International Atomic Energy Agency

United Nations Educational, Scientific and Cultural Organization

International Centre for Theoretical Physics

News from ICTP

No. 78 July-September 1994

Impact of ICTP on the Promotion of Scientists and Science & Technology in Nepal

Lok Narayan Jha

During my visit as an Associate Member which started on 29 July 1994, I found a few Nepalese visitors in different ICTP activities. In about a month of my stay, some of them returned home and some new ones arrived at ICTP. This observation forced me to recall the names and hence the number of Nepalese visitors of the past years. Though the figure was not very high, I could count, from my memory, a few hundred person-months for visitors from Nepal. Hence, a motivation to write this article developed during my stay in Trieste to express my feelings. I wanted to thank and acknowledge the ICTP family for its support to individual scientists from Nepal, and also to request ICTP authorities to take extra care, to the best of their capacity, to develop Science & Technology in Nepal since its condition Technology in Nepal since its condition still remains at the bottom end of development, and most importantly to ask the Nepalese visitors to assess how their country in general and themselves in particular have benefited from their visits to ICTP. The purpose of this article is to highlight the role of the ICTP in the development of individual scientists and hence its impact on the Government for the development of Science & Technology in the small Himalayan country, Nepal.

Nepalese participation in scientific activities at the ICTP began in the very first year of its inception. It is well known that ICTP was founded under the extraordinary leadership of Professor Abdus Salam who had a vision of creating a home for scientists from the developing world. The atmosphere of this home, as conceived, has been healthy. It is where cultural and scientific exchanges among scientists of both worlds are maintained through many meetings covering various fields of science. The library and computing facilities of very high quality make a great contribution towards the achievement of the ICTP's aims and objectives.

Thousands of guest scientists including Nobel Laureates visit the ICTP every year. About a thousand scientists from the developing countries are associated with the ICTP through different schemes such as Associateship, Federation Agreements, and Training and Research at Italian Laboratories. Many external activities are also sponsored by the ICTP. In the process, hundreds of Nepalese scientists have participated over three decades in almost all areas of three decades in almost all areas of theoretical, experimental, computer and electronics based programmes in physics as well as in mathematical, biological, agricultural and environmental programmes. Every participation has given the visitors impetus and motivation for national development through Science & Technology. It has also given further opportunities to a few to be trained in Italian laboratories. Under this particular Programme, one Nepalese is presently working for his Ph.D. degree. The contacts made during attendance has also led to at least one South-South fellowship for completing a Ph.D. degree in physics.

The interactions and consultations made at ICTP have further expanded in different forms at regional level such as Nepalese scientists' participation in the scientific activities in Nathiagali scientific activities in Nathiagali (Pakistan), the meetings of the Bangladesh Physical Society, different schools/workshops in India and China, etc. As a result of interaction in the activities on laser experiments at ICTP, one of the participants had further opportunity of training in laser-plasma interaction in Malaysia. Similarly, some guest scientists from India and Bangladesh were invited to participate in the Second National Conference of the Royal Nepal Academy of Science and Technology (RONAST) in June 1994. In short, Nepalese scientists have availed a chain of opportunities for which the credit goes to the ICTP since all but the RONAST Conference were partially sponsored by the ICTP.

Nepalese scientists have also derived benefits from other schemes and

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programmes like Diploma, Training at Italian Laboratories, BCSPIN Schools, Associate Scheme, etc.

The first Nepalese appointed as Regular Associate was Professor R.M. Shrestha in Mathematics. He has achieved recognition of high level in Nepal including being appointed as the Rector of Tribhuvan University. Professor G. Shrestha has the honour of being the first lady to be appointed as Associate, again in Mathematics. She achieved the prestigious recognition of being nominated as Academician of RONAST. Professor H.N. Bhattarai, another Associate in Mathematics, has recently been appointed as a Member Secretary of the newly constituted University Grants Commission, in addition to being nominated as a Member of the Academic Council of the Tribhuvan University.

The author of this article was appointed the first ICTP Associate from Nepal in Physics. His first tenure was during 1986-91 and the second one is for the period 1994-96 i.e., he has constantly been in association with the ICTP during the last ten years. In Nepal, he was appointed as the Head of the Central Department of Physics, nominated as a Member of Tribhuvan University Council; elected Secretary and later President of the Nepal Physical Society. He has contributed to RONAST through several committees and was awarded the HRH Crown Prince Deependra Science & Technology Youth Award in 1988. He had an opportunity to be an invited lecturer at the International Workshop on Laser Plasma Interaction at CAT, India, in 1989, and to go on several scientific trips to Asian and European countries during the past ten years of
scientific trips to Asian and European countries during the past ten years of
association with ICTP.

Another three Associates from Nepal are scientists contributing to the nation in several ways through their involvement in soil physics, geophysics and communication in addition to their regular jobs. About half a dozen of Nepalese ICTP Junior Associates in different fields of physics and mathematics have availed a support of about US$350 per year from the ICTP for reading materials including research journals (though not regular).

The Royal Nepal Academy of Science and Technology, RONAST, was instituted ten years ago. It is expanding in several senses. It has established collaboration and federation schemes with several academies including the Third World Academy of Sciences (TWAS, Trieste, Italy) and other research organizations. It has also sent quite a few of its scientists to participate to ICTP activities. Its objective has not only been to guide the Government for the national Science & Technology policy, but also to foster other activities such as organizing scientific meetings at national, regional and international level, providing research fellowships and grants for scientific research, science popularization and publication, central laboratories and library facilities as well as developing a few other laboratories. In a short time, in the context of Nepal, it has proved its concern for national Science & Technology development. Awards for scientists at different levels, including that of TWAS for young scientists, are also a regular activity to encourage them to pursue their work. It is expected, within the new constitution of the Academy through a number of reputed scientist Academicians, that the promotion of Science & Technology would be faster and more responsive.

Similarly, the Tribhuvan University is one of the leading, or one can say the only institution for higher level teaching and research in Science & Technology in Nepal. More than 90% of the ICTP visitors from Nepal are working in this University. The respective departments and students of the country get benefits indirectly. The materials collected during the visits to the ICTP are used for teaching at all levels. The skills, both experimental and theoretical, developed during the stay at Trieste have been very useful to the institution. The present leadership of the University is much concerned to improve the quality of teaching and learning. A
University is much concerned to improve the quality of teaching and learning. A
three-year graduation scheme and entrance tests at all intakes of students have been enforced. The University grants duty leave to its faculty members, if invited by other institutions, for academic development in addition to the regular career development programme. In spite of willingness to improve the situation, things do not move fast enough because of several reasons. One of the aims of the present article is to request the Nepalese authorities to put extra effort towards creating a healthy environment for teaching and research in science.

The vision of Professor Salam and his associates to foster Science & Technology in the developing world, with the moral support of visiting scientists at ICTP from BCSPIN countries, gave birth to the ICTP-BCSPIN Kathmandu School in Nepal. Scientists from Bangladesh, China, Sri Lanka, Pakistan, India and Nepal participate in this regional scientific activity. Four such schools, out of which one was held in India, have already been organized. Exchange of knowledge between regional scientists and distinguished scientists from developed nations may be considered as very beneficial to Nepal. The commitment for local financial support has been generously met jointly by Tribhuvan University and RONAST. The interaction between young Nepalese scientists and lecturers during the schools has led to further training including Ph.D. enrolment in various countries. Similarly, seven young Nepalese scientists have benefited from the ICTP Diploma Course. Four of them participated in BCSPIN schools to a certain extent. Overall performance in the Diploma Course has been satisfactory since some of them got further opportunity for Ph.D. studies in well-known, reputable universities.

The Nepal Physical Society (NPS) feels honoured to have Professor Abdus Salam as its Honorary Life Member. Most of the ICTP visitors from Nepal are members of the Society. So all the benefits discussed earlier contribute to the professional development of its members and hence to the NPS. All necessary information about ICTP reaches the NPS and is further disseminated to its members. The NPS extends all possible help for the success of ICTP-BCSPIN Kathmandu School. The NPS needs reading and research materials including journals for its overall development.
research materials including journals for its overall development.

The role of the ICTP for the scientific promotion of individual scientists of Nepal has been so far discussed in brief. In the national context, the Government and Science & Technology-related institutions are now convinced that Science & Technology development is very essential for the all-round development of the country. Till the very recent past, there had not been any mention of Science & Technology in the national planning documents. Now this situation has changed to some extent. Mention of and commitment to Science & Technology were made by the Prime Minister during the RONAST Second National Conference on Science & Technology in 1994, where he promised to increase the budget for Science & Technology substantially in the coming years. All concerned authorities now listen attentively to Nepalese scientists and ICTP visitors about matters related to Science & Technology, since the visitors often quote ICTP activities and initiatives for the advancement of the developing world, including Nepal. In other words, a major impact of the ICTP on individuals and planners can be seen these days. However, there is still a long way to go and Nepal remains at the bottom end of Science & Technology development. The ICTP and its Chapters are, therefore, requested to pay special attention to Nepal in every scientific activity for the promotion of Science & Technology.

The author would also like to raise a question to the Nepalese visitors to the ICTP (about 300 person-months) as to how their visits have been useful to them and hence to their country. It is now time for self-evaluation. All of us become motivated and active in Science & Technology during our visits to Trieste but still our scientific research activities and development remains at a very low level, and there has not yet been a significant contribution towards technological development. Let all Nepalese visitors maintain the spirit of the ICTP and assemble in Kathmandu, the capital of Nepal, to assess the situation and select a few areas of national interest in which to concentrate our efforts for the betterment of society and future generations, through Science & Technology. This could also help to create an effective lobby to influence Science & Technology planners.

Lastly, the author would like to thank the ICTP for its support to all Nepalese visitors. Sincere personal thanks also go to every member of the ICTP family, and in particular to Professor Abdus Salam for his personal encouragement to me and to other Nepalese scientists at every meeting. I give my thanks also to all the visiting scientists with whom I had fruitful interaction, as well as to the Swedish Agency for Research Cooperation with Developing Countries, SAREC, for sponsoring my visits as Associate Member to the ICTP. ♦

Dr. Lok Narayan Jha is a Regular Associate Member of the ICTP. His permanent address is Central Department of Physics, Tribhuvan University Campus, Kirtipur, Kathmandu, Nepal.

1994 Dirac Medal of the ICTP

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On the occasion of the birthday of P.A.M. Dirac, the Dirac Prize Committee takes pleasure in announcing that the 1994 ICTP Dirac Medal and Prize will be awarded to Professor Frank Wilczek (Institute for Advanced Study, Princeton, USA).

Prof. Wilczek is recognized for his contributions to the development of theoretical physics. In 1973 he was one of the discoverers of the phenomenon of "asymptotic freedom" in non-Abelian gauge theories. This fundamental observation — that the effective interaction at short distances becomes weak, even in strongly interacting systems — led to the development of a realistic model for hadron physics. In particular, it provided an explanation of scaling and its logarithmic corrections in hadron physics at high energies. Asymptotic freedom has become a cornerstone of the Standard Model of elementary particles and in the theoretical extensions of this model that aim to unify the fundamental forces.

Prof. Wilczek has also made important contributions to the study of particle-like excitations in 2-dimensional systems that obey "fractional statistics". These particles, for which he coined the name "anyons", are now recognized to have a role in phenomena such as the fractional quantum Hall effect. ♦

Summer Leisure for ICTP Scientists

Besides the intense scientific life our guests are bound to spend while at ICTP, opportunities are provided for them to have some leisure and learn about local life and cultural traditions. Summer is the ideal season for taking trips during the day and be outside in the evening, attending a concert or a show. This is why numerous opportunities are offered to our scientists in the Summer, quite often free-of-charge thanks to the generosity of local authorities who mean to welcome in this way such distinguished guests to Trieste.

"Concert on Friday" was a series of musical events which took place at the Adriatico Guest House from mid May to mid August, the busiest period of the year at ICTP. The programme was especially devised for presenting our foreign guests the musical genres which are typical of this part of Europe — arias from operas, light opera, chamber music, chorus — and to review such music from 1500 to our century.

The initiative and enthusiasm of a collaborator of the ICTP, Signor Sergio Bradaschia — a genuine Triestino — gives our scientists the unique opportunity of visiting places in town which the Triestinos only hear of. Only our scientists are so lucky as to visit the coffee-roasting factory "Illycaffè", the port and docks in a tow-boat, and the ferry-boat on service from Trieste to Greece. And, living so near Miramare Castle, it is so easy for them to go and spend an hour watching
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them to go and spend an hour watching the sound and light show, in the English language, on the romantic life of the Archdukes of Hapsburg.

On Summer saturdays, the Tourist Office put at the disposal of ICTP scientists 20 seats on the bus for the guided tour of the "Carso" hills. This unique plateau is well worth seeing because of its beautiful caves and peculiar flora.

Thanks to the enthusiastic response of our scientists, the Tourist Office has launched a new programme whereby initiatives of this kind shall be extended to all the scientific institutions of the town. ♦

The ICTP Office of External Activities (OEA)

G. Denardo

Courtesy of
Trieste International Foundation for Scientific Progress and Freedom.

Introduction

After 20 years of successful activities, mainly carried out at the Trieste premises, the ICTP was prepared to export its scientific cooperation directly to the countries of the Third World.

The ICTP Office of External Activities (OEA) was established in 1985 and became operational in 1986. The purpose of this Office is to assist scientists in the Third World in developing their research and education activities by offering financial assistance and scientific cooperation.

Structure

The Office relies on the general infrastructure of the ICTP and is supervised by the Committee on External Activities whose Members are appointed by the Directors General of the IAEA and UNESCO. The Committee is chaired by the Director of the Division of Technical Assistance & Cooperation of the IAEA and the Secretary is the Head of the OEA. Other ICTP scientists, together with representatives of UNESCO and TWAS, are Members of the Committee. The Committee advises the Director of the ICTP on policy matters and guides the OEA on the implementation of the programmes and in making decisions.
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The Office receives advice from

- the Regional Representatives who are senior scientists in countries distributed in the main regions of the Third World. They are consulted by the Office on matters relevant to their region and are supposed to be the ICTP Ambassadors in the regions. So far, eight Regional Representatives have been appointed.
- a world wide roster of distinguished referees who help evaluate projects and screen the various applications. Their valuable comments and suggestions are often passed on to the activity organizers and are an essential element in the success of the programmes. The Office is very grateful to them for giving their time and attention freely. There are about 400 referees including many ICTP scientists.

Programmes

Support and advice is provided towards activities organized by scientists in Third World countries and carried out within their regions, through the following programmes:

- *Scientific Meetings* (conferences, workshops, courses/colleges) which are short-term activities with regional character. They can be at an advanced level or have training or educational purposes.
- *ICTP Affiliated Centres (ICAC)* are institutes or university departments engaged in long-term projects carried out in cooperation with the OEA. In 1988, it was decided to launch this programme aiming at enhancing the cooperation between the ICTP and some ICTP Federated Institutes. The Directors of these institutes were invited to submit scientific projects planned over a period of 3 to 5 years in view of appointing some of these institutes as ICTP Affiliated Centres. The purpose of the affiliation is to upgrade an institute, to support well-defined projects there, and to promote it as a regional centre. An Affiliated Centre
regional centre. An Affiliated Centre
receives special support for several years and, in addition, particular attention is reserved to the applications submitted by ICAC scientists for support from other OEA/ICTP programmes.
- *Networks* are agreements between several research groups or individuals in a region who carry out a common research activity over an extended period. Support is provided to exchange scientists within the Network and to purchase some equipment/literature for those Members of the Network who are in a more difficult situation.
- *Visiting Scholars/Consultants* provides support to an expert in a specific field from any country for a minimum of two visits of about one month over a period of 3 years. The aim is to stimulate new links between high level scientists and research groups in Third World countries.

For all the supported activities, the OEA requests that local institutions provide at least matching funds and it is essential to show evidence of the local authorities' commitment.

Mechanism

Information about the OEA programmes and relevant application forms are sent periodically to the ICTP mailing list. All requests and proposals are refereed by experts and by the ICTP Regional Representatives and, finally, examined by the Committee on External Activities. The activities which receive favourable consideration are supported according to the availability of funds, and following a criterion of excellence and a balanced geographical distribution. The Office follows the development and checks the accomplishment of each activity. At the end of an activity, or once a year for the long-term projects, organizers and co-ordinators are requested to submit a detailed report in order to monitor the validity of the programmes.

Scientific geography

For each request of financial support which is accepted, the OEA maintains contacts and corresponds with the organizers over a period of at least one year and, in many cases, on a regular permanent basis. Therefore, for every sponsored activity, a special link is established from which the OEA is able to gather important information about the
to gather important information about the
scientific activities in the corresponding country.

In eight years of operation, the OEA has established contacts with several thousand institutes, research groups, individual scientists and, thanks to a considerable cooperation established with some of them, the Office has been able to gain a good knowledge of the "scientific geography" in the Third World. The distribution of the scientific interest according to the countries/regions is important when certain projects are to be initiated. Actually, a project can be undertaken more realistically in those institutes where there is some expertise in the relevant field, and when the subject is consistent with the scientific culture and needs of the region.

Interaction between ICTP local and external activities

A very special feature of the ICTP is that it carries out research and training-for-research programmes at the level of a scientific institution of excellence and that it implements cooperation projects outside its premises at the level of a big international agency. This peculiarity is of outstanding advantage to the OEA. Between 3,000 and 4,000 scientists take part every year in the ICTP scientific activities. About 50% of the ICTP visiting scientists come from the Third World. At the ICTP they find a stimulating environment and are offered the opportunity to interact with colleagues from other countries with similar interests. In several cases, scientists from the same country working in the same field meet for the first time at ICTP. On these occasions, new cooperation projects are conceived and are later transferred to the home countries of the ICTP visiting scientists. At this stage, the OEA intervenes in the activities which are planned to take place in developing countries by offering further cooperation and support. The ICTP is therefore an institute where physicists and mathematicians meet, and is also a system to export international cooperation programmes through the OEA. For example, several Network projects originated from scientists who first met and worked at the ICTP, and then decided to continue their cooperation in their home countries. We have the opportunity to discuss a remarkable part, maybe most, of the activities supported by the OEA,
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of the activities supported by the OEA,
personally with the organizers or with the participants on the occasion of their visits to the ICTP.

I wish to briefly quote as an example the origin and evolution of an activity involving African countries.

In the eighties, two young researchers, Dr. Paul Buah-Bassuah from the University of Cape Coast, Cape Coast (Ghana), and Dr. Ahmadou Wagué from the Université Cheikh Anta Diop, Dakar (Senegal), attended one of the Winter Colleges on Laser and Atomic Physics, which are held at the ICTP every year. Subsequently, Dr. Buah-Bassuah was offered the opportunity, under the ICTP Programme for Training and Research in Italian Laboratories, to work at the Istituto Nazionale di Ottica, INO, in Florence (Italy), where a few years later he obtained his Ph.D. Throughout the years, these two physicists kept close contacts with the ICTP and attended several activities organized by the ICTP. In 1989, the Laser Atomic and Molecular Physics Group was established at the ICTP, and in 1990 the ICTP/ICS Laboratory of Laser and Fibre Optics began its activities. Together with the scientists from Ghana and Senegal present at the ICTP during the 1990 Winter College, we planned to organize a long-term activity on optical physics in their countries. In fact, in May 1991, the First International Workshop on the Physics and Modern Applications of Lasers was held at the Université Cheikh Anta Diop in Dakar with the participation of more than 50 physicists from many African countries. On that occasion, the African Atomic and Molecular Network (LAM) was launched. The purpose of this Network is to stimulate cooperation and interaction among African physicists working on optical physics and technology. The Network now involves scientists from almost all African countries. In 1992, the O.E.A. appointed the Department of Physics of the University of Cape Coast and the Department of Physics of the Université Cheikh Anta Diop as ICTP Affiliated Centres. Scientists from these two Centres cooperate on a permanent basis and exchange visits.

The Second International Workshop on the Physics and Modern Applications of Lasers was held in Harare (Zimbabwe) in September 1993 where an ICTP Affiliated Centre was established. The activities of this Centre concentrate on
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the use of computers in science education, especially including optics. The Third Workshop was organized at the ICAC in Cape Coast in August 1994 with 60 participants from 20 African countries. Remarkably, after the successful activities of the ICAC, the University of Cape Coast approved to start soon Ph.D. courses in physics: the activities within the ICAC will be one of the strongest points of the Ph.D. courses in Cape Coast.

The Fourth International Workshop of the LAM Network will be organized in 1995 at the Affiliated Centre established at the Department of Physics of the University of Khartoum. Besides other activities carried out by this ICAC, a project aiming at setting up a scientific group and a Laboratory on Optics, in contact with the LAM Network, has been undertaken in order to strengthen the M.Sc. courses at the Department of Physics of the University of Khartoum.

The ICTP maintains close contacts with the Affiliated Centres in Africa. Scientists from these Centres are offered the opportunity to attend the Winter Colleges and other training activities organized by the ICTP. On these occasions, scientists from the Affiliated Centres meet to interact and discuss the co-ordination of their activities within the LAM African Network. In addition, every year scientists from these Centres working on optics, spend a training period at the ICTP and at the ICTP/ICS Laboratory of Lasers and Optical Fibres which enables them to establish a permanent cooperation with the ICTP experts on lasers.

The example which I quoted above is not at all unique. A similar story would describe the birth and development of the ICTP Affiliated Centres in Benin, Côte d'Ivoire and Morocco which carry out projects on mathematics and theoretical
d'Ivoire and Morocco which carry out
physics. A permanent link has been established among these Centres which constitute a Network of Institutes in West

Scientists from the ICTP Affiliated Centre established in Africa working in the ICTP/ICS Laboratory of Lasers and Optical Fibres.

Africa (French-speaking Africa). The exchange of scientists between these Centres are frequent and contacts with the ICTP Mathematics section and High Energy Physics group are maintained.

Analogously, also the OEA programmes in Asia and Latin America aim at supporting research and stimulating regional links.

Cooperation with other organizations

The OEA keeps contacts, exchanges information and cooperates with many national and international organizations aiming at supporting scientific research and education in developing countries. The most important case of long-term cooperation is with the Swedish Agency for Research Cooperation with Developing Countries (SAREC). A generous yearly contribution is provided by SAREC to the ICTP External Activities Programme in Africa and to the ICTP Associateship Scheme. The strategy of the programmes to be carried out in sub-Saharian Africa is decided jointly by the ICTP and SAREC thanks to periodical discussions and meetings. Exchange of information and reciprocal aid is also achieved with the International Program in the Physical Sciences, Uppsala.

A strong long-term cooperation programme, namely the "IAEA-ICTP Sandwich Progamme", is being launched by the OEA and the IAEA with the purpose of strengthening the Ph.D. or M.Sc. courses in Africa. The programme, co-ordinated by the OEA, will offer grants to Ph.D. and M.Sc. students in sub-Saharian African universities in order to alternate stays at ICTP and at their home universities for the three years of the courses with the stays at ICTP and at their home universities for the three years of the courses with the condition that they hold the final exams at their own institutes.

The OEA conducts specific projects in collaboration with the United Nations University, Tokyo; the International Centre for Pure and Applied Mathematics, Nice; UNESCO, Paris. Special contacts are kept with the International Union for Pure and Applied Physics to exchange information.

The OEA has established links with other organizations which are extremely important. Several of these contacts were made possible thanks to the prestigious position acquired by the ICTP as a research centre. Many other cooperation agreements established between the OEA and national institutions, universities and academies could be in fact quoted, especially those in neighbouring countries such as Hungary, Slovakia, Slovenia and Germany where scientists from the ICTP are hosted upon recommentation of the OEA. We hope to expand this cooperation to other European countries in order to offer scientists from Third World countries, who are involved in the OEA programmes, the opportunity to benefit also from a South-North scheme.

Achievements

Over eight years, the OEA has supported and provided scientific advice to about 800 scientific meetings in not less than 65 developing countries; a hundred eminent scientists visited institutes of physics or mathematics under the Visiting Scholar/Consultant Programme; twenty Networks were created and fifteen Affiliated Centres established. These data give an idea of the number of scientists and institutes which were or still are in contact with the OEA. There are probably very few departments of physics and mathematics in the Third World which are not aware of the existence of ICTP and OEA.

The Head of the OEA and/or the Regional Repesentatives visit those departments where ICTP Affiliated Centres were established in order to emphasize the interest of the ICTP to strengthen links with the scientific community abroad. During my visits to some of the Affiliated Centres, I had the opportunity to meet university and governmental authorities who in turn are invited to visit the ICTP. Now, the ICTP projects and the Affiliated Centres are better known to the local authorities, and projects and the Affiliated Centres are better known to the local authorities, and scientists who cooperate with the ICTP on a long-term basis have more direct contacts with them. The role of scientists is more appreciated thanks to an enhanced scientific awareness of local authorities. The support provided by the ICTP through the OEA has certainly produced tangible effects in many departments of physics and mathematics although, in some special cases, an induced effect should be mentioned as well. In an unfavourable local situation scientific activities could be carried out mainly thanks to the cooperation with the OEA. The psychological effect on scientists who know that they can count on the ICTP and that they are not forced to interrupt their work or to leave their country in times of political or economical difficulties, is extremely important.

The future

In the nineties the world is different than it was in the years of the birth of the ICTP. Geopolitical changes occurred, some developing countries have made significant progress, improved their scientific environment, and become economically stronger. Some of these countries already exhibit the features of industrial powers. Meanwhile, other countries are lagging behind, still facing huge difficulties. The Third World of the sixties-seventies is no longer that of the nineties because the rate of improvement in various countries and regions is very different. Scientific and industrial differentiation is more evident now than it was in the past. Countries in the Confucian Belt have made progress both in the formation of scientists, as well as in the establishment of industries. However, scientific research in these countries is still fragile. Even in situations where there is a good number of scientists, the problem is how to utilize them effectively and how to keep them to work in those institutions where basic research is carried out. Therefore, the real problem is to offer researchers reasonable conditions to carry out their work in order to avoid a depletion of the universities in favour of the production sector only. Breaking the smooth continuity between basic research and applied sciences would interrupt the development process. The new international cooperation programmes should motivate scientists in these young nations and stimulate the development of their capabilities. In brief, even in nations and stimulate the development of their capabilities. In brief, even in countries with a positive development rate, basic research must be consolidated. In a new vision, the most advanced Third World countries should become active partners of international institutions in developing joint cooperation programmes for mutual benefit. Emphasis of the programmes of the international organizations should be devoted to work with developing countries directly, develop their infrastructures, support the growth of strong focal points for research with regional character and, in the most favourable cases, establish an equal partnership cooperation. After five years of implementation of the ICTP Affiliated Centre scheme, the OEA is now stimulating the most promising ICACs to host students from other countries in the region and to acquire a regional character.

Some other countries suffer from a negative rate of development. Not only industrialization is lagging behind, but also academic research, which may have existed in the seventies or eighties, is getting weaker. Brain drain, more attractive salaries in the private sector, and the need for a second job hinder the progress of academic research. Due to the unsufficient turnover of faculty scientists, in some countries it seems difficult even to keep the level of the universities scientific staff as it was in the past years. In some universities, the average age of the physics and mathematics faculty members is so high that when they retire there can be only a modest replacement with younger professors. The strongest effort should be made in those countries to stimulate young scientists to undertake the academic career. Strengthening the tertiary level of education is then a necessary step. Programmes supporting M.Sc. and Ph.D. courses are outstanding and urgently needed. The OEA is in fact devoting a substantial part of its energies in this direction particularly in sub-Saharian Africa.

We remark on the dragging effect of some countries on the neighbouring countries so that development and underdevelopment have really regional, more than barely national, significance.

Physics and mathematics for technology

The international aid and cooperation programmes seem to give high priority to projects dealing with science and technology of nutrition, agriculture, technology of nutrition, agriculture, environment, medicine, etc. These are imperative problems which must be tackled directly and immediately. Nevertheless, the process of advancement of science and technology in the Third World should not neglect appropriate scientific programmes which may have an impact on the industrialization process. Actually the problems are closely connected and none of them can be solved without considering the others. No longer are raw materials or labour force the source of wealth, but high technology which is the basis of modern industry. The areas of high technology or science-based technology we are here referring to may include: microelectronics, photonics, new materials and space technologies. High technology is subject to a fast development which is closely related to the programme of scientific research. It stems from the interaction of

- scientific research (basic science)
- development (applied science)
- production (utilization of science).

Industries in high technology must prospect original products into the market in order to be competitive. This capability requires however a highly educated force! The involvement of scientists in the advancement of modern industry is necessary. In the developing countries, it is necessary to support high level educational programmes, and to stimulate interaction between the academic world and the production sector.

Conclusions

In the different countries, the diffusion of scientific culture varies considerably and the levels of scientific education are very different. Therefore, the ICTP diversifies its programmes according to the needs and to the requests both in the projects which are carried out at the ICTP in Trieste, and in the implementation of the OEA schemes. The OEA activities, aim not only at supporting basic research and scientific education programmes, but also at stimulating scientific awarness in the developing countries and at enhancing the role of scientists within their own societies. The OEA programmes are mainly implemented by contacting individual scientists and much less through governmental institutions. The direct cooperation with the ICTP, through the OEA, lends a recognition of international value to those scientists who thus could play a more important role within their society. This stimulates the involvement and commitment of local institutions which is the necessary pre-requisite for every long lasting progress in any country.

The ICTP was conceived by Professor Abdus Salam as a centre run by scientists for the scientists and, consistently, the OEA is an ICTP Office run by scientists in close cooperation and directly linked with scientists. ♦

Once for all one should recollect what the Japanese apparently did: "... we at Sony took the basic transistor and redesigned and rebuilt it for a purpose of our own that the originators had not envisioned. We made a completely new kind of transistor, and in our development work, our researcher, Leo Esaki, demonstrated the electron tunneling effect, which led to the development of the tunnel diode for which he was awarded the Nobel Prize seventeen awarded the Nobel Prize seventeen years later, after he had joined IBM. (...) The highly educated work force of Japan continue to prove its value in the field of creative endeavour. In the recovery from the war, the low cost of this educated labour was an advantage for Japan's growing low-technology industry. Now that the industrial demand is for high technology, Japan is fortunate to have a highly educated work force suited to the new challenge". - Akio Morita, author of "Made in Japan". (Quoted from SALAM Abdus, *Notes on Science, Technology and Science Education in the Development of the South*, Third World Academy of Sciences, Trieste, 1989).

Biographical note

Professor Gallieno Denardo was born in Trieste on 23 July 1935. He received his Ph.D. from the University of Trieste in 1971 and was appointed full professor for Relativity at the Department of Theoretical Physics of the University of Trieste in 1982. He has worked on problems related to Physics of Elementary Particles, and in particular, of Weak Interactions. Subsequently, the main field of interest was focused on classical general Relativity, Quantum Field Theories in Curved Space-Times, Phase Transitions in Cosmology. Space-Times, Phase Transitions in Cosmology. In the last years he concentrated on Quantum Optics and the Physics of Lasers. At present, he works on problems of phase transitions in quantum laser systems. He is responsible for the organization of the ICTP activities in Optical Physics, Lasers and Optical Fibres. Since 1989, he is Head of the ICTP Office External Activities, and responsible for the ICTP/ICS Laboratory of Lasers and Optical Fibres. On a regular basis he offers his co-operation towards the scientific programmes of the Third World Academy Sciences (TWAS–UNESCO) and the International Centre for Science and High Technology (ICS of UNIDO).

Dirac Medal of the ICTP 1993
Prof. Peter van Nieuwenhuizen

Professor Peter van Nieuwenhuizen (Department of Physics, SUNY, Stony Brook, NY, USA) was awarded the 1993 Dirac Medal of the International Centre for Theoretical Physics during a ceremony which was held in the Main Lecture Hall of the institution on 26 July 1994.

Prof. van Nieuwenhuizen was honored for the discovery of supergravity theory and research in its subsequent development. Prior to the discovery of supergravity, he made important contributions to the understanding of the quantum behaviour of ordinary gravity as well as matter coupled to gravity, through a systematic study of their divergence structure. The search for a gravity theory with better quantum behaviour, by inclusion of fermionic fields, eventually led to a highly non-trivial fusion of supersymmetry with gravity, culminating in the seminal paper with Sergio Ferrara and Daniel Z. Freedman in 1976, where the first supergravity theory was proposed. This theory combines, in a non-trivial fashion, the spin 2 graviton with a spin 3/2 particle called the gravitino to elevate supersymmetry to a local gauge symmetry. This led to an explosion of interest in quantum gravity and it transformed the subject, playing a significant role in very important developments in string theory as well as Kaluza-Klein theory. Prof. van Nieuwenhuizen played a major role in the development of the subject, with his studies on the quantum aspects of supergravity, coupling of supergravity to matter, super Higgs effect, extended supergravity theories, conformal supergravity and many other aspects of the theory. In particular, he contributed to the construction of the ten dimensional Einstein-Yang-Mills supergravity, which has been studied intensely in recent years as the low energy limit of the ten dimensional heterotic string theory. Currently any grand unified theory incorporating gravity is based on a supergravity theory
theory incorporating gravity is based on a supergravity theory
coupled to matter in four dimensions. These theories emerge naturally from the compactifications of the ten dimensional heterotic string.

Professor Peter van Nieuwenhiuzen was born in Utrecht (The Netherlands) on 26 October 1938. He studied both physics and mathematics at the University of Utrecht, and in 1971 he obtained his Ph.D in physics with a thesis on Radiative Corrections to Muonic Processes under the supervision of Prof. M.Veltman. From 1965 to 1969 Professor van Nieuwenhuizen was Fellow at the Dutch National Science Foundation. From 1969 to 1971 he was Fellow at CERN in the Theory Division and from 1971 to 1973 Juliot Curie Fellow at the University of Paris at Orsay in France. From 1973 to 1975 he was Research Associate at Brandeis University in Waltham, Mass., USA. From 1975 to 1985 he held different positions at the State University of New York at Stony Brook where he is now Leading Professor of Physics. Professor van Nieuwenhuizen is

Professor Peter van Nieuwenhuizen shows the public and photographers the Medal which he has just received.

editor of the Journal of Modern Physics A, and was editor of the Journal of Mathematical Physics and Classical and Quantum Gravity. In 1985 he was appointed Teyler Professor of Physics at Leiden University. He is the author of 250 scientific publications; his Physics Report on Supergravity was on the CERN list of the 20 most referenced publications during the decade 1980-1990.

Prof. van Nieuwenhuizen is one of the three recipients of the 1993 Dirac Medals of the ICTP, the other two being Professor Sergio Ferrara (Theory Division, CERN, Geneva, Switzerland) and Professor Daniel Z. Freedman (Department of Mathematics, MIT, Cambridge, Mass., USA). They were awarded the Medals
MIT, Cambridge, Mass., USA). They were awarded the Medals
for their discovery of supergravity theory in 1976 and their major contributions in the subsequent developments of the theory.

The Dirac Medals were instituted in 1985 by the International Centre for Theoretical Physics (Trieste, Italy) to honour one of the greatest physicists of this century and a staunch friend of the institution. They are awarded on P.A.M. Dirac's birthday — 8th August — for contributions to theoretical physics and mathematics. The Selection Committee included Professors S. Lundqvist, Y. Nambu, J. Schwinger*, S. Weinberg, E. Witten and Abdus Salam.

The Dirac Medals of the ICTP are not awarded to Nobel Laureates or Wolf Foundation Prize winners. ♦

* *Sadly, Prof. J. Schwinger died on 16 July 1994. Prof. Nicola Cabibbo (Italy) has replaced him on the Selection Committee.*

Dirac Lecture

Some Personal Recollections about the Discovery of Supergravity

Peter van Nieuwenhuizen

1 Introduction

It is a very great honor to stand here today, 18 years after the discovery of supergravity, to receive together with Dan Freedman and Sergio Ferrara, the Dirac medal and prize for the year 1993. I would like to thank Abdus Salam for his continuing strong support over the years of new theoretical ideas such as supersymmetry, supergravity and superstrings. In the early 1980's I helped organize with him and others a series of schools at Trieste on supergravity which later became the Trieste Spring Schools on strings. We had many meetings together and I recall, with pleasure, his intense interest in supergravity (on which he wrote many papers) as well as his sense of humor.

Before coming to the topic of my lecture, I would like to acknowledge the gratitude I feel for two other great physicists. First, Tini Veltman, my Ph.D. advisor: from him I learned to do Feynman graph calculations on the computer which I used in the final stages of the construction of supergravity. He will shudder at the thought that he indirectly contributed to the discovery of supergravity because he has become, with Glashow and others, an outspoken critic of all super-things, but our friendship has only increased over the years. As to the validity of their criticism I can only say that interesting and clean problems in traditional areas of physics are nowadays very hard to find, whereas the new fields abound with such problems. The idea that for every boson there should be a fermionic partner, and vice-versa, is so radical that it repels some physicists, but it is not more radical than the prediction of Dirac in the 1930's that for every particle there should be an antiparticle. The recent dramatic precision of the unification of the running $SU(3) \times SU(2) \times U(1)$ coupling constants in the minimal supersymmetric extension of the standard model (precision 1 in 1000) clearly is an indirect manifestation of supersymmetry, but what the future of supersymmetry and supergravity will be. I cannot tell.
of supersymmetry, but what the future of supersymmetry and supergravity will be, I cannot tell.

The other great physicist I feel very grateful to, is Frank Yang. Not only is he one of this century's greatest physicists (parity violation, Yang-Mills theory, Yang-Baxter equation etc.), but also he has managed to create an institute where, for the almost 20 years I have worked there, a very friendly and constructive atmosphere exists, among professors and students. Quite a difference from some other places where graduate students and junior faculty are often viewed as lower forms of life. When I was a high school student, my father came to me one day with Time magazine, where he had just read that two young Chinese physicists had been awarded the Nobel prize "for discovering that God is left-handed". He told me it must be marvelous to make such discoveries. I could hardly have imagined that one day I would be Frank's colleague and friend.

I realize that a lecture like the one today should not be a technical lecture on some of one's latest results, but rather a historical lecture looking back at the times when the discovery was made. My lecture will be in this vein, and among other anecdotes I will recall my encounter with Dirac and his reaction to supergravity.

If I would have the time, I would in the second part of my lecture present a very simple proof of supergravity, much simpler than our (FvNF) original proof, for the equivalent first-order reformulation of Deser and Zumino (DZ). Now I must refer you to lectures I gave this month in Varenna. Those of you who have never studied or understood supergravity, will find there the simplest version I am aware of. It was constructed over the years by combining the ideas of quite a few people (Freedman, Ferrara, myself, Deser, Zumino, Townsend, Volkov, Soroka, MacDowell, Mansouri, Chamseddine, West and others). According to this approach, the action for $N = 3D1$ supergravity with a supercosmological constant can be written in the following Yang-Mills-like form by "gauging" the super anti-de Sitter algebra

$$I = 3D \int [R_{\mu\nu}{}^{mn}(M) R_{\rho\sigma}{}^{pq}(M) \epsilon_{mnpq} + \bar{R}_{\mu\nu}(Q) \gamma_5 R_{\rho\sigma}(Q)] \epsilon^{\mu\nu\rho\sigma} d^4x \quad (1)$$

provided one imposes the curvature constraint $R_{\mu\nu}{}^m(P) = 3D0$. The curvatures $R_{\mu\nu}{}^{mn}(M)$ and $R_{\mu\nu}{}^{\alpha}(Q)$ are Yang-Mills curvatures belonging to the Lorentz generators M_{mn} and the supersymmetry generators Q_α of the super-anti de Sitter algebra. One begins by first "gauging" the latter, i.e., by associating to each generator (M_{mn}, Q_α, P_m) a gauge field $(\omega_\mu{}^{mn}, \psi_\mu{}^\alpha, e_\mu{}^m)$ and constructing the corresponding Yang-Mills curvatures. But then one must impose the constraints $R_{\mu\nu}{}^m(P) = 3D0$. These constraints are a gauge choice which leaves only the diagonal subgroup in the direct product of Yang-Mills transformations corresponding to P_m and general coordinate transformations. They express the spin connection $\omega_\mu{}^{mn}$ as a complicated composite object depending on vielbein fields $e_\mu{}^m(m = 3D0, 3)$ and spin 3/2 gauge fields ("gravitinos") $\psi_\mu{}^\alpha(\alpha = 3D1, 4)$. The constraint $R_{\mu\nu}{}^m(P) = 3D0$ is also a field equation, namely the field equation of the spin connection itself, $\delta I/\delta\omega_\mu{}^{mn} = 3D0$. Imposing these constraints (equivalently: solving this field equation), one recovers the
tion itself, $\delta I/\delta\omega_\mu{}^{mn} = 3D0$. Imposing these constraints (equivalently: solving this field equation), one recovers the
second-order formulation of FvNF, but a crucial simplification is that one can keep denoting $\omega_\mu{}^{mn}(e, \psi)$ by the symbol $\omega_\mu{}^{mn}$ (like in the first-order approach of DZ) without ever expanding it, since the variation $\delta\omega_\mu{}^{mn}(e, \psi)$ is (of course) multiplied by the field equation $\delta I/\delta\omega_\mu{}^{mn}$ which vanishes identically. Of course, even with this simplification, the proof of invariance of the action is not totally trivial. If one does not impose the constraints and keeps $\omega_\mu{}^{mn}$ as an independent field, the transformation law of $\omega_\mu{}^{mn}$ is nonzero (and complicated) [1], as first correctly found by Deser and Zumino.

[1] Volkov and Soroka gauged the super Poincaré algebra in 1973, and treated $\omega_\mu{}^{mn}$ as an independent field, like DZ, but did not impose a constraint or field equation. Consequently, they found $\delta\omega_\mu{}^{mn} = 3D0$, which is incorrect, as with this law the action is not invariant.

Supergravity can also be written in superspace. Superspace was invented by Salam and Strathdee as an application of the theory of coset manifolds (the coset manifold is here $\{P_m, Q_\alpha, M_{mn}\}/\{M_{mn}\}$). In superspace one also needs constraints (on the supertorsions as first found by Wess and Zumino and solved by Siegel and Gates) but a simple geometrical derivation of all these constraints has not yet been found. In the geometrical approach to W gravity by Schoutens, Sevrin and myself, one has constraints on all curvatures, but here corresponding "W-superspace" is even unknown. Perhaps some of you can solve these intriguing problems.

2 Some historical recollections

In this section I will recall how and why I came to supergravity. This is not a historical review where related work is discussed and compared with my own; rather it contains some personal recollections.

In the fall of 1975 I came to Stony Brook as an assistant professor and thereby became a colleague of Dan Freedman whom I had met at the Paris summer institute. The previous two years I had been at Brandeis University, busy applying the then recent covariant quantization rules of 't Hooft and Veltman to gravity, in collaboration with Stanley Deser, Marc Grisaru and others. These rules dispensed with the problems of operator ordering and unsolvable constraints which had been complicating the Hamiltonian approaches to quantum gravity, and now one could really calculate. Moreover, unitarity was guaranteed provided one introduced ghosts for the spacetime gauge symmetries, so the main problem was renormalizability. We had used a background field formalism to compute the one-loop divergences for all kinds of systems: the Maxwell-Einstein system, the Dirac-Einstein system, the Yang-Mills-Einstein system, QED coupled to gravity, gravitational lepton-lepton scattering, etc. Together with the earlier computation of 't Hooft and Veltman for pure gravity and gravity coupled to scalar fields, the results were uniformly disastrous: in all these cases (except pure gravity) there were one-loop divergences which were nonrenormalizable. For example, in the Maxwell-Einstein system, we found, using dimensional regularization, and imposing the Maxwell field equation $D^\mu = 46_{\mu\nu} = 3D0$ and the Einstein field equation $G_{\mu\nu} = 3D - \frac{1}{2}T_{\mu\nu}$ (photon)
the Maxwell field equation $D^\mu = 46_{\mu\nu} = 3D0$ and the Einstein field equation $G_{\mu\nu} = 3D - \frac{1}{2}T_{\mu\nu}$ (photon)

$$\Delta\mathcal{L} = 3D\frac{\sqrt{-g}}{n-4}\,\frac{137}{60}R_{\mu\nu}R^{\mu\nu} \tag{2}$$

(The number 137 was curious but it was an integer, not α^{-1}.) Since the form of this counter term is different from the form of the terms in the original action, ordinary renormalizability could not be used to get rid of these divergences, and hence these divergences were unrenormalizable. There were some unexpected or, as we called it, "miraculous?" cancellations (which we attributed to the duality invariance of the action and of $T_{\mu\nu}$ (photon) $= 3DF^2{}_{\mu\nu} +^* F^2{}_{\mu\nu}$ under $\delta F = 3D^*F$) due to which $F_{\mu\nu}$ only appeared in the combination $T_{\rho\sigma}$ (photon) and $(D^\mu F_{\mu\nu})^2$ but not as $(F^2)^2, R_{\mu\nu\rho\sigma}F^{\mu\nu}F^{\rho\sigma}$ or RF^2. However, terms with ${R_{\mu\nu}}^2, R^2, {T_{\mu\nu}}^2, T_{\mu\nu}R^{\mu\nu}$ and $(D^\mu F_{\mu\nu})^2$ remained, and these yielded the above quoted final result after using the classical field equations.

[Of course, a shift $g_{\mu\nu} \to g_{\mu\nu} + \alpha R_{\mu\nu} + \beta g_{\mu\nu} R$ produces in the Einstein action terms like ${R_{\mu\nu}}^2$, but such field redefinitions do not modify the on-shell divergences.]

So it seemed, as it does today, that a perturbative approach to Einstein quantum gravity leads to non-renormalizable divergences. Physically, it was clear that due to the dimensionality of the gravitational coupling constant κ, one was expanding in powers of κk where k is a momentum, which is not a good expansion for ultraviolet divergences. That was the end of the story, so it seemed.

However, although in QED coupled to gravity the infinities did not cancel, there remained in several people's minds a lingering doubt that perhaps a magical combination of fields existed for which the infinities did cancel. The reason for this hope was that the coefficients of divergences proportional to ${R_{\mu\nu}}^2$ or ${T_{\mu\nu}}^2$ were always positive as followed from unitarity (whether due to fermion loops or boson loops) but that cross terms $R_{\mu\nu}T^{\mu\nu}$ had often an opposite sign when one used the Einstein equation $G_{\mu\nu} = 3D - \frac{1}{2}T_{\mu\nu}$. The big question, of course, was what that magical combination of fields was.

It seemed highly probable that it should have an extra symmetry, beyond the spacetime symmetries (general coordinate (Einstein) invariance and local Lorentz invariance), but it was not clear what that extra symmetry should be. Natural candidates were: local scale, or perhaps even local conformal symmetry, or the fermi-bose symmetry (also called supersymmetry, or "susy") discovered by Gel'fand and Lichtman (1971), Akulov and Volkov (1973) and Wess and Zumino (1974).[2]

One problem with the latter symmetry was that so far no local fermi-bose symmetry had been constructed, only a rigid one. In an early attempt in 1975, Arnowitt and Nath had proposed a gauge theory for supersymmetry in superspace ("supergauge theory" as they called it) which they obtained from Einstein gravity by simply letting everywhere all indices become super indices (with a bosonic and a fermionic part). This theory has no constraints and as a consequence it contains higher spin fields and ghosts, and for that reason it has been abandoned. Yet, I recall that already at that time two physicists suggested to study the one loop ultraviolet divergences for spin 3/2 fields cou-
that already at that time two physicists suggested to study
the one loop ultraviolet divergences for spin 3/2 fields coupled to gravity: Salam at the London conference of 1975, and Veltman. I did not get down to computing the divergences of this system, although I reported this as a research project at a conference at Christmas 1975 in Caracas, because I was a bit tired of all these long calculations which in the end always gave a negative result.

In the spring of 1976, Dan Freedman came back from the Ecole Normale Supérieure in Paris, where he had studied various topics in physics, as well as the remarkable food market on the rue Mouffetard. The year before he had with Bernard de Wit applied the low energy theorems of

[2]Originally it was called supergauge symmetry, but because the parameter ϵ^α is constant, it was changed to global supersymmetry. However, to avoid the impression that global meant "defined on the whole manifold", the name was finally changed to rigid supersymmetry, and that is the present name.

current algebra to spontaneously broken supersymmetric systems, in order to find out whether the neutrino could be the supersymmetric partner of the photon. Their conclusion was negative, as it remains today, although the argument today is not based on current algebra but on the simple fact that in the standard model they have different $SU(3) \times SU(2) \times U(1)$ quantum numbers. (The conjugate Higgs doublet has the same quantum numbers as the (ν_e, e^-) doublet, but there are no partners for the (ν_μ, μ^-) and (ν_τ, τ^-) doublets).

In the very friendly atmosphere of the Institute for Theoretical Physics at Stony Brook, we had lunch together every day in the common room, and much of the remaining time was spent near the coffee machine, which was next to my office. It was only natural that colleagues would enter my office in a relaxed mood with a cup of coffee in their hand, and begin discussing physics. In this way, Dan and I came into scientific contact. Dan suggested that we start looking into a gauge theory of supersymmetry, which I immediately fully embraced because it was something new, exciting, and still in the domain of gravity with spinors where I had spent so much time. In this way we started working together. In Paris, Dan had also met Sergio Ferrara, who was an expert in rigid supersymmetry, and who had suggested to construct a theory of local supersymmetry, and he joined us from CERN. In those days there was no e-mail, but we managed to stay in touch.

So, how should we start? The basic property of rigid supersymmetry was (and is) that the commutator of two supersymmetry transformations gives a translation, $\{Q_\alpha, Q_\beta\} = 3D\gamma^\mu{}_{\alpha\beta}P_\mu$, so upon making supersymmetry local, we would expect to obtain a local translation. Now the concept of local translations looked to us very much like a general coordinate transformation, so we expected that a theory of local supersymmetry would necessarily contain gravity, and this explains the name supergravity for the gauge theory of supersymmetry. Conversely, in the presence of gravity a constant supersymmetry parameter becomes spacetime dependent after a local Lorentz rotation, hence rigid supersymmetry in the presence of gravity must turn into local supersymmetry.

So, local supersymmetry predicted the existence of gravity, and that was for us one of the most attractive aspects of supergravity. Nowadays, people like to motivate their
ity, and that was for us one of the most attractive aspects
of supergravity. Nowadays, people like to motivate their
interest in supersymmetry by referring to the hierarchy problem which is solved by supersymmetry (provided one accepts some plausible assumptions which resolve the so-called μ-problem). Also, for supergravity the motivation has changed over time: whereas originally it was hoped that it might solve the nonrenormalizability problem of ordinary quantum gravity, nowadays one considers supergravity rather as the "low-energy" limit of superstring theory. The latter is finite and thus solves the problem of quantum gravity, but for phenomenology one needs the effective field theory which results at low energy, and this effective field theory inevitably carries along with it an infinite tower of higher-dimensional operators divided by powers of the string mass scale, and any truncation of this infinite tower is nonrenormalizable. In 1976, none of these interesting developments were known, of course.

Given that supergravity must contain at least gravity, we expected to need at least one other field, its fermionic partner which should be the gauge field of local supersymmetry. The gravitational field describes gravitons, with spin 2, or rather helicity ± 2, and from the theory of massless irreducible representations of the super Poincaré algebra it was known that susy required fermi-bose pairs with adjacent spins $(j, j+1/2)$. Clearly, we needed either a massless spin 3/2 field, or a massless spin 5/2 field. Any sensible person would begin with spin 3/2, and that is what we did. (Later it was found that one cannot couple massless spin 5/2 fields to gravity in a consistent way. At the level of algebra that is also clear: one would need spin 3/2 generators, but then the anticommutator of two such generators would produce a spin 3 generator, which is not known to exist in 4 dimensions. In 2 dimensions it exists and leads to W gravity, but that we did not know in 1976).

In fact, in the 1960's and 1970's many concepts which are now so well understood that they have become almost trivial, were then confusing. Just to illustrate this, I may tell an anecdote of the 1960's concerning quantization of gauge field theories. My advisor was (and is) referee of *Physics Letters B*, and received one day a paper by Faddeev-Popov dealing with path-integrals, quantization and gauge theories. Now path-integrals were little used in those days, so people were unfamiliar with them. He could not make much sense out of the article (it did not contain their ghosts in the quantum action but rather there was a determinant in the measure) but neither could he find anything obviously wrong with this paper, so he decided, after much hesitation, to accept it for publication. Fortunately (with hindsight), just imagine what would have happened if he had rejected this article.

Although a spin (3/2, 2) doublet seemed to us the obvious choice, massless spin 3/2 fields were in disrepute due to the Johnson-Zwanziger-Velo "theorem". They had observed that if one coupled complex massless spin 3/2 fields to electromagnetism, this coupling was inconsistent. The field equation was expected to be $\gamma^{[\mu}\gamma^\nu\gamma^{\rho]}D_\nu\psi_\rho = 3D0$ with $D_\mu\psi_\nu = 3D\partial_\mu\psi_\nu - ieA_\mu\psi_\nu$, so upon contracting with D_μ one would get $F_{\mu\nu} = 3D0$, clearly too strong a condition. These couplings also led to signals which traveled faster than light. We were never intimidated by those no-go theorems, because we believed that the case of spin (1
faster than light. We were never intimidated by those no-
go theorems, because we believed that the case of spin (1, 3/2) is very different from the case of spin (3/2,2). In fact, by the time you have carefully formulated a no-go theorem, you can often see the solution and turn it into a "yes-go" theorem. (Later it was indeed found that one can couple spin 3/2 to spin 1 provided also gravity to present: this coupling leads to $N = 3D2$ extended supergravity, which is the susy extension of the Maxwell-Einstein system which unifies electromagnetism and gravity. When we get there, we shall of course come back to the question of " magical cancellation of infinities").

Although we decided to begin with the free field action for spin 3/2 fields and couple it in the usual way (the minimal way, like spin 1/2) to gravity, there arose immediately a problem: which action? We went to the library, and found a paper by Bargman and Wigner, who discussed free-field higher-spin theories, in particular some spin 3/2 theories. Most of them were really field equations with subsidiary conditions, so of no use for us. We were looking for an action with a vector-spinor field ψ_μ, because gauge fields have always the structure of ∂_μ times the parameter. Soon we found a gem of a paper with this field ψ_μ: the famous Rarita-Schwinger paper. These authors had entertained in 1941 the conjecture that the neutrino in β decay had spin 3/2 instead of spin 1/2, and computed the angular distribution of the neutrinos. The results were in complete disaccord with the experimental data, so that was the end of that idea, but for us this was no set-back: it seemed to us that rather than the action for neutrinos in flat space, Rarita and Schwinger had found the leading fermionic term of supergravity. Their free-field action reads (for our purposes we distinguish between curved indices of the gauge fields ψ_μ and flat indices of the constant Dirac matrices γ^m).

$$\mathcal{L}(RS) = 3D - \frac{1}{2}\bar{\psi}_\mu \gamma^{[m}\gamma^n\gamma^{r]}\partial_\nu \psi_\rho \delta^\mu_m \delta^\nu_n \delta^\rho_r \tag{3}$$

and it has a local gauge invariance, namely $\delta\psi_\sigma = 3D\partial_\sigma \epsilon(x)$ where $\epsilon(x)$ is a 4-component spinor, just what one needs for a gauge field of supersymmetry! (Recall that gauge fields always transform into the derivative of the parameter + more). Since the fermionic partner of the real graviton should be real, ψ_σ too should be somehow real. If the matrices $\gamma^0, \gamma^1, \gamma^2, \gamma^3$ (satisfying $\{\gamma^m, \gamma^n\} = 3D2\eta^{mn}$ with $\eta^{mn} = 3D(-1, +1, +1, +1)$) should be real (a so-called Majorana representation of the Dirac matrices) then also ψ_σ can be taken real, and $\mathcal{L}(RS)$ is real. That seemed a problem to us, because then the conjugate momentum of ψ_μ would be a linear combination of $\psi_\nu{}^\beta$. (Later I learned about Dirac quantization which resolves this problem.) So, we decided to work with complex Dirac matrices but we still needed some reality condition on ψ_μ to avoid over-counting. Here we must make a short technical stop and discuss Majorana spinors.

A Majorana spinor $\psi^\alpha (\alpha = 3D1, 4)$ satisfies the property that its Majorana conjugate $\bar{\psi}_M \equiv \psi^T C$ (with the charge conjugation matrix C defined by $C\gamma^m C^{-1} = 3D-(\gamma^m)^T$) is equal to its Dirac conjugate $\bar{\psi}_D \equiv \psi^\dagger i\gamma^0$. It is easy to show that $\bar{\psi}_M$ and $\bar{\psi}_D$ transform in the same wav under Lorentz transformations and satisfy the same
is easy to show that $\bar{\psi}_M$ and $\bar{\psi}_D$ transform in the same way under Lorentz transformations, and satisfy the same
Dirac equation. So $\bar{\psi}_\mu$ in $\mathcal{L}(RS)$ is both equal to $\psi_\mu^T C$ and $\psi_\mu^\dagger i\gamma^0$; and this shows that the action is hermitian and that $\bar{\psi}_\mu \gamma^{[m}\gamma^n\gamma^{r]}\psi_\rho$ is symmetric in μ and ρ. For what follows it is also important to know that $\bar{\psi}_\mu \gamma^m \psi_\nu$ is antisymmetric in (μ, ν).

In 4 dimensions one can write $\gamma^{[m}\gamma^n\gamma^{r]}$ as $\epsilon^{mnrs}\gamma_5\gamma_s$ (as it in fact occurs in the Rarita-Schwinger paper) and this is useful because putting the Rarita-Schwinger action in curved space (coupling it to gravity), the ϵ-tensor becomes a density and eliminates the need to add the usual factor $\sqrt{-g}$. Furthermore, as I knew from the Einstein-Dirac system, we had to replace $\delta_m{}^\mu$ by "vierbein fields" $e_m{}^\mu$ (tetrads, later called "vielbein" fields by Gell-Mann at the EST conference in San Francisco because vier=3D four and viel=3D many in German) and finally we had to replace the curl $\partial_\nu\psi_\rho - \partial_\rho\psi_\nu$ by $D_\nu\psi_\rho - D_\rho\psi_\nu$ where D_ν is a suitable gravitationally covariant derivative. So

$$\mathcal{L}(RS,\ \text{gravity}\ ) = 3D - \frac{1}{2}\epsilon^{\mu\nu\rho\sigma}\bar{\psi}_\mu\gamma_5\gamma_\nu D_\rho \psi_\sigma \tag{4}$$

The symbol $\epsilon^{\mu\nu\rho\sigma}$ is ± 1 or 0, and a density while the factor 1/2 is arbitrary but customary for real (bosonic or fermionic) fields.

The problem was, of course, what that suitable covariant derivative D_ρ was. We knew (for example from Weinberg's book on general relativity) that one possibility was

$$D_\rho\psi_\sigma = 3D\partial_\rho\psi_\sigma - \Gamma_{\rho\sigma}{}^\tau(g)\psi_\tau + \frac{1}{4}\omega_\rho{}^{mn}(e)\gamma_m\gamma_n\psi_\sigma \tag{5}$$

where $\Gamma_{\rho\sigma}{}^\tau(g)$ is the usual Christoffel symbol and $\omega_\rho{}^{mn}(e)$ the spin connection, related to $\Gamma_{\rho\sigma}{}^\tau(g)$ by the "vielbein postulate"

$$\bar{D}_\rho e_\sigma{}^m \equiv \partial_\rho e_\sigma{}^m - \Gamma_{\rho\sigma}{}^\tau(g) e_\tau{}^m + \omega_\rho{}^m{}_n(e) e^n{}_\sigma = 3D0. \tag{6}$$

But we also studied papers by Hehl and collaborators, who introduced torsion in theories involving bosonic matter fields, where they wrote

$$\Gamma_{\mu\nu}{}^\rho = 3D\Gamma_{\mu\nu}{}^\rho(g) + K_{\mu\nu}{}^\rho \tag{7}$$

with $K_{\mu\nu}{}^\rho = 3D - K_{\nu\mu}{}^\rho$ the "contorsion tensor". We adopted this procedure for our problem and wrote $\omega_\mu{}^{mn} = 3D\omega_\mu{}^{mn}(e)$+3 terms involving the contorsion tensor, omitting $\Gamma_{\rho\sigma}{}^\tau(g)$ in (4) because it cancelled in the curl. By this ansatz as starting point we already committed ourselves to what is now called second-order formalism (with gravitino torsion).

So, our starting point was

$$S^{(0)} = 3D \int d^4x[\mathcal{L}_2 + \mathcal{L}_{3/2}] = 3D$$
$$\int d^4x[-\frac{\sqrt{-g}}{\kappa^2}R - \frac{1}{2}\epsilon^{\mu\nu\rho\sigma}\bar{\psi}_\mu\gamma_5\gamma_\nu D_\rho\psi_\sigma] \tag{8}$$

where $\gamma_\nu = 3D\gamma_n e_\nu{}^n$ with constant γ_n. The Einstein-Hilbert action is $R = 3DR_{\mu\nu}{}^{mn} e_m{}^\nu e_n{}^\mu$ and $R_{\mu\nu}{}^{mn} = 3D\partial_\mu\omega_\nu{}^{mn} + \omega_\mu{}^m{}_k\omega_\nu{}^k{}_n - \mu \leftrightarrow \nu$ with $\omega_\mu{}^{mn} = 3D\omega_\mu{}^{mn}(e)$ to lowest order in κ. As lowest order supersymmetry trans-
$3D\partial_\mu\omega_\nu{}^{mn} + \omega_\mu{}^m{}_k\omega_\nu{}^k{}_n - \mu \leftrightarrow \nu$ with $\omega_\mu{}^{mn} = 3D\omega_\mu{}^{mn}(e)$ to lowest order in κ. As lowest order supersymmetry trans-
formation rules we took

$$\delta^{(0)}\psi_\mu = 3D\frac{1}{\kappa}D_\mu\epsilon = 3D\frac{1}{\kappa}(\partial_\mu\epsilon + \frac{1}{4}\omega_\mu{}^{mn}(e)\gamma_m\gamma_n\epsilon) \tag{9}$$

with again $\omega_\mu{}^{mn}(e)$ but anticipating further terms, and

$$\delta^{(0)}e_\mu{}^m = 3D\alpha\kappa\bar{\epsilon}\gamma^m\psi_\mu,\ \alpha \text{ a constant.} \tag{10}$$

This latter law was not obvious, but it was linear in fields, just like in rigid susy where one has δ (boson) $\sim$ (fermion) ϵ. An alternative, $\delta e_\mu{}^m = 3D\alpha\kappa\bar{\epsilon}\gamma_\mu\psi_\nu e^\nu{}_m$ we rejected because it was not linear in fields. The law for $\delta^{(0)}\psi_\mu$ was also to lowest order in fields and for constant ϵ of the expected form δ (fermion) =3D ∂ (boson) ϵ, since $\omega_\mu{}^{mn}(e)$ contains to lowest order indeed only terms of the form ∂ (boson), namely derivatives of the vielbein field.

The first test came immediately: are there encouraging cancellations in $\delta I^{(0)}$? One obtains from varying the vielbeins in $\mathcal{L}_2$, using $g_{\mu\nu} = 3De_\mu{}^m e_\nu{}^n \eta_{=mn}$,

$$\delta\mathcal{L}_2 = 3D \quad \frac{1}{\kappa^2}(R^{\mu\nu} - \frac{1}{2}g^{\mu\nu}R)\delta g_{\mu\nu}$$

$$= 3D \quad (R^{\mu\nu} - \frac{1}{2}g^{\mu\nu}R)\frac{\alpha}{\kappa}(\bar{\epsilon}\gamma_\mu\psi_\nu + \bar{\epsilon}\gamma_\nu\psi_\mu) \quad (11)$$

On the other hand, varying $\bar{\psi}_\mu$ and ψ_σ in $\mathcal{L}_{3/2}$, gave

$$\delta\mathcal{L}_{3/2} = 3D \quad -\frac{\epsilon^{\mu\nu\rho\sigma}}{2\kappa}(\bar{\psi}_\mu\gamma_5\gamma_\nu D_\rho D_\sigma\epsilon + (D_\mu\bar{\epsilon})\gamma_5\gamma_\nu D_\rho\psi_\sigma)$$

$$= 3D \quad \frac{\epsilon^{\mu\nu\rho\sigma}}{16\kappa}R_{\rho\sigma}{}^{mn}(\bar{\epsilon}\gamma_5\{\gamma_\nu, \gamma_m\gamma_n\}\psi_\mu) \quad (12)$$

where we partially integrated the derivative on $D_\mu\bar{\epsilon}$, used $[D_\rho, D_\sigma]\epsilon = 3D\frac{1}{4}R_{\rho\sigma}{}^{mn}\ \gamma_m\gamma_n\epsilon$, and finally used the Majorana property $\bar{\psi}_\mu\gamma_5\gamma_\nu\gamma_m\gamma_n\epsilon = 3D - \bar{\epsilon}\gamma_n\gamma_m\gamma_\nu\gamma_5\psi_\mu$. We then found a fantastic cancellation ("heart warming" we called it): the variations of $\mathcal{L}_2$ and $\mathcal{L}_{3/2}$ in (11) and (12) actually cancelled. To see this, one may replace $\{\gamma_\nu, \gamma_m\gamma_n\}$ by $2e_\nu{}^t\epsilon_{tmns}\gamma_5\gamma_s$, use $\gamma_5{}^2 = 3D1$ and write $\epsilon^{\mu\nu\rho\sigma}\epsilon_{rmns}$ as a product of four vielbeins fields, properly antisymmetrized. Then, for suitable α, these variations cancelled.

However, this was only the beginning of a whole series of cancellations which were needed to prove that the final action was susy. Not yet taken into account were: the variations of $\omega_\mu{}^{mn}(e)$, the derivative $D_\mu e_\nu{}^r$ picked up in the process of partial integration and the variation of $e_\nu{}^r$ in γ_ν. We solved this problem by adding new suitable terms of higher order in κ to action and transformation laws each time when the variations of the action did not cancel. ("The Noether method", see below). This was tedious work, which required a steady hand in manipulations with Dirac matrices and Riemannian geometry. Every morning I could hear Dan coming into the institute, humming always the same two sentences, "In heaven there is no beer, that's why we drink it here", but we actually did not drink any beer, but worked very hard, at least 12 hours a day, weekends included, for several months. We never knew whether our approach would work, and many times we thought supergravity was dead, only to find the next day a solution which brought it back to life. An amusing incident happened when at some point we found that
ing incident happened when at some point we found that
a sum of five terms involving Riemann tensors and complicated spinor structures had to cancel. By taking special values for indices and fields, we got strong indications that they did. We started reading J. Schouten's famous book, but did not find there an explanation, and then went to some mathematicians, who got very interested and thought we might have discovered some new identity. Eventually, we realized the truth was much more pedestrian: in 4 dimensions a tensor with 5 indices, totally antisymmetrized, always vanishes. Yet, as a tribute to this episode, we introduced the verb to "Schoutenize" which indicates the interchange of indices which results from this identity, and even today this word can be found in the literature.

In this way we pushed, with a lot of algebra, the proof of invariance up to the level of five gravitino fields and one ϵ in $\delta\mathcal{L}$. This last calculation was so complicated that only a computer seemed able to do it.

We had at that time a connection to the big computer at Brookhaven National Laboratory, at least big for those years. I started writing a simple Fortran program, to collect all variations and check whether the coefficients of all independent spinor combinations were zero. Rather than work with Majorana spinors, we rewrote them as 2 component Weyl spinors since this saved memory , and wrote all terms in the form

$$t^{abcdefgh}(\psi_a^\dagger\sigma_b\psi_c)(\psi_d^\dagger\sigma_e\psi_f)(\epsilon^\dagger\sigma_{=g}\psi_h) \quad (13)$$

where t is an integer-valued tensor constructed from ϵ symbols and Kronecker deltas. In some test runs we found output values like 0.1875. I was puzzled, but for Dan it was obvious that this was $\frac{3}{16}$ (the factor $\frac{1}{16}$ we later traced to our normalization of spinors) and he still sees this as a characteristic difference between a European and American education. (Americans measure length in units of 1/16 of an inch, and students are trained to convert this into decimals.)

Taking into account antisymmetry relations between the spinors, we needed to compute about a thousand coefficients, each of which should come out zero. We spent an enormous time simplifying the program in order to reduce the costs of computing time, (which was in the end of the order of 50 dollars) and we got it down to about 3 minutes. Many trial runs were made to get rid of all bugs, but after days of work, one night everything was ready, and now it was up or down. I was sitting alone that night in the computer room, except for a colleague (Junn-Ming Wang), who often worked late. It was late (2 o'clock at night) and after starting the decisive run and waiting the expected 3 minutes, the results came in. As always the first few hundred entries were zero, but that was no reason for optimism because we already knew that these terms were zero. However, zeros kept coming, and I started making strange noises. Jimmy asked me what was going on, and I told him that I needed still a few hundred zeros, and if there was at least one nonzero entry, all our work would be in vain. The zeros kept coming, the tension mounted and then the program came to the end with only having produced zeros. It worked, supergravity existed!! Instead of being happy I was very, very tired. I phoned Dan, who was in a hotel in Chicago for a conference and who had
was in a hotel in Chicago for a conference and who had
told me to inform him of the result, no matter what the time was, and he said "Oh, that is wonderful" in also a very tired voice. I then went home, and felt depressed. In fact, I have often heard that physicists feel depressed just after a major discovery; perhaps that is the physicists' equivalent of post-partum depression.

However, the next days we became again enthusiastic. It was clear that an almost endless series of problems lay ahead of us, each problem even more interesting than the previous one. We had to redo for this new gauge theory all that one had done in the past for Yang-Mills gauge theories. The first problem was, of course, the coupling of matter to supergravity. By then it was summer 1976, and I went to Europe (Paris) while Dan went to Aspen. We decided that each should press on with research in supergravity. In Paris, I met for the first time Sergio Ferrara, with his usual cigar, and suggested to him that we try to couple scalar fields to supergravity. That was the first time I noticed his superb instinct for making the right choices, for he told me that my suggestion was excellent and we certainly should try to couple scalars, but perhaps spin 1 fields were even more interesting because of the extra Maxwell gauge invariance. Since I had no strong feelings one way or the other, I accepted his proposal. Later it was found that the coupling to scalars is much more complicated than the coupling to vectors. So the choice of vectors was very lucky. In that collaboration also Joel Scherk joined. At some point we got stuck because we were left with a term proportional to $F_{\mu\alpha}\epsilon^{\alpha\nu\rho\sigma}F_{\rho\sigma}$, but Joel remembered that he had passed a summer in Cambridge deriving (under a tree, but not being hit by apples!) all kind of identities for fun, and he vaguely remembered that there was something interesting with this term. He went to a pile of notebooks in the corner of his office, and produced from the middle a notebook in which he found that this term is proportional to $\delta_\mu{}^\nu$. Joel did work for years with us; he was absolutely creative, and his death in 1980 was a great blow to all workers in supergravity, and to me personally, as I had become very close to him.

This brings me to a point I want to stress here, and which I think is not at all sufficiently understood by physicists outside the circle of supergravity practitioners. From 1976 on, a group of young, enormously enthusiastic physicists did work that, in my opinion, is of an almost unique high standard in physics. Some older physicists have told me later that they also tried to enter the field, but that as soon as they sat down to begin this study, a flood of new papers by these young physicists deflated their energy. The drawback of this situation has been that relatively few senior physicists were involved with supergravity, so that when these young people needed a faculty position they had not always the backing from the establishment which they should have had. Still, looking around, I see that most of them have become professors, and almost all of them are still as active today as then.

The coupling of matter to gravity (and also all subsequent couplings, and also the construction of the gauge action itself) was achieved by using the "Noether method", where one evaluates $\delta\mathcal{L}$ order by order in κ, and when $\delta\mathcal{L}$ is nonzero, one adds further terms to the action and/or transformation laws such that up to that level in κ $\delta\mathcal{L}$ becomes nonzero, one adds further terms to the action and/or transformation laws such that up to that level in κ $\delta\mathcal{L}$ becomes zero. For example, if $\delta\mathcal{L}$ contains a term $\partial_\mu\epsilon$ one could add a new term to the action obtained by replacing $\partial_\mu\epsilon$ by $-\kappa\psi_\mu$ since varying ψ_μ into $\frac{1}{\kappa}\partial_\mu\epsilon$ in the new term would cancel the old variation. However, this would not work with a term like $\bar{\psi}_\mu\gamma^m\partial^\mu\epsilon$ since $\bar{\psi}_\mu\gamma^m\psi^\mu = 3D0$, so there were fermionic integrability conditions. As a byproduct we also found two alternative derivations of supergravity: 1) by starting with rigidly susy matter and then making ϵ local and at the same time introducing the gauge fields of supergravity, 2) by starting with the S-matrix and 3-point couplings and deducing the 4-point and higher couplings by imposing gauge-invariance (transversality). These approaches are well-known in ordinary gauge field theories, and it was comforting to see that they also worked well here.

In the fall of 1976, after the coupling of spin (1, 1/2) and later spin (0, 1/2) matter of supergravity, another interesting system to consider was the coupling of a rigidly susy spin (3/2, 1) matter system to supergravity which is a spin (3/2,2) system. It seemed to Ferrara and me that there should in the end be an extra 0(2) symmetry in the action between both gravitinos, and that is what we found. The resulting system was "N=3D2 extended supergravity" with $N = 3D2$ gravitinos. This theory unifies electromagnetism and gravity ("Einstein's dream") by adding gravitinos as "glue". Later, Dan constructed $N = 3D3$ extended supergravity with Ashok Das, and discovered that one can couple the spin 1 fields to the other fields as an $SO(3)$ Yang-Mills system, provided one also added a supercosmological constant. And then the $N = 3D4$ and $N = 3D8$ (and $N = 3D5, 6, 7$) extended supergravities were constructed.

Of course, the quantization was a topic of major interest. It turned out that the covariant quantization rules of 't Hooft and Veltman could once more be applied, with as gauge-fixing term for susy the expression $\bar{\psi}\cdot\gamma\partial\gamma\cdot\psi$, leading to commuting spinorial Faddeev-Popov ghosts. However, because the gauge algebra[3] was "open", one needed an unusual 4-ghost coupling to restore unitarity. A direct Feynman graph calculation revealed that the coupling of supergravity to spin $(0, 1/2)$ or spin $(1/2, 1)$ matter was in general nonrenormalizable, but that in the extended sugras, the infinities cancelled at the one-loop level. So, here finally we found a "magical combination of fields". For me the latter result was very gratifying because (i) it showed that supergravity was at least one-loop finite, and (ii) it also showed that my previous one-loop calculations for matter-supergravity systems with nonvanishing divergences were correct because they were used as input into this calculation. After the one-loop divergences were found to cancel in the $N = 3D2$ and $N = 3D4$ extended supergravities, the question was of course: do they cancel at the 2-loop level? I had a bet with a very good friend for a crate of champagne that they would cancel. Marc Grisaru found a nice argument that they do.[4] Then Stanley Deser and Kelly Stelle found that at 3-loop level one could write down a possible counterterm, but till today nobody has computed its coefficient. Most people believe that its coefficient is nonzero, but nobody knows. (The counterterm is of the generic form R^3. Also in 6 dimensions the one- efficient is nonzero, but nobody knows. (The counterterm is of the generic form R^3. Also in 6 dimensions the one- loop counterterm is of this form, and I have shown that there its coefficient is nonzero. However, I do not think this gives information on the 4-dimensional situation, and it would be interesting if somebody would compute the 4-dimensional coefficient).

Incidentally, the name gravitino has also some history to it. With Marc Grisaru and Hugh Pendleton, I looked into the S-matrix of supergravity, and found relations between various cross-sections such as graviton-graviton scattering and the scattering of two massless spin 3/2 particles. At a short visit to Caltech, Gell-Mann had looked

[3] Open gauge algebras, field dependent structure functions, auxiliary fields which close the gauge algebra, and that all in the context of superalgebras has become a whole new field in mathematics.

[4] I got in the end only one bottle of champagne from my friend.

with me in dictionaries for a venerable name for these particles and had come up with "hemitrion" ("half-3"). So, in that S-matrix paper, we wrote "hemitrion-hemitrion scattering", but the editors of *Physical Review* did not allow this neo nomen, and we had to revert to "massless Rarita-Schwinger-massless Rarita-Schwinger scattering". It was Sidney Coleman and Heinz Pagels who coined "gravitino". (Actually, I was surprised some years later to read in a letter of recommendation that Sidney wrote that he was uninterested in gravity and superinterested in supergravity. He seems to have changed his mind a bit).

While all this work on supergravity was going on, our students had a golden time, because (unlike today) there were far more exciting and doable problems than people. We also gave many seminars. I recall a few interesting occasions. On one occasion, I was to discuss (at the request of the chairman of that department) the progress in supergravity, and after he had introduced me (with the usual statement that he hoped to have pronounced my name correctly), he whispered to me, "Oh, I forgot to tell you, but please do not use the Dirac equation or other such difficult things because our faculty is mostly specialized in ..." (some other field). That required some improvisation on the spot ! On another occasion, I was in Tallahassee, where to my delight Professor Dirac was in the audience. To my even greater delight, when the chairman asked at the end of my lecture if anybody wanted to ask a question, Dirac raised his hand. "How many anticommuting variables does your theory have?". I quickly thought: at each point in spacetime a real 4-component spinor ($\epsilon^{\alpha}(x)$), so I answered: "Infinity to the fourth power." "That is a large number", he replied. I waited for a further comment, but no more was forthcoming. Later, he told me that Feynman graph calculations were in his opinion not the way to quantum theory; rather, they were like the coupling of Bohr-orbits in the early days of quantum mechanics. I was invited that evening for a dinner at his home, and as I knew that he was not an effusive speaker, I was not surprised that he only turned to me at the end of the dinner to ask me "Have you ever read (the book) the Red Rose?". I said I had not, and again no further comment was forthcoming. I have a short movie from that visit where you can see Dirac swimming among the mangroves.
There were also alligators nearby, and I was too afraid to where you can see Dirac swimming among the mangroves.
There were also alligators nearby, and I was too afraid to swim, but he told me there was no danger. A last recollection I have is that he told me that he found life in the USA a bit different from life in England. "Did you know that if you buy here a grand piano you get a gun for free?" I have now lived in the States for 20 years, and must agree with him that it sometimes is a bit different from Europe, but it is a very positive optimistic country and as a physicist I appreciate that young people are treated equally to older people, and that there is not much secrecy in appointments or promotions.

These were a few recollections of the exciting early days of supergravity. Supergravity then went on: there came a Kaluza-Klein era, and a 2-dimensional era with σ models, and supersymmetric quantum mechanics, and then came superstring theory which is also a kind of supergravity theory as it is also based on a local fermi-bose symmetry. We have now reached a level of sophistication where we should be able to explain nature around us, and, as always in fundamental science, many people become somewhat pessimistic about the chances of success. Some people go even further these days and say that particle physics is dead. Also that has been said before. I would like to state that the unification of running coupling constants I mentioned before is a clear though indirect manifestation of the existence in nature of rigid susy. Also gravity exists. Rigid susy plus gravity is supergravity, that we showed in 1976. For these reasons, I must conclude that supergravity exists and will be detected. I am confident that nature is aware of our efforts.

1994 Distinguished Service Award to Ms. Anne Gatti

On 26th September, the International Atomic Energy Agency granted Ms. Anne Gatti, Principal Secretary of the President of the International Centre for Theoretical Physics, the 1994 Distinguished Service Award in the presence of Members of the Board of Governors at the IAEA Headquarters in Vienna. This singular recognition of her work was "for her dedication, highly developed skills and creative thinking, which enabled her to maintain the standards of the Director's Office, ICTP, during the Director's absence in 1993 and 1994".

Ms. Gatti's valuable experience before joining ICTP includes an M.A. degree in languages from the University of Glasgow; secretary in the Foreign and Commonwealth Office, London, and in the Office of the Director General, International Atomic Energy Agency. Since 1983 she has been Secretary and then Principal Secretary in the Office of the Director, ICTP. ♦

Ms. Anne Gatti receiving the Distinguished Service Award 1994 from Dr. Hans Blix, Director General of the International Atomic Energy Agency, at the IAEA Headquarters in Vienna on 26 September 1994.

Obituary
Nobel Laureate Professor Julian Schwinger

Julian Schwinger, 76, a theoretical physicist whose work in electrodynamics earned him a Nobel Prize in 1965, died in Los Angeles on 16 July 1994.

He had been a faculty member of the University of California at Los Angeles for the last 22 years. Prof. Schwinger shared the Nobel Prize with Richard Feynman (USA) and Shinichiro Tomonaga (Japan). They were cited for their independent contributions in the field of quantum electrodynamics. Specifically, Prof. Schwinger and Prof. Feynman broke ground in the late 1940s and early 1950s for what became a revolution in theoretical physics and the quantum field theory. They helped bring about much of the progress in physics over the next four decades, particularly in ultrahigh-energy physics and in probing the ultimate structure of matter.

In a career that spanned nearly 60 years, Prof. Schwinger made varied and highly important contributions to the theory of elementary particles and fundamental interactions.

He was associated with the ICTP as a member of the Dirac Medals Selection Committee since the institution of the Medals in 1985. ♦

From the Editorial Office
From the Editorial Office
to All Readers

It is important for us to have feedback from scientists, in order to keep our service geared to their needs.

Your suggestions and constructive criticism is therefore invited, with an aim at making News from ICTP a tool which is really useful for the scientific community all over the world.

Please write Attn Scientific Information Office, or send e-mail to sci_info@ictp.trieste.it.

Activities at ICTP July-September

Title: Summer School in High Energy Physics and Cosmology, 13 June – 29 July, including the Workshop on Perspectives in Theoretical and Experimental Particle Physics, 7–8 July, and Workshop on Strings, Gravity and Related Topics, 28–29 July.

Organizers:

School: Professors E. Gava (Italian National Institute of Nuclear Physics, INFN, Trieste, Italy), A. Masiero (Italian National Institute of Nuclear Physics, INFN, Padua, Italy), K.S. Narain (ICTP), S. Randjbar-Daemi (ICTP) and Q. Shafi (University of Delaware, Newark, USA).

Workshop on perspectives in theoretical and experimental particle physics: G. Barbiellini (University of Trieste and Italian National Institute of Nuclear Physics, Trieste, Italy) and G. Furlan (University of Trieste and ICTP).

Report:

School: As usual, the School was divided into two parts: the first one, from the beginning till 6 July was devoted to phenomenological aspects of high energy physics and cosmology. The last two days of the first part were devoted to a Workshop on the Perspectives of Theoretical and Experimental Particle Physics, organized by G. Barbiellini (INFN) and G. Furlan.

The second part was focused on more formal aspects of modern theoretical physics and based on two main topics — the first concerned String
physics and based on two main topics —
the first concerned String compactifications and related issues, like N=2 topological theories, Mirror Symmetry (T-duality), S-duality, and finally "String Phenomenology". Black Holes in Quantum Gravity was the other main theme. The last two days of the second part were devoted to a Workshop, open to contributions of participants of the School.

There were altogether about 30 lecturers and 200 participants, almost equally distributed between the two parts (some of the selected participants, on the basis of their background and origin, attended both parts). We had three lectures a day, of one hour and a quarter each, two in the morning and one in the afternoon. A discussion session was put at the end of each week. Both the first and second parts had introductory lectures, mainly by local scientists (ICTP, INFN, Department of Theoretical Physics of Trieste University–DFT, and International School for Advanced Studies–SISSA), with the purpose of recalling to the participants basic background material, hopefully useful for a better understanding of the subsequent, more advanced topics.

In the first part Iengo lectured on basic techniques in QFT (renormalization etc.), Nason (CERN) on perturbative QCD and chiral Lagrangians, and Verzegnassi (DFT) on the Standard Model. Masiero (INFN) introduced and motivated supersymmetry. This took the first week and part of the second. We had then more specialized lectures on the main topics of the present research in particle phenomenology: Fogli (Bari) lectured on the precision tests of the Standard Model (4 lec.), Smirnov (ICTP) on neutrino physics (3 lec.), Dvali (Pisa) on supersymmetric GUTS (2 lec.), Raby (Ohio) on fermion masses, mixings and ansatzes (4 lec.), Shaposnikov (CERN) on non perturbative aspects within the (standard) electroweak theory and baryogenesis (4 lec.), and Thompson and Hussain lectured on heavy quark effective theories.

Concerning Cosmology, Lazarides (Thessaloniki) reviewed the Standard Cosmology and Inflation, (4 lec.) Perilovalopoulos (Harvard) lectured about topological defects in cosmology and their applications (4 lec.), Matarrese (Padua) lectured on large scale structure formation (4 lec.).

The Workshop at the end of the first part was very useful for the participants
The Workshop at the end of the first
part was very useful for the participants of the School, in giving an updated overview of the present status and future developments of High Energy Physics, particularly from the experimental point of view, as the most important groups and laboratories were represented.

We decided this time to reduce the number of different topics to be covered in the "formal" part of the School, and concentrate only on two main topics, String Compactification and Black Holes. As for String Compactification, apart from covering the most recent formal developments, we also aimed to provide a review of the basic open problems facing String Theory as a possible, phenomenologically viable candidate for the unification of fundamental forces.

In the first week Gava, Narain and Randjbar-Daemi gave review lectures on String theory, Ellis (Cape Town) reviewed classical aspects of Black Hole physics (4 lec.), Greene and Aspinwall (Cornell) gave lectures (4 each) on moduli of N = 2 theories, Mirror Symmetry and Topology change in String theory. Bershadsky (Harvard) discussed N=2 topological strings. In the second week Giddings (Stanford) and Verlinde (Princeton), in 4 and 3 lectures respectively, discussed different approaches to possible solutions of the quantum mechanical puzzles facing Black Hole physics, Sen (Tata) gave 3 lectures on very recent (and exciting) developments concerning weak-strong coupling Duality Symmetry in String and Field Theory. Distler (Princeton) discussed in 3 lectures a Landau-Ginzburg approach to (2,0) models. In the last week Louis (Munich) reviewed the most important aspects of String Phenomenology and related open problems (4 lec.) and Schoutens (Princeton) presented a new formulation of conformal field theory.

The second part of the School ended with a two-days Workshop, including 14 speakers, most of which were School participants, selected by the Directors.

Edi Gava

Workshop on perspectives in theoretical and experimental particle physics: The two-days Workshop on Perspectives in Theoretical and Experimental Particle Physics concluded the first part (i.e. 13 June – 8 July) of the Summer School in High Energy Physics and Cosmology (13 June – 29 July). We found these two days extremely fruitful and Cosmology (13 June – 29 July). We found these two days extremely fruitful and stimulating, in spite of the fact that it was not possible to have all the desired lecturers.

The speakers who contributed offered the best of their experience and knowledge and provided a rewarding glance at the theoretical problems and experimental programmes in particle physics:

C. POPE (Texas A & M University and SISSA) – String theories with higher spin world-sheet symmetries.

J. RUSSO (Univ. of Texas at Austin and SISSA) – Heterotic strings, phase transitions and rotating black holes.

S. MUKHERJI (ICTP) – Boundary dynamics in dylaton gravity.

A. MIKOVIC (SISSA) – Hawking radiation and back-reaction in a unitary theory of 2-d quantum gravity.

Y. KIEM (Princeton University) – Exchange algebra for non-spherical infalling stress-energy flux in 4-d Einstein gravity.

M. BLAU (ICTP) – Localization in the G/G model and the Verlinde formula.

N. MOHAMMEDI (University of Bonn) – Mirror symmetry in Wess-Zumino-Witten models.

J. MALDACENA (Princeton University) – Exact solution of a boundary conformal field theory.

O. JOFRE (Astronomy Institute and Univ. of Buenos Aires) – Strings in plane wave background revisited.

A. ZHELTUKHIN (Kharkov Inst. of Physics and Technology) – On the problem of covariant quantization of supersymmetric extended objects.

Y. CHO (IAS, Princeton) – Gauge theory of diff S^1 and loop groups — A new approach to strings.

C.V. JOHNSON (IAS, Princeton) – Heterotic cosets.

S.F. HASSAN (TIFR, Bombay) – O(d,d,R) deformations of complex structures and extended world-sheet supersymmetry.

E. GAVA (INFN/ICTP) – Topological amplitudes in string theory.

G. Furlan

Title: Research Workshop on Condensed Matter Physics, 13 June – 19 August.

Organizers: Professors A. Aronov (A.F. Ioffe Physical-Technical Institute, Academy of Science, St. Petersburg, Russia, and Weizmann Institute of Science, Rehovot, Israel), G. Baskaran (Institute of Mathematical Sciences, Science, Rehovot, Israel), G. Baskaran (Institute of Mathematical Sciences, Madras, India), F. Bassani (Scuola Normale Superiore, Pisa, Italy), E. Burstein (University of Pennsylvania, Philadelphia, PA, USA), P.N. Butcher (University of Warwick, Coventry, UK), H. Cerdeira (Universidade Estadual de Campinas, UNICAMP, Campinas, Brazil, and ICTP), S. Fantoni (International School for Advanced Studies, SISSA, Trieste, Italy, and ICTP), F. Garcia-Moliner (Instituto de Ciencias de Materiales, Madrid, Spain), F. Gautier (Université Louis Pasteur, Strasbourg, France), N. Gershenfeld (Massachusetts Institute of Technology, Cambridge, MA, USA), Bai-Lin Hao (Institute of Theoretical Physics, Academia Sinica, Beijing, China), S. Lundqvist (Chalmers University of Technology, Gothenburg, Sweden, and ICTP), Chi Wei Lung (International Centre for Materials Physics, Academia Sinica, Shenyang, China), N.H. March (University of Oxford, UK), A. Mookerjee (S.N. Bose National Centre for Basic Sciences, Calcutta, India), F.S. Persico (Università di Palermo, Italy), T.V. Ramakrishnan (Indian Institute of Science, Bangalore, India), S.R. Shenoy (University of Hyderabad, India, and ICTP), E. Tosatti (International School for Advanced Studies, SISSA, Trieste, Italy, and ICTP), M.P. Tosi (Scuola Normale Superiore, Pisa, Italy) and Yu Lu (Institute of Theoretical Physics, Academia Sinica, Beijing, P.R. China, and ICTP).

Report: This has been the 25th of the series of Condensed Matter Summer Workshops organized at ICTP and has been the third year that the Workshop combines some focused activities with researches along certain lines. 279 scientists including Research Leaders, Participants, Associates and Affiliates attended this Workshop.

Three major activities, namely, the Workshops on "Submicron Quantum Dynamics" (13 June – 1 July), the Miniworkshop on "Strong Correlations and Quantum Critical Phenomena" (4 – 22 July) and Workshop on "Non-Linear Electromagnetic Interactions in Semiconductors" (1 – 10 August) have been the "highlights" of this Condensed Matter Workshop and have been very successful. Moreover, the other two focused activities, Miniworkshop on "Nonlinear Time Series Analysis" (8 – 12 August) and Working Group on "Disordered Alloys" (8 – 19 August) have 12 August) and Working Group on "Disordered Alloys" (8 – 19 August) have also attracted a large number of outstanding lecturers as well as active participants. In addition, the group activities along the research lines "Atom-Radiation Interactions", "Classical and Quantum Liquids" and "Semiconductors Physics" have been also well-organized and successful.

In general, this re-organization of the Workshop helps to expose Condensed Matter physicists to the latest developments in the field. The overall response has been positive. At the same time, more pedagogical lectures are needed in the future to prepare less experienced researchers for entering new areas.

Yu Lu

Advanced Workshop on algebraic geometry, 15 – 26 August.

Title: ADVANCED WORKSHOP ON ALGEBRAIC GEOMETRY, 15 – 26 August.

Organizers: Professors M.S. Narasimhan (ICTP), C. Procesi (University of Rome I, Italy), and C.S. Seshadri (SPIC Science Foundation, Madras, India).

Report:

Objectives — The Workshop was organized for an audience of experts and young mathematicians from developing organized for an audience of experts and young mathematicians from developing countries, working in the area of Algebraic Geometry.

We selected two main topics for the Workshop, namely Geometric Invariant Theory (GIT) and Moduli Problems in Algebraic Geometry. These two fields are closely related and the developments in one have influence on the other. Classical Invariant Theory, which is at the background of GIT, has recently found many applications in Algebraic Geometry. Because of different motivations and the technical tools involved, mathematicians working in these areas do not often come together and our intention has been to bring them together to this Workshop.

We also intended to cover the new exciting developments coming from Physics, like Conformal Field Theory (CFT), which have influenced these areas.

Structure and organization

1. Two expository mini-courses;
2. Twenty-four one-hour talks by invited speakers;
3. Nineteen parallel sessions, where young mathematicians presented their own work.

own work.

Participation

The response from the mathematical community for the Workshop was very enthusiastic. There were invited speakers from all over the world and a large number of well-known experts and young mathematicians contributed significantly to the Workshop.

The meeting was also attended by several young European mathematicians, sponsored by the European Commission's Euroconference programme. There was also a strong participation from countries of the former Soviet Union. Several mathematicians from developing countries obtained full travel support from their countries to participate in the Workshop.

Total number of participants:	135
From developing countries:	57
EC-sponsored:	23
From the former Soviet Union:	9
From developed countries:	46

Scientific Content

There were two mini-courses, one on "Geometric Invariant Theory" by C.S. Seshadri and the other on "Quasi-projective moduli schemes for polarized Seshadri and the other on "Quasi-projective moduli schemes for polarized manifolds: A survey" by E. Viehweg.

The most recent results in the following main topics were presented:

- moduli of vector bundles on curves and surfaces and relationship with CFT;
- moduli of Riemann surfaces and relationship with matrix models;
- geometric and combinatorial methods in the representation theory of semi-simple groups;
- classical invariant theory and non-commutative algebra;
- recent developments in classical projective geometry;
- construction of new moduli spaces via GIT.

C. Procesi, C.S. Seshadri

Title: Third Trieste Conference on Chemical Evolution — Conference on the Structure and Model of the First Cell, the Alexander Ivanovich Oparin 100th Anniversary Conference, 29 August – 2 September.

Co-sponsors: European Commission (Brussels, Belgium), International Centre of Genetic Engineering and Biotechnology (ICGEB, Trieste, Italy), International Centre for Science and High Technology (ICS, Trieste, Italy), UNESCO (Paris, France) and International Science Foundation (ISF, Washington, DC, USA).

Organizers: Professors J. Chela Flores (Instituto Internacional de Estudios Avanzados, Caracas, Venezuela, and ICTP) and C. Ponnamperuma (University of Maryland, College Park, MD, USA).

Report: Sixty-seven participants came to the Third Trieste Conference on Chemical Evolution distributed geographically as follows: 20 from the Third World, 11 from East Europe, 22 from the countries of the European Union, and 14 from other industrialized nations.

This Conference commemorated the pioneering work of Alexander Ivanovich Oparin, whose fundamental contribution was published in 1924. Two years earlier the young biochemist had made a preliminary oral presentation at a meeting of the Russian Botanical Society. Oparin has the merit of having formulated the problem of life's origin in scientific terms. Charles Darwin had anticipated the importance of the problem in the last chapter of *The Origin of the Species*: *"Probably all the organic beings which have ever lived on this earth have descended from some primordial cell, into which life was first breathed"*. The science that Oparin created in his classical book *The Origin of Life* has now come of age, as it became evident to the participants of the Third Trieste Conference on Chemical Evolution.

Multiple factors have contributed to this recent advance, among which we may mention the remarkable growth of molecular biology, the emergence of computer chemistry, the robust efforts in improving the available instrumentation in preparation for a second generation of exploration of the solar system — Titan's atmosphere, which is a natural laboratory for chemical evolution; the forthcoming Japanese-Russian collaboration in the search for signs of life; new instruments that are being proposed for investigating interstellar matter for the most basic signature of life — amino acid chirality. In addition, progress has occurred in the work of micropaleontologists in identifying fossils of several species of cyanobacteria, and the independent work of geochronologists verifying the exact dates assigned to such fossils.

At the Oparin 100th Anniversary Conference these questions were discussed in depth. The Conference itself was introduced by Cyril Ponnamperuma (University of Maryland, USA) with a review of our current insights into the origin of the first cell from the work of Oparin himself to the present day. The most recent efforts in planetary search for signs of life were summarised by François Raulin (University of Paris) from the extensive studies of Titan's reducing atmosphere, and by Takeshi Saito (University of Tokyo, Japan) who described the extensive Japanese collaboration with Russia in their plans for sending a probe to Mars in a search for bioorganic compounds. The relevance of

Third Trieste Conference on Chemical Evolution — Conference on the Structure and Model of the First Cell, the Alexander Ivanovich Oparin 100th Anniversary Conference, 29 August – 2 September.

comets in the context of chemical evolution was carefully scrutinized in contributions by J. Mayo Greenberg (University of Leiden, The Netherlands), Alicia Negron-Mendoza (UNAM, Mexico), and Franz Krueger (Darmstadt, Germany). Vitalii Goldanskii (N.N. Semenov Institute, Russia) discussed the formation of complex molecules in extraterrestrial conditions.

Manfred Schildowski (Max-Planck-Institut für Chemie, Germany) and Steven Moorbath (University of Oxford, UK) presented, in their respective contributions, a well-balanced view of the antiquity of life on earth. Schildowski discussed the data on the isotopic signature of Archean rocks suggesting an early onset of life immediately after the cessation of the heavy impact period (Hadean era), but from the point of view of geochronology Moorbath argued that due care is needed with the earliest dates assigned to the fossil data (3.5 x 10^9 years before the present, ybp), or the analysis of the Isua sedimentary rocks (3.8 x 10^9 ybp). The early paleontological record was further analysed by Mohindra Chadha (Bhabha Atomic Research Centre, India) and by Vinod Tewari (Wadia Institute of Himalayan Geology, India).

The progress in the relevant areas of molecular biology was discussed by Peter Schuster (University of Jena, Germany), Alexander Spirin (Russian Academy of Sciences, Moscow), and Klaus Dose (I. Gutenberg University, Germany). A comprehensive view of the RNA world was balanced by the more recent work on pre-RNA world scenarios which Dose reviewed. The interest on these topics was enhanced as the earlier work on was enhanced as the earlier work on protein-before-nucleic-acid alternative was amply discussed by the pioneers in these studies of the thermal precursors of amino acids and proteinoid microspheres: Sydney Fox (University of South Alabama, USA), Kaoru Harada (Tsukuba University, Japan), as well as by their co-workers. Significant theoretical insights into the origin of the plasma membrane were brought to the attention of the conference by Emilio Del Giudice (University of Milan, Italy). Juan Oró (University of Houston, USA), Martino Rizzotti (University of Padua), and Dinesh Shah (University of Florida, USA) addressed the question of the formation of phospholipids and mechanisms for membrane formation in the primordial environment. Both Oró in his contribution on the primordial phospholipids and Georgi Gladyshev (Institute of Ecological and Biophysical Chemistry, Russia) in his theoretical approach to the thermodynamics of evolution emphasised the Darwinian basis of the search for the structure and function of the first cell. A closer look at the biochemistry of the membranes of the archaebacteria (Domain Archaea) was discussed in separate contributions by Tahiro Oshima (Tokyo Institute of Technology, Japan) and by Otto Kandler (University of Munich, Germany). Further aspects of the biochemistry of the early cells were discussed by Mikhail Kritsky and Ludmilla Moiseeva (A.N. Bach Institute of Biochemistry, Russia). Yu-Fen Zhao (Tsinghua University, China) presented her work which has given a new thrust to the simulation studies in prebiotic chemistry; she has identified an active molecule made up of an amino acid coupled to a phosphorylating agent.

The question of the handedness of the macromolecules of life is technically referred to as the problem of chirality, a term coined last century by Lord Kelvin, Professor of Natural Philosophy in the University of Glasgow. In the Oparin Conference the theoretical basis for chirality in the context of chemical evolution was, quite fittingly, described by Laurence Barron, a Professor of chemistry of the same university. Alexandra MacDermott (University of Oxford, UK) presented a new suggestion for the experimental search for extraterrestrial homochirality in interstellar matter. Lajos Kelszthelyi (Biological Research Center, Hungary) (Biological Research Center, Hungary) presented an updated review of the experimental question of the amplification mechanisms required if the electroweak interaction is correlated with the phenomenon. This included the novel mechanism which Abdus Salam had proposed three years ago at the First Trieste Conference. Wang Wenqing and Pan Xianming (Beijing University, China) discussed preliminary tests of the Salam amplification mechanism and recent modifications of it which may be responsible for homochirality; they considered specific heat anomalies in D- and L-valine and discussed some of the experimental difficulties in testing modifications, which avoid the large activation energies that ought to be overcome by the phase transition in the racemic mixture of protein amino acids.

The emergence of computer chemistry as a powerful technique in origin-of-life studies was illustrated by Benoît Prieur (University of Pierre and Marie Curie, France) in an original discussion on the origin of the genetic code, a topic which was further discussed by José Eduardo and Yvone Maria Hornos (University of São Paulo, Brazil), and Vladimir Otroshchenko (A.N. Bach Institute of Biochemistry, Russia).

Informational aspects of the evolution of the first cell were discussed by Carlo Bauer (University of Pisa, Italy), Romeu Guimaraes (Universidade Federal de Minas Gerais, Brazil), and by K. Tahir Shah (International Centre for Theoretical Physics, Italy).

The conference concluded with a discussion of the beginnings of biodiversity and the related question of eukaryogenesis. This topic was brought into focus by Julián Chela-Flores (International Centre for Theoretical Physics, Italy) in his discussion of the origin of the chromosomes, and by Joseph Seckbach (The Hebrew University of Jerusalem, Israel) in a detailed discussion of the hot springs alga *Cyanidium calidarium*.

The participants of this truly international gathering felt that a timely well-balanced review was achieved of the vast interdisciplinary field of research. The proceedings of the Conference will be published.

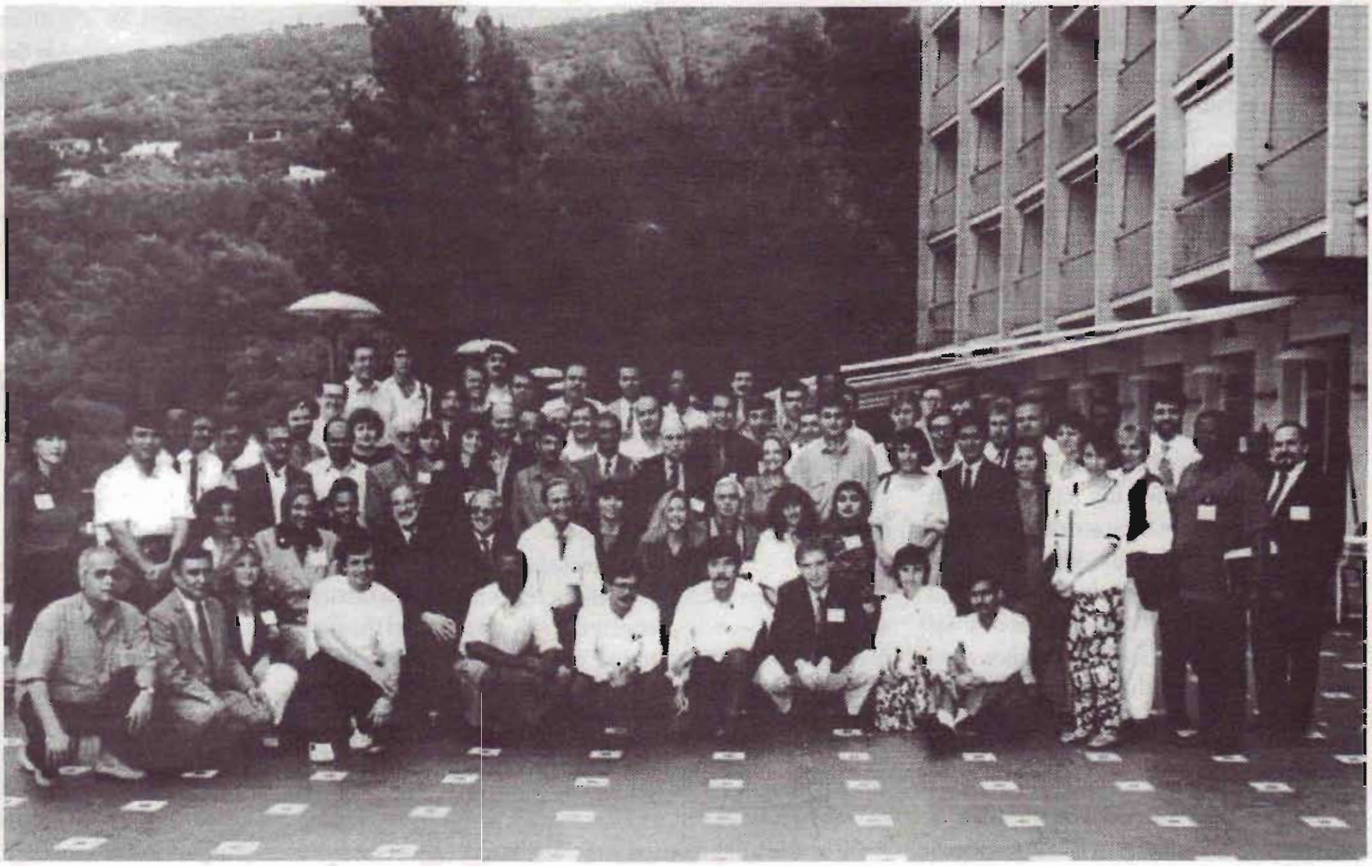
J. Chela-Flores

Title: College on medical physics: Radiation protection and imaging Radiation protection and imaging techniques, 5 – 23 September.

Co-sponsor: Kuwait Foundation for the Advancement of Science.

Organizers: Professors A.M. Benini (International Atomic Energy Agency, Vienna, Austria), R. Cesareo (Università "La Sapienza", Rome, Italy), J. Chela-Flores (Instituto Internacional de Estudios Avanzados, Caracas, Venezuela, and ICTP), H.A. Farach (University of South Carolina, Columbia, SC, USA), and S. Mascarenhas (Empresa Brasileira de Pesquisa Agropecuaria, São Carlos, Brazil).

Report: The College on Medical Physics fulfilled its objectives, namely to cover important current aspects in two topics of medical physics, specifically,



College on medical physics: Radiation protection and imaging techniques, 5 – 23 September.

new techniques in imaging applied to clinical requirements and radiation protection in diagnostic radiology. This subject was covered by a staff of 25 lecturers coming from Austria, Brazil, Denmark, Italy, Slovenia, Spain, Sweden, and the USA.

There was a poster session in which the participants had the opportunity to present results they had obtained in their the participants had the opportunity to present results they had obtained in their own institutions. Visits and practical exercises at Cattinara and Maggiore Hospitals were also organized.

There were 71 participants with a broad background coming from:

(i) Atomic energy agencies, commissions and institutes, Area di Ricerca (Trieste).
(ii) Cancer centers and clinics.
(iii) Departments of Atomic Physics, Biochemistry, Biology, Biomathematics, Biophysics, Clinical Pharmacology, Electrical Engineering, Health, Medical Center, Medical Engineering, Medical Physics, Neurology, Nuclear Medicine, Nuclear Physics, Oncology, Pathophysiology, Physics, Radiology, and Radiotherapy.
(iv) Institutes of Hygiene and Epidemiology, Meteorology and Hydrology.
(v) Medical Colleges.
(vi) National Centres for Radiation Research and Technology and National Institutes of Public Health.
(vii) Nuclear Research Centres.

National Institutes of Public Health.
(vii) Nuclear Research Centres.

The geographical distribution of the participants' 32 countries of origin was as follows:

AFRICA: Ethiopia, Ghana, Nigeria.
ARAB REGION: Algeria, Egypt, Jordan, Iran, Israel, Lebanon, Sudan, Syria.
ASIA: Bangladesh, India, Indonesia, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Russia, Ukraine, Uzbekistan, Viet Nam.
LATIN AMERICA: Argentina, Brazil, Cuba, Dominican Republic, El Salvador, Mexico.
EUROPEAN UNION: Italy, Portugal.
NON EUROPEAN UNION: Albania, Bulgaria, Czech Republic, Poland, Romania, Slovak Republic, Slovenia, Turkey.

	Countries	Participants
AFRICA	3	5
ASIA	12	17
ARAB REGION	8	14
LATIN AMERICA	6	11
EUROPEAN UNION	2	6
NON EUROPEAN UNION	8	16
TOTAL	39	69

TOTAL 39 69

The main subjects discussed by the invited speakers during the College were divided as follows:

- Dosimetry,
- Imaging,
- Nuclear Medicine,
- Principles of Electronic Spin Resonance & Nuclear Magnetic Resonance,
- Radiation Protection.

The practical sessions were followed by the participants. Adequate equipment was provided for them.

The excellent work of the Directors should be preserved by retaining them as a team. Their work guaranteed the high standard that ICTP should strive for in its activities.

Recommendations

The experimental part of the College was extremely valuable and provided excellent academic opportunities to the participants. It is the opinion of the organizers of the College that this is an essential aspect of the activities. In fact, sometimes the greatest benefits from the College are the close personal contacts between the lecturers and the participants, as well as the detailed discussions on research topics which are greatly appreciated by the participants.

The poster session is another fundamental part of the activities. It is the main opportunity for the participants to communicate what they are doing in their own countries. This provides an excellent opportunity for discussions and consultations. The organizers are of the opinion that posters should be announced in the first bulletin; they recommend that the ICTP authorities envisage awarding a prize for the best contributions to the poster session.

The College of Medical Physics, a well established activity of ICTP, responds to a real, urgent need of developing countries and should not only be continued, but it should also be reinforced as far as the available funds will allow.

Additional Workshops (as the one in March 1994) and Conferences (such as the Giorgio Alberi Memorial Conferences) should be encouraged.

J. Chela-Flores

Title: INTERNATIONAL WORKSHOP ON PARALLEL PROCESSING AND ITS APPLICATIONS IN PHYSICS, CHEMISTRY AND MATERIAL SCIENCE, 5 – 23 September.

Co-sponsors: International Centre for

Co-sponsors: International Centre for Science and High Technology (ICS, Trieste, Italy), and United Nations University (Tokyo, Japan).

Organizers: Professors M.V. Bhatkar (Centre for Development of Advanced Computing, Pune, India), A. Nobile (ICTP), and M.V. Pitke (Tata Institute of Fundamental Research, Bombay, India).

Report: Parallel Processing has been a subject of intense research all over the world. Although a large number of conferences and workshops is organized every year, most of them deal with theoretical aspects of parallel processor architectures and languages. Very few, if any, deal with real applications. Also, the field of parallel processing has reached a good degree of maturity with extensive applications in different branches of science and engineering. These factors and the interest and support of several well-known experts in the field have resulted in the successful organization of this Workshop which was devoted entirely to parallel processing applications with laboratory exercises for hands-on experience. Perhaps the most important feature of this Workshop was the availability of two parallel processors, the CHIPPS and the PARAM (both from India) in the laboratory, along with remote access to the APE system from Italy. A simulator for the ANUPAM system (from India) was also available for getting first-hand programming experience.

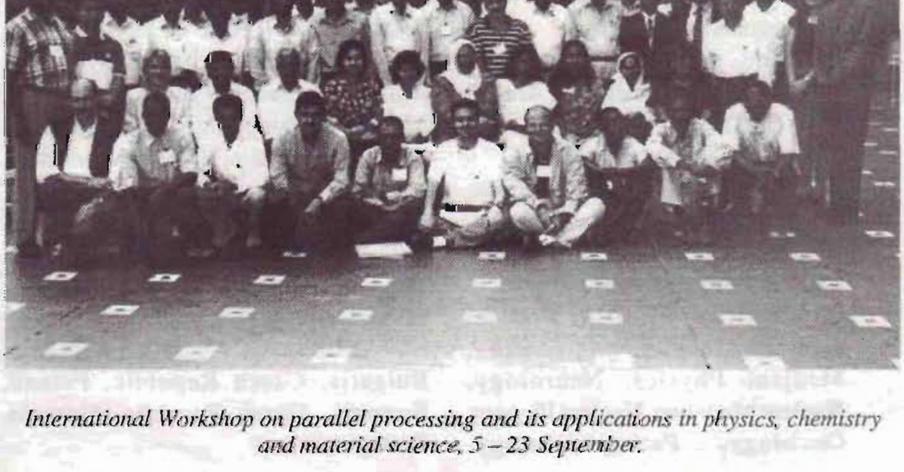
The programme of the Workshop was split into three areas. The first week was devoted towards architectural and algorithmic issues. During the second week, lectures on basic techniques such as matrix, FFT and Monte Carlo were covered. A number of applications such as weather modelling, high energy physics, molecular dynamics, energy, and industrial artificial vision were discussed during the third week. This was also a good opportunity for designers and users of the parallel processing systems to discuss their ideas, experiences and problems. Issues in real time processing and fault tolerance were also highlighted. A direct result of this Workshop was the establishment of feasibility of developing a teraflop machine based on a gallium arsenide gigabit crossbar switch chip that could be designed at the ICTP Microprocessor Laboratory.

There were 54 participants (which included 10 ICTP associates) in all, 12 instructors and 15 lecturers representing about 35 nationalities. The total number of lectures was forty two. In the laboratory, a total of 30 experiments were available. Every participant was given 10 hours on each parallel processing system. They could choose the experiments most suited to their background and applications. A detailed laboratory handbook was also provided. Most participants could complete about 10 different applications.

Participants expressed their satisfaction with the laboratory facilities and the support and guidance provided by the instructors. Considering their varied background, it was felt that more time was required to complete the laboratory exercises. Many wished to have this workshop organized periodically and if possible in their region (a regional workshop is being organized in Yaoundé, Cameroon, during July/August 1995).

Prof. L. Bertocchi, Acting Director of ICTP, inaugurated the Workshop on 5 September. Dr. V.P. Bhatkar of CDAC, India and Prof. M.V. Pitke of TIER, India, were the directors. Dr. M. Periasamy coordinated the laboratory. Prof. Alvise Nobile was the local coordinator.

M.V. Pitke



International Workshop on parallel processing and its applications in physics, chemistry and material science, 5 – 23 September.

Calendar of Activities at ICTP in 1995

SMR	Activity	Dates
838	Seventh international workshop on computational condensed matter physics: total energy and force methods	11 - 15 January
815	Tempus meeting on fiberoptics	30 January - 11 February
841	Fourth ICTP-URSI-ITU (BDT) college on radiopropagation: propagation, informatics and radiocommunication system planning	30 January - 3 March
	followed by	
	846 Second workshop on rural communications in developing countries	6 - 10 March
842	Conference on ultrafast transmission systems in optical fibres	13 - 17 February
899	First Bolivian course on computerized data acquisition techniques	13 - 25 February
843	Theoretical and experimental workshop on the physics of semiconductor microstructures, to be held in Campinas, Brazil	13 - 24 February
844	Adriatico research conference on lower dimensionality semiconductor systems, to be held in Campinas, Brazil	20 - 24 February
845	Second winter college on optics	20 February - 10 March
847	Conference on topological and geometrical problems related to quantum field theory	13 - 24 March
893	Seminar on signalling system No. 7 for French-speaking African countries	20 - 24 March
848	Spring school and Workshop on string theory, gauge theory and quantum gravity	27 March - 7 April
849	Conference on recent developments in statistical mechanics and quantum field theory	10 - 12 April
894	Third ESF Workshop: Network on quantum fluids and solids "Excitations and spin-polarised systems"	20 - 26 April
852	Conference on perspectives in nuclear physics at intermediate energy	8 - 12 May
853	Antonio Borsellino College on neurophysics	15 May - 9 June
854	College on computational physics	15 May - 9 June
855	Workshop on dynamical systems	22 May - 2 June
856	Trieste Conference on S-duality and mirror symmetry in string theory	5 - 9 June
865	Workshop on computational methods in material science and engineering	12 - 23 June
858	Summer school in high energy physics and cosmology	12 June - 28 July
	including Workshop on strings, gravity and related topics	29 - 30 June
859	Research workshop on condensed matter physics	12 June - 18 August
	including Working group on "Surface and bulk magnetism"	26 June - 7 July
	and Working party on the fabrication, physics and applications of quantum dots	31 July - 4 August
860	Adriatico research conference on physics of sliding friction	20 - 23 June
862	Workshop on quantitative biophysics at the molecular and macromolecular scales	29 June - 7 July
	including	
	866 Adriatico research conference on biophysics at the molecular and mesoscopic scale	4 - 7 July
857	Miniworkshop on strong electron correlations	3 - 21 July
863	4th School on non-accelerator particle astrophysics	17 - 28 July
861	Adriatico research conference on chaos in atoms and moleculs	18 - 21 July
851	Symposium on African drought	31 July - 4 August
892	African regional workshop on parallel processing and its applications, to be held in Yaoundé, Cameroon	31 July - 11 August
889	Miniworkshop on Josephson junction arrays	7 - 11 August
867	Workshop on nonlinearity: noise in nonlinear systems	14 - 25 August
...	Adriatico Research Conference on contemporary concepts in condensed matter physics, to be held in Gothenburg, Sweden	18 - 22 August
869	Conference on partial differential equations and applications to geometry	21 August - 1 September
868	Adriatico research conference on randomness, stochasticity and noise	22 - 25 August
870	Adriatico research conference on information theory in classical and quantum physics	29 August - 1 September
895	Trieste conference on chemical evolution IV: Physics of the origin of life	4 - 8 September
871	Workshop on general theory of partial differential equations and microlocal analysis	4 - 15 September
873	College on soil physics	11 - 29 September
872	Workshop on non-conventional energy sources	18 September - 6 October
874	Autumn college on plasma physics	18 September - 13 October
875	Workshop on telematics	2 - 20 October
876	Topical workshop on plasma physics: Collective processes in nonlinear media	16 - 20 October
888	Conference on oceanography: "Antonio Michelato" memorial	23 - 27 October
896	Summer school in radiophysics	23 - 27 October
880	IX International symposium on ultrafast processes in spectroscopy (UPS '95)	30 October - 3 November
877	Third school on the use of synchrotron radiation in science and technology: "John Fuggle memorial"	30 October - 1 December
879	Third workshop on non-linear dynamics and earthquake prediction	6 - 17 November
878	Workshop on "Physics and chemistry and of transitional metal oxide including high T_c superconductors, to be held in Bangalore, India	19 November - 5 December
897	UN/ESA conference on optics in space science and technology	20 - 25 November
898	Adriatico Research conference on trends in collider spin physics	4 - 8 December

869 Conference on partial differential equations and applications to geometry ... 21 August - 1 September

Getting Information on ICTP Activities via Computers

Information on the various ICTP activities throughout the year can be retrieved via electronic mail, the Internet Gopher and WWW. The procedure is as follows.

Using Electronic Mail

(1) Scientific Program of ICTP Activities

The complete Scientific Program can be obtained by sending an e-mail to

`smr@ictp.trieste.it`

using as `Subject:` **`get calendar`**

Note: The Scientific Program is constantly updated. So, please check the issue date.

To each activity listed in the Scientific Program there is an associated **`smr-`*`number`*** from which you can obtain more detailed information, when available.

(2) Information on a specific ICTP activity

To receive a list with the names of documents available for a particular activity, you should first identify the `smr###` code as indicated above. Then send an e-mail to

`smr###@ictp.trieste.it`

using as `Subject:` **`get index`**

If you send another mail to

`smr###@ictp.trieste.it`

using as `Subject:` **`get`** *document_name* (e.g., **`announcement`**, etc.)

you will receive detailed information on the topic *document_name*.

Note: If you wish more than one document of an activity then use

`Subject:` **`get`** *doc1 doc2* ... etc.

Using Internet Gopher

The ICTP Gopher server allows you to explore, search and retrieve general information regarding the many scientific activities carried out at ICTP. It is possible to access the Gopher space by issuing the Gopher command and exploring the branch *"Other Gopher servers in the world"* pointing to the geographical region: `Europe→Italy→ICTP`.

To access directly to the ICTP server, you can issue the command:

`gopher gopher.ictp.trieste.it`

Using World-Wide Web

The ICTP WWW server allows you to obtain basically the same information available on the ICTP Gopher server, but through the World-Wide Web protocol.

server, but through the World-Wide Web protocol.

The ICTP WWW server URL is: **`http://www.ictp.trieste.it/`**

News from ICTP is also available on Gopher server.

International Centre for Theoretical Physics
of IAEA and UNESCO
P.O. Box 586
34100 Trieste
Italy

Telephone: (40) 2240111
Cable: CENTRATOM
Telex: 460392 ICTP I
Telefax: (40) 224163
E-mail: sci_info@ictp.trieste.it

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Editor: Faheem Hussain. Editorial Assistant: Anna Triolo. Photos: L. Scrobogna (except Page 15).