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International Centre for Theoretical Physics

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Contents

Minister Gianni De Michelis at the ICTP

At times, the routine scientific work at the International Centre for Theoretical Physcs is broken by happenings assuming a more political tone. This was the case on 26 and 27 March, the two days fixed for the Trieste Conference on Scientific Cooperation with Eastern Europe to which Gianni De Michelis, Minister of Foreign Affairs of Italy, had been invited as the guest of honour by Abdus Salam, Director of the International Centre for Theoretical Physics and President of the Third World Academy of Sciences.

Prof. Abdus Salam and Minister G. De Michelis.

In less than a year, dramatic changes have occurred in Eastern Europe. The ideological basis which had moulded the life of the Poles, East Germans, Czechs, Hungarians and Bulgarians for more than four decades has been overthrown in generally quiet revolutions. The emotional phase of these revolutions were quickly followed by a pragmatic approach to the problems raised by this extreme transformation. There is the problem of the re-unification of the two Germanies, the transformation of the Comecon and of the Western and Eastern military alliances, the modernization of the industry from state-governed economies to market economies. This mutation will require huge investments for many years to come, radical changes in management styles, increase in productivity and so forth. Summarizing this, the *Economist* writes *"The public*

repudiation of communism by communists, however astonishing, was in fact the easy part. The hard part is just starting". West European countries have already made their plans for challenging this new situation which will open up a new market of 415,000,000 people if one includes the Soviet Union. The European Economic Community, for instance, is creating a new financial institution, the Bank for Reconstruction and Development of Eastern Europe which will contribute to financing these huge projects and this, in addition, to other forms of co-operation or assistance.

In this context of great mobilization, the problem of the developing countries may run the risk of being shifted into the background of the rich countries' priorities. "None of that", said the Italian Minister of Foreign Affairs Gianni De Michelis in his address to the participants in the Conference; "Italy has a plan for co-operation with Eastern Europe, Mediterranean countries and with all the other developing countries". These plans and ideas were recorded by Fabio Pagan, journalist from the Trieste newspaper "Il Piccolo", in an interview which we publish in these columns.

Interview with Minister De Michelis

by Fabio Pagan,
"Il Piccolo",
Trieste, Italy.

Q.: Minister De Michelis, you took part in the Conference on Scientific Co-operation with Eastern Europe, organized by the International Centre for Theoretical Physics in Trieste. Its Director, Nobel Prize Laureate Abdus Salam, has asked the Government of Italy for 2 or 3 million dollars for extending to Eastern Europe those privileged relations which the Centre has until now maintained with the countries of the Third World. How will the Government respond to this request?

A.: There are two possibilities in front of us. The first one is to use funds from the Co-operation for Development[1] which depends from the Ministry of Foreign Affairs. However, I would prefer to keep these funds for the South of the world. The other alternative is the new law for the co-operation with the East European countries which I intend to submit to the Parliament in May. This should be the instrument to be used by Italy in favour of the countries of Central Europe. In particular, the four-nation agreement including Italy, Yugoslavia, Austria and Hungary which will soon become a five-nation one since it will include Czechoslovakia as well. In this law, there will be a specific chapter on scientific collaboration where we could find the resources for the implementation of the projects which Professor Salam and the Trieste Centre have in mind for Eastern Europe.

Q.: A recent British report has stressed the possibility that investments in Eastern Europe could be detrimental to the Third World, that Eastern Europe countries — because of their low labour costs — could transform themselves into potential competitors to Asian manufacturers. Is this a concrete possibility?

A.: One must be precise on this point. It is a fact that there is a concern in developing countries for a decreased attention in their respect and there is not the slightest doubt that today Eastern Europe is at the centre of our attention. We must, however, prove our ability to develop a co-operation policy with the Mediterranean Region — in parallel with an intensification of the relations with Eastern Europe. This means a jump of quality in the policy of the Community[2]. We shall deal with this, under the Italian Presidency at the beginning of July, when we shall discuss our proposal of 1% at the EEC Commission.

Q.: What is it about?

A.: We propose to dedicate 1% of the gross domestic product to international co-operation from 1992 onwards that is when the great European market will enter into force, and more precisely 0.25% for Eastern Europe, 0.25% for Mediterranean countries and 0.5% to the other developing countries. One should remember, however, that the resources which will be made available to Eastern Europe will have the character of investments, they are not without security. And we expect that these investments will produce returns very quickly. They are to be used for the development of the economy of countries which may rely on a potential market of 140 million people.

Q.: Is there any risk of bad surprises, if one invests in countries which later on turn out to be insolvent?

A.: These countries were insolvent in the past because there were communist regimes, because they were based on wrong economic models. Much of the funds made available by German and Italian banks to Poland in the late seventies have turned into an external debt of US$40 billion which in reality cannot be recovered. What we have in mind for the near future is to invest: that is to say, we shall contribute to a great transformation operation which will lead to economic systems comparable to ours, in a position to guarantee a return to the investment. This is what should happen with the new Bank for the East which we are launching in the next weeks.

Q.: But will the German unification not end up with its domination upon the rest of the European continent?

A.: There is such a risk and this risk is also felt in the countries of Eastern Europe. An important summit has been convened on 9 April in Bratislava, involving Czechoslovakia, Hungary and Poland, precisely to call the attention on Central Europe and, so to say, to recall that Central Europe exists as well as Germany does. It is noteworthy that the Austrian, Yugoslav and Italian Ministers of Foreign Affairs have been invited to this meeting. Italy will therefore be the only EEC country present in this Bratislava meeting. This is a recognition of our role, of our Ostpolitik.

Q.: Last year, in Trieste precisely, you suggested a Barcelona-Trieste axis to counterbalance the French-German axis. Is this concept still valid?

A.: This idea is even more valid than ever, after the recent events. Today, or

[1] Part of the activities of the ICTP and most of the TWAS are financed by the General Directorate for Cooperation to Development.

[2] European Economic Community.

rather after the elections in Hungary, this axis should extend to Budapest so as to link the centre of Europe strongly. This axis will include "hard" relations as well as "soft" ones. On one hand, infrastructure such as roads, fast railways, airlines, electric lines, and on the other hand a network of research centres, universities and of tourism exchange. A flow of common interest in both directions, able to stimulate Southern Europe for counterbalancing the East-West axis based on the unification of Germany, to link the Mediterranean area to the "Mitteleuropa" of the twenty-first century. There is a great role for Italy which involves its North-East through that region centered on Venice-Trieste. We should not become a suburb of tomorrow's Europe.

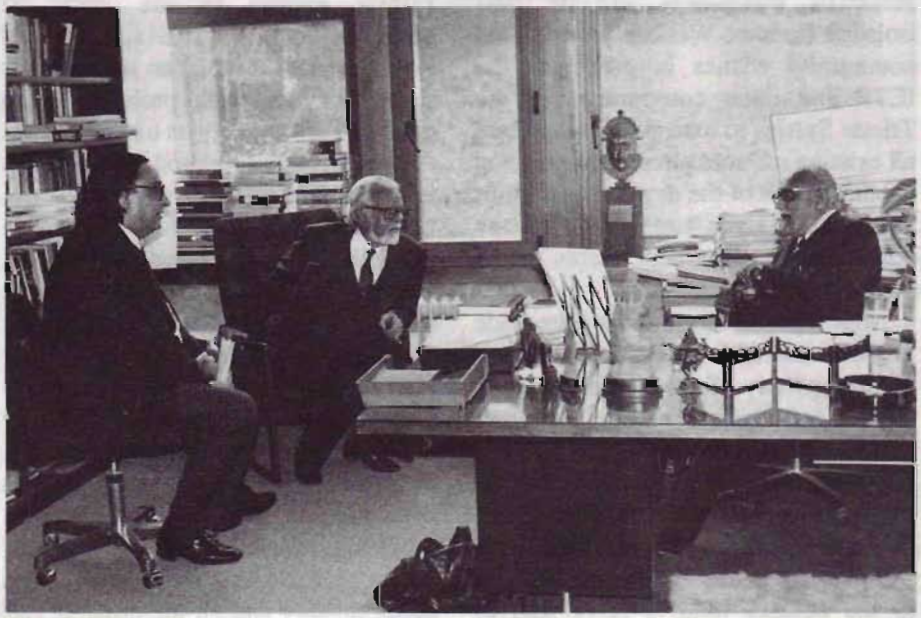
Footnote to the interview:

At the Spring meetings of the World Bank and International Monetary Fund, the fear that development capital would be diverted to emerging Eastern European democracies was expressed once more. Barber B. Conable Jr. — President of the World Bank — replying to twenty-four finance ministers from the Third World, said "...while the World Bank's mandate requires us to take an active role in Eastern Europe, our human and financial resources will not be reduced in continuing the fight against poverty wherever it exists."
(International Herald Tribune)

The Trieste Conference on Scientific Co-operation with Eastern Europe (26 - 27 March 1990)

Many old friends of the ICTP but also many personalities from the academic and political world of Eastern Europe and from Italian and international organizations met on 26 and 27 March at the International Centre for Theoretical Physics in Trieste to discuss new prospects of co-operation after the upheaval which has radically changed the face of Europe. Though the preparation time for the Conference on Scientific Co-operation with Eastern Europe was rather brief, Abdus Salam, the convenor, had all good reasons to feel satisfied not only for the wealth of information collected after two days of discussions but also for the reassuring statements made by Mr. G. De Michelis, Minister for Foreign Affairs of Italy and honoured guest of the Conference, in connection with future aid to Eastern Europe and to the Third World. In his opening address, Abdus Salam remarked that in 25 years, co-operation with Eastern European scientists have always been excellent, perhaps because of the special international status of the ICTP. Out of a total of forty-two thousand scientists who have been in Trieste in one or another capacity since 1964, some five thousand of them were from Eastern Europe. He also said that he was aware of the great scientific potential of Eastern Europe and of its desire to collaborate with the West; however, in the present situation, he felt, as far as the ICTP was concerned, that any increase of collaboration with Eastern countries should not be at the expense of the Centre's work for the developing countries. Collaboration will be enhanced only if additional funding — two to three million dollars per year —is obtained.

He then introduced brief addresses by Ambassador Corrado Taliani, Permanent Representative of Italy to the International Organizations in Vienna and Representative of the Italian Government to the ICTP, by Mr. Dario Rinaldi, Minister for Finance of the Regional Government of Friuli Venezia Giulia, and by Professor Domenico Romeo, Chairman of the Research Area of Trieste. Mr. J. Jabbar, Minister of State for Science and Technology of Pakistan, and Mr. M. Ayatolahi, International Relations Advisor at the Atomic Energy Agency of Iran, represented the developing countries and through their statements outlined the wishes of those countries. Professor Paolo Budinich concluded this part of the opening session with a keynote speech on the international role of Trieste in Science and Technology for Development.



Prof. Abdus Salam (right) had a meeting with Minister G. De Michelis in his office at ICTP. Prof. P. Budinich, former Deputy-Director of ICTP, was also present.

After the opening, a session was dedicated to the description of the Trieste System, i.e. the conglomerate of scientific institutions comprising the International Centre for Theoretical Physics, the Third World Academy of Sciences, the forthcoming International Centre for Science, the International Centre for Genetic Engineering and Biotechnology and the International School for Advanced Studies by L. Bertocchi (Deputy Director of ICTP), M. Hassan (Executive Secretary of TWAS), G. Rosso Cicogna (Project Leader of ICS), A. Falaschi (Director of

ICGEB) and D. Amati (Director of SISSA), respectively.

In the afternoon of the first day, several scientists and politicians took part in the discussion on the present state and future perspectives of science and technology in Eastern Europe. From the speeches and subsequent discussions, the picture which emerged was that of a large community* of qualified scientific manpower seriously exposed to the temptation of migrating to other countries due to the present economic difficulties, lack of up-to-date scientific equipment and to their isolation from the Western World. That community wishes in particular the ICTP and other components of the Trieste System to extend to its members all existing schemes already in operation for the benefit of the developing nations and at the same time to offer the collaboration of its best talents to the system in various forms.

More specific suggestions were made in the round table discussions held on the second day of the Conference. In physics and high technology, earth and environmental sciences (chaired by Prof. W. Kummer, Vienna), Eastern European scientists proposed to contribute more than in the past to providing lecturers and even temporary laboratory facilities to the courses held at ICTP and to follow up research work started in the Trieste facilities in their own laboratories. Hungarians wish to do this in photonics and in high-temperature superconductivity facilities in Budapest. They offer contributions in cash and kind for hosting courses in their laboratories, in advanced ceramics and semiconductors, infrared laser devices in Hungary, in atmospheric physics and space sciences in Bulgaria. They would also welcome long-term researchers from developing countries in all scientific disciplines in their institutions and wish to participate in projects on the exploration of hybrid solar systems (Czechoslovakia and Yugoslavia), earth sciences in Poland, earth sciences (Yugoslavia and Czechoslovakia) and marine sciences in Yugoslavia. In chemistry (Chairman: Dr. J. Marton-Lefevre, ICSU), Prof. V. Crescenzi (ICS) proposed the creation of an Advanced Instrumentation Laboratory in Trieste which would be made available also to Eastern European scientists. Hungarians wish to share their know-how in pharmaceutical products, biopolymers, control of chemical processes including very fast reactors and chemistry of environment. Yugoslavs wish to enhance their collaboration with Trieste groups in the study of biopolymers, catalysis, use of synchrotron light radiation in molecular science, environmental problems and in computer communications. Czechoslovakia proposed collaboration in heterogeneous catalysis — selective oxydations, zeolites etc. — and in theoretical chemistry and, in addition, invited ICS to take part in the organization of Italian-Czechoslovak symposia in catalysis.

The Italian National Research Council, through Prof. I. Bertini, offered its collaboration in spectroscopy, theoretical chemistry and in pollutants monitoring and elimination.

A third round table also chaired by Dr. J. Marton-Lefevre, focussed on biotechnology and on the possible role of the International Centre for Genetic Engineering and Biotechnology. Bulgaria, Yugoslavia and Hungary are already member countries of the ICGEB and host affiliated centers. Czechoslovakia and Poland expressed their interest in joining ICGEB as well as hosting affiliated centres. Possible areas of co-operation between the East and the Trieste System include: human genome structural and functional studies; plant viruses; applications of gene manipulation; protein engineering and protein or cell immobilization; advanced fermentation; bioreactors; large-scale cell production and macromolecules. Bulgaria, in particular, offered to host a laboratory of genetic engineering of plant viruses jointly supported by the Bulgarian Academy of Agriculture and ICGEB.

The last round table dealt with scientific communication. Hungary has a great experience in physics teaching and wishes to share it with the ICTP. Czechoslovakia uses TV and video for the popularization of science in the public and in public schools, Trieste has its Laboratorio dell'Immaginario Scientifico. There are plenty of opportunities for co-operation in the future.

After the Conference, a working group was set up for the co-ordination of future action. In synthesis, Eastern European scientists wish to take part in all the schemes created in the Trieste System, in the same way scientists from developing countries do. On the other hand, they are also in a position to help scientists from the Third World. Some areas of collaboration were indicated during the Conference but others will undoubtedly emerge in the near future. Let us hope that funding will follow rapidly so that the implementation of the programme can start as soon as possible.

The Conference was attended by 148 participants including 22 ministers, presidents or high officials from academies of sciences.

* In an exhaustive analysis of science in Eastern Europe, *Nature* quotes *"more than 250,000 people work professionally as scientists and technologists"* (*Nature*, Vol. 344, April 1990).

Catalunya Prize to Abdus Salam

by Azim Kidwai

Courtesy of TWAS Newsletter.

Prof. Abdus Salam, Director of ICTP and President of TWAS, has been awarded the Premi Internacional Catalunya 1990. The Prize carries a cash award of one hundred thousand dollars and is *"awarded to those who, through their creative endeavour, have made a significant contribution to the development of culture, science or human values throughout the world."*

The prize, conferred by the Institut Català d'Estudis Mediterranis of Catalonia, Spain, is awarded every year to a person adjudged by the Advisory Council of the institution as the most deserving. The first award was given last year to Sir Karl R. Popper.

Prof. Salam, in March 1990, after the announcement that he is the recipient of the prize, said that the whole amount will be donated by him towards the

promotion of science in the developing countries.

Dirac Medal 1989 to Michael B. Green

On 24 April, Michael Green from Queen Mary College in London, received from Abdus Salam, Nobel Laureate for Physics in 1979 and Director of the International Centre for Theoretical Physics in Trieste (Italy), one of the 1989 Dirac Medals. Two medals are awarded every year on 8 August, birthday of the late P.A.M. Dirac. John H. Schwartz from Caltech (Pasadena) is the recipient of the other 1989 Medal. Both

Prof. M.B. Green receiving the Dirac Medal from Prof. Abdus Salam.

recipients were honoured for their fundamental contribution to superstring theory. The award ceremony took place during the Spring School on String Theory and Quantum Gravity. After receiving the medal, Michael Green gave a brilliant lecture on the history and recent developments in superstring theory.

Professor Michael B. Green was honoured *"for research in the area of elementary particles and gravitation. After making several important contributions in the initial period of research on string theory as a theory of strongly interacting particles, he continued to work in this area through the late 1970's, a time when almost everyone else had abandoned string theory. He developed the theory of superstrings in a series of classic papers written in collaboration with John Schwarz between 1979 and 1984. Such theories are candidates for unified theories of all the physical forces and elementary particles and are based on a radical modification of conventional supersymmetric field theories in which pointlike fundamental particles are replaced by Planck-length relativistic strings. In 1981, they showed that certain superstring theories are probably free of ultra-violet divergencies and in August 1984 they showed that these theories are also free of the chiral gauge anomalies that plague conventional field theories with chiral fermions. This indicated that superstring theory with a specific gauge symmetry may provide a consistent unified quantum theory of gravitation together with all the other physical forces and particles. These results led to an explosion of interest in string theory which has transformed the study of unified quantum theories of particles and their forces".*

Professor Michael B. Green was born on 22 May, 1946. In 1964, he got an Open Scholarship at Churchill College in Cambridge, obtained a B.A. in Natural Sciences – Theoretical Physics (First class) in 1967 and a Ph.D. in Elementary Particle Theory (Cambridge) in 1970. From 1969 to 73, Professor Green held a Denman Baynes Research Studentship, Clare College, Cambridge. The Rayleigh Mathematics Prize of Cambridge University was awarded to him in 1969. He worked at the Institute of Advanced Study, Princeton, N.J., USA, in 1970-72, at Cavendish Laboratory, Cambridge, under an SRC Fellowship from 1972 to 1977 and at the Department of Theoretical Physics, Oxford, in 1977-79 under an SRC Advanced Fellowship. He became a lecturer in Physics at Queen Mary College, University of London, in 1979 and Professor of Physics at the same college in 1985. He was a visiting Associate at the California Institute of Technology, Pasadena, Ca., in 1981, 82, 84 and 85, at CERN in the summers of 1973, 76, 77, 79, 81 and 83, at the Aspen Center for Physics, Aspen, Colorado, in the summers of 1974, 78, 80, 81, 82 and 84. Prof. Green held a Nuffield Foundation Sciences Research Fellowship (1984-86) and currently holds a SERC Senior Fellowship. He will visit Caltech as a Distinguished Fairchild Scholar in 1990.

Prof. Green won the Maxwell Medal and Prize (Institute of Physics) in 1987, the William Hopkins Prize (Cambridge Philosophical Society) in 1987 and became a Fellow of the Royal Society in 1989. He is on the Editorial Board of the Journal of Mathematical Physics and on the International Advisory Committee for the Journal of Physics. He is the author of 60 research papers, 27 review articles and conference proceedings and of one book. He has lectured in many courses and workshops and has given plenary talks at about 15 major conferences.

The other Dirac Medal 1989 will be awarded to Professor John H. Schwarz (California Institute of Technology, USA) in July 1990.

Top Twenty of the 1980s

Courtesy of CERN Courier, April 1990.

What was the hottest particle physics of the past decade? When CERN information specialist David Dallman looked into the high energy physics database to find the most frequently cited papers of the 1980s he found two dominant themes, one theoretical — string theory, and one experimental — the discovery of the W and Z carriers of the weak nuclear force at CERN in 1983.

(The rankings cover only work originating during the 1980s — obviously frequent references were made during the decade to papers written earlier. The results were compiled using the HEPDATA high energy physics information system managed on the CERNVM computer system by the UK Particle Data Group at Durham, which uses the SLAC preprint database.)

The discovery of the W and Z particles at CERN's proton-antiproton collider in 1983 was a watershed in modern science, providing the final rivets for the already solid structure of the electroweak picture — the synthesis of electromagnetism and the weak nuclear force. (Before becoming CERN library's subject specialist, David Dallman had been part of the Vienna team in the UA1 experiment which discovered the W and Z particles in 1983.)

discovered the W and Z particles in 1983.)

The finding of the W and Z particles by the UA1 and UA2 experiments at CERN were reported in four 1983 Physics Letters, together providing a formidable block of 2254 citations.

With or without big discoveries, the periodic summaries of current information by the international Particle Data Group are well appreciated, the most frequently cited being those in 1986, 1980 and 1988.

The citation rankings show that strings, supersymmetry and related developments became a major industry among theoretical physicists.

Initial efforts to merge the successful electroweak picture with quark forces and with gravity to form a single 'Grand Unified Theory' (GUT) describing everything had been plagued with several major difficulties, notably the vastly different mass scales of the various forces. While electromagnetism and the weak force merge smoothly together at the W and Z mass scale (about 100 GeV), electroweak and quark effects only become comparable at 10^{15} GeV, and gravity has to wait until 10^{19} GeV before it gets an equal vote.

The new ingredient in supersymmetry is to double the number of basic particles — every fundamental quark or lepton gets a supersymmetric field particle counterpart ('squark' or 'slepton'), while the known field particles (photon, W, Z, gluon, graviton) acquire supersymmetric partners (photino, Wino, Zino, gluino, gravitino). With this extra layer of particles, the theory becomes much neater. While no sign of superparticles has yet been found, the search goes on as new machines open up higher energy ranges. Physics Reports review papers on supergravity in 1981 by P. van Nieuwenhuizen (404 citations) and on supersymmetry in 1984 by H.P. Nilles (426) were prominent.

String theory, where pointlike particles are replaced by one-dimensional strings, first emerged in the 1970s as an elegant formulation of the dual resonance structure of strong interactions. At first these ideas languished in a wilderness, but gradually string descriptions were seen to reproduce recognizable physics, especially when combined with supersymmetry. With such

especially when combined with supersymmetry. With such

'superstrings', many theorists feel that a framework for a Grand Unified Theory is within their grasp.

Most frequently cited (1091 times) was the 1985 Nuclear Physics B paper by P. Candelas, G.T. Horowitz, A. Strominger and E. Witten which proposed the first quasi-realistic solutions to the 'heterotic string'. More developments in this direction came in E. Witten's 1985 Nuclear Physics B paper (505 citations) on symmetry breaking patterns.

The now famous heterotic string had been introduced by D.J. Gross, J.A. Harvey, E. Martinec and R. Rohm, (the so-called 'Princeton String Quartet') in a series of frequently cited papers, two in Nuclear Physics B (969 citations to the 1985 paper and 507 to one in the following year) and one in Physical Review Letters (1985), with 897 citations. In biology, heterosis refers to the vigour and growth potential often seen as a result of cross-breeding. In string theory, the name was adopted when bosonic and fermionic strings were combined, producing new properties not belonging to either.

E. Witten's 1986 Nuclear Physics B paper (470 citations) made a brave attempt at formulating a complete string theory language.

The quantum geometry of bosonic and fermionic strings had been pioneered in successive 1981 Physics Letters by A.M. Polyakov (925 and 446 citations respectively).

Referred to 828 times was the 1984 Physics Letter by M.B. Green and J.H. Schwarz which was a precursor of the heterotic string and pointed out how anomaly cancellations force consistency conditions. Schwarz was also the author of a classic pre-heterotic string 1982 Physics Reports review article (764 citations).

The Green and Schwarz proposal was in turn foreshadowed in a 1984 Nuclear Physics B paper (413 citations) by L. Alvarez-Gaumé and E. Witten which explored the consistency conditions for gravitational and gauge interactions of chiral (left-right asymmetric) matter.

Not superstrings as such, but plenty of citations (811) for the seminal 1984 paper on conformal symmetry by A.A. Belavin, A.M. Polyakov and A.B.

paper on conformal symmetry by A.A. Belavin, A.M. Polyakov and A.B. Zamolodchikov in Nuclear Physics B, with applications in critical phenomena studies and string theory.

A 1986 Nuclear Physics B paper by D. Friedan, E. Martinec and S. Shenker (598 citations) reformulated superstrings in the conformal language proposed by Belavin et al and now widely used. Also building on the ideas of Belavin et al was the 1984 Physical Review Letter by D. Friedan, Zongan Qiu and S. Shenker (423 citations), with important applications in statistical mechanics.

Outside the superstring area, two successive 1983 Nuclear Physics B papers by E. Witten (652 and 408 citations) looked at the low energy

behaviour of strong interactions, with baryons behaving as solitary waves (solitons).

E. Witten's 1984 Communications in Mathematical Physics paper exploring fermion-boson correspondence in two dimensions drew 478 citations.

Another goal of 1980s theory was to explain how our Universe with all its idiosyncrasies emerged from the initial Big Bang. Various scenarios were put forward based on 'inflation' — abrupt phase transitions — early in the Universe's history. Frequently cited ideas were those of A.H. Guth in 1981 (842 citations), A. Albrecht and P.J. Steinhart in 1982 (542) and A.D. Linde, also in 1982 (537).

The 1980s also saw the emergence of 'lattice gauge theory', where the introduction of an artificial lattice facilitates calculations otherwise difficult or impossible. The first published numerical simulations using lattice ideas, by M. Creutz in 1980, were well cited (523 times).

The listings

The initial figure is the citation score:

1091 P. Candelas et al: *Nuclear Physics B258* (1985) 46
969 D.J. Gross et al: *Nuclear Physics B256* (1985) 253
925 A.M. Polyakov: *Physics Letters 103B* (1981) 207
897 D.J. Gross et al: *Phys. Rev. Letters 54* (1985) 502
893 Particle Data Group: *Physics Letters B170* (1986) 1
842 A.H. Guth: *Phys. Rev. D23* (1981) 347
842 A.H. Guth: *Phys. Rev. D23* (1981) 347
828 M.B. Green, J.H. Schwarz: *Physics Letters 149B* (1984) 117
811 A.A. Belavin et al: *Nuclear Physics B241* (1984) 333
764 J.H. Schwarz: *Physics Reports 89* (1982) 223
652 E. Witten: *Nuclear Phsics B223* (1983) 422
598 D. Friedan et al: *Nuclear Physics B271* (1986) 93
592 G. Arnison et al (UA1): *Physics Letters 126B* (1983) 398
585 P. Bagnaia et al (UA2): *Physics Letters 129B* (1983) 130
582 G. Arnison et al (UA1): *Physics Letters 122B* (1983) 103
542 A.Albrecht, P.J. Steinhart: *Phys. Rev. Letters 48* (1982) 1220
537 A.D. Linde: *Physics Letters 108B* (1982) 389
523 M. Creutz: *Phys. Rev. D21* (1980) 2308
507 D. Gross et al: *Nuclear Physics B267* (1986) 75
505 E. Witten: *Nuclear Physics B258* (1985) 75
495 M. Banner et al (UA2): *Physics Letters 122B* (1983) 476
478 E. Witten: *Commun. Math. Phys. 92* (1984) 455
470 E. Witten: *Nuclear Physics B268* (1986) 253
466 Particle Data Group: *Reviews of Modern Physics 52* (1980) S1
446 A.M. Polyakov: *Physics Letters 103B* (1981) 211
426 H.P. Nilles: *Physics Reports 110* (1984) 1
423 D. Friedan et al: *Phys. Rev. Letters 52* (1984) 1575
413 L. Alvarez-Gaumé, E. Witten: *Nuclear Physics B234* (1984) 269
408 E. Witten: *Nuclear Physics B223* (1983) 433
406 Particle Data Group: *Physics Letters B204* (1988) 1
404 P. van Nieuwenhuizen: *Physics Reports 68* (1981) 189

Physics Stands out as Foremost Field in Soviet Science

by David Pendlebury

As a follow-up to the Conference on Scientific Co-operation with Eastern Europe held at ICTP, we publish an article by David Pendlebury on Physics in the Soviet Union.

From "The Scientist", February 19, 1990;

It is all too easy to focus on the deficiencies of Soviet science. Ask Soviet scientists themselves and they will readily recite a laundry list of their research system's failings. Perhaps the greatest impediment, they say, is a lack of lab equipment and computers. Now that Soviet scientists can more easily travel to the West, if only temporarily, many are jumping at the opportunity. In fact, among eight of the most-cited living Soviet scientists (see below), at least four are visiting professors at Western universities or have recently held such posts. One wonders: Unless the system is soon improved, will the Soviet Union be faced with a serious brain drain in science?

An overview of Soviet science that focuses on shortcomings and ignores successes, however, makes for only a partial — and an inaccurate — assessment. A physicist in the West has a very different opinion of science in the Soviet Union from that of a molecular biologist or an immunologist. That's because physics, especially theoretical physics, is a widely recognized strong suit of the Soviet research enterprise.

The Scientist undertook a search for the best of Soviet science — in particular, for centers of excellence, for outstanding scientists, and for fields in which the Soviet Union performs above expectation. With the help of the Philadelphia-based Institute for Scientific Information's Science Indicators File, 1973-88 (derived from the *Science Citation Index [SCI]* database), *The Scientist* compiled a list of the 10 most-cited Soviet scientists. To gauge field strength, *The Scientist* consulted a recently published study of national performance in science that was based on ISI's data for 1981 through 1985 (see "Highest Impact Fields" below).

The Scientist's goal was to discover whether quantitative indicators matched anecdotal and subjective opinion, and whether this citation-based analysis of Soviet science turned up any surprises.

Centers of Excellence

Physics dominates the accompanying list of the highest impact Soviet institutes; it is the main focus of six of the top 10 research centers. Chemistry is represented by two institutes, and the life sciences by only one — the M.M. Shemyakin Institute in Moscow. The giant Moscow State University is a fully diversified institution, conducting research in the sciences and humanities as well as offering instruction at the

The Best of Soviet Science: High-Impact Institutions

Rank	Institute	No. Papers	No. Citations	Citation Impact
1.	L.D. Landau Institute of Theoretical Physics, Moscow	1,254	19,896	15.86
2.	Theoretical and Experimental Physics Institute, Moscow	1,001	13,324	13.31
3.	M.M. Shemyakin Institute of Bioorganic Chemistry, Moscow	1,203	10,490	8.71
4.	P.N. Lebedev Physics Institute, Moscow	4,615	32,742	7.09
5.	I.V. Kurchatov Institute of Atomic Energy, Moscow	1,812	11,246	6.20
6.	N.D. Zelinsky Institute of Organic Chemistry, Moscow	1,408	8,647	6.14
7.	Joint Institute for Nuclear Research, Dubna	2,729	16,702	6.12
8.	A.F. Ioffe Physicotechnical Institute, Leningrad	5,539	28,153	5.08
9.	Moscow M.V. Lomonosov State University, Moscow	16,952	82,080	4.84
10.	L.Y. Karpov Physicochemical Research Institute, Moscow	2,165	9,964	4.60

Source: ISI's Science Indicators File, 1973-88.

undergraduate and graduate level.

To compile this list, *The Scientist* identified all Soviet research institutes and universities whose investigators published a minimum of 1,000 articles indexed in the *SCI* from 1973 to 1988. For each institute's papers, the total number of citations earned was divided by the total number of cited papers published. This calculation yielded the citation impact, or average number of citations per paper. Those institutes with the highest citation impact were then selected and ranked.

Because the life sciences generally exhibit a higher citation impact than do the physical sciences — owing to the greater number of scientists and publications in the life than in the physical sciences — the relative absence of molecular biology and biochemistry research institutions is significant. The Soviet Union's highest impact institutes are predominately centers concentrating on the physical sciences.

The Landau Institute, ranking first in citation impact, is one of the Soviet Union's most distinguished centers for the study of theoretical physics. Second in impact is the Theoretical and Experimental Physics Institute in Moscow, which specializes in particle physics, applied nuclear physics, and computational mathematics. The fourth-ranked Lebedev Institute, also in Moscow, specializes in lasers, optics, spectroscopy, and plasma and particle physics, among other subjects. Representing the field of nuclear physics are the Kurchatov Institute, which produced the first Soviet atomic bomb, and the Joint Institute for Nuclear Research in Dubna, a suburb of Moscow. Researchers at the Ioffe Institute, located in Leningrad, conduct research in semiconductor, plasma, and mathematical physics, as well as astrophysics.

Chemistry is represented by the

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Karpov Physicochemical Research Institute and the Zelinsky Institute, both in Moscow. The Zelinsky is the nation's premier establishment for applied and theoretical chemistry.

The status of the Shemyakin Institute in Moscow as a leading center for life sciences research seems assured by the recent announcement of the construction of a pilot plant for biotechnology at the institute, at a cost of some $75 million.

It should be noted that the average citation impact for all institutions in ISI's Science Indicators File for the years 1973 to 1988 is 11.01. Thus, even the best of the Soviet Union's research centers — with the exception of the Landau Institute and the Theoretical and Experimental Physics Institute — fall short of the world average. However, Russian-language articles reduce somewhat the citation impact of papers from the Soviet Union because they are relatively inaccessible to Western readers and are, therefore, less cited.

Most-Cited Scientists

A focus on physics also emerges from an analysis of the most-cited Soviet scientists during the period 1973-88. In the accompanying Top 10 list, six are physicists, two are chemists, and the other two represent the life sciences (biochemistry and molecular biology).

Aleksandr M. Prokhorov, ranking 10th, is the only Nobel laureate on the list. Along with his colleague Nikolai G. Basov and American Charles Townes, he won the physics prize in 1964 for — as the citation of the Nobel Assembly reads — "fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle."

The other physicists in the list rank first through fourth, and sixth.

V.I. Zakharov and M.A. Shifman are colleagues at the Theoretical and Experimental Physics Institute in Moscow and frequent collaborators in work on particle physics with A.I. Vainshtein, who is at the Institute for Nuclear Physics in Novosibirsk. Vainshtein is a visiting professor at the University of Minnesota. He recently spoke with *The Scientist* and stated that

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the trio's work on quantum chromodynamic sum rules probably accounts for many of the citations. Indeed, three articles on this topic, appearing in 1979, have collectively received more than 1,700 explicit citations (M.A. Shifman, et al., *Nuclear Physics B*, 147:385,448, and 519). Separately and together, they have also contributed significantly to other aspects of theoretical particle physics.

Aleksandr M. Polyakov, of the Landau Institute and currently at Princeton University, is one of the world's top theoretical physicists. He discovered magnetic monopoles, advanced work on gauge theories, and

The Best of Soviet Science: Most-Cited Scientists

Rank	*Name*	*Field*	*Citations*
1.	V.S. Letokov [Spectroscopy Institute, Troitsk]	Physics	4,575
2.	V.I. Zakharov [Theoretical and Experimental Physics Institute, Moscow]	Physics	4,401
3.	M.A. Shifman [Theoretical and Experimental Physics Institute, Moscow]	Physics	4,268
4.	A.I. Vainshtein [Institute for Nuclear Physics, Novosibirsk]	Physics	4,181
5.	Y.A. Ovchinnikov (deceased) [M.M. Shemyakin Institute of Bioorganic Chemistry, Moscow]	Biochemistry	4,082
6.	A.M. Polyakov [L.D. Landau Institute of Theoretical Physics, Moscow]	Physics	3,980
7.	N.K. Kochetkov [N.D. Zelinsky Institute of Organic Chemistry, Moscow]	Chemistry	3,326
8.	M.G. Voronkov [Organic Chemistry Institute, Irkutsk]	Chemistry	3,290
9.	G.P. Georgiev [V.A. Engelhardt Molecular Biology Institute, Moscow]	Molecular Biology	3,140
10.	A.M. Prokhorov [General Physics Institute, Moscow]	Physics	3,177

Source: ISI's Science Indicators File, 1973-88.

has recently concentrated on string theory. He is the author of at least seven citation classics (papers receiving more than 300 citations).

The first-ranking scientist, V.S. Letokov of the Spectroscopy Institute in Troitsk, is a pioneer in laser spectroscopy. He wrote more than two dozen papers cited more than 50 times, according to *SCI* data, 1945-88.

Nikolai K. Kochetkov (...) and Mikhail G. Voronkov, of the Organic Chemistry Institute in Irkutsk — ranking seventh and eighth, respectively — represent the best of Soviet chemistry. Kochetkov has to his credit at least half a dozen papers cited more than 100 times. So does Voronkov, who is particularly prolific. In 1989, he and his team produced more than 70 papers that deal with a very wide range of topics in organic chemistry.

Ninth-ranking G.P. Georgiev of the V.A. Engelhardt Molecular Biology Institute in Moscow specialized in research on RNA, while the other life scientist on the list, the late Yuri A. Ovchinnikov, was a world famous biochemist. Georgiev has written more than a dozen papers cited more than 100 times. Ovchinnikov has at least a dozen cited at that frequency.

The history of the Nobel Prize corroborates the dominant position of physics within Soviet science. Of the 10 Nobel Prizes that have gone to Soviet researchers, seven have been in physics (Cerenkov, Frank, and Tamm in 1958; Landau in 1962; Basov and Prokhorov in 1964; and Kapitsa in 1978). The Soviets have secured only one chemistry prize (Semenov in 1954). To find a Soviet scientist as the recipient of the prize in physiology or medicine, however, one must return to prerevolutionary Russia (Pavlov in 1904 and Mechnikov in 1908, although Mechnikov was at the time at the Pasteur Institute in Paris).

Highest Impact Fields

Various U.S. government studies have, from time to time, tried to assess strengths in Soviet science — and for various reasons. The White House Office of Science and Technology Policy recently rated the Soviet Union as "comparable to the United States" in mathematics, theoretical oceanology, materials science, theoretical and experimental high-energy physics, fluid dynamics, theoretical condensed matter physics, theoretical astrophysics, and theoretical and experimental laser physics (see OSTP's *A Study of Soviet Science*, 1988). And last March, the U.S. Department of Defense reported to the U.S. congress that Soviet science was superior to U.S. science in two of 22 specialty areas of military significance: high-power microwaves and mobile lasers (see DOD's *Critical Technology Plan*, March 15, 1989). These and other studies rely on the subjective assessment of expert observers.

Recently, the Information Science and Scientometrics Research Unit (ISSRU) of the Hungarian Academy of Sciences, Budapest, used quantitative citation indicators to gauge field strengths of nearly 100 countries, including the Soviet Union, using ISI's *SCI* data from the period 1981-85 (A. Schubert, W. Glänzel, T. Braun, *Scientometrics*, 16:3-478, 1989). For each country, the ISSRU researchers identified fields in which a nation's scientists were publishing highly cited articles in high-impact journals. Using this methodology, 18 fields or subfields were rated highly for the Soviet Union. They are listed in the third table. Five of the 18 represent physics, five chemistry or physical chemistry, and the other eight a variety of specialties, including mycology, metallurgy and mining, oceanography, and photographic technology.

A survey of ISI's 1988 Research Front database for specialties in which Soviet scientists contributed more than 20 papers yielded similar results. The fields, ranked by total number of specialty areas, were: general physics, biomedicine, superconductivity, optics, nuclear magnetic resonance, spectroscopy, quantum transport, organic and inorganic chemistry, amorphous and chaotic systems, and geosciences. Biomedicine probably appears, as mentioned, because of the large

population of publishing biomedical scientists not only in the West, but in the Soviet Union as well.

Thus, according to quantitative indicators of both impact and output, physics and chemistry are the areas in which Soviet scientists make their biggest mark among the body of high-impact journals indexed by ISI — a finding that will probably not surprise Soviet science watchers.

The Best of Soviet Science: Strong Fields
Applied Physics
Astronomy and Astrophysics
Crystallography
Dermatology and Venereal Diseases
Geosciences
Hygiene and Public Health
Inorganic and Nuclear Chemistry
Metallurgy and Mining
Mycology
Nuclear Physics
Oceanography
Organic Chemistry
Photographic Technology
Physical Chemistry
Physics of Condensed Matter
Physics of Particles and Fields
Polymer Science
Virology

Source: ISI's Science Citation Index, 1981-85, and Information Science and Scientometrics Research Unit, Hungarian Academy of Sciences, Budapest (Scientometrics, *16:12-14, 1989).*

Mobility Will Boost East European Science

The political and social tidal wave

The political and social tidal wave that recently swept over Eastern Europe is sure to change the lives of its scientists. Restructuring the centralized economies will probably make conditions worse before they get better, and that means government support for science may shrink. On the other hand, if investment from joint ventures with science-based companies in the West begins to flow in, scientists may find their laboratories filled with equipment they could never before afford, owing to the lack of hard currency.

There's one thing, however, that has never been lacking in Eastern Europe: scientific brainpower. A recent field-by-field analysis of scientific performance shows Czechoslovakia to be strong in chemistry; Hungary and Poland in mathematics; and East Germany in mathematics, engineering, and physics. Even the relatively weaker Romania and Bulgaria have their niches: chemistry for Romania, and mathematics and chemistry in Bulgaria (A. Schubert. W. Glänzel, T. Braun, *Scientometrics*, 16:3-478, 1989).

According to citation data from the Science Indicators File of the Institute for Scientific Information, Philadelphia, papers from Eastern Europe published between 1973 and 1987 earned only about half as many citations as the average paper in the file. The exception has been Hungary, whose papers began the period at about 60% and ended up at about 72% of the average citations per paper rate (*The Scientist*, Oct. 3, 1988, page 13). What helped Hungary improve its performance?

One explanation is the greater mobility that Hungarian scientists experienced over this period, as compared to that of their colleagues in the rest of the East Bloc nations. If nothing else, greater mobility should improve the quality of science in Eastern Europe — and increase the attention its papers get from scientists in the West and elsewhere.

David Pendlebury is an analyst in the Corporate Research Department of the Institute for Scientific Information in Philadelphia. He is also editor of the monthly newsletter Science Watch.

Plasma Research Group Starts: Three Questions to S. Mahajan

Prof. S.M. Mahajan is a Staff Associate of the ICTP and is the Head of the newly-established Plasma Physics Research Group. He also works at the Institute for Fusion Studies, University of Texas at Austin, USA.

Q.: Professor Mahajan, you have been at the Centre several times. You are now in charge of the research in an important field — plasma physics. How do you intend to proceed?

A.: Very naturally! We are making a very modest beginning in building a resident theoretical plasma physics group. We are in the process of hiring a group of your people from the Third World who would work together in the congenial and, hopefully, inspiring surroundings of ICTP to conduct enquiries into the nature of hot plasmas. At present, we have resources for three people. I do hope, however, as time goes on, that our tribe will increase. Since ICTP has strong commitment to the promotion of fundamental sciences, we shall (in our group) concentrate on basic problems of plasma physics; kinetic theory, plasma turbulence, general nonlinear theories, and exotic plasmas like the quark-gluon plasma.

Q.: Plasma physics is considered as an important subject for fusion energy and space physics. Can you explain why?

A.: A very large part of our universe is in the plasma state (ionized gas). It is little wonder, then, that space physics and solar physics will have plasma physics as an important, in fact, as a crucial component. Thus one could imagine that plasma physics should be an old and hoary subject. But it is really not so; plasma physics became a major branch of physics as a consequence of our quest for fusion energy. Since fusion can take place only between nuclei, one has to deal with a collection of nuclei. Such a system with non-zero net charge is not stable. Production of significant fusion energy, however, will require reasonably long lived systems. We must then deal with the nuclei along with the electrons (which they had in the atomic state) altogether confined in a atomic state) altogether confined in a certain region of space; we are again relentlessly led to a study of plasma physics.

Q.: Plasma physics is also considered as a discipline for the "rich". On the other hand, we note that plasma physics colleges attract quite a number of young and bright scientists from developing countries. How do you reconcile this?

A.: Scientific disciplines, in general, tend to transcend economics. Even the technological outcomes of science are beneficial both to the rich and to the poor, making the rich richer, and the poor not so poor. I shall then interpret your question as to mean whether the poor countries can afford to indulge in

expensive research like fusion. I would first point out that plasma physics is much bigger than fusion, and experiment in plasma physics may not be much more expensive than in other traditional fields. A more important point, however, is that science is expensive; it is a long-term commitment of money, mind and other measures. Many bright people from the Third World intuitively understand that future will be infinitely more expensive if we do not spend on science now. Nuclear fusion, in addition, may be the only route to development for the poor countries. Poor countries are often even poorer in energy resources.

Visit of Korean Ambassador

On Friday, 27 April 1990, Ambassador Li Jong Hyok and First Secretary Li Ung Ghil from the Democratic People's Republic of Korea to FAO and IFAD in Rome, paid a one-hour visit to Professor Abdus Salam.

Visit of Chinese Ambassador

The new Chinese Ambassador in Rome, Mr. Li Bao-Chen, visited the ICTP on 28 March. He is a professional diplomat and is interested in the development of science and technology.

He met Professor Abdus Salam and discussed the scientific change between China and ICTP as well as problems of scientific policies. Then he met Chinese scientists present at the Centre to discuss the situation in China.

Appointments

News from ICTP welcomes communications on appointments and news on ICTP scientists for publication.

R.C. Agrawal

Born on 20 June 1950 and educated in India. Received M.Sc. geophysics degree from BHU, Varanasi, and was awarded PhD. degree by Kurukshetra University on thesis entitled *Travel-times for the Indian region.*

Joined the Faculty of Earthquake Engineering Department of Roorkee University, India, in 1976 as lecturer. Became reader there in 1979 and was promoted to the post of Professor in January 1990.

Dr. Agrawal visited the Centre in 1983 and 1986 as a participant to geophysics workshops and became its Regular Associate Member in 1988 for a period of six years.

Dr. Mondjalis-Poto

Prof. Mondjalis-Poto, M.Phil., from the Institut National pour l'Etude et la Recherche Agronomiques (INERA), Zaire, was appointed on 15 January as the Head of the National Research Program for environmental resources use and conservation.

Hot Papers

From "The Scientist", February 5, 1990 and February 19, 1990;

The articles listed below, all less than two years old, have received a substantially greater number of citations than others of the same type and vintage, according to data from *The Science Citation Index* of the Institute for Scientific Information, Philadelphia. Why have these research reports become such stand-outs? A comment following each reference, supplied to *The Scientist* by one of the authors, attempts to provide an answer.

The Particle Data Group: G.P. Yost, et al., "Review of particle properties," *Physics Letters B*, 204, 1-486, 14 April 1988.

Thomas G. Trippe (Lawrence Berkeley Laboratory, University of California, Berkeley): "This review is an international effort of 32 authors and 75 consultants to provide high-energy physicists with the most useful review possible. It provides high-energy physicists with much of the information needed for designing and analyzing experiments and developing theories. It is also very useful for teaching high-energy physics.

"The heart of the review is the compilation of data on elementary particles and the resulting summary tables giving the Particle Data Group's best values of particle masses, mean lives, decay rates, decay modes, and so on. The paper also contains parameters and formulas for calculations related to particle interaction and detection; for example, tables of physical constants, atomic and nuclear properties of materials, mean range and energy loss plots, electromagnetic relations, kinematics and cross section formulas, and so on. Other sections summarize current theory; for example, the standard model of electroweak interactions, quantum chromodynamics, Kobayashi-Maskawa mixing, the quark model, and others."

M. Tinkham, "Resistive transition of high-temperature superconductors," *Physical Review Letters*, 61, 1658-61, 3 October 1988.

M. Tinkham (Lyman Laboratory of Physics, Harvard University, Cambridge, Mass.): "Soon after the discovery of the new high-temperature superconductors, it was found that their transition from the normal resistive state to zero resistance broadened greatly when a strong magnetic field was applied, even in the case of oriented single crystals. This raised a crucial question: Would these materials retain sufficient resistance to limit their use in practical applications even well below T_c?

"This paper addressed that question by proposing a theoretical model, which could account quite well for the experimentally observed broadening by attributing the resistance to thermally activated flux motion. The model involves only a single parameter and uses a form of field-dependent activation energy proposed earlier by Yeshurun and Malozemoff of IBM (*Physical Review Letters* 60:2202-5, 23 May 1988) to account for the 'irreversibility line' observed in studies of the magnetization

of the new superconductors."

R.J. Cava, B. Batlogg, K.M. Rabe, E.A. Rietman, et al., "Structural anomalies at the disappearance of superconductivity in $Ba_2YCu_3O_{7-\delta}$: evidence for charge transfer from chains to planes," *Physica C*, 156, 523-7, 1 November 1988.

R.J. Cava (AT&T Bell Laboratories, Murray Hill, N.J.): "The superconductor $Ba_2YCu_3O_{7-x}$ was a revolutionary material, as it was the first of the now handful of chemical compounds to be superconducting above the temperature of liquid nitrogen. It continues to surprise and stimulate physicists and materials scientists around the world. Over its surprisingly large range of oxygen stoichiometry, the compound is superconducting at 90K and 60K and is an antiferromagnetic insulator. The crystal structure consists of one-dimensional copper-oxygen chains and infinite planes of CuO_5 pyramids. Superconductivity occurs in the infinite copper-oxygen planes.

"While analyzing our data for samples of $Ba_2YCu_3O_{7-x}$ prepared by an unusual low temperature route, we noticed an unanticipated and dramatic jump in one crystallographic cell length at precisely the composition at which superconductivity disappeared and antiferromagnetism appeared. This jump was entirely due to the abrupt change in length of one chemical bond — that of the pyramidal plane coppers to the oxygen atoms at their apices. The apical oxygens were effectively acting as 'pith ball[illegible] at their apices.' The apical oxygens were effectively acting as 'pith balls' responding to an abrupt transfer of negative electrical charge from the copper-oxygen chains into the copper-oxygen planes. We were then able to conclude that the role of the chains in superconductivity is that of a 'charge reservoir,' controlling the superconductivity in the planes by titrating the amount of electrical charge on those planes. This idea of considering the copper oxide superconductors as a microscopic interleaving of charge reservoir layers and superconducting layers is a unifying concept for understanding the importance of local electrical charge distribution in all the known copper oxide superconductors — no matter how complex their crystal structures."

Articles Alert

From "The Scientist", February 19, 1990;

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The Scientist has asked a group of experts to comment periodically upon recent articles that they have found noteworthy. Their selections, presented herein every issue, are neither endorsements of content nor the result of systematic searching. Rather, the list represents personal choices of articles the columnists believe the scientific community as a whole may also find interesting. Reprints of any articles cited here may be ordered through The Genuine Article, 3501 Market St., Philadelphia, Pa. 19104, or by telephoning (215) 386-4399.

MATERIALS SCIENCE

by Theodore Davidson, Institute of Materials Science, University of Connecticut, Storrs.

• "Ionenes" are polymers bearing ionic charge on their back-bone chain. A recent paper describes their unique combination of optical properties: The refractive index is in the range on inorganic glasses, and the dispersion can be varied by altering chain structure and counterions. When processed from a solution or a melt, ionenes produce glassy films with excellent optical transmission in the visible and near-ultraviolet regions.

H.-U. Simmrock, A. Mathy, L. Dominguez, W.H. Meyer, G. Wegner, "Polymers with a high refractive index and low optical dispersion," *Angewandte Chemie International Edition in English*, **26**, 1122-3, August 1989. (Max Planck Institute for Polymer Research, Mainz, W.Ger.)

• Metal lines of submicron width have been deposited electrochemically on polymer films and substrates, using a variant of the scanning tunneling microscope. The use of an ionically conducting polymer as the solid electrolyte improves resolution and avoids electrodeposition on the tip. Gold, silver, copper and palladium have been deposited atop the polymer. Alternatively, conductive substrates coated with polyelectrolyte can serve as sites for deposition or etching.

O.E. Hüsser, D.H. Craston, A.J. Bard, "Scanning electrochemical microscopy," *Journal of the Electrochemical Society*, **136**, 3222-9, November 1989. (University of Texas, Austin)

• Another milestone study in the National Research Council's continuing appraisal of scientific progress and opportunities details research hotspots, compares international efforts, and surveys manpower and education.

National Research Council (U.S.) Committee on Materials Science and Engineering, "Materials Science and Engineering for the 1990s: maintaining competitiveness in the age of materials," National Academy Press, 1989. (Washington, D.C.)

• In his Institute of Metals Lecture, William D. Nix describes several nontraditional techniques for mechanical measurements on thin films. Submicron indentation tests measure hardness, elastic modulus, and time-dependent deformation properties. Laser scanning reveals biaxial stresses and shows that both elastic and plastic properties can be measured on microfabricated cantilever beams. Applications discussed include microelectronic and magnetic thin films.

W.D. Nix, "Mechanical properties of thin films," *Metallurgical Transactions A*, **20A**, 2217-45, November 1989. (Stanford University, Calif.)

• In experiments using careful reactor design, the bimolecular hydrogen abstraction reaction is made to dominate over monomolecular methane decomposition. The result is fewer impurities in the polycrystalline diamond film and more regular facet development.

H. Alkyo, K.-I. Kondo, "Diamond synthesis suppressing the thermal decomposition of methane in a hot-filament CVD," *Japanese Journal of Applied Physics*, **26**, L1631-3, September 1989. (Tokyo Institute of Technology)

• High resolution (1.6Å) transmission-electron micrographs show the lattice and defect structure in thin film high-T_c superconductors. Flux pinning, crucial for thin films to carry large critical currents, seems to depend on structural defects in the lattice. A large assortment and density of defects is found in thin films, owing to nonequilibrium deposition conditions. Observation of these new stacking sequences points out the utility of laser deposition processes "to produce new metastable structures with novel properties."

R. Ramesh, D.M. Hwang, T. Venkatesan, T.S. Ravi, et al., "Direct observation of structural defects in laser-deposited superconducting Y-Ba-Cu-O thin films,". *Science*, **247**, 57-59, 5 January 1990. (Bellcore, Redbank, N.J., Rutgers University, Piscataway, N.J.; et al.)

COMPUTATIONAL SCIENCE

by Bruce G. Buchanan, Department of Computer Science, University of Pittsburgh, Pittsburgh, Pa.

• Constraints are ubiquitous in problem solving, but there are no computational algorithms both powerful enough and general enough to solve all enough and general enough to solve all constraint satisfaction problems. Three authors present a family of algorithms and focus on one: an incremental constraint propagation procedure.

B.N. Freemen-Benson, J. Maloney, A. Borning, "An incremental constraint solver," *Communications of the ACM*, **33**, 54-63, January 1990. (University of Washington, Seattle)

• A major problem in using networked computers effectively has been the absence of so-called seamless file systems, in which data can be retrieved from heterogeneous databases as if they were a single, centralized database. An architecture for a distributed database system, named DATAPLEX, addresses this problem.

C.-W. Chung, "DATAPLEX: an access to heterogeneous distributed databases," *Communications of the ACM*, **33**, 70-80, January 1990. (General Motors Research Labs, Warren, Mich.)

• Security of computer systems is a well-publicized problem. Part of the quandary is conceptual: We don't know how to define security in a formal way. Another aspect is technical: Given that formal mode of security, we need theorems that guarantee the behavior of implementations of the model.

J. McLean, "The specification and modeling of computer security," *IEEE Computer*, **23**, 9-16, January 1990. (Naval Research Laboratory, Washington, D.C.)

• Legal questions surrounding software protection have always been murky. One such question is analyzed, regarding the reconstruction of a program based on observing its behavior. Partly owing to the fact that reverse engineering is so widespread and widely viewed as speeding the development of improved products, it is argued that laws against reverse engineering would be counterproductive.

P. Samuelson, "Reverse-engineering someone else's software: Is it legal?" *IEEE Software*, **7**, 90-6, January 1990. (University of Pittsburgh, Pa.)

• The process of writing software is

• The process of writing software is itself only modestly understood; understanding the process of managing software projects is far behind. F.P. Brooks (*The Mythical Man-Month*, Reading, Mass., Addison-Wesley, 1978) highlighted the fallacy that assumed one could halve the production time by doubling the manpower. The relationships among scheduled time, actual time, staffing, and costs of large software projects are observed.

T.K. Abdel-Hamid, "Investigating the cost/schedule trade-off in software development," *IEEE Software*, **7**, 97-105, January 1990. (Naval Postgraduate School, Monterey, Calif.)

Activities at ICTP in March-April 1990

Title: WORKSHOP ON REACTOR PHYSICS CALCULATIONS FOR APPLICATIONS IN NUCLEAR TECHNOLOGY, 12 February - 16 March 1990.

Organizers: Dr. D.E. Cullen (Lawrence Livermore Laboratory, USA), Prof. M. Mehta (International Atomic Energy Agency, Vienna, Austria, and Bhabha Atomic Research Centre, Bombay, India - retired), Dr. R.G. Muranaka (International Atomic Energy Agency, Vienna, Austria) and Dr. J.J. Schmidt (International Atomic Energy Agency, Vienna, Austria), with the assistance of Professors H.R. Dalafi (Iran/ICTP) and L. Fonda (University of Trieste and ICTP).

Lectures: Nuclear data — their importance and application in fission reactor physics calculations. Evaluated nuclear data processing and nuclear reactor calculations. Basic reactor physics. Pointwise processing modules of NJOY. Introduction to the computer code NJOY and its applications. Multigroup processing modules of NJOY. Lattice cell calculations, slowing down theory and computer code WIMS. Output modules of NJOY. Preparation of input for the WIMS code. Computer programme services of the NEA data bank. International Benchmark studies for reactor physics codes. VVER type reactors. Computer code ANISN, multiplying media and shielding multiplying media and shielding calculation — theory; code description (input/output); sample problems and special aspects of plate type reactors. Neutron optics. Neutron interferometry and coherent scattering length measurements. Reactor neutron dosimetry and safety — past achievements and future perspectives; calculational methods; radiation damage estimates for reactor construction materials. Plan for the use of ENDF/B files in research reactors. In core fuel management — computer code PSU-LEOPARD; computer code MCRAC. Some core analysis of the TRIGA MARK II research reactor at AERE, Savar development of a pseudo-AMPX

system for customised cross-section library preparation. Nuclear data activities at the Institute for Advanced Studies (IEA, Brazil). "WILMA" a WIMS library management program (brief description). High conversion reactor concept and nuclear data processing related problems. Introduction to research reactors TRIGA and research reactor management. Importance of nuclear energy for future development. Advanced reactors concepts and safety features. TRIGA research reactors. Advances in personal computers for scientific applications. PC2 — a NPP primary circuit simulation software for personal computer. Fluid flow and heat transfer model — the HEATHYD code. Physics aspects of fast breeder test reactor at Kalpakkam (India); safety considerations in fast breeder reactor design. Inverse point kinetics for the reactivity determination: description of KINIK code. Reactor safety. Advanced reactors, advancement and relevance to operating reactors. Nuclear power in the context of the general energy problem. Advanced nuclear model calculations for evaluations of nuclear data.

The Workshop was attended by 82 lecturers and participants (16 from developing countries).

Title: ADRIATICO RESEARCH CONFERENCE ON FOURIER OPTICS AND HOLOGRAPHY, 6 - 9 March 1990.

Organizers: Professors G. Denardo (ICTP) and H. Tiziani (Universität Stuttgart, Federal Republic of Germany), with the co-sponsorship of the International School for Advanced Studies (ISAS-SISSA, Trieste, Italy).

All Adriatico Conferences are organized by a local committee composed of Professors S. Lundqvist (Chairperson; Chalmers University of Technology, Göteborg, Sweden, and ICTP), H. Cerdeira (Co-chairperson; Universidad Estadual de Campinas, UNICAMP, Campinas, Brazil, and ICTP), E. Tosatti (International School for Advanced Studies, ISAS-SISSA, and ICTP, Trieste, Italy), M. Tosi (University of Trieste and ICTP, Italy) and Yu Lu (Academia Sinica, Beijing, P.R. China, and ICTP).

Lectures: Introduction to wave theory and Fourier optics. Optics for CD. Optical correlation, Tripel correlation. Analogue optical correlation. Optical correlation and application. Introduction to laser. The Fourier optics laboratory. Optical computer. Connections for optical computers. Analogue optical computer; nonlinear coupling. Speckle phenomena. Introduction to interferometry. Interferometry and applications. Introduction to holography and holographic interferometry. Holophotography: an analysis of the capability of photographing images in full parallax.

The Conference was attended by 52 lecturers and participants (13 from developing countries).

Title: EXPERIMENTAL WORKSHOP ON HIGH TEMPERATURE SUPERCONDUCTORS AND RELATED MATERIALS (basic activities), 12 - 30 March 1990.

Organizers: Dr. G. Leising (Graz Technical University, Graz, Austria), Dr. F.C. Matacotta (Istituto per la Tecnologia dei Materiali Metallici non Tradizionali, Milan, and ICTP), Dr. C. Segre (Illinois Institute of Technology, Chicago, USA) and Prof. M. Tosi University of Trieste and ICTP), with the co-sponsorship of the Italian Direzione Generale per la Cooperazione allo Sviluppo (Ministry of Foreign Affairs, Rome, Italy).

Lectures: Introduction to superconductivity. Metal oxides: normal state properties. HTS synthesis and processing. Some new results on superconducting cuprate. The flux-line lattice in old and new superconductors. X-ray diffraction techniques. Transport and magnetic properties. Josephson effect. Current status of high T_c theories. Critical currents. Function and application of refrigerator cooled cryostat. HTS thin films. Special measurement of high current density in HTSC samples. X-ray absorption spectroscopies. Magnetic nuclear resonances. High magnetic field properties of HTS ceramics. Infrared properties. Pseudo spark ablation mechanism. Electron microscopy and structural aspects. Crystal chemistry of HTS. Evidence for superconducting phase decoupling between Cu-O stacks in YB_2CuO. Some correlations between RF-SQUID behaviour of Y-Ba-Cu-O ceramic devices and its critical current density. Stabilization of some superconducting phases in the Tl-system with oxide additives. Heat transport in $YBa_2Cu_3O_{7-\delta}$ vs. oxygen content (thermal conductivity measurements). Effect of oxygen content in Pb doped BiSrCaCuO polycrystals (resistivity measurements). One particle tunnelling in BiCaSrCuO single crystals. Room-temperature (electro)-chemical oxygen-content changes in High-T_c superconductors (mainly $Y_1Ba_2Cu_3O_7$): results and significance. Studies of flux pinning by using rotating sample magnetic measurements. Oxygen content effects in the normal state resistivity of $La_{1.8}Sr_{0.2}CuO_{4-\delta}$. XPS studies of YBCO superconductors. Screen printed thick films of YBaCuO on different polycrystalline substrates. Preparation of $Y_1Ba_2Cu_3O_{7-\delta}$ and $Bi_{0.8}Pb_{0.2}Sr_1Ca_1Cu_{1.5}O_{7-\delta}$ by sol-crel technique. Positron annihilation study of high-Tc superconductors $YBa_2Cu_3O_{7-\delta}$. Elastic measurements on Tl-based superconductors. Superconducting fibres of Bi-based oxide materials. Strontium content effect on the normal state resistivity of $La_{2-x}Sr_2CuO_{4-y}$. Superconducting thin/ultrathin films by pulsed laser deposition technique. The oxygen diffusion in 1-2-3 ceramics. Complex susceptibility of the single phase $(Bi_{1x}Pd_x)_2Sr_2Ca_2Cu_3O_y$. Same effects of limiting long range order in high-T systems. Preparation of 110K superconductor in Bi-Sr-Ca-Cu-O system.

The Workshop was attended by 91 lecturers and participants (34 from developing countries).

Title: WORKSHOP ON GROUP THEORY FROM A GEOMETRICAL VIEWPOINT, 26 March - 6 April 1990.

Organizers: Professors E. Ghys (Ecole Normale Supérieure de Lyon, France) and A. Haefliger (Université de Genève, Switzerland).

Lectures: Introduction to hyperbolic groups. An invitation to

Coxeter groups. An example of torsion group. Quasi-convex subgroups and a theorem of Howson. The lower central series of the free group. Amalgamated products of hyperbolic groups. Automatic groups. Geometry of the modular group. Constructions of hyperbolic groups via hyperbolization of polyhedra. Actions on real trees. 2-generator Kleinian groups and injectivity radii of hyperbolic 3-manifolds. Lectures on Buildings. Identities among relations of group presentations. Orbit closures in homogeneous spaces. Projective aspects of the Higman-Thompson group; automorphisms of Riemann surfaces and graphs at infinity. Continuing functions for Coxeter systems. Some examples of nice manifolds. Groups which are quasi-isometric to planes. Actions on trees, according to Rips. Discrete parabolic groups on negatively curved manifolds.

The Workshop was attended by 100 lecturers and participants (30 from developing countries).

Workshop on reactor physics calculations for applications in nuclear technology, 12 February - 16 March 1990.

Experimental workshop on high temperature superconductors and related materials (basic activities), 12 - 30 March 1990.

Workshop on group theory from a geometrical viewpoint, 26 March - 6 April 1990.

External Activities Sponsored by ICTP in 1990

Country	*City*	*Title*	*Dates*
Africa			
Burkina Faso	Ouagadougou	Interafrican seminar for harmonization of programmes in mathematics.	January 8-13
Egypt	Alexandria	Course on infrared spectroscopy between theory techniques and applications.	October 6-11
Egypt	Cairo	Cooperative Arab network in physics education. A workshop for modernizing solid state physics teaching at university level.	January 15-18
Egypt	Cairo	Third international school and workshop on crystallography on x-ray.	January 14-23
Ghana	Cape Coast	Fourth international workshop on the use of microcomputers in science and mathematics education.	27 Dec 89-10 Jan 90
Asia			
Bangladesh	Dhaka	International symposium/workshop on recent advances in physics.	January 15-19
India	Bangalore	International conference on superconductivity.	January 10-14
India	Bombay	International colloquium on modern quantum field theory.	January 8-14
India	Hyderabad	International conference on quantum optics.	December 1-5

contd.

Country	*City*	*Title*	*Dates*
India	Jaipur	International workshop on X-ray absorption fine structure (XAFS).	January 1-14
India	Karaikudi	CECRI conference on LUMINISCENCE.	January 12-14
India	New Delhi	International symposium on physics of medical imaging & advances in computer applications.	February 21-23
India	New Delhi	Second international workshop on physics of solar energy.	February 19-24
Iran	Tehran	IV Regional conference on mathematical physics.	May 12-17
Sri Lanka	Peradeniya	Workshop for physics teachers in secondary school in Sri Lanka.	October 1-5
Turkey	Bodrum	III International Bodrum school of physics.	Sep 26 - Oct 5
Far East			
China	Beijing	International conference on activation analysis and its applications.	May 28-June 1
China	Shanghai	High power laser and its applications.	Oct r 24-Nov 6
China	Shanghai	Workshop on laser chemical physics.	May (1991)
China	Tianjin	International conference on physics education through experiments.	April 23-27
Indonesia	Bali	International astronomical union, symposium no. 143.	June 18-22
Korea	Seoul	Fourth Asia pacific physics conference.	August 13-17
Malaysia	Bangi	International school for young astronomers.	May 28-June 15
Malaysia	Kuala Lumpur	Fourth tropical college on applied physics laser and plasma technology.	3 weeks in May
Singapore	Singapore	25th International conference on high energy physics.	August 2-8
Vietnam	Hanoi	International workshop on materials science.	October 15-30
Latin America			
Argentina	Buenos Aires	10th Course and training programme on metallurgy and materials technology.	March-December
Argentina	San Miguel de Tucumán	Symposium on the beacon satellite group.	March 27-31
Brazil	Brasilia	Workshop on the modern theory of solids.	January 8-19
Brazil	Campinas	Gleb Wataghin school on high energy phenomenology.	February 12-23
Brazil	Ribeirão Preto	New trends in chemical, biological and medical physics research.	January 8-12
Brazil	Rio de Janeiro	III ICFA instrumentation school.	July 16-28
Brazil	Rio de Janeiro	International conference on transport properties of superconductors.	April 29-May 4
Brazil	Rio de Janeiro	Sixth international conference on valence fluctuations - VI ICVF.	July 9-13
Chile	Santiago	Quantum mechanics of fundamental systems III.	January 8-12
Brazil	Rio de Janeiro	Sixth international conference on valence fluctuations - VI ICVF.	July 9-13
Chile	Santiago	Quantum mechanics of fundamental systems III.	January 8-12
Chile	Santiago	Tercera escuela internacional de sistemas dinámicos.	Nov 26 - Dec 1
Colombia	Bogotá	School on design of dedicated microprocessors.	April 16-27
Cuba	Havana	III Workshop for current problems of nuclear science.	October 22-27
Cuba	Havana	Latin American conference on the applications of the Mössbauer effect, LACAME '90.	Oct 29 - Nov 2
Dominican Rep.	Santo Domingo	Course on quality control in radiodiagnostic.	February 8-10
Peru	Lima	Sixth Latin American symposium on surface physics, thin films and small particles.	September 3-7
Middle East			
Jordan	Amman	Teaching of physics and mathematics for the gifted.	July 1 - August 15
Syria	Latakia	Summer school on lasers and quantum optics.	October 15-25

Activities at ICTP in 1990-91

1990	
College on recent developments and applications in mathematics and computer science	7 May - 1 June
First ICFA school on beam dynamics and engineering of synchrotron light sources	7 - 18 May
College on atmospheric boundary layer physics: I – "Modelling of the atmospheric flow fields" II – "Air pollution modelling for environmental impact assessment"	21 May - 15 June 21 May - 1 June 4 - 15 June
Miniworkshop on quantum chaos	4 June - 6 July
Adriatico Research Conference on Quantum chaos	5 - 8 June
Trieste conference on topological methods in quantum field theory	11 - 15 June
Miniworkshop on strongly correlated electron systems	18 June - 27 July
Research workshop in condensed matter, atomic and molecular physics	18 June - 28 September
Summer school in high energy physics and cosmology	18 June - 28 July
Adriatico Research Conference on Quantum fluctuations in mesoscopic and macroscopic systems	3 - 6 July
Adriatico Research Conference on "Physics of strongly correlated systems"	10 - 13 July
Symposium on Frontiers in condensed matter physics	11 - 13 August
Adriatico Research Conference on Defects in HCP crystals	14 - 17 August
6th Trieste IUPAP Semiconductor Symposium on "Hydrogen and semiconductors: Bulk and surface properties"	27 - 31 August
Working party on electrochemistry – Condensed matter aspects	27 August - 7 September
International conference on medical physics	3 - 7 September
College on medical physics	10 - 28 September
School on qualitative aspects and applications of nonlinear evolution equations	10 September - 5 October
College on neurophysics: "Neural correlates of behaviour, development, plasticity and memory"	1 - 19 October
College on "The design of real time control systems"	1 - 26 October
Workshop on atmospheric limited area modelling	15 October - 3 November
Third autumn course on mathematical ecology	29 October - 16 November
Workshop on earthquake sources and regional litospheric structures from seismic wave data	19 - 30 November
Workshop on composite materials	26 November - 7 December.
Experimental workshop on high-temperature superconductors and related materials (advanced activities)	26 November - 14 December
First International School on Computer network analysis and management	3 - 14 December
1991	
Second college on theoretical and experimental radiopropagation physics	7 January – 1 February
Fifth international workshop on computational condensed matter physics	16 – 18 January
Winter college on "Multilevel techniques in computational physics (Physics and computations with multiple scales of lengths)	21 January - 1 February
Second training college on physics and characterization of laser and optical fibres	21 January – 15 February
Second ICTP-INFN course on basic VLSI design techniques	4 February – 1 March
Experimental workshop on high temperature superconductors and related materials (basic activities)	11 February – 1 March
Winter college on ultrafast phenomena	18 February – 8 March
Workshop on mathematical physics and geometry	4 – 15 March
ICTP-WMO international technical conference on long-range weather forecasting research	8 – 12 April
Spring school and workshop on superstrings	8 – 19 April
Course on "Oceanography of semienclosed seas"	15 April - 4 May
Fifth workshop on perspectives in nuclear physics at intermediate energies	6 – 10 May
Spring college in materials science on "nucleation, growth and segregation in materials science and engineering	6 May – 7 June

Interface of high energy and condensed matter physics (joint conference with condensed matter group)	13 – 17 May
Third ICFA school on instrumentation in elementary particle physics	13 – 31 May
Structural and phase stability of alloys (Adriatico Research Conference)	21 – 24 May
Spring school on plasma physics	27 May – 21 June
Second school on non-accelerator particle astrophysics	3 – 14 June
Working party on initiation and growth of cracks in materials	3 – 14 June
Working party on simulation of materials degradation	3 – 14 June
Materials science of inhomogeneous materials (Adriatico Research Conference)	11 – 14 June
Miniworkshop on nonlinearity: fractals, pattern formation	11 June – 5 July
Topics in quantum field theory and applications	17 June – 5 July
Research workshop in condensed matter, atomic and molecular physics	17 June – 27 September
Summer school in high energy physics and cosmology	24 June – 26 July
International conference on complexity: fractals, spin glasses and neural networks	2 – 5 July
Miniworkshop on strongly correlated electron systems	8 July – 2 August
Strongly correlated electron systems (Adriatico Research Conference)	16 - 19 July
Course on functional integration and its applications	19 - 30 August
College on singularity theory	19 August – 6 September
Working party in condensed matter	2 - 13 September
Workshop on materials science and physics of non-conventional energy sources	2 - 20 September
Functional integration and its applications (Adriatico Research Conference)	3 – 6 September
School on dynamical systems	9 – 27 September
Sixth college on microprocessors: technology and applications in physics	23 September – 25 October
Conference on recent developments in the phenomenology of particle physics	30 September – 4 October
Workshop on soil physics	30 September – 25 October
Workshop on upper-medium-lower atmosphere	October-November
Workshop on stochastic and deterministic models	7 – 11 October
Second international workshop on radon monitoring in radioprotection and earth science	7 - 18 October
Training college on the applications of synchrotron radiation	14 October – 8 November
Workshop on climate and global change	28 October – 1 November
Third workshop on telematics	28 October – 15 November
Experimental workshop on high temperature superconductors and related materials (advanced activities)	4.– 22 November
Remote sensing applications in earth sciences	11 November - 6 December
School on materials for electronics: growth, properties, and applications	18 November – 6 December
Workshop on non-linear dynamics and earthquake prediction	25 November – 13 December

For information and applications to courses, kindly write to the Scientific Programme Office.

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EDITORIAL NOTE - *News from ICTP* is not an official document of the International Centre for Theoretical Physics. Its purpose is to keep scientists informed on past and future activities at the Centre and initiatives in their home countries. Suggestions and criticisms should be addressed to Dr. A.M. Hamende, Scientific Information Officer.