International Centre for Theoretical Physics

News from ICTP

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1986 ICTP Prize Alfred Kastler to Li Jia Ming

Prof. Li Jia Ming from the Institute of Physics of the Chinese Academy of Sciences was awarded the 1986 ICTP Prize for his outstanding contributions in the field of atomic and molecular physics. The prize was awarded at a special ceremony on 30 March, 1987, in the Main Lecture Hall of the International Centre for Theoretical Physics in Trieste, Italy.

The ICTP Prize is named after the late Prof. Alfred Kastler, Nobel Laureate in Physics in 1966 and Chairman of the ICTP Council from 1970 to 1983.

Professor Li was born on 16 November 1945 and is an expert in the multichannel quantum defect theory (MQDT) who has made significant contribution towards the development of this theory. His main scientific achievements include: (1) the establishment of the relativistic version of MQTD; (2) the application of MQTD to photoionization, photodetachment and other processes with a large number of good results; (3) the establishment of the multiple scattering method for calculating the MQTD physical parameters, namely the energy levels of parameters, namely the energy levels of molecular Rydberg states; (4) the proposal of a method to measure the compressed core density of high-power laser imploded spherical target; (5) the investigation of atomic shell effect on the equation of state at high temperature and high pressure and the application of quantum electrodynamics to high energy atomic processes.

Professor Li has about 50 scientific publications including three invited papers. He received his Ph.D. from the University of Chicago in 1974 and worked as a Research Associate at the Department of Physics of the universities of Chicago (1974) and Pittsburgh (1975-1976) and as a Senior Research Associate at the Laboratory for Laser Energetics of the University of Rochester (1977-1978). He returned to China in 1979 as an Associate Professor at the Chinese Academy of Sciences and was appointed Professor in 1983.

The citation was read by Professor Abdus Salam, Director of the ICTP and President of the Third World Academy of Sciences, while the prize consisting of a US$ 1,000 cheque, a medal and a diploma was handed to Professor Li by Professor Louis Emmerij, President of the Development Centre of the Organization for Economic Cooperation and Development in Paris.

Prof. Yu Lu of ICTP made a presentation of the work of Prof. Li while Mr. C.R. O'Neal of the Third World Academy of Sciences paid a tribute to the memory of Prof. A. Kastler.

The ICTP 1983, 1984, and 1985 Prizes were awarded to three scientists from Asia, Latin America and Africa in the fields of solid state, plasma physics and mathematics respectively.

1987 ICTP Prize Nikolaj N. Bogolubov to Abdullah Sadiq

On 7 August at a special ceremony in honour of the 300th anniversary of the honour of the 300th anniversary of the publication of the *Principia* by Sir Isaac Newton, held at the International Centre for Theoretical Physics (ICTP), in Trieste, Italy, the Centre's 1987 prize in honour of Prof. Nikolaj N. Bogolubov, was awarded to Dr. Abdullah Sadiq of Pakistan. The prize was awarded in recognition of Dr. Sadiq's contribution to scientific knowledge in the field of Solid State Physics. His diverse research interests in condensed matter physics have included Ising models, correlated percolation and its relations to spin glass transition and long chain polymers. He has been active in the area of computer simulation of physical systems and his current studies relate to the kinetics of irreversible chemical processes. Dr. Sadiq is a staff member of the Pakistan Institute of Nuclear Science and Technology in Rawalpindi, Pakistan.

Contents

Dr. Sadiq was born in Peshawar, Pakistan in 1940. He has devoted himself to research in various fields related to solid state physics for more than 17 years, and has to date published some 20 papers. He plans to continue his activities in this area of physics and is currently working on kinetics of irreversible processes.

Dr. A. Sadiq (right) receiving the award from Professor Bogolubov (left). In the middle, Prefetto E. de Felice.

Professor Bogolubov presented the award, consisting of a medal, a certificate and a cheque in the amount of US$ 1,000, in front of more than 200 scientists from all over the world. Prof. Bogolubov who was born in Gorky, USSR in 1909, wrote his first scientific paper at the age of 14 and received his doctorate in mathematics from the doctorate in mathematics from the USSR Academy of Sciences at the age of 21. He has since made decisive contributions in the fields of mathematical physics, non-linear mechanics, quantum statistics, the theory of superconductivity, nuclear theory, quantum field theory and elementary particle physics. Among his many contributions were the development of the methods of second quantization as well as a brilliant physical explanation for the phenomenon of superfluidity, the construction of the famous Bogolubov transformation, and the introduction of Bogolubov's microcausality condition in the field of quantum theory. Professor Bogolubov has received some of the highest awards from the Soviet Union and the world scientific community for his achievements. He has been elected an honorary member of various national Academies of Science, such as that of the USA, the Federal Republic of Germany, Poland, Bulgaria and the German Democratic Republic.

As part of the ceremonies as well, Professor Bogolubov and three other distinguished individuals were honoured, and presented with ICTP Medals. Professor Bogolubov was the first recipient and the award was presented by Professor Abdus Salam (Nobel Laureate 1979), Director of the ICTP and President of the Third World Academy of Sciences. While Professor Salam read the individual citations, Professor the individual citations, Professor Bogolubov then presented the other medals to Dr. Eustachio de Felice of Trieste, Sir Rudolf Peierls and Professor John Ziman.

During the course of the ceremonies, which took place in the morning and afternoon, lectures were given by several distinguished professors from the United Kingdom, including John Ziman on the Development of Scientific Thought after Newton, Sir Rudolf Peierls on the Meaning of Models, Hypotheses and Approximation, James Eells on Variational Theory, Alan Cook on the System of the World, and Dennis Sciama on Cosmology, Astronomy and Fundamental Physics.

1986 Dirac Medal Award Ceremony

On Thursday 23 July 1987, one of the 1986 Dirac Medals of the International Centre for Theoretical Physics (ICTP) in Trieste was officially given to Professor Yoichiro Nambu (Enrico Fermi Institute for Nuclear Studies, Chicago University, USA) by Professor Abdus Salam, Director of the ICTP, and Professor Herwig Schopper, Director General of CERN.

More than three hundred scientists and officials attended the award ceremony which took place in the Main Lecture Hall of the ICTP during the two-day Conference "Search for Scalar Particles: Experimental and Theoretical Aspects".

After the Medal was handed over, Professor Nambu lectured on BSC Mechanisms in Nuclear Physics.

Professor Yoichiro Nambu was honoured *"for being one of the first physicists to formulate the idea of spontaneous symmetry breaking and, in particular, chiral symmetry breaking in relativistic particle physics. His contributions to the quark model in the sixties and, later, his geometrical formulation of the dual resonance models as the dynamics of a relativistic string are of fundamental importance. The scope and intensity of current research in string theory are witness to the profundity of Nambu's contributions to particle physics".*

Professor Yoichiro Nambu was born in Tokyo on 18 January 1921. He studied at the University of Tokyo where he received his B.Sc. in 1942 and his D.Sc. in 1951. He was appointed as a Professor at the Osaka City University Professor at the Osaka City University in 1950. After two years as a Member of the Institute for Advanced Study of Princeton (1952-1954), Prof. Nambu joined the University of Chicago as a Research Associate (1954-1956) first and then as an Associate Professor (1956-1958). He has been a full Professor since 1958. He was Chairman of the Department of Physics from 1974 to 1977.

Professor Nambu is a member of the National Academy of Sciences (since 1971), American Academy of Arts and Sciences (since 1971) and an Honorary Member of the Japan Academy (since 1984). He has received the following awards: Dannie Heineman Prize for Mathematical Physics (1970), Distinguished Service Professor

Professor Y. Nambu and Professor Abdus Salam at the ICTP Dirac Medal Award ceremony.

(University of Chicago, 1971), J. Robert Oppenheimer Prize (1976), Harry Pratt Judson Distinguished Service Professor (1977), Order of Culture awarded by the Government of Japan, United States National Medal of Science (1982) and Max Planck Medal (1985).

He is the author of 126 scientific papers.

The other 1986 Dirac Medal was given to Professor Alexander Polyakov (Landau Institute for Theoretical Physics, Moscow, USSR) on 15 November 1986.

1987 Dirac Medals to DeWitt and Zumino

The Dirac Medal, instituted by the International Centre for Theoretical Physics in 1985 to honour the memory of the eminent physicist, was awarded in August, 1987 to Professor Bruno Zumino and Professor Bryce S. DeWitt for their outstanding contribution to theoretical physics.

Prof. Zumino has been for the last twenty years one of the leading experts in field theory. Together with Prof. Julius Wess he has made fundamental contributions to the study of chiral anomalies in gauge theories with fermions. Also in collaboration with Prof. Wess, he proposed the first renormalizable Lagrangian field theories to realize supersymmetry in 4-dimensional space-time. With Prof. Stanley Deser he constructed one of the first supergravity theories in four dimensions. In addition to this important early work, he has been a leader in the application of modern geometrical ideas in field theory. In particular he has illuminated the role of Kähler geometry in extended supergravities and, more generally, the value of differential geometric methods in the study of anomalies.

Prof. Bryce S. De Witt has made fundamental contributions to the study of classical and quantum gravity and non-Abelian gauge theory. His pioneering work with quantum, effective action underlies much of the modern formalism. Particularly important are the background field method which he invented, and the methodology of ghost loops in gauge theory, which he did much to develop. His name is associated with the Wheeler-DeWitt equation, which provides the basis for most work on quantum cosmology, and with the Schwinger-DeWitt expansion, which is widely used in studying field theories in curved space-time and in string theory computations.

TWAS Awards

The Council of the Third World Academy of Sciences upon the recommendation of the TWAS Awards Committee has decided to award the following four Prizes for the year 1986. The prizes will be presented to scientists from developing countries who have made singular contributions to basic sciences.

Physics - Prof. Zhong-xian Zhao (China) - *for his fundamental and pioneering contributions to high temperature superconductivity, in particular for achieving the superconductivity above liquid nitrogen temperature in Ba-Y-Cu-O system.*

Chemistry - Prof. Saad S.M. Hassan (Egypt) - *for his fundamental contributions to Modern Analytical Chemistry, in particular for developing new simple and selective micromethods for the analysis of pharmaceutical and biomedical compounds.*

Biology - Prof. Mysore Ananthamurthy Viswamitra (India) - *for his fundamental contributions to the understanding of DNA structure, in particular for his discovery of sequence dependent fine structure in DNA segments in single crystals.*

Mathematics - Prof. Mauricio Matos Peixoto (Brazil) - *for his fundamental and pioneering study of structural stability of dynamical systems, in particular for proving that flows on closed surfaces are generically structurally stable.*

Each prize will consist of an award of Ten Thousand Dollars and a Medal. The presentation of these Awards will take place in Beijing, China, at the Great Hall of People on 14 September 1987 at the ceremonial session of the Third World Academy's Second General Conference: "The Future of Science in China and the Third World".

Geophysics at ICTP

by Alan Cook[1]

Courses on geophysical topics have been held at the Centre for many of the past twenty-three years and I shall show in this article that geophysics is particularly appropriate for the Centre, alike for its international nature and its theoretical problems and also because on it rests our understanding and exploitation of our natural world, in developing and in industrialised societies. The physical study of the world beneath our feet and of the seas, atmosphere and plasmas around it, began when the Greeks first gained some idea of the size of the Earth, but in a modern sense the first geophysicist was William Gilbert († 1603), a student first at St. John's College, Cambridge (the college of Dirac and Abdus Salam) and then of the famous medical school of Padova. He constructed in the manner of the modern scientific method a model of the magnetic field of the Earth which, so far as it goes, is very much in accord with our present knowledge, but the real start of geophysics came a century later, with Isaac Newton and Edmond Halley, whose contributions to physics we particularly recall in 1987. Newton applied his idea of universal gravitation to calculate the shape of the Earth, demonstrating that the polar axis was shorter than any axis in the equator, and also that the attraction of gravity should be greater at the poles than on the equator. He drew upon some observations of the pendulum that Halley had made as a very young man at St. Helena, as well as other more recent observations of the size of the Earth and of the length of the other more recent observations of the size of the Earth and of the length of the seconds pendulum, to compare with his theory. Cassini, in Paris, had proposed that the polar axis of the Earth was the longest; the settlement of the conflict involved careful measurements in Lapland and Peru which confirmed Newton, were the origin of modern geodesy and led eventually to international agreement on the metric system in which the metre was defined as 1/40,000,000 of the length of a meridian. Much of Halley's scientific work arose from his concern with seamanship and navigation, he observed the magnetic field and the tides from a ship at sea, he studied the world-wide system of winds and he found from the study of ancient eclipses that, as we would say now, the spin of the Earth is slowing down. Of the main fields of geophysics, two were unknown to Newton and his successors - seismology and the ionised gases and magnetic fields around the Earth.

Geophysics as we know it to-day has developed over the last fifty years, mainly through the application of three techniques to geophysical observation - the measurement of geophysical quantities from ships at sea, the use of space craft in geophysical studies, and the use of very powerful computers. Until the 1930's, geophysical observation had been effectively confined to the land, after that time, and especially from about 1950 onwards, measurements of gravity and of magnetic fields, but above all, seismic observations, were made in the deep oceans and completely altered ideas about the nature of continents and oceans, as summarised in the concept of plate tectonics. Traditional studies of the magnetic field and the size and shape of the Earth were greatly helped by space techniques, but a new realm was opened with the discovery early in the history of satellite observations, of the van Allen radiation and of the magnetosphere, while in very recent years, ways of making better synoptic observations of the oceans are being devised. Satellite observations can be exceedingly numerous, as indeed, are many others made by modern methods, and they could not be used without computers to organise them. Computers are not just filing systems, they are also used to manage the observations, while much filing systems; they are also used to manage the observations, while much theoretical work depends on computers being available. Geophysics deals with the whole world, world-wide observations are needed, of quantities that vary in time, and computers are necessary to get a grasp of the results. The use of very powerful computers meant that advanced geophysics was until recently developed in a few industrialised countries, but now that so much can be done on microcomputers, physicists and mathematicians in developing countries can do comparable original work. Geophysics is international - geophysics confined to one country would be ludicrous to-day - and it is also highly theoretical. The theoretical concepts and mathematical techniques are no less demanding and rewarding than in the most advanced fields of physics, so that it is wholly appropriate that theoretical geophysics should be pursued in the International Centre. Furthermore, geophysics has far reaching practical applications in science and technology in developing countries. In the following sections of this article, I will say more about some theoretical problems and give a hint of how geophysical studies bear upon development.

Geophysics falls naturally into two parts - internal geophysics, dealing with the interior of the Earth, inaccessible as it is to direct observation, and external geophysics which studies the fluids on and around the Earth. There is a fundamental distinction between the methods of the two branches; in external geophysics the physical properties of the region can be observed directly, especially with the aid of space craft, whereas the internal properties have to be inferred from observations at the surface of the Earth. One wishes to find some physical property of the Earth (density, elastic moduli, heat generation, and so on) as a function of position within it, but the observations are of functionals evaluated at the surface (such as gravity, travel times of elastic waves between points on the surface, heat flow, magnetic field). The mathematical problem is to infer the function from the functional. It cannot be solved uniquely or exactly, only within some range, and the study of the methods and scope of solutions is the province of inverse theory, which has been developed in a very sophisticated and elaborate manner in terms of Hilbert space theory. Beside the general theory, each particular field of study requires a solution of the appropriate direct problem, the calculation of the functional from a appropriate 'direct problem,' the calculation of the functional from a specified function. The direct problems are aspects of classical physics, but that does not mean they are elementary. The Earth when shocked by a large earthquake, vibrates as a whole in a complex superposition of normal modes; the calculation of the eigenfunctions and eigenperiods and the way in which they depend on the rotation of the Earth (analogous to the Zeeman effect in atoms) and its ellipticity requires powerful mathematics similar in some ways to that for atomic structure theory. Again, the study of the transmission of elastic waves through the Earth has close analogies with the theory of electromagnetic waves in plasmas which, of course, is the basis of much of the study of the plasmas around the

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[1] *Professor Alan Cook is the Master of Selwyn College in Cambridge. He has been involved as Director and Lecturer in all the ICTP activities in geophysics.*

Earth. While they may be elaborate and sophisticated, the bases of these theories are classical and deterministic. It is however, now well understood that not all solutions of the equations of classical physics are well determined and that some may behave in a random and chaotic manner. Chaotic conditions may quite well obtain in the behaviour of the oceans, the theory of which is one of the outstanding major problems of classical physics. Only quite recently, by means of satellite observations, has it become possible to observe the sea surface at more than the very few isolated points on ships' tracks, and even when those observations will have been made is adequate numbers and over a sufficient space of time, much of the behaviour of the oceans in depth will still be unknown. Correspondingly, important aspects of the theory are obscure and difficult. The influence of geometry is complex because of the irregular and asymmetrical shapes of the ocean basins, there are considerable non-linear interactions and one of the principal driving forces, the action of the wind at the surface, is as yet poorly understood. To describe and account for the behaviour of the oceans is a great challenge to human intellect.

Geophysics can stand on its own as a scientific activity, but at the same time, there are important connexions with other fields of physics and chemistry. Geophysics calls upon much of rheology, of plasma physics, solid state physics among others, to interpret its phenomena, but at the same time it returns to laboratory physics ideas which might not have occurred if it were only in the laboratory that physics were studied. Thus, the idea and theory of the high pressure metallic state of hydrogen had their origin over fifty years ago in thoughts about the interior of the Earth, and observations of Jupiter and Saturn from space craft have led to much recent work on that subject, which raises many of the fundamental issues of the theory of metals and of our understanding of the liquid state. These and other developments in the behaviour of condensed matter at very high pressures, were explored three years ago in ICTP at a joint working group of the condensed matter and geophysics programmes.

While the theoretical problems and scientific interest of geophysics would, on their own account, justify a programme of theoretical geophysics at the ICTP, the importance of an understanding of geophysics for the ways we live in and use our Earth, especially in developing countries, adds weight to that scientific justification. The applications of geophysics to human life are indeed many. Locally, geophysical methods are used extensively in looking for oil, minerals, water and other substances that are economically important or on which the existence of a community may depend. Developing countries which may want to find their own indigenous resources need geophysics and geophysicists. Countries with sea coasts need a good knowledge of their oceanographic conditions, for building ports, or identifying areas subject to floods, and so on, and that simple, essential knowledge is often quite lacking. Then again, a good understanding of the tropical ionosphere is needed for planning radio communications in tropical lands. Important though these immediately practical matters are to developing countries, the significance of geophysics goes much further. Most people in most parts of the world are unaware of the physical processes that shape and control our world, and of the limits they set as well as the possibilities they offer for changing the world to our benefit and profit. In many industrialised countries that is an unhappy but not a disastrous state of affairs, but in some developing countries it is much more serious, for many of those countries are especially subject to natural disasters, from storm, or flood, or earthquake or volcanoes or drought, and some natural conditions may be very sensitive to changes man brings about, as changes at the margins of deserts seem to show. Education in the physical state of the world is very necessary in most developing countries. There is a further way in which geophysics can contribute to education, for the phenomena of the world around us afford many examples of the principles of classical physics that might be more economically and effectively used in teaching physics, in university and in school, than demonstrations taken over from laboratory practice in industrialised countries, for which the apparatus is apt to be expensive, sophisticated and difficult to keep in order by local technicians.

The uses of geophysics thus range widely, from fundamental theory to severely practical industrial use, with the advancement of education in physics and development of understanding of what we can and cannot do with nature as very important. All those aspects have had their place in the geophysics programme of the ICTP over the past two decades and there is every reason why all should be extended in the future.

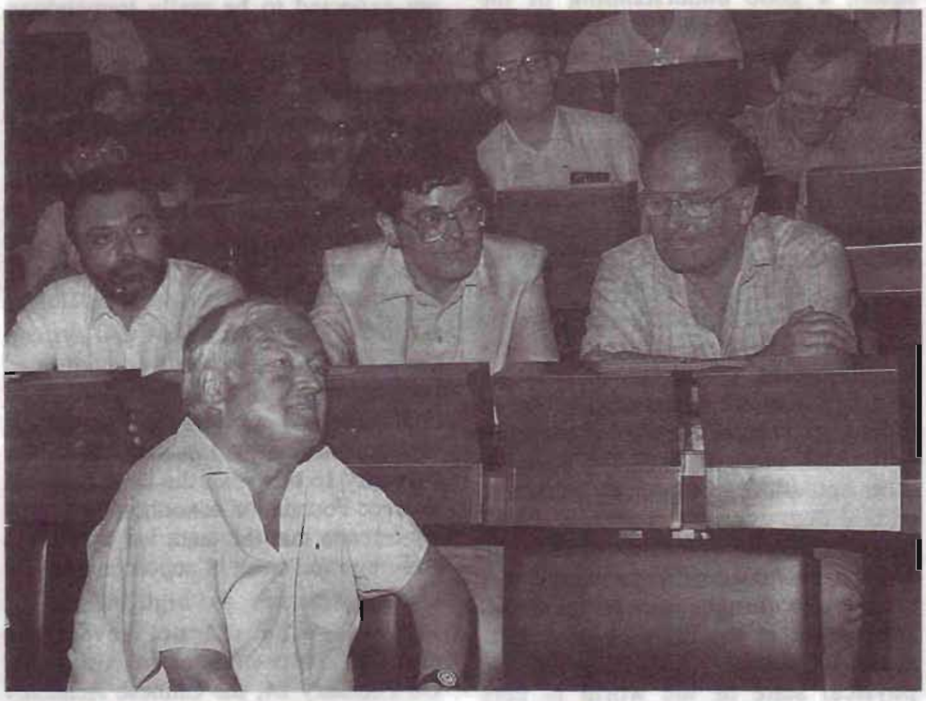
High Temperature Superconductivity

by Yu Lu
Senior Scientist, ICTP

The discovery of room temperature superconductivity has been a long-standing dream of many condensed matter physicists. The technological implications of such a discovery in electronics, power industries and so on are expected to be really tremendous. Until 1986, the painfully slow progress in raising the superconducting transition temperature had made most physicists quite pessimistic about the possibility of ever materialising this dream.

A revolutionary breakthrough came in early 1986 when G. Bednorz and A. Müller of the IBM Zurich Research Laboratory first found the signature of superconductivity in the temperature range 30°K in the La-Ba-Cu-O system. Later on, this result has been confirmed by themselves, and has also been confirmed and extended by other groups in Japan, China, and in the U.S.A. On February 16 this year, the USA National Science Foundation announced at a press conference that the team led by P. Chu had observed onset of superconductivity at temperatures as high as 92°K. However, Chu did not reveal the chemical composition of the compound. On February 24, the Chinese Academy of Sciences in Beijing announced that the research team led by Zhao Zhongxian had observed superconductivity up to 100°K in an oxide of yttrium, barium and copper. From then on, the race for higher T_c started. The perspectives of such high temperature superconductors for applications are so attractive and the problems arising in understanding the superconductivity mechanism are so challenging that a major fraction of both experimentalists and theorists in condensed matter physics have rushed into this field instantaneously. Almost all major laboratories all over the world have been involved in this high T_c"heat wave", a spectacular demonstration of which was the "Woodstock" meeting of the American Physical Society held on March 18 in New York and ended at 3:15 the next morning.

A special Adriatico Research Conference "High Temperature Superconductors" took place on July 5-8, right on the crest of this "heat wave" at the International Centre for Theoretical Physics (ICTP) in Trieste to provide a forum for a discussion of the latest developments in this extremely rapidly moving field. This conference co-sponsored by the ICTP, the SISSA (International School for Advanced Studies - Trieste) and IBM Italy, has been a first truly international meeting on this subject with about 200 registered participants and over 300 actual attendees including scientists from other disciplines, top-level managers and journalists.



Professor Stig Lundqvist (front), Chairman of the ICTP Scientific Council and moving spirit of the Adriatico Conferences, with Prof. R. Schrieffer, Nobel Prize 1972 (right).

The response of the world's scientific

The response of the world's scientific community to this Conference has been extremely warm. More than 60 invited papers were presented covering all major developments in materials experiments, theory and applications of high temperature of superconductors. Scientists from more than 35 countries all over the world including Africa, Asia, Europe, Oceania, South and North America, have communicated their latest achievements. Some of the speakers had been invited only a few days before the conference because of the unusual pace in this field. Nevertheless, they managed to come and to share with other colleagues their "hot" results.

It is impossible to summarize in a few words the numerous exciting results reported at this Conference (the proceedings will be published very soon by the World Scientific Publishing Company in Singapore). However, we would like to give here a very brief description of the current status in this field. These oxide superconductors are distinguished from the ordinary superconductors in many ways. Firstly, they are characterized by special layer-like, or even chain-like structures of copper and oxygen ions. Secondly, the superconductivity properties (critical temperature, energy gap, the specific heat jumps at the transition temperature and so on) are extremely sensitive to the oxygen deficiency and, therefore, to the way of sample preparation. It is well

known that superconductors show zero

known that superconductors show zero electrical resistance and perfect diamagnetism (Meissner effect). However, the Meissner effect is not complete for these high temperature superconductors, even in the best samples available. On the other hand, there are clear-cut experiments showing the macroscopically quantum nature of the superconducting state in these oxides, namely the magnetic flux quantization and the Josephson tunneling between these and the ordinary superconductors.

The theoretical explanation of why the transition temperature for such superconductors is so high, is a great challenge to the condensed matter theory. For thirty years, following the microscopic theory advanced by Bardeen, Cooper and Schrieffer, the interaction of electrons with phonons (sound waves) leading to electron pouring, was the only documented mechanism for superconductivity. It is doubtful that the superconductivity in these oxides can be entirely explained by this theory. There are some strong experimental indications supporting that viewpoint. Up to now there are two families for high T_c superconductors. The La-Cu-O system doped with Ba or Sr with transition temperature around 90°K. For the La-Cu-O system, the undoped compound is an *antiferromagnetic insulator* while the superconductivity transition temperature upon doping is strongly correlated with the whole concentration measured by the Hall effect. Also, there is an additional optical absorption in the insulating gap in both systems when the composition deviates from the stoichiometric one. Previously, the isotope effect - the transition temperature is inversely proportional to the square root of the isotope mass - has been a direct evidence for the phonon mechanism. However the yttrium superconductors do not show any isotope effect at all, whereas only partial isotope effect has been observed in lanthanum superconductors.

At the moment, more than a dozen of theoretical models have been proposed to interpret this new type of superconductivity. All of them should be scrutinized and selected by further experiments.

The race for higher T_c is still continuing. From time to time there are reports on 240°K or even room temperature superconductivity. However, up to now, the reproducible superconductivity is still in the 90°K range. The big advantage of oxide superconductors is their easy range. The big advantage of oxide superconductors is their easy accessibility to most developing countries. In fact, they have already brought in their own contributions. As mentioned before, China was among the first to confirm and extend the pioneering discovery of Bednorz and Müller. Professor Zhao Zhongxian from the Institute of Physics, Academia Sinica, Beijing, has been awarded the 1987 Third World Academy of Sciences Prize in Physics for his outstanding contributions to this field. India has very strong teams working on oxide compounds. Nowadays even high-school students in advanced countries can make their own samples and demonstrate the striking "floating" effects of superconductivity (see the article by Paul

1987 Nobel Prize for Physics

On going to press, we learn that Professor Alex Müller and Professor Georg Bednorz share the 1987 Nobel Prize for Physics in recognition of their work on high-temperature superconductors. Our congratulations to the two Laureates.

The Centre was fortunate in having Professor Müller as a lecturer at the Adriatico Conference on High-Temperature Superconductors.

The photograph shows him attending a lecture in the main auditorium at the ICTP.

Grant in *New Scientist*, 30 July 1987). To polarize the research on the high T_c superconductors in developing countries, the ICTP will hold an "Experimental Workshop on High Temperature Superconductors" on April 11-22, 1988. Many leading experts and laboratories in this field are giving advice and assistance in this activity. The attendants of this workshop will not only listen to the latest state-of-art lectures but will also make samples and carry out physical measurements
lectures but will also make samples and carry out physical measurements
themselves.

The 1987 special Adriatico Conference on High-Temperature Superconductors was a great success. All the major laboratories involved from both the West and the East, the developing and developed world, were well represented at this exciting event. Even leading experts in this field have got new inspiration at this Conference and have started new projects as soon as they got back home. However, this is only a start but not the end of an heroic chapter in physics. Many questions remain open and challenging. To continue the efforts along this line, the ICTP is going to organize two more activities on this subject in 1988: a mini-workshop on "Mechanisms of High-Temperature Superconductivity", June 20 - July 29, co-sponsored by SISSA, and an Adriatico Conference on "Towards Theoretical Understanding of High-Temperature Superconductivity", July 26-29, co-sponsored by SISSA and IBM Italy. The first activity is a research-oriented special-purpose workshop with a small but meaningful fraction of actively working scientists in this field in the same spirit as the Workshop on "Nonlinear Charge
this field in the same spirit as the Workshop on "Nonlinear Charge
Density Wave Systems" held in 1987. The Adriatico Conference will concentrate on a critical overview of the main experimental results in this field and an in-depth discussion of the mechanisms leading to the high-temperature superconductivity.

Association of Visitors to the ICTP (AVICT)

On 9 September 1987, the Association of Visitors to the International Centre for Theoretical Physics (AVICT) was constituted at the ICTP.

The aim of AVICT will be to:

(a) propagate the ideals of ICTP (functioning like an alumni association) and advocate the use of science for peace and prosperity;

(b) promote international contact and co-operation for scientific activities, supplementing the efforts of ICTP and making them effective;

(c) advocate the involvement of scientists in national developmental efforts, especially in developing countries; and

(d) express collective views publicly in national and international forums on science policy matters like administration, education, budget and management of research and development in science and technology.

All the visitors to ICTP are eligible to become members of AVICT.

The most important parts of AVICT will be the local and regional chapters whose activities will be carried out by an executive committee consisting of a president, a vice-president, a treasurer, a secretary and some executive committee members. Apart from other activities, the local chapters must meet once a year and elect its executive committee. Lecturer and discussions on topics related to the aim of AVICT can be arranged by the regional chapters. Regional organizations of visitors to ICTP which already exist can become regional chapters of AVICT without loss of identity.

The overall co-ordination will be done by the AVICT general executive committee based at ICTP, Trieste. The Director of ICTP will be the Patron of AVICT.

The general executive committee will have a term of two years for its
The general executive committee will have a term of two years for its president, vice-president, treasurer and secretary who will be elected in one of the annual meetings held at ICTP. The presidents and secretaries of local chapters will be members of the general executive committee. Some additional members may also be elected.

The General Secretary will operate the Bank account of AVICT along with the General Treasurer.

Life membership fee will be US$ 1.-, payable to AVICT account with Cassa di Risparmio di Trieste. Donations to AVICT may be paid into the above-mentioned bank account. Regional and local chapters of AVICT may seek separate donations and contributions for their activities.

Changes in the constitution can be done in annual meetings of AVICT at ICTP, Trieste, by a simple majority of votes.

The following visitors were elected to the General Executive Council of AVICT:

President: Professor S. Lundqvist, Institute of Theoretical Physics, Chalmers University of Technology, S-41296 Göteborg, Sweden;

Vice-president: Professor A.A.M. Sayigh, Department of Engineering, University of Reading, Whiteknights, P.O. Box 225, Reading RG6 2AY, UK;

General Secretary: Professor M. Yussouff, Departement of Physics, I.I.T., Kanpur, India (presently visiting Fakultat Physik, Universität Konstanz, Konstanz, D-7750 Konstanz 1, Federal Republic of Germany);

General Treasurer: Professor Abdul Aziz Sabir, Department of Mathematics and Statistics, University of Agriculture, Faisalabad, Pakistan.

ICSU and Third World Scientists: Reflections Over 30 Years

F.W.G. Baker,
ICSU Executive Secretary

As part of a presentation about ICSU, Mohamed Hassan asked me to look back over thirty years of work in ICSU to reflect on some of the changes that have occurred between 1957 and 1987 especially with regard to the Third World.

ICSU, which brings together in a loose federation, 20 International Scientific Unions, 74 National members. Associates and Observers. 24 Scientific Unions, 74 National members, Associates and Observers, 24 Scientific Associates and over 20 Scientific and Standing Committees, Commissions and Groups, is the largest international non-governmental organization in the natural and physical sciences. ICSU's principal objective is to encourage international scientific activity for the benefit of mankind. It has been responsible for initiating, designing and coordinating a number of major global interdisciplinary research programmes such as the International Geophysical Year (1957-58), the Upper Mantle Project (1961-70), the International Biological Programme (1964-74), etc. It is currently developing a study of the interactions between various parts of the geosphere and biosphere known as the Global Change Programme. In addition, it has been responsible, with members of the UN family, for launching a number of programmes such as the International Indian Ocean Expedition, the World Science and Technology Information System, the International Geological Correlation Programme, a study of Climate Change and the Oceans, and the International Biosciences Network with UNESCO, and the Global Atmospheric Research Programme and the World Climate Research Programme with WMO, and others.

ICSU also acts as a focus for the exchange of ideas, the communication of scientific information and the development of scientific standards, nomenclature, units, etc., and in comparison of methods and intercalibration of instruments. Various members of the ICSU family organize scientific conferences, congresses, symposia, summer schools, and meetings of experts, as well as General Assemblies in many parts of the world as well as other meetings to decide policies and programmes. A wide range of publications is produced, including newsletters, handbooks, proceedings of meetings, congresses and symposia, professional scientific journals, data, standards, etc. Some of these are published by the ICSU Press. ICSU also assists in the creation of international and regional networks of scientists with similar interests, and it initiates special studies such as those on Radioactive Waste Disposal and on the Disposal of Toxic Wastes, and that carried out by SCOPE on the Environmental Consequences of Nuclear War (ENUWAR).

The first thing that struck me in February 1957 when I joined the Secretariat of the International February 1957 when I joined the Secretariat of the International Geophysical Year was the deep interest in Africa. The Secretary General of the IGY Committee was attending in Bukava the joint IGY/CSA meeting of coordination for the IGY in Africa South of the Sahara which was examining how to improve the network of stations in Africa.

One of the reasons for this and other regional meetings was the interest of the geophysicists to obtain as complete a cover as possible of the Earth and its atmosphere using ground-or-sea-based observing platforms with a few countries launching rockets and a much larger number launching instrumented balloons. Africa was one of the continents with the least dense network of stations, and a plan was developed with UNESCO and WMO to help train African geophysicists and to install new stations in key locations. Although the network of stations and of scientists in Africa is still less dense than in many other parts of the world, combined efforts - with UNESCO particularly recently in the framework of the African Biosciences Network and in those developed by IUGG and IUG Sciences and with WMO in the framework of the GARP and WCRP - have improved considerably the situation. It is sad to note that the network of these stations established in Africa for the GARP Atlantic tropical Experiment has not been maintained, and important gaps in the observational network in Africa have reappeared.

But it was not only in Africa. Other parts of the Third World were assisted by ICSU with the strong support of UNESCO and WMO so that when the IGY began on 1 July 1957 there were countries from the Third World participating. (It is interesting to note in passing that in the First International Polar Year of 1882-83 - one of the predecessors of the IGY - there were seven stations in the Third World making observations, most of them in the tropics!).

There was not, however, a focus for ICSU activities in the Third World until the early 60's when a small study group was established to look into the question of what ICSU might do to help developing countries. The report of this group was instrumental in the decision made by the 12th General Assembly held at the Tata Institute of Fundamental Research in Bombay in January 1966 to establish a Committee on Science and Technology for Developing Countries (COSTED). I believe that another factor which influenced some of the delegates (COSTED). I believe that another factor which influenced some of the delegates in their decision was their first contact with people of the Third World and a sharp realization of the conditions under which some of them existed.

COSTED began to function in 1966 under the Chairmanship of Patrick Blackett with the writer as Secretary. In its first six years the Committee made contacts with the developing countries already adhering to ICSU and sought their advice. It also stimulated others to join ICSU. The most successful programme was that of sending one or more experts in answer to requests from National Members in the Third World.

The first of these was a group of experts in land use who went to Indonesia in 1967. The Indonesian authorities brought together most of the Indonesian scientists involved in land use for a series of discussions and an exchange of views about the Indonesian situation. Similar missions were organized to other countries in the Third World at their request.

The last mission organized by COSTED under Blackett's leadership was one to East Africa in 1968. It was at the time when ICSU and UNESCO were carrying out the feasibility study for a World Scientific Information System (UNISISTS). A specialist in science information was sent to East Africa at the request of the East African Academy of Science to study the possibilities of creating a scientific information centre for the region. The report was sent by the East African Academy to a UN body with a request that funds be made available to help set up the Centre. Unfortunately, none were made available.

The Chairman suggested that all the members of COSTED should give lectures at the University of Nairobi when COSTED held its meeting there in 1969. Only one lecture was given to a small audience: the start of the lectures unfortunately coincided with a strike of the students which lasted longer than the stay of the potential lecturers in Nairobi.

Perhaps the most interesting study during this early part of COSTED's existence, however, was that of how science and technology could be applied to the economic and social betterment of the developing countries: a subject long dear to Blackett's heart. COSTED decided to prepare a small book with the title *The Role of Science & Technology in Developing Countries*. An author, Graham Jones, was engaged to work for two years under Blackett's direction with the costs shared by ICSU and the Royal Society. In the introduction Blackett the costs shared by ICSU and the Royal Society. In the introduction Blackett describes the contents of the book as follows: *"The content of the book was planned taking fully into account the large literature already existing on the problems of the developing countries. This literature covers a very wide range of subject and form, from wide global surveys to highly detailed studies. However, many of these studies are hard to come by and only a small fraction of them could be studied in detail by a working Qualified Scientist or Engineer (QSE), if only for lack of time. The book therefore contains an extensive bibliography and many of the previous studies are critically evaluated in the text. One reason why it was thought that such a book would be timely is that in recent years important advances in understanding have been, both in the DCs and the LDCs, of just how the process of innovation take place - meaning by the word 'innovation' the whole process from scientific discovery or invention to the final emergence of a marketable product, or a social service".* He goes on to say *"To get science and technology used to best adavantage for the benefit of the LDCs, it is not sufficient that a few top economic and social planners should understand what should be done: this must also be understood in the research laboratory, at the industrial work bench and in the fields. Thus a somewhat flippant and even presumptuous sub-title of this book might be* What Every QSE Ought to Know". The book was published by Oxford University Press in 1971 and was later translated into and published in Spanish.

The preparation of this book provided a stimulus to the USSR Academy of Sciences which prepared a book entitled *The Third World and Scientific Technical Progress* published in 1976 in English by the Nauka Publishing House, Moscow. In his introduction, A.P. Vinogradov states: *"The present work, which expresses the views of a groups of Soviet scholars, is such a publication. It reflects the results of investigations into the utilisation of science and technology in developing countries, carried out in recent years by various institutes of the USSR Academy of Sciences, including a scientific conference - "The Scientific and Technical Revolution and the Developing Countries", held in Moscow in February 1971."*

There is a great deal of wisdom in these two books that continues to be rediscovered.

The first phase of COSTED's rediscovered.

The first phase of COSTED's activities ended in Helsinki in 1972 when an Ad hoc Group under the chairmanship of S. Bhagavantam made a recommendation: *"The Assembly Ad hoc Working Group on Developmental Issues under the chairmanship of Dr. S. Bhagavantam, made a recommendation, which the Assembly adopted, that COSTED be continued with a small Committee of nine members, drawn from all parts of the world and representing different philosophies of development, with the following basic objectives: to coordinate and to encourage the Unions' assistance to developing countries; to encourage participation by scientists of developing countries in the Special and Scientific Committees; to foster regional to national affiliations in which identification of developmental scientific and technical problems would be furthered; to provide liaison and advisory services to international scientific development organizations".*

Bhagavantam became Chairman of COSTED in 1972, and a new phase began with the establishment of the COSTED Secretariat in India where it still is today thanks to the generosity of the Indian authorities and of the Indian Leather Research Institute.

One of the major developments in ICSU in the last 30 years has been the growth in the number of members of the ICSU family. In 1957 there were 13 International Scientific Unions Members, now there are 20, and 24 Scientific Associates. In 1957 ICSU Unions and Committees had adhering organizations in 60 countries and now in 118 so that most of the countries of the Third World are now involved in the activities of the ICSU family. But it is in the developoment of the Scientific and Special Committees, which have the responsibility for international interdisciplinary programmes, that the greatest change has taken place. In 1957 there was only one Special Committee (for the IGY) and now there are 11 Scientific or Special Committees for interdisciplinary studies in Antarctic, Oceanic, Space and Water Research, Science and Technology in Developing Countries, Teaching of Science, Data for Science and Technology, Genetic Experimentation, Biotechnology, the Geosphere-Biosphere Programme, etc. All of these have programmes of particular relevance to scientists and to the population of countries in the Third World in general.

Another area in which there has been an interesting series of stop-go Another area in which there has been an interesting series of stop-go developments is in relation with the media and the question of visibility. Although relations with the media was not one of the first concerns of the Special Committee for the International Geophysical Year, the launching of the first Sputnik in 1957 brought the IGY, and to a lesser extent ICSU, to the public eye. ICSU did not profit greatly from being in the limelight as can be seen by the fact that already in 1960 ICSU set up a Committee on Public Understanding of the Objectives of ICSU which was asked to review ways and means by which the objectives of ICSU should become fully known to the working scientists of the world, and to this end, to examine the possibilities of closer liaison: a) with the more important world scientific news periodicals and b) with the leading national newspapers in countries adhering to ICSU, and with the principal world news agencies.

Several such reviews have taken place since then, but a certain reluctance to be involved with the media has until recently remained a feature of the scientists who have been members of the ICSU Executive Board. The Ringberg Conference in October 1985 once again drew attention to the need for ICSU to increase its visibility and to communicate better with scientists, with decision-makers and the general public as a whole. An Ad hoc Group on ICSU, the Scientific Community and the Media, held a meeting in January 1987 that brought together representatives of ICSU and a number of science communicators.

Looking back over thirty years of working with ICSU, one of the most striking things is the strongly developed desire for cooperation between scientists of different countries and disciplines. In spite of the various cold and warm wars that have occurred and continue to occur, the universality of science and global cooperation among scientists form a comparatively peaceful island of hope in the world of today. One region of the world where science is a dominant force, Antarctica, remains an unchallenged example of what is possible. Let us hope that when the Antarctic Treaty comes up for renewal in 1999 sense will prevail and Antarctica will continue to be a peaceful demonstration of friendship among scientists of the world.

First Meeting of The Association for the Advancement of Physics in the Caribbean Basin

F. Brouers[1]

The first meeting of the Association for the Advancement of Physics (APCB) in the Caribbean Basin was held, from 30 March to 10 April 1987, in Mona Campus, a pleasant site well equipped for teaching activities belonging to the University of the West Indies (UWI) in Jamaica. This university has the unusual distinction of being an international, rather than a national institution, with presently more than 11,000 students from 14 English-speaking Caribbean territories. The meeting had an international character; speakers were from the USA, Europe, South America and the Caribbean Basin. The high level of the lecturers was combined with a simple but effective approach. The lectures offered a broad selection of science research topics, which are being developed in the most advanced countries, as well as the Caribbean region, with emphasis on the amorphous state, porous materials, ceramics and rocks. The atmosphere was optimistic and markedly influenced by a recent break-through (high temperature superconductivity) in solid state physics. The audience mostly from the academic world of the Caribbean Basin, Central and South America, played an active role in the seminars and discussions. All the graduate students in materials science and energy from the three campuses (Barbados, Jamaica and Trinidad) attended the meeting. There was significant participation from the academic staff in physics, chemistry and geology from UWI, the College of Art, Science and Technology (CAST), the Scientific Research Council, public and private sector institutions, and from professional bodies and associations in Jamaica. Among the highlights of the meeting was the demonstrated interest of the academic and political authorities in the perspectives offered by international cooperation in the field of science and technology.

It was fortunate that the workshop came so closely on the heels of the Jamaica Society of Scientists and Technologists award dinner, where Prof. Abdus Salam gave the key address in which he suggested that the scientists should be allowed to play a more important role in the effort of nation building, technological development and policy decision making in the Third World. The addresses of Prof. Seraphin and the Hon. Don Mills, an eminent Jamaican personality, at the Conference Banquet, chaired by Dr. Taylor, Executive Director of the Scientific Research Council of Jamaica, were in the same genre. Both speakers developed the theme of "self reliance and the need to stimulate local scientific development to solve local problems". They suggested that these scientists working in the Third World and to some extent in partial isolation from the wider scientific community could possibly establish and maintain contact through the ICTP, TWAS and other similar organizations.

Along these lines, considering that Jamaica has a richness of clay, limestone and alumina, and that the University of the West Indies has good facilities in materials sciences and thin films, a broad activity in ceramics cermets, thin films, and physics of rocks should be considered as a priority. The setup and upgrading of the related facilities should also be included. This research has started with a grant from TWAS to Prof. F. Brouers.

As for energy, a realistic starting point could be the characterization of materials and components, with a view to the design of suitable systems for *in situ* applications.

As far as the Association for the Advancement of Physics in the Caribbean Basin is concerned, the following committee has been elected during the general meeting on 10 April, 1987:

Chairperson: Prof. E. Morillo de Escobar, El Salvador;
Executive Secretary and contact person with CLAF: Prof. F. Brouers, Jamaica;
Treasurer: Prof. Gonzalez, Colombia;
Deputy Secretary and contact person with ICTP: Prof. Lopez Pineda, Honduras and Italy;
Members:
Prof. Saunders, Trinidad and Tobago;
Prof. Mosely, Barbados;
Prof. Nieves, Puerto Rico;
Prof. Trallero, Cuba;
Prof. Negrete, Venezuela.

The organization has been founded by the ICTP Associates of the region. It is open to all scientists of the Caribbean Basin, essentially the islands and Central America. The participation of physicists from Colombia, Mexico and Venezuela who work in fields overlapping the regional interests is also welcomed.

The lecturers and participants of the West Indies have expressed the wish to find a way to be integrated into the UNESCO-CLAF network.

World Lab Supports the Establishment of CCAST

At the Annual General Assembly of the World Laboratory, held in Geneva on 27 July, 1987, the President, Prof. A. Zichichi, announced the approval of the Scientific Committee to support the

[1] *Prof. F. Brouers is a Senior Associate Member of the ICTP. He is currently at the Department of Physics, University of the West Indies, Kingston 7, Jamaica.*

establishment of the China Centre for Advanced Science and Technology (CCAST). The World Lab will provide funds for purchasing necessary equipment and for running the programmes of the Centre. The Chinese government will provide the building and support the personnel.

In describing the structure and programmes of the new centre, Prof. T.D. Lee, the Director of the Centre, informed the assembly that CCAST will consist of four divisions: Theoretical Physics, Condensed Matter Physics, High Energy and Sychrotron Radiation, and Astronomy and Astrophysics. Thirty five eminent Chinese scientists have been selected as members of the Theoretical Physics division and an equal number of experimental physicists have been selected for the Condensed Matter and High Energy and Synchrotron Radiation divisions. Prof. Lee indicated that the main objective of the Centre is to carry out world class research work in these fields and estimated that about 200 research papers will be published in international journals by members of CCAST every year. The World Lab is financed by the Government of Italy.

Constrained Systems

by Victor Tapia
International School for Advanced Studies, Trieste

Constrained systems play a fundamental role in contemporary physics. In fact, all physically sensible theories must be constrained systems. This is due to the general covariance, or reparametrisation invariance, requirement for them. We are not going to show why this is so [cf. 1.]; instead, we concentrate our efforts to exhibit what the general structure of a constrained system is. The formalism to deal with constrained systems was first developed by Dirac [2., 3., and 4., cf. also 1., 5., and 6.].

In order to show how constrained systems appear, we restrict the arguments to classical mechanics where a dynamical system is described by a Lagrangian $L=L(q^i,\dot{q}^i)$, where q^i, with $i=1, ..., N$, are generalised coordinates. The generalisation to field theory presents only minor technical problems. In order to integrate the Euler-Lagrange equations, it is necessary to have $W=\det W_{ij}$ different from zero, where $W_{ij}=\dot{\partial}_i\dot{\partial}_j L$ is the Hessian matrix; $\dot{\partial}_i=\partial/\partial\dot{q}^i$. In this case the Lagrangian is called regular. The number of initial data which can be given independently is $I=2N$. The number of degrees of freedom is $f=I/2$. For a regular Lagrangian $f=N$.

If $W=0$, then the solution of the Euler-Lagrange equations contains arbitrary functions. This corresponds to a constrained or singular system. Before going to deal extensively with constrained systems, it is useful to remember some fundamentals of the Hamiltonian formalism where they find a proper mathematical setting.

The canonical Hamiltonian H_c depends only on the variables (q,p) where p_i is the canonical momentum conjugated to q^i; this is a general property of the Legendre transformation defining the Hamiltonian independent of the regularity of the Lagrangian. The fundamental variables of the Hamiltonian formalism are the canonical variables (q,p) spanning the 2N-dimensional phase space Ω. So one must solve for the velocities in term of (q,p). The necessary condition for doing that is to have $W\neq0$.

The time evolution of any dynamical quantity $F=F(q,p)$ is given by the canonical Hamiltonian together with the Poisson bracket. When F is put equal to the canonical variables, one obtains the Hamilton equations. The necessary condition in order to have the equivalence between the Hamilton and the Euler-Lagrange equations is $W\neq0$.

For a constrained system $W=0$. Then rank $W_{ij}=M<N$ and the Hessian matrix has $K=N-M$ null eigenvectors. Contracting the Euler-Lagrange equations with these null eigenvectors, one obtains K relations $\phi_a(q,\dot{q})=0$ where $a=1,...,K$. Some of these relations, K_1, let us say, are identities. They are independent of the validity of the equations of motion and correspond to the reparametrisation invariance of the action. The rest, $K_2=K-K_1$, are relations between the coordinates and the velocities. These are the constraints. Not all the 2N initial data can be given independently, they must satisfy the constraints, therefore the number of degrees of freedom is lesser than N. For an extensive treatment of constraints at the Lagrangian level [cf. 5].

At the Hamiltonian level the previous relations translate to $\phi_a(q,p)=0$ and restrict the dynamics to unfold on a (2N–K)-dimensional submanifold, Σ, of Ω. Constraints appearing in this way are called primary to emphasize that the equations of motion have not been used to obtain them, only the form of the Lagrangian.

The Hamilton equations are not equivalent to the Euler-Lagrange ones. This is due to the fact that the constraints do not appear either in H_c or in the Poisson bracket. Thus, in order to obtain the correct equations of motion, one must take account of the constraints modifying either H_c or the Poisson bracket (or both).

By definition, constraints are zero on Σ, but not on its neighbourhood; one expresses this fact by writing $\phi_a\approx0$, where '$\approx$' is the weak equality sign different from the usual strong one '=' valid on Σ. Now, all dynamical quantities must be defined in the neighbourhood of Σ, i.e., weakly. It can be shown that two weakly equal quantities differ at most by a linear combination of the constraints. E.g., for the canonical Hamiltonian one obtains the extended one $H_{ext}=H_c+U^a\phi_a$ where the U's are, at the moment arbitrary, Lagrange multipliers. Since, in general, constraints have non-null Poisson brackets with the canonical variables, the weak equalities become strong ones only after all the Poisson brackets have been evaluated, i.e., when the equations of motion have been explicitly written.

Constraints are classified in first-class, γ_μ, $\mu=1,...,R=K-J$, and second-class, χ_α, $\alpha=1,...,J$. First-class constraints correspond to the gauge invariance of the system and they individually weakly commute with all other constraints. Second-class constraints correspond to redundancies in the definition of the canonical variables; they satisfy $\det\{\chi_\alpha,\chi_\beta\}\neq0$.

The extended Hamiltonian is now written as $H_{ext}=H_c+u^\alpha\chi_\alpha+v^\mu\gamma_\mu$. The time-evolution of a dynamical quantity F is now given by the extended Hamiltonian plus the Poisson bracket. According to Dirac, at this point one must impose as consistence condition, in order to guarantee that under the time-evolution induced by H_{ext} the dynamics does not go out of Σ, that the constraints be preserved in time. Then one is able to determine the J Lagrange multipliers u^α. The other R, v^μ, remains undetermined and completely arbitrary.

Some of the consistence conditions can give rise to extra relations on the canonical variables. According to Dirac, these must be treated on the same footing as the primary constraints; they are called secondary constraints. The situation is now as before imposing the consistence conditions. There is the canonical Hamiltonian and a set of primary and secondary constraints. The previous procedure must be applied until all the consistence conditions are satisfied. One finally ends with R' first-class and J' second-class constraints. The time evolution of a dynamical quantity F is given by an extended Hamiltonian containing all, primary and secondary, constraints together with the Poisson bracket.

The Hamilton equations contain R' arbitrary Lagrange multipliers, even when the physical situation they describe is the same. One already knows of a similar situation in theoretical physics, namely gauge theories. Any ambiguity in the value of the dynamical quantities must be a physically irrelevant one. This ambiguity is due only to the first-class constraints in the extended Hamiltonian. It can be shown that the first-class constraints are the generating functions of transformations which do not change the physical state of the system i.e., of gauge transformations. Usually gauge theories are dealt with using the Fadeev-Popov ghost formalism. It can be shown [7,8] that both formalisms are equivalent.

When only first-class constraints are present, the Poisson bracket of two constraints is a linear combination of the constraints $\{\gamma_\mu,\gamma_\nu\}=C_{\mu\nu}^{\lambda}\gamma_\lambda$. If the C's are constant, as happens in Yang-Mills theories, they correspond, since the γ's are the gauge symmetry generators, to the structure constants of the gauge symmetry group. If the C's depend on the canonical variables, one can define a symmetry group. If the C's depend on the canonical variables, one can define a series of higher-order structure functions. The relevance of them to the physical world is at the quantum-mechanical level of the theory through the Becchi-Rouet-Stora-Tyutin (BRST) operator [9,10]. A detailed account of this can be found in [11,12]. The Dirac conjecture establishes that all, primary and secondary, first-class constraints are generators of gauge transformations.

The main motivation of Dirac was, in his own words, *"to Hamiltonise a singular Lagrangian"*. This can be done when only second-class constraints are present. The dynamical evolution of the system is given in terms of the canonical Hamiltonian together with the Dirac bracket. The main property of the Dirac bracket is to be identically zero when one of the entries is a second-class constraint. This allows to put the second-class constraints strongly equal to zero; they are used just to construct the Dirac bracket after which they can be disposed of. The evolution equations define a dynamics restricted to a (2N-J)-dimensional Σ and, since second-class constraints are now strongly zero, one can consider as independent canonical variables a subset of (2N-J) of the original ones. Then, by the Darboux theorem, one can find new variables Q^α, P_α, on Σ such that $\{Q,P\}^*=\delta$; $\{,\}^*$ is the Dirac bracket.

If first-class constraints are also present, then they must be transformed in second-class. This was done by Dirac in his work on gravitation [3] by introducing another kind of constraints, namely, the gauge constraints, ψ_μ, not implied by the form of the Lagrangian. In order to have all the constraints of second-class, it must be $\det\{\gamma_\mu,\psi_\nu\}\neq 0$.

This is nothing more than fixing the gauge. Now quantization can be done as for a standard system, but this, as the BRST theory, merits separate consideration.

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Development: Third World Must Develop Own Technology, Scientist Says

By courtesy of SUNS, Special United Nations Service, No. 1668, 7 March 1987

Third World countries must undergo a major cultural transformation to cope with their need for rapid development in the field of science and technology, a leading Brazilian physicist said.

"A country where carnival, soccer and indiscipline are the most important parts of culture, has lesser possibilities of cultural interface with modern science and technology", the scientist Sergio Mascarenhas said at a meeting with experts from the United Nations. The meeting was organised by the U.N. Center for science and technology for development (CSTD).

Mascarenhas, a former professor at the Universities of Harvard, Princeton and London, and at the Massachusetts Institute of Technology (MIT), is currently the director of bio-medical physics at the U.N. Center for Physics in Trieste, as well as a professor at the University of São Paulo, Brazil.

Brazilian scientists are discovering their own capabilities in the fields of computers, energy and biotechnology among others as the result of financial restraints imposed on their country by the foreign debt, Mascarenhas explained.

"Our job is to make the most out of the crisis, to improve our situation. And I wish Brazil had selected ad-hoc crises, because they show how people are able to face the challenge", he said.

Brazil is the Third World's most

Brazil is the Third World's most indebted country, with external obligations of 108 billion dollars, and last month its government imposed a unilateral moratorium on interest payments.

To cope with the need for a new social approach to science and technology, Mascarenhas proposed the reform of the whole educational system of Third World nations and the creation of regional scientific centres for the young through South-South cooperation.

Simultaneously, he added, Third World countries should establish transnational corporations with governmental support to boost technological research and take advantage of huge Third World markets such as Brazil. According to Mascarenhas, the Brazilian market for pharmaceutical products currently reaches six billion dollars a year, the electronics and informatics market, four billion dollars, and the high-tech medical equipment market earns one billion.

He also proposed the establishment of regional science and technology organisations within the framework of the U.N. system, to monitor the degree of scientific development in each country according to previously set standards.

Mascarenhas asserted that Third World countries have no choice but to rapidly achieve the level of knowledge and know-how industrialised countries have. And that requires a strong political commitment from governments.

He sharply criticised the existing academic structures in developing countries — mainly national academies of sciences — which in most cases are composed, he said, of *"old people who got those positions by designation and are doing nothing."*

"I only believe in individuals determined to make the difference through their own work," he added.

Mascarenhas himself is leading a team of experts and students in his home country to develop endogenous solutions to practical problems — like understanding the motion of water in soils to create and improve irrigation systems in the mostly semi-desert areas of northeastern Brazil. Mascarenhas' team applied computerised topography scanning techniques derived from medical science to observe the motion of water in soils. They then modified a micro-computer and designed special software to carry out the job, saving 450,000 dollars in the process. The irrigation project for northeastern Brazil includes computerised meteorological stations.
project for northeastern Brazil includes computerised meteorological stations, and will be able to irrigate two million hectares of land in the next two years.

The scientist warned, however, that despite remarkable achievements by Brazil, India, Argentina and other countries, industrialised nations are doing far better because of their larger financial resources and because of the close relationships between industry, government, universities and research institutions.

According to Mascarenhas, there is no such thing as "technology transfer" between North and South, but rather a large sale of *"black boxes full of buttons that only increase dependence"* on the North.

What Third World countries need, he added, is a process of cultural adaptation similar to that experienced by Japan in the 19th century, and beginning with changing the attitudes of children and the scientists themselves. *"We'll get nothing in meetings with developed countries' universities, governments or industries. We'll get what we are looking for through live exchange between individuals and scientists who belong to the same club"*, he said.

After all, he concluded, the Third World cannot rely on the past because it is gone, and it must not be afraid of the future because *"the only thing we have is the future."*

A New International Centre

The International Centre for Applied Sciences (ICAS) was inaugurated in Gradisca d'Isonzo on 28 September 1987. The main objective of the Centre is to promote international scientific and technological co-operation, particularly with developing countries, in the fields of energy resources, mineral and metallurgical processing, plant design and optimization of industrial processes. The ceremony took place at Palazzo Torriani, a beautiful 17th-century building of the Gradisca Municipality, made available to ICAS for this occasion as well as a temporary seat for its activities.

After the addresses of the President of ICAS and of the dignitaries from the Town, the Province and the Region, Professor Abdus Salam, Director of the International Centre for Theoretical Physics and President of the Third World Academy of Sciences, expressed his wishes for a successful enterprise and gave a lecture on the present status of the theory of elementary particles.

The President of ICAS is Professor Hassan Dalafi, rector of the University for Science and Technology of Teheran (Iran) until mid 1980. He joined the ICTP and the International School for Advanced Studies (ISAS-SISSA) in September 1980 as a research physicist first and took up the duties of scientific liaison as well as other responsibilities in 1983. The Membership of ICAS include distinguished personalities from the academic world and industrialists.

The first 8-day workshop of ICAS started on 1 October and was devoted to the improvement of joint interpretation of geophysical and geological data. For the time being, ICAS will cater mainly for European scientists but as soon as its resource basis improves, it will extend its invitations to scientists from the Third World. ICAS has another seven workshops on board until the end of 1987.

Distinguished Guest at ICTP: Sir Rudolf Peierls

Professor Ernest Rudolf Peierls was the honoured guest of the ICTP from 6 to 28 August. He stayed at the Adriatico Guest House and from there he could witness the Summer programme in Condensed Matter Physics. Though he has reached the age of 80, Sir Rudolf

took an extremely active interest in the ways of operation and, in particular, in the guidance of the younger generation of physicists by their senior colleagues. After his return home, he wrote his suggestions to the Director of the ICTP, Professor Abdus Salam.

Sir Rudolf has had many assignments; first in Manchester and Cambridge, before World War II, then the Manhattan Project and, after the war, Birmingham, Oxford and Washington University until retirement. He was knighted in 1986 by Queen Elizabeth. His publications, in addition to his scientific papers, include: *Quantum Theory of Solids; The Laws of Nature; Surprises in Theoretical Physics* and *Bird of Passage* (an autobiography).

Directory of Physicists from Developing Countries

Last year, the ICTP issued a preliminary version of a Directory of Physicists from Developing Countries with about 1,000 entries. A second version with 2,700 names will be published in December 1987.

The Centre is aware that the Directory as it is now is far from being complete and, therefore, requests the collaboration of all ICTP former Associates, Visiting Scientists, Course Lecturers and Participants. Anyone who did not have the opportunity to fill out the questionnaire for the Directory are invited to write to:

Directory of Physicists from Developing Countries
ICTP
Strada Costiera, 11
P.O. Box 586
34136 TRIESTE
ITALY

Their names will be included in the 1988 version. We remind that the criteria for inclusion are:

- qualification of Doctor in Physics (or its equivalent);
- in cases where the last academic qualification is a Master of Science degree (or its equivalent), the authorship of a minimum of three publications in international journals or, alternatively, three patents.

We thank those who have checked the entries of their own countries and have sent us additional information.

Future Activities at ICTP

1987	
Fourth College on Microprocessors: Technology and Applications in Physics	*5 - 30 October*
College on Soil Physics	*2 - 20 November*
College on Riemann Surfaces	*9 November - 18 December*
Second Workshop on Cloud Physics and Climate	*23 November - 18 December*
1988	
College on Variational Analysis	*11 January - 5 February*
Spin and Polarization Dynamics in Nuclear and Particle Physics	*12 - 15 January*
Second School on Advanced Techniques of Computing in Physics	*18 January - 12 February*
Workshop on Functional-analytic Methods in Complex Analysis and Applications to Partial Differential Equations	*8 - 19 February*
Workshop on Applied Nuclear Theory and Nuclear Technology Applications	*15 February - 18 March*
Winter College on Laser Physics: Semiconductor Lasers and Integrated Optics	*22 February - 11 March*
Workshop on Optical Fibre Communication	*14 - 25 March*
Impact of Digital Microelectronics and Microprocessors on Particle Physics	*28 - 30 March*
Experimental Workshop on High-Temperature Superconductors	*11 - 22 April*
Spring School and Workshop on Superstrings	*11 - 22 April*
School on Non-accelerator Physics	*25 April - 5 May*
Spring College in Condensed Matter Physics: The Interaction of Atoms and Molecules with Solid Surfaces	*25 April - 17 June*
Spring College in Condensed Matter Physics: The Interaction of Atoms and Molecules with Solid Surfaces	*25 April - 17 June*
Workshop on Boundary Layer and Wind Modelling	*16 - 20 May*
Course on Physical Climatology and Meteorology for Environmental Applications	*23 May - 17 June*
Mini-Workshop on "Mechanisms of High-temperature Superconductivity"	*20 June - 29 July*
Summer School in High-Energy Physics and Cosmology	*27 June - 5 August*
Research Workshop in Condensed Matter, Atomic and Molecular Physics	*20 June - 30 September*
Unoccupied Electronic States	*21 - 24 June*
Computer Simulation Techniques for the Study of Microscopic Phenomena	*19 - 22 July*
Towards the Theoretical Understanding of High T_c Superconductors	*26 - 29 July*
Fifth Trieste Semiconductor Symposium (IUPAP) on Superlattices	*8 12 August*
Summer School and Workshop on Dynamical Systems	*16 August - 23 September*
The Application of Lasers in Surface Science	*23 - 26 August*
Working Party on "Electron Transport in Small Systems"	*29 august - 16 September*
Frontier Sources for Frontier Spectroscopy	*30 August - 2 September*
Summer workshop on Dynamical Systems	*5 - 23 September*
Fourth Summer College in Biophysics	*12 September - 7 October*
Course on Ocean Waves and Tides	*26 September - 28 October*
African Regional College on Microprocessors (Yamoussoukro, Ivory Coast)	***September - October***

contd.

College on Medical Physics	*10 October - 4 November*
Workshop in Mathematical Ecology	*31 October - 18 November*
College on Neurophysics	*7 November - 2 December*
Workshop on Global Geophysical Informatics with Applications to Research in Earthquake Predictions and Reduction of Seismic Risk	*15 November - 16 December*
College on Global Geometric and Topological Methods in Analysis	*21 November - 16 December*

1989	
Winter:	College on Atomic and Molecular Physics
	Workshop on Mathematics in Industry
	College on Aeronomy and Geomagnetism
	Workshop in Mathematics
Spring:	Workshop on Superstrings
	Workshop on Nondestructive Testing
	College on Material Science
	Workshop in Mathematics
	College on Plasma Physics
Summer:	Summer Workshop in High Energy Physics and Cosmology
	Summer Workshop in Condensed Matter, Atomic and Molecular Physics, including Adriatico Conferences and Working Party
Autumn:	Workshop on Nonconventional Energy Sources
	College on Microprocessors
	College on Soil Physics
	College in Mathematics
	College on Cloud Physics

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, Chief Administrative and Scientific Information Officer.