction" as the 'top story' of the week in its 2 November 2000 edition, and this past fall *Nature*, *Science*, *Scientific American*, *Science News*, *Physics Today* and *Physics News* all gave extensive coverage to his work.

The press attention generated numerous requests for lectures by Hla, including presentations at international conferences in Canada, China, France and Sweden, and invited seminars at IBM's T.J. Watson Research Center and Clemson University in the United States, and the University of Freiburg in Germany. It also brought Hla back to Trieste to speak at the Workshop on Nanoscale Spectroscopy hosted by ICTP last December.

"I was delighted to return to Trieste," says Hla. That's where he had spent much of his time during the 1990s—first, from 1992-1993, as a student concentrating on condensed matter physics in ICTP's Diploma Course (where he completed his thesis under the direction of Maria Peressi, professor at the University of Trieste's Department of Theoretical Physics); then from 1994-1997 as a doctoral student at the J. Stefan Institute (IJS) in Ljubljana, Slovenia, in a programme sponsored jointly by ICTP and IJS (where he earned a doctorate under Velibor Marinkovic and Albert Prodan, focussing his research on experimental surface science and thin film physics); and finally, from 1997-1998, as a fellow in ICTP's Training and Research in Italian Laboratories (TRIL) programme, working at the TASC laboratory at the *Elettra* synchrotron light facility in Area Science Park, Trieste, on experiments related to surface science.

"I owe my success," Hla notes, "largely to the education and training I received in Trieste. My experience there allowed me the opportunity to hone my skills both in theory and experimentation. I hope to put this background to use again in moving my research from the realm of laboratory observations (the ability to use the scanning tunnelling microscope to see the most intimate details of chemical reactions) to the world of molecular manipulation and creation, which could spur the creation of novel chemical compounds that cannot be made through conventional means."

"I consider myself an alumnus of ICTP and, more generally, of the Trieste scientific community. There's no doubt that ICTP and the intricate network of scientific institutions in Trieste and the surrounding area are largely responsible for whatever success I have achieved to date and whatever success I might achieve in the future."¤

TRIBUTE

Ugo Fano, 1912-2001

Ugo Fano, professor emeritus at the University of Chicago, whose pioneering contributions to the theory of atomic and radiation physics proved instrumental in the development of gas lasers and the use of radiation in medical diagnosis and therapy, died in Chicago on 13 February. Fano, who began his career working with Enrico Fermi at the University of Rome in the 1930s, received the Enrico Fermi Award from President Bill Clinton in a White House ceremony in 1996. His influence in physics is reflected in the number of discoveries that now bear his name, including the "Fano effect" and the "Fano factor." He visited ICTP on two occasions, in 1988 and in 1990, to attend the Research Workshop in Condensed Matter, Atomic and Molecular Physics.

InterAcademy Panel (IAP)

The first meeting of the InterAcademy Panel's (IAP) Executive Committee, since members voted last spring to move the secretariat to Trieste under the umbrella of the Third World Academy of Sciences (TWAS), was held on 22 January in the Enrico Fermi Building on the ICTP campus. Representatives of 10 science academies—including Africa, Australia, Brazil, China, France, Italy, Sweden, Turkey, the United Kingdom and the United States—took part in the event. Gianfranco Facco Bonetti, director general for the promotion of culture and cooperation in the Italian Ministry of Foreign Affairs, announced that the Italian government would provide 1 million Euros (approximately US$900,000) to IAP over the next two years to help fund its programmes. Additional money, intended to cover IAP's operational costs, has been pledged by the municipality of Trieste, the region of Friuli-Venezia Giulia and the province of Trieste. IAP, which is comprised of nearly 80 science academies worldwide, is designed to bring together academies of all nations to discuss scientific issues of global concern. The panel's first activity, a workshop focussing on strategies for capacity building of science academies in Africa, will take place in Trieste this May. Workshops on science and the media and science and education are also planned as part of IAP's initial agenda.

IAEA Diplomats

Some 20 diplomats assigned to the permanent missions of member states of the International Atomic Energy Agency (IAEA) visited the Centre on 1-2 February. The diplomats, who hailed from Asia, Australia, Europe, Latin America, and the United States, discussed, among other items, potential IAEA/ICTP collaborative activities related to the new Agency sub-programme, "Preservation of Knowledge in Nuclear Science and Technology." The schedule included meetings with ICTP director Miguel Virasoro and the heads of ICTP scientific activities.

ICO-ICTP Prize

Arashmid Nahal (left), researcher at the Institute of Advanced Studies in Basic Sciences, Zanjan, Iran, and Luis Fernando Perez Quintian, researcher at the Department of Physics at the University of Buenos Aires, Argentina, shared the International Commission for Optics (ICO)-ICTP Award for 2001. Established in 1999, the ICO-ICTP Award is given to young researchers who were born and continue to live and work in developing countries. Nahal was honoured for his theoretical studies on polarised light effects in photosensitive films. Perez Quintian was honoured for his theoretical studies on the diffusion of light on surfaces. Each received US$500. The award ceremony took place in the ICTP Main Lecture Hall on 2 March, as part of the Winter School on Laser Spectroscopy and Applications. ICO, which has 44 institutional members, is dedicated to advancing global knowledge and high-level research findings on optics through conferences, meetings, schools, fellowships and awards. Headquartered in Washington, D.C., ICO is an affiliate commission of the International Union of Pure and Applied Physics (IUPAP).

Astronaut Touches Down at ICTP

Julie Payette, an astronaut with the Canadian Space Agency, delivered a public lecture, "Working in Space: A Challenge and a Privilege," in the ICTP Main Lecture Hall on 2 April. The event was organised by the United World College of the Adriatic located in Duino, near Trieste. In 1982, Payette earned an international baccalaureate at the United World College of the Atlantic in South Wales, UK. In spring 1999, she spent 10 days on the space shuttle *Discovery*, helping to deliver logistical support and supplies to the International Space Station in preparation for the arrival of its first crew.

2 - 10 April
Spring School on Superstrings and Related Matters

23 April - 4 May
Third Antonio Borsellino College on Neurophysics: Evolution of Intelligent Behaviour

23 - 27 April
Workshop on Technologies for Desalination

30 April - 4 May
Workshop on Desalination Economic Evaluation

7 - 11 May
Third International Conference on Perspectives in Hadronic Physics

7 - 25 May
Spring College on Numerical Methods in Electronic Structure Theory

15 - 19 May
ICTP/TWAS/UCSB Workshop on Frontiers in Advanced Materials

21 - 25 May
Workshop on Statistical Physics and Capacity-Approaching Codes

21 May - 8 June
School on High-Dimensional Manifold Topology

28 May - 15 June
Summer Colloquium on the Physics of Weather and Climate: Land-Atmosphere Interactions and the Hydrological Cycle

11 - 22 June
Workshop on Protein Folding, Structure and Design

18 June - 6 July
Summer School on Particle Physics

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 2001`
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`
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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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