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International Centre for Theoretical Physics

News from ICTP

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Upon his arrival, Prof. G. Furlan (ICTP) was welcomed by (from left to right) Prof. H.P. Garg (Unesco Chair at the Indian Institute of Technology, IIT, New Delhi, and President of the India-ICTP Chapter), Shri S. Krishna Kumar (Minister of State for Non-conventional Energy Sources and Agriculture), and Prof. N.C. Nigam (Director of IIT).

Inside:

India-ICTP Chapter
Renewable Energy Technology in India

Access to renewable energy sources

Access to renewable energy sources in a context of sustainable development is an important issue for the world in general and for India in particular. Considerable efforts in Research & Development in this area, in the last ten-fifteen year, are now bearing fruit in industrial applications. To review and discuss the present status of the knowledge in these applications, a workshop on renewable energy technology was organized by the India-ICTP Chapter and held at the Indian Institute of Technology (IIT) of Delhi on 20-22 April 1994. The organizers of the meeting were Profs. H.P. Garg (IIT), G. Furlan (ICTP), and Dr. G. Sciarabba, Scientific Attaché of the Italian Embassy in Delhi. The programme of lectures

covered the main aspects of renewable

covered the main aspects of renewable energy i.e., biomass gasification, biogas technology, wind power technology, mini- and micro-hydropower, passive solar energy devices, photovoltaics, materials for energy conversion and others.

The opening ceremony, presided over by Prof. N.C. Nigam, Director of IIT, was attended by Shri S. Krishna Kumar, Minister of State for Non-conventional Energy Sources and Agriculture, Shri L.M. Menezes, Secretary (Ministry of Non-conventional Energy Sources), and H.E. Dr. G. Menegatti, Ambassador of Italy in India.

In addition to the Indian lecturers, thirteen Italian scientists and technologists from the Italian National

Council for Research, the Italian Agency

Council for Research, the Italian Agency for New Technologies, Energy and Environment (ENEA) and from other institutions or industries contributed to the scientific programme. More than two hundred scientists took part in the Workshop. The meeting provided an opportunity for discussing and making preliminary plans for scientific cooperation between Indian scientists and the ICTP.

The Workshop was also an occasion for the Members of the India-ICTP Chapter to meet, to discuss their problems and to know one another better, for the first time after the creation of the Chapter. More than a hundred and sixty scientists from all over India took part in

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Nuclear Data for Nuclear Science and Technology — Services to and Contributions by the Developing Countries

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1. Introduction

Seventeen percent is the share of nuclear energy in the world's current electric energy production. It is produced in 424 operating nuclear power reactors with a total output of 331.000 MW (electric) in 14 advanced and 16 developing countries. The addition of further 72 nuclear power reactors with 60.000 MW(electric) now under construction in 6 advanced and 13 developing countries will, when completed, bring the nuclear share of worldwide electricity production to 400.000 MW(electric), produced by about 500 nuclear power reactors in 14 advanced and 19 developing countries. In many countries, including several developing countries, nuclear energy has thus become an indispensable part of the national energy production. The leading advanced country is France with a nuclear share of 73%; in 9 developing countries the nuclear share amounts already today to more than 20%. Moreover, while the growth of nuclear power is currently slowing down in advanced countries, an upward trend can be observed in developing countries [1]. advanced countries, an upward trend can be observed in developing countries [1].

Currently 304 nuclear research reactors are operating in 59 countries of which 213 are in 19 advanced countries, i.e. 82 in the USA and 131 in 18 other advanced countries [2, 3]. While nuclear power reactors are still almost exclusively used for electricity production and thus contribute significantly to meet the growing energy demand of developing countries, nuclear research reactors and associated laboratories are multidisciplinary tools for basic and applied research, commercial services, industrial applications and nuclear manpower training for peaceful uses. They have thus become important for the development of the national economy and scientific-technological infrastructure particularly in developing countries [3, 4], where they represent a relatively huge investment in national research and development. Applications of research reactors cover such diverse fields as physics, chemistry, biology, agriculture, medicine, geology and mining, environmental sciences, archaeology and forensic sciences as well as nuclear reactor physics, engineering and safety, and training in these disciplines [4].

While advanced countries exhibit a significant decrease in the number of research reactors, illustrated by the shutdown of altogether more than 240 facilities and only 8 facilities being under construction or planned, the corresponding figures for developing countries — only 21 facilities shutdown and 16 under construction or planned — show a slow, but steady increase [4].

As a consequence, in a number of developing countries, nuclear sciences and industries contribute increasingly to the growth of the national scientific-technological infrastructure, energy production, economy and human technological infrastructure, energy production, economy and human welfare.

The introduction of nuclear technology and sciences requires a wide variety of scientific and engineering skills and personnel who are thoroughly trained not only in all engineering aspects of nuclear technology including the design, operation and safety of nuclear power and research reactors, their incorporation in the national research and energy distribution domain, and in the production and use of nuclear radiations and isotopes, but also in the physical and chemical principles of nuclear reaction and decay processes and radiation transport, including an understanding of the nuclear fission process basic to nuclear reactors and the type, mechanism and size of this and all other nuclear reaction and decay processes occurring in nuclear reactors as well as in the various applications of radiations and isotopes. Nuclear experimental and theoretical physics and also nuclear chemistry are the basic research tools for the qualitative understanding and quantitative determination of these nuclear reactions and decay processes in terms of nuclear data. These nuclear data form the basic input to nuclear reactor physics design, operation and safety calculations as well as to the prediction and analysis of the dose strengths and environmental effects of nuclear radiations and isotopes [5, 6]. It is these basic aspects of nuclear energy and sciences, quantitatively expressed in terms of nuclear data, which we shall examine in detail with particular emphasis on the needs and contributions of the developing countries.

2. Definition of nuclear data

Nuclear physics data or briefly nuclear data are numerical values which characterize and quantify the interactions of particles and radiations with atomic nuclei as well as the intrinsic properties, internal structure and decay modes of atomic nuclei. For nuclear technology and science applications of nuclear radiations and isotopes the following four types of nuclear data are important [7]:

(1) *Nuclear constants* such as nuclear masses, nuclear binding energies of nucleons and heavier particles, and isotopic abundances;
(2) *Nuclear structure data* comprising isotopic abundances;
(2) *Nuclear structure data* comprising nuclear ground and excited states, and their energies and quantum properties;
(3) *Nuclear decay data* comprising total and partial half lives of decaying nuclear ground and excited states, and decay branching ratios, energies and intensities of alpha-, beta- and gamma-radiations emitted in radioactive decay of nuclei, energy spectra of neutrons emitted in spontaneous fission of actinide isotopes etc.;
(4) *Nuclear reaction data* comprising neutron nuclear reaction data, photonuclear, charged particle (p, d, t, He-3, alpha) and light and heavy ion nuclear reaction data.

Nuclear data are the basic indispensable input data for all scientists and engineers in the solution of nuclear problems; they must be universally available in forms convenient for use and with specified accuracies to meet the requirements for the design, operation and safety of nuclear installations as well as for environmental radiation protection. Nuclear scientists and engineers, designing the physics and safety characteristics of nuclear power and research reactors, need predominantly computer files of cross section data for neutron nuclear fission and a variety of competing neutron scattering, absorption and multiplication reactions. Nuclear and other sciences such as physical, chemical, life, earth and social sciences, agriculture, material research and industry employing nuclear methods, need mostly comprehensive and up-to-date handbooks and computer files of data on nuclear structure and radioactive decay [6, 7].

3. Sources of nuclear data

The main source of nuclear data are nuclear physics experiments with nuclear particle accelerators such as linear accelerators, Van de Graaff and tandem accelerators, cyclotrons and 14 MeV neutron generators as well as nuclear research reactors. The nuclear data requirements for nuclear energy and sciences, however, are so large that they cannot be satisfied by experimental measurements alone [7, 8].

More recently, the theoretical understanding and modelling of nuclear reactions has been significantly improved and refined to the extent that,
reactions has been significantly
improved and refined to the extent that,
with suitable parameterisation and fitting to accurately known experimental data, they are being used for filling gaps, inter- and extra-polation and consistency checking of available experimental data, as well as for bulk computations of whole classes of nuclear reaction data such as nuclear activation cross sections. They are also being used for the prediction of "unmeasurable" data such as neutron cross sections of highly radioactive fission products and actinide nuclei. A variety of comprehensive nuclear model computer codes are used for this purpose, a development which was also enabled and stimulated by the recent rapid development of ever more powerful computers.

4. How are nuclear data used?

We restrict ourselves to several prominent examples of the importance and actual use of nuclear data in nuclear reactor design and safety and in nuclear science applications. For a more comprehensive review the reader is referred to reference [7].

The fissionability of very heavy nuclides by neutrons detected by Hahn, Meißner and Strassmann 55 years ago [9] and the emission of more than one neutron in the fission process detected shortly afterwards by Halban, Joliot and Kowarsky [10], combined with the liberation of an average energy of about 200 MeV per fission event, are the physics basis of nuclear power and research reactor technology. Their quantification in terms of the microscopic neutron fission cross section — the average number and the energy spectrum N(E) of the neutrons emitted in fission, as a function of the kinetic energy of the neutrons causing fission — are the basic and most important input nuclear data to nuclear reactor physics design and safety calculations.

More specifically, the energy output of a nuclear reactor is directly proportional to the kinetic energy of the fission fragments converted to thermal energy by their slowing down in the fuel medium. The fission cross section determines the quantitative importance of fission reaction rates in a reactor relative to other competing neutron absorption, scattering and multiplication cross sections and reaction rates. The effective neutron multiplication factor of a nuclear reactor — keff — is directly
effective neutron multiplication factor of
a nuclear reactor — keff — is directly
proportional to the average number of neutrons emitted in fission. When calculating keff, all other neutron absorption reactions in a reactor competing with fission, as well as the leakage of neutrons out of the fissioning zone of the reactor, have to be taken into account. The energy spectrum of fission neutrons with an average neutron energy of 2 MeV is the neutron source term in reactor physics calculations, and, depending on the material composition of the reactor and upon neutron slowing down through elastic and inelastic scattering with reactor material nuclei, determines the neutron energy spectrum of a reactor. Most of the fission neutrons are emitted promptly during the fission process; a small fraction is emitted afterwards by several fission fragments with a delay of up to several tens of seconds. This causes a time delay in neutron multiplication which allows the reactor operator to control the criticality of the reactor.

In fission processes more than 800 different fission products, 200 of them important for the reactor neutron economy, are produced with atomic weights ranging from A = 60 to A = 160, with maximum yields for atomic weights between 90 and 100, and between 130 and 140. These fission products are gradually being built up during the operation of a reactor and form an increasingly important source of "parasitic" neutron absorption causing keff to decrease as a function of reactor operation time. In addition to fission products, during reactor operation inventories of higher actinides (up to 200, 30 being important) are being built up through neutron capture and (n,2n)-processes in the main fissile and fertile actinides and subsequent alpha- and beta-decays. The calculation of reactor inventories of fission products and higher actinides and of their influence on keff as a function of reactor operating time requires an input of all neutron scattering, absorption and, for higher actinides, fission cross sections of these nuclei as well as of their decay half lives, radiation energies and intensities.

The so-called resonance Doppler effect plays an important role as an inherent safety mechanism of nuclear reactors. It consists in the increase of neutron fission and capture rates in fuel isotope neutron resonances with
neutron fission and capture rates in fuel
isotope neutron resonances with
increasing fuel temperature due to the temperature dependence of the relative motion of neutrons and nuclei in the fuel lattice. The Doppler temperature coefficient describes the temperature-dependent change of keff due to this effect. Reactor designers require it to be negative, so that keff drops automatically below 1 and the reactor shuts down in case of an accidental sudden increase of the fuel temperature. This condition is fulfilled, if with increasing temperature the neutron capture rates in the fuel increase more strongly than the neutron fission rates. In thermal nuclear power reactors with natural or slightly enriched uranium fuel this condition is always fulfilled, whereas in fast reactors it limits

the admissible proportion of fissile to fertile material. Correct predictions of the Doppler coefficient of a reactor require the accurate knowledge of the parameters of hundreds of resonances of fissile and fertile nuclei. Only after more than 30 years of intensive experimental research and theoretical analysis a satisfactory knowledge of fuel resonance properties could be achieved.

An indispensable safety requirement of any nuclear reactor is that the neutrons and gamma-radiations produced in the reactor are shielded to the reactor environment below tolerance doses. This is technically achieved by surrounding the reactor with a thermal shield followed by a thick biological shield. The thermal shield consists of heavy materials such as Fe or Pb which are particularly efficient in absorbing the gamma-radiation. The biological shield which absorbs mostly the neutrons consists usually of concrete with Ba, Ca, Fe, Si and O as main constituents. For accurate and economic estimates of the thickness and effectiveness of the shield, the cross sections for all neutron reactions with the isotopic constituents of all thermal and biological shield materials have to be known and entered as input data to the Monte Carlo or discrete ordinate computer code calculations of neutron and gamma-ray shielding.

These few examples taken from nuclear reactor technology and safety must suffice to illustrate the importance, large variety and volume and actual utilisation of nuclear data required for reactor physics design, operation and safety calculations.

Material analysis through neutron
safety calculations.

Material analysis through neutron activation and the production and use of radioisotopes are two prominent examples of nuclear data requiring nuclear techniques employed also in many developing countries in a large variety of nuclear and non-nuclear sciences.

Activation of material samples with thermal neutrons in nuclear research reactors or with 14 MeV neutrons in fast neutron generators and subsequent analysis of the characteristic gamma-rays emitted by the activated isotopes of the irradiated materials is widely used for the analysis of bulk material compositions as well as of minor or trace elements such as impurities in geological, biological, medical, agricultural, environmental, archaeological, and industrial research. The theoretical analysis of the experiments and their results requires correct input values for the isotopic cross sections for the neutron activation reactions used at thermal and 14 MeV neutron energies respectively as well as for the decay half lives and gamma-ray spectra of the activated isotopes. The high sensitivity of neutron activation analysis in thermal neutron research reactors and fast neutron generators to about 80% of the naturally occurring isotopes [4] gives an idea of the widespread applications and the large volume of nuclear data needed for the successful application of this technique.

A large variety of radioisotopes are produced mainly in nuclear research reactors and in cyclotrons and widely used in medical diagnostics and therapy, non-destructive material testing, hydrological investigations of subterranean water flow and resources, agriculture, chemical processing, meteorology and mining. In nuclear research reactors the nuclear fuel has to be arranged so as to create optimum conditions for radioisotope production. This requires extensive calculations of neutron flux and power distributions within the reactor, requiring neutron cross sections of all reactor materials as input data as well as neutron cross sections and decay data for the production of the desired and competing non-desired radioisotopes. In cyclotrons, irradiation of specimens with fast neutron or proton beams is commonly used for radioisotope production. Again, not only the desired isotope, but usually also competing unwanted isotopes are being
the desired isotope, but usually also competing unwanted isotopes are being produced. In order to create optimum irradiation conditions for the production of the desired isotope, the neutron cross sections for the production of the wanted and not wanted isotopes and their nuclear decay properties have to be known.

5. Collection of nuclear data

From the above few examples it is apparent that physics computations in the field of nuclear energy and safety as well as in nuclear science applications require a very large volume of nuclear reaction, structure and decay data for particle energies from below meV to higher than 10 MeV for a large number of elements and their isotopes over the whole periodic table of the elements. A worldwide co-operative effort for more than 30 years between many nuclear research laboratories, nuclear data centres and data users in nuclear sciences and industries was needed to create user-tailored, comprehensive, nuclear data bases and to make them internationally available to every nuclear scientist and engineer in the world. The major efforts were and are still concentrated in advanced countries with major nuclear power programmes. Developing countries, with few noticeable exceptions, embarked later than advanced countries in nuclear science and technology programmes. Since they were and are usually still lacking the necessary expertise, facilities and funds, they had and still have to be provided with extensive nuclear data services and detailed advice in the utilisation and processing of nuclear data. Over the last decade this situation has slowly started to change. Due to the combined assistance by the IAEA Nuclear Data Section (IAEA/NDS), the IAEA Technical Cooperation (TC) Programme and biennial workshops jointly organised by the ICTP and IAEA/NDS and held at the ICTP in nuclear and reactor physics and nuclear data, many developing countries are now not just passive receivers of nuclear data information, but render small but significant contributions to the international nuclear data effort, as shall be illustrated below.

Since 30 years the IAEA/NDS coordinates the worldwide systematic collection, exchange and dissemination of neutron nuclear reaction data through a network of four major nuclear data centres, i.e.:
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centres, i.e.:

- National Nuclear Data Center (NNDC), Brookhaven National Laboratory, USA;
- OECD/Nuclear Energy Agency Data Bank (NEA-DB), Paris, France;
- Centr po Yadernym Dannym (CJD = Nuclear Data Centre), Obninsk, Russia; and
- IAEA Nuclear Data Section, Vienna, Austria.

Upon mutual agreement, a geographical service area is assigned to each of these data centres as follows:

NNDC	– USA and Canada;
NEA-DB	– Western European countries and Japan;
CJD	– Russia and countries belonging to the former USSR;

IAEA/NDS – All other countries comprising (mostly developing) countries in the Middle East and Asia (except Japan), Africa, Latin America, Eastern Europe (except countries served by CJD), Australia and New Zealand.

Each centre collects the nuclear data originating from its service area, stores and exchanges them with the other data centres in agreed-upon computer formats, and disseminates nuclear data to scientists in its service area. Note that almost all developing countries are located in the service area of IAEA/NDS. This entails a specific responsibility to IAEA/NDS for co-operation with developing countries and the transfer of nuclear data and associated expertise to these countries.

The main continuously updated products of this co-operation are

EXFOR a comprehensive annotated computer file of experimentally measured neutron cross sections with several million data records [11]; and

CINDA a comprehensive compact computer index to the scientific literature references on experimental, theoretical and evaluated neutron data, available as retrievals from the computer master file as well as in the form of an annually updated handbook published by the IAEA [12].

Usually, neither experimentally nor theoretically determined data can be used directly in nuclear technology and science applications. They have to be transformed into sets of numbers which can be conveniently used as input to such transformed into sets of numbers which can be conveniently used as input to such applications. This transformation process is called evaluation, and its results are called evaluated data. Evaluation includes critical comparison, selection, renormalization and averaging of the available experimental data and their complementation with nuclear data calculated with nuclear models, and as last step the creation of computer files of the evaluated data.

Nuclear data evaluation and the development of evaluated nuclear data files is usually performed by evaluation groups or individual evaluation scientists at universities and national nuclear laboratories in many countries. The co-operation between these groups and individuals is coordinated by the NEA-DB and IAEA/NDS on an international scale and by national data centres on a national scale such as by NNDC in the USA, CJD in Russia and other countries of the former USSR, JNDC, the Japanese Nuclear Data Centre in Japan, and CNDC, the Chinese Nuclear Data Centre in China.

The main products of these coordinated efforts are the following evaluated nuclear data files in their latest freely available versions (all released after 1990):

ENDF/B – 6 US Evaluated Nuclear Data File, Version 6;

JEF – 2 Joint Evaluated File produced by NEA countries and coordinated by NEA–DB, Version 2;

JENDL – 3 Japanese Evaluated Nuclear Data Library, Version 3;

BROND – 2 Russian Evaluated Nuclear Data File, Version 2;

CNDL – 2 Chinese Evaluated Nuclear Data File, Version 2.

As another major achievement of the co-operation between nuclear data centres and evaluators, the ENDF format has been adopted as the internationally valid computer format for the storage, exchange, comparison and utilization of all the above and other evaluated nuclear data files.

The major basic file for nuclear structure and decay data is the internationally freely available computer-based Evaluated Nuclear Structure Data File (ENSDF) which comprises the currently recommended "best" values of all nuclear structure and decay data. This file is the result of a co- operation between 19 data centres and decay data. This file is the result of a co- operation between 19 data centres and evaluation groups in 11 countries and three international organisations which is jointly coordinated by NNDC and IAEA/NDS. Through a topical subdivision of work by isobaric mass chains assigned to each participating group, this network aims at a complete and continuously updated evaluation of all nuclear structure and decay data with a 6 year update cycle, which are being published in the journal Nuclear Physics A [13] and in the Nuclear Data Sheets [14]. Another widely used comprehensive source of nuclear structure and decay data is the Berkeley Table of Radioactive Isotopes Handbook [15].

6. Nuclear data services and technology transfer to developing countries

Apart from the assessment of nuclear data needs and the coordination of nuclear data research, collection and exchange, the main task of the IAEA/NDS as partner in the Four Data Centre Network is to render nuclear data services and to organise the transfer of expertise in nuclear data production, utilization and processing to scientists in developing countries. In this task the co-operation between IAEA/NDS and the ICTP plays an important role. The following remarks are partially based on a thorough evaluation by the author of the IAEA/NDS data service and transfer activities in the period 1985-88, many results of which still hold for the present situation [16].

According to this review, IAEA/NDS receives and fulfils an annual average of 500 specific requests from individual nuclear scientists and engineers in 170 scientific institutions in close to 60 developing countries for numerical nuclear data files, scientific documents and data processing codes. The purposes of these requests range from design and safety analysis of nuclear power and research reactors, the planning and testing of nuclear data measurements and computations to nuclear analyses connected with the production of radioisotopes, biomedical and industrial applications. In addition, IAEA/NDS disseminates about 10000 documents per year to nuclear scientists and engineers in 76 developing countries. These documents include scientific reports issued under the auspices of the International Nuclear Data Committee issued under the auspices of the International Nuclear Data Committee (INDC), the permanent international advisory body to the Director General of IAEA in the field of nuclear data, the proceedings of scientific meetings, data handbooks, bulletins and nuclear data newsletters; the distribution of these documents is tailored in accordance with continuously updated 40 different interest profiles.

These nuclear data services are supplemented and supported by biennial training workshops organised jointly by IAEA/NDS and ICTP and held at the ICTP in Trieste, interregional technical co-operation (TC) training courses and TC projects. Fifty-six developing countries benefit from these activities.

The subjects of the joint IAEA/NDS-ICTP workshops alternate biennially between application of nuclear data in reactor physics and safety calculations, of main interest to nuclear reactor physicists and engineers in universities, national nuclear laboratories and industries, and nuclear model computation and analysis of nuclear data relevant to nuclear energy and safety, of main interest to basic and applied nuclear physicists from universities and national nuclear laboratories working in nuclear data evaluation, computation, analysis and processing of nuclear cross sections and in the development of nuclear models and associated computer codes. A specifically important training feature of these workshops are computer exercises which complement the systematic high level topical lectures. In these exercises the workshop participants are thoroughly trained in the utilization of widely recognized computer codes for nuclear model calculations of nuclear data, nuclear data processing, and nuclear reactor physics design and safety analysis. These workshops are worldwide the only training opportunities for nuclear scientists and engineers from developing countries in the nuclear data, nuclear and reactor physics aspects of nuclear technology and represent a very necessary and useful complement to the more engineering-oriented TC training courses organised by the IAEA in the field of nuclear power. The proceedings of the lectures presented at these workshops are published by World Scientific Publishing Co., Singapore [7, 8] and more than 500 copies on the average are distributed in
Singapore [7, 8] and more than 500 copies on the average are distributed in
developing countries. These proceedings have become reference textbooks in the field, are widely quoted in nuclear scientific publications and form the basic material for the development of educational curricula in nuclear and reactor physics at many universities in developing and also advanced countries. The impact of these workshops can also be measured by the almost threefold increase in nuclear data requests received by IAEA/NDS since the initiation of these workshops at the beginning of the eighties, furthermore by the large number of nuclear data processing, nuclear model and reactor physics computer codes requested and provided through the services of the NEA-DB in France and, for codes originating from the USA, the Radiation Shielding Information Center (RSIC) in the USA.

While the ICTP workshops deal with theoretical subjects supported by computer exercises, complementary interregional training courses, which are organized by IAEA/NDS about once a year under the auspices of and financed by the IAEA TC programme, deal with applied experimental nuclear research and nuclear data measurement and analysis techniques with low-energy accelerators and nuclear research reactors. These courses address the needs of experimental nuclear scientists in developing countries with the objective to acquaint them with recent developments in low-energy accelerator and, to a lesser extent, nuclear research reactor technology, and with accelerator-based experimental nuclear techniques used in fast neutron cross section and neutron physics measurements as well as in elemental and material analysis. The course curricula include topical lectures supplemented by practical experimental exercises and visits to local accelerator and nuclear installations. Lecture manuscripts and other useful background material are provided to the participants and are also made available to a larger community of nuclear research groups in developing countries.

The above training activities through theoretical workshops and experimental training courses are supplemented by IAEA TC projects technically conducted by the IAEA/NDS and administrated and financed by the IAEA TC programme.

The hitherto most important project was the Interregional TC Project INT/1/
The hitherto most important project was the Interregional TC Project INT/1/
018 in Nuclear Data Techniques and Instrumentation. This project was conducted for six years from 1981 to 1986 and involved the active participation of nuclear laboratories in 30 developing and 9 advanced donor countries [16]. This project had the primary objective to train young nuclear scientists at universities, research laboratories and other national institutes in the methods of measurement and analysis, and the techniques and instrumentation typically used in the field of nuclear data. Further aims were to twin research groups from developing and advanced countries in common research work and to give scientists from developing countries an opportunity to participate in an internationally coordinated training and research effort and to learn and do necessary and useful measurements using up-to-date methods. The project was intended to contribute to the full appropriate utilization of neutron generators and nuclear facilities usually provided by the IAEA under its TC programme and thus to the development of self-supporting nuclear scientific infrastructures. The expertise gained during work for the project was usefully employed in many fields of nuclear science and technology of vital importance to developing countries, such as agriculture, medicine and industry, nuclear reactor design, operation and safety.

Under this project, 17 expert missions with a total duration of 36 person-months were carried out and grants awarded for 37 fellowships and scientific visits to advanced laboratories for a total duration of 309 person-months. Auxiliary equipment and special materials needed for measurements such as tritium targets and isotopic foils were purchased and provided by the IAEA amounting to a total of US$ 785.000,-.

Since 1987 IAEA/NDS conducts TC projects for the development of multi-group nuclear data bases and processing techniques in which an increasing number of developing countries are beginning. Typical examples are multi-year projects with national reactor physics and nuclear data groups in Algeria, China and Indonesia. The reason behind these projects is that a number of developing countries do not want to depend upon "black-box" nuclear data provided by reactor utilities as part of
depend upon "black-box" nuclear data provided by reactor utilities as part of
their turnkey packages (sometimes not!), but want to develop an independent understanding of nuclear data and an indigenous capability of their computer processing in flexible adaptation to the needs of their nuclear programmes. This is particularly important if a country wants to compare and check the relative merits of different options of reactors offered by different reactor utilities. Another case, where the need for indigenous capability in nuclear data application and reactor physics calculations is obvious, is the planning and implementation of fuel management during the whole life time of operation of a reactor.

These TC projects typically provide

requested nuclear data files and processing codes and, where needed, appropriate computer facilities and expert assistance for local training in the implementation and utilization of these data bases and codes. Supplementary training of young scientists from these laboratories in nuclear data compilation and processing is provided by IAEA/NDS at its own facilities [16].

7. Contributions by developing countries to the international nuclear data effort

As an outgrowth of the nuclear data services and technology transfer activities described in Chapter 6, a number of developing countries are rendering increasingly valuable contributions to the international nuclear data effort. Several typical examples are given below.

The most important impact was so far provided by the joint IAEA/NDS-ICTP Workshops. For example, the Interregional TC Project INT/1/018 on Nuclear Data Techniques and Instrumentation was developed and concretely designed by a working group of 40 participants mostly from developing and some from advanced countries during the second Course held at the ICTP in 1980. This Project brought several laboratories in developing countries, e.g. the University in Rabat, Morocco, PINSTECH in Pakistan and the Chiang Mai University in Thailand, to the level of self-supporting nuclear analytical laboratories. These and other laboratories possessing neutron generators and/or accelerators could be incorporated in and made recognised incorporated in and made recognised contributions to high-level coordinated research programmes of the IAEA, designed to fill gaps and improve the reliability of neutron cross section data required for fission and fusion reactor applications through measurements, theoretical computations and analyses of such data. The project led to a significant increase in the number of scientific papers and participants from developing countries at recent international nuclear data conferences. Also, leading staff of the more advanced developing laboratories are now being used by the IAEA TC programme as technical experts to assist in the technical development of less advanced laboratories. Moreover, other laboratories in developing countries which were already quite advanced in the beginning of the project, turned their interest to the development of more sophisticated techniques and measurements to meet international nuclear data needs; an excellent example of this kind is the Experimental Physics Institute at the University of Debrecen, Hungary.

The educational aftereffect of the Workshops is illustrated by the fact that quite a few scientists who were participants in the first courses held around the beginning of the eighties have in the meantime advanced so much that they could be invited to serve as lecturers and tutors in the later workshops.

Another project was started at the joint IAEA/NDS-ICTP Reactor Physics Workshop in 1990. The WIMS-D4 code [17] is one of the most widely used computer codes in thermal reactor physics, particularly in developing countries. It is freely available internationally and formed one of the main topics in lectures and computer exercises at both the 1990 and 1994 workshops. However, the nuclear data input library to this code was generated more than 20 years ago from less reliable nuclear data available in the sixties and is now outdated. Therefore, a project for the stepwise improvement, updating and testing of this old library, from modern much improved nuclear data using advanced nuclear data processing codes such as NJOY [18, 19] was developed by several participants and their tutors at the 1990 Workshop. This project proved to be an excellent educational exercise in nuclear data processing for the project nuclear data processing for the project participants; its results will simultaneously improve the reliability of thermal nuclear research and power reactor physics calculations. Reactor and nuclear data physicists from 20 institutes in 16 developing countries participated in the initial stages of this project; its progress was reviewed at the 1994 ICTP Workshop [20, 21]. Under technical contract with the IAEA, the project is lead by an experienced group of reactor and nuclear data physicists from the Jozef Stefan Institute of the University of Ljubljana in Slovenia [21]. As an important side effect, a number of defects and errors in the very complex NJOY processing code system were detected by several fellows from developing countries, hosted by IAEA/NDS, and were communicated to the authors of the system, leading to improvements in this important and widely used data processing code system.

At the beginning of the nineties, the need for bulk nuclear model computations of nuclear data for nuclear reactor decommissioning, nuclear waste incineration, environmental radiation protection, planning of advanced nuclear reactors and other nuclear energy and safety related purposes led IAEA/NDS to initiate a new project for the development of reference nuclear parameter files to serve as standardised input to nuclear model calculations of nuclear data, covering of the order of 1000 nuclei with atomic weights over the whole periodic table of elements. This project was discussed in depth at the 1992 Nuclear Data Workshop in Trieste. These discussions led to the practical involvement of very capable scientists from, so far, four developing countries (China, India, Pakistan and Romania) in that part of the project which deals with the collection and optimization of optical model potential parameters. Several scientists from developing countries also participated successfully in several international exercises for the analysis and comparison of nuclear model codes which are being conducted by the NEA-DB [22].

Finally, participation in the ICTP workshops led to the development and/or consolidation of nuclear data groups and centres in several developing countries, including Argentina, Brazil, Cuba, India and Slovenia. Some of these centres, such as the one at São José dos Campos in as the one at São José dos Campos in Brazil and the Chinese Nuclear Data Centre in Beijing, China, serve as focal points for the generation, collection, processing and dissemination of nuclear data in their countries [5]. The Chinese Nuclear Data Centre, as was already mentioned in Chapter 5, has coordinated and actively participated in the development of CENDL, the Chinese Evaluated Nuclear Data Library, the second version of which was recently released. Though not yet as comprehensive as other evaluated nuclear data files from long experienced groups, the Chinese file has a good physics quality and is now being tested, together with the other evaluated data files, for its validity.

Last, but by far not least, the results of nuclear data research in developing countries and associated literature references are being regularly collected by IAEA/NDS in the international EXFOR and CINDA files mentioned in Chapter 5, with the assistance of the aforementioned data centres and individual scientists. Over the period from 1970 to 1990, 32 developing countries provided more than 9% of the neutron data input to EXFOR [16].

8. Summary and outlook

The examples given in Chapter 7 amply demonstrate the importance of the co-operation between the IAEA and the ICTP in commonly organized workshops for the benefit of the emerging nuclear programmes in the developing countries. In these workshops, several hundred nuclear and reactor physicists and engineers were trained in nuclear physics and nuclear data basic to nuclear energy and safety and in nuclear research and power reactor physics design, operation and safety planning and computations. Since the introduction of safe nuclear energy needs a sound nuclear physics basis, it was and is particularly important that these workshops spanned the full range from the relevant fundamental nuclear physics to the physics of nuclear energy and safety. The publications originating from these workshops fertilized university curricula in nuclear theory and models, nuclear data and reactor physics, providing a comprehensive physics basis for the introduction of nuclear energy in many developing countries.

There is no institution in the world
developing countries.

There is no institution in the world other than the ICTP which covers and combines in its training activities the nuclear and reactor physics aspects of nuclear energy and safety. ICTP, in co-operation particularly with the IAEA Nuclear Data Section, has the unique merit for organizing and maintaining these training activities, in full accordance with its basic philosophy and mandate to transfer the expertise and creativity in many fields of theoretical physics to the isolated scientists in developing countries.

These Workshops respond to a real need of those Third World countries which are planning to develop a peaceful nuclear programme. This is demonstrated by the high number of applications for all workshops and courses held so far: due to limited facilities and funds, ICTP could accept at most only about one third to at most one half of the well qualified applicants.

As a consequence, and since the nuclear programmes are growing in developing countries, it appears highly advisable to continue these workshops also in the future. They should continue to follow the same philosophy which turned out to be so successful in the past, i.e. to always transfer the innovations and new developments over the full range of subjects from basic and applied nuclear physics and data to nuclear energy and safety physics.

In the field of applied nuclear physics and nuclear data relevant to nuclear energy and safety, a number of projects are currently being started which aim at the consolidation and international standardisation of nuclear data for nuclear energy and sciences applications. As was mentioned in Chapter 5, several comprehensive evaluated nuclear data libraries have only very recently been finished and internationally released. Intensive efforts have started, under the coordination by the NEA-DB and IAEA/NDS, to systematically compare, test and improve these files, so that the still existing discrepancies between these files can gradually be removed or at least reduced. Scientists from developing countries can and do make valuable contributions to these efforts.

Considering the many still existing gaps, inconsistencies and discrepancies in nuclear activation data and the widespread requirements pointed out before with an emphasis on
widespread requirements pointed out
before with an emphasis on environmental radiation protection, there is an urgent need for the development of a universal, internationally accepted file of "best" values of neutron and charged particle nuclear activation cross sections for about 30000 reactions plus associated nuclear decay data. Experiments can only provide useful accurate check points for normalizing theoretical model predictions; the bulk of the data must be provided by systematic nuclear model calculations using an internationally agreed set of selected nuclear model computer codes and nuclear input parameters. For this purpose, the reference input parameter set mentioned in Chapter 7 is urgently needed as well as an expansion, improvement and selection of best suited nuclear model codes, through extensive testing and physical intercomparisons. This latter work is being performed by a special working group recently set up by the NEA Nuclear Science Committee.

Another project is just being started by IAEA/NDS, which should be of very particular interest to all nuclear and reactor physicists in developing countries. In the past there have been different charts of the nuclides prepared and updated in irregular intervals by institutions in France, Germany, Japan, Russia and USA. Now there is neither enough manpower nor enough money available anymore to pursue these activities on a national scale, though there is a continuing widespread interest in these nuclide charts. Some of them are also outdated and contain discrepant information. Considering that e.g. the Karlsruhe Chart of the Nuclides has been distributed in 20000 copies all over the world and is found even in the least developed and most isolated laboratories, there is an urgent need to combine and share the national expertise in an international project and to develop one unique international chart of the nuclides.

These are only a few examples of future projects in the field of applied nuclear physics and nuclear data to which scientists from developing countries can make very useful and valuable contributions. The ICTP represents an excellent and unique meeting ground between scientists from developing and advanced countries to review and discuss the progress of these projects and to use them as guidelines for the programmes of
future ICTP workshops in the field.
them as guidelines for the programmes of future ICTP workshops in the field.

Also in nuclear research and power reactor physics design and safety and related nuclear data application and processing there is a variety of subjects which are of basic interest to any country on the road to developing a peaceful nuclear programme, which should be dealt with at future joint IAEA-ICTP workshops and which open opportunities for creative contributions by scientists from developing countries.

There should first be more intensive discussions of the physical features and of the importance and the economic and design impact of accurate nuclear data in reactor physics and safety computations. Related to this subject, sensitivity studies of the influence of uncertainties in the input nuclear data bases on the uncertainties of calculated reactor physics and safety characteristics and their design margins should be reported and discussed. For this purpose data uncertainty files associated with evaluated data files are needed, but are still largely missing. Efforts under the auspices of the NEA-DB are underway to gradually establish covariance files of nuclear data uncertainties.

The methods and codes for the processing of evaluated nuclear data files into multigroup cross section and collision probability sets should be introduced and discussed in their full complexity, since the reliability of reactor physics and safety calculations eventually depends critically also upon the reliability of evaluated nuclear data processing. The reactor physics workshops should enter into detailed discussions of modern advanced reactor design and safety concepts, in particular of small and medium power reactors of specific interest to smaller developing countries [23]. So far the workshops concentrated essentially on discrete ordinate methods for reactor core calculations and analysis; they should be extended to cover also Monte Carlo techniques and codes such as the MCNP code and coupled neutron-gamma transport calculations as required e.g. for the calculation of reactor radiation shielding. Last but not least in view of their importance for the public acceptance of nuclear energy, more emphasis should be put in future workshops on detailed discussions of all safety aspects including the underlying workshops on detailed discussions of all safety aspects including the underlying physics features of the various reactor types in operation or planned. This should include detailed analyses of actual reactor accidents and discussions of the successes and failures of the safety concepts originally incorporated in these reactors.

These few examples should suffice to illustrate the ample potential and importance of continuing the joint IAEA-ICTP Workshops for the safe introduction and development of nuclear energy and research programmes in the developing world. In view of the adverse environmental impact of most other energy options and the dwindling of fossile fuel resources, in the long run also developing countries will have to rely heavily on nuclear energy.

Acknowledgement

The author wishes to express his deep-felt gratitude to the President of the ICTP, Professor Abdus Salam, for the initiation and continuing support of the nuclear and reactor physics workshops organized jointly between the ICTP and the IAEA Nuclear Data Section.

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Biographical data

Born in 1931 in Recklinghausen, Germany, Dr. Schmidt studied physics, mathematics and chemistry at the universities of Göttingen, Paris (one year at the Sorbonne), Hamburg and Kiel. He received the Dr.rer.nat. in Kiel in 1960. From 1960 to the Dr.rer.nat. in Kiel in 1960. From 1960 to 1969, he worked at the Nuclear Research Centre Karlsruhe as member of the Karlsruhe Fast Breeder Reactor Project and leader of a small nuclear physics group. His main activity consisted in developing nuclear physics and a nuclear data basis for this project. From 1969 to 1992, Dr. Schmidt worked at the IAEA as Head of the Nuclear Data Section, developed a computer-based system for the international exchange and dissemination of nuclear and atomic data and international coordination of nuclear and atomic data centres and associated nuclear and atomic physics research for applications in nuclear sciences and technology. He retired from the IAEA in 1992 and lives in Vienna, Austria. His main professional interests are theoretical nuclear physics, theoretical reactor physics, and nuclear data. He devotes his free time to music, history and philosophy. ♦

1993 Dirac Medal
Prof. Sergio Ferrara

Prof. Sergio Ferrara (CERN, Geneva, Switzerland) was awarded the 1993 Dirac Medal of the ICTP during a ceremony which took place in the Main Lecture Hall of the ICTP on 19 April 1994. He received the Medal from the hands of his friend and colleague Prof. Luciano Bertocchi, Deputy Director of the ICTP.

Professor Sergio Ferrara was honoured *"for the discovery of supergravity theory and research in its subsequent development. Prior to his work in supergravity, he made important contributions to the development of globally supersymmetric field theories along with J. Wess and B. Zumino and to the discovery of extended superconformal algebras which played a major role in the subsequent construction of superstring theories. In the spring of 1976, in a seminal paper with Daniel Z. Freedman and Peter van Nieuwenhuizen, 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.*

Professor Ferrara played a major role in the development of the subject, with his studies on coupling of supergravity to matter, super Higgs effect, extended supergravity theories and many other aspects of supergravity theories. After string theories came to eminence, he made significant contributions with his explorations of connections between low energy limit of superstrings and supergravity theories. Currently any grand unified theory incorporating gravity is based on a supergravity theory coupled to matter in four dimensions, a most general form which Professor Sergio Ferrara constructed in 1983 with E. Cremmer, L. Girardello and A. van Proeyen. These theories emerge most naturally from the compactifications of the ten dimensional heterotic string."

Professor Sergio Ferrara was born in Rome (Italy) on 2 May 1945. In 1968 he obtained his degree in physics from the University of Rome. From 1969 to 1973

Prof. Sergio Ferrara (centre) being complimented by his friend and colleague Prof. Luciano Bertocchi, Deputy Director of ICTP. On the right, Prof. Paolo Budinich, former Deputy Director of ICTP.

he was at first fellow and then staff member at the Frascati National Laboratory. From 1974 to 1979 he held different positions at CERN in the Theory Division and at the Ecole Normale Supérieure in Paris. In 1980 he became full professor of theoretical physics in Italy. Since 1984 he has been permanent senior researcher at CERN. Since 1985 he has been full professor of physics at the University of California, Los Angeles.

Professor Ferrara was member of INFN and official representative of the Italian Ministry of Industry. He was member of the Scientific Committee of CNRS for the Ecole Normale Supérieure in Paris. He has directed many international conferences and he is referee of international journals. Professor Ferrara was referee for the Nobel Committee for Physics from 1988 to 1994. He is author of more than two hundred scientific publications in international scientific journals and editor of several books. In 1991 he was awarded the Scientific Prize UAP (Union Assurance de Paris).

The winners of the Dirac Medals of the ICTP are announced every year on 8 August, P.A.M. Dirac's birthday. In 1993, there were three winners, namely, Prof. Daniel Z. Freedman (MIT), Prof. Sergio Ferrara (CERN) and Prof. P. van Nieuwenhuizen (SUNY). Prof. Freedman received the Medal at ICTP on 19 November 1993, while Prof. van Nieuwenhuizen will be at ICTP to receive it on 26 July 1994.

During the same ceremony on 19 April, the ICTP and the Consortium of the Institutes of Physics of Trieste University jointly presented the Member of Parliament Signor Sergio Coloni with a statuette representing Minerva — the Roman goddess of knowledge — in recognition of his action in favour of science in Trieste. ♦

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.

Centre for Applicable Mathematics and Computer Sciences, B.M. Birla Science Centre

The Centre for Applicable Mathematics and Computer Sciences is a new constituent of the B.M. Birla Science Centre, Hyderabad, India, an institution recognized by the Government for Research and Higher Education. This constituent was born out of the Research and Higher Education. This constituent was born out of the discussions with Prof. Abdus Salam when he visited the B.M. Birla Science Centre to deliver the B.M. Birla Memorial lecture.

Objectives

Apart from ongoing research programmes, the Centre will be organizing courses, workshops and conferences from time to time.

The Centre aims to exploit the unique scientific infrastructure of Hyderabad: there are several scientific research institutes, laboratories and universities with a large community of active mathematicians, physicists and other specialized scientists in fields as diverse as geophysics, chemical technology, electronics, computer sciences, molecular biology, material sciences, etc.

There are also three small research groups in the Centre, working on (i) natural language processing software, (ii) differential equations, dynamical natural language processing software, (ii) differential equations, dynamical systems and neural networks, and (iii) aspects of theoretical physics, particularly quantum theory and scattering.

The Centre has already earned a feather in its cap, thanks to a major breakthrough which has led to the development of the grammar based translation software, Birla Trans.

A few of the scholars of the Centre have been awarded the Ph.D. degree in mathematics of the Osmania University, Hyderabad.

Several physicists and mathematicians from Europe and North America have visited the Centre and delivered lectures in the Technical Lecture Series and Seminar Talks.

Distinguished Visitorships

Under this Programme, distinguished scientists visit the B.M. Birla Science Centre to deliver the B.M. Birla Memorial Lectures and the Frontiers of Science Forum Lectures.

Amongst the prominent scientists who have delivered these lectures are Nobel Laureates Prof. Abdus Salam, Prof. William Fowler, Prof. Antony Hewish, Prof. Lord George Porter, Dr. Simon Van der Meer, Prof. Norman Ramsay, Prof. Werner Arber, the Simon Van der Meer, Prof. Norman Ramsay, Prof. Werner Arber, the renowned cosmologist Sir Fred Hoyle, Sir Hermann Bondi and others. Prof. Ilya Prigogine is expected amongst others in 1995.

Visiting Professorships

One Visiting Professorship has been instituted and others may also be established. Prof. Yogesh Pati of the University of Maryland, USA, will be taking up the B.M. Birla Visiting Professorship at the Centre, starting 1995.

Visiting Scientists Programme

The Centre has an ongoing Visiting Scientist Programme under which scholars can visit the Centre, typically for a period ranging from a few days to a month. Full hospitality will be provided by the Centre. The scholars are expected to fund their travel from their own sources.

During their stay the scholars are expected to deliver lectures or organize workshops or short courses and interact with local scientists.

To make the visit effective, it is desirable to plan it in advance to coordinate with the relevant local group. Interdisciplinary work is particularly welcomed.

The programme is open throughout the year.

Awards

The Centre has instituted the prestigious B.M. Birla Science Prizes for Indian scientists, below the age of forty, for outstanding contributions in the fields of mathematics, chemistry, life sciences and physics.

The first Prizes were given away by the prime Minister of India, Mr. P.V. Narasimha Rao, while the second awards were given away by Nobel Laureate Lord George Porter.

Some forthcoming activities in 1995

The Centre is organizing, from February 20-23, 1995, an International Conference on "Differential Equations — Theory, Methods and Applications".

Later in 1995, workshops on mathematical modelling and neural networks, as also courses on software development, are being organized.

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India-ICTP Chapter

continued from Front Page

the meeting which was hosted by the Indian Institute of Technology of Delhi.

After the addresses of Profs. N.C. Nigam (IIT), G. Furlan (ICTP), M.G.K. Menon (ICSU), Dr. J.V. Kingston (UNESCO), H.E. Dr. G. Menegatti (Ambassador of Italy in India), Prof. P. Garg (President of the Chapter) and other eminent Indian personalities, the Members took part in a round table discussion on the role of science in industry. The last part of the meeting was devoted to proposals for enhancing the collaboration with the ICTP and with the Italian Embassy in India in the framework of the agreement on scientific and technological cooperation between Italy and India. ♦

A.M. Hamende

A New Centre for Mathematics in Scotland

On 8 April 1989, the President of the ICTP Professor Abdus Salam was honoured with the Edinburgh Medal. In his address, he proposed the

establishment of a new international his address, he proposed the

establishment of a new international centre with scientific and social objectives similar to those of the Trieste International Centre for Theoretical Physics. Professor Abdus Salam's recommendation is now a reality. The International Centre for Mathematical Sciences recently officially opened in its first permanent home, 14, India Street, Edinburgh, the birth place of James Clark Maxwell. It has already gained a high reputation for its interdisciplinary research and for involving scientists from developing countries. ♦

Activities at ICTP April-June 1994

Title: SPRING SCHOOL ON STRING THEORY, GAUGE THEORY AND QUANTUM GRAVITY, 11 - 19 April, and SPRING WORKSHOP ON STRING THEORY, GAUGE THEORY AND QUANTUM GRAVITY, 20 - 22 April.

Organizing Committee: Professors R. Dijkgraaf (University of Amsterdam, The Netherlands), R. Iengo (SISSA/ICTP), I. Klebanov (Princeton University; did not attend this year), K.S. Narain (ICTP) and S. Randjbar-Daemi (ICTP).

Report: This year's Spring School, like the ones of previous years, attracted a good number of very bright physicists from all countries that are members of the United Nations. The level of the School was as high as in previous years. As can be seen from the list given below, a wide range of topics in theoretical high energy physics centered on gauge theories and gravitational physics, were covered. By tradition, the speakers of the Spring School are always invited to talk on their most recent work. This year's School was no exception. Almost all of the speakers lectured on topics which they had developed during the year preceding the School.

During the seven and a half days of the School, a total of 35 lectures were given by 10 distinguished lecturers who spoke on the following subjects:

R. DIJKGRAAF (Univ. of Amsterdam) – *Introduction to string theory and*

R. DIJKGRAAF (Univ. of Amsterdam) – *Introduction to string theory and topological field theory.* This was a set of introductory lectures setting the background for most of the other lectures.

T. BANKS (Rutgers Univ., Piscataway) – *Black holes and information loss.* The speaker presented this rather controversial subject which is still at the centre of many debates and investigation.

L. ALVAREZ-GAUME (CERN) – *Duality, abelian and non-abelian.* A general framework was presented to discuss duality in quantum field theories. Special attention was paid to the application of the general ideas to the WZW models.

G. MOORE (Yale and Rutgers Univ., Piscataway) – *D=2 Yang-Mills theory, equivariant cohomology and topological* *string theory.* A mathematically rigorous presentation was given of the lecturers recent work on two dimensional QCD.

L. THORLACIUS (Univ. of California, S. Barbara) – *Black hole evolution.* These lectures were in some sense complimentary to those of Banks. The speaker covered the work he has been doing together with his collaborators in the last few years.

A. MIGDAL (Princeton Univ.) – *Turbulence, matrix models.* The speaker gave a set of lectures on the loop formulation of QCD and explained his recent work on this subject. He also devoted one lecture on the application of the ideas from the loop formulation of QCD to the solution of Navier Stokes equation in the theory of turbulence.

M. DOUGLAS (Rutgers Univ., Piscataway) – *Physics and mathematics of large N.* Various aspects of large N techniques were discussed, mostly in the context of 2-dimensional QCD. The speaker also explained his recent work on generalizations of QCD.

H. OOGURI (Kyoto University) – *Quantum string theory on a Calabi-Yau manifold.* The lectures were based on recent work of Ooguri with his collaborators, which make use of techniques of differential and algebraic geometry to evaluate string amplitudes, at least in the topological sector of the theory.

B. GREENE (Cornell University) – *Mirror symmetry.* A set of very pedagogical lectures were presented by the speaker mostly on the work developed by him and his collaborators on mirror manifolds.

K.S. NARAIN (ICTP) – *Topological amplitudes in string theory.* These lectures

K.S. NARAIN (ICTP) – *Topological amplitudes in string theory.* These lectures

were in some sense complementary to those of Ooguri and covered the work done at the ICTP by E. Gava and K. Narain.

On Tuesday, 19 April, there was the presentation of the Dirac Medal to Professor Sergio Ferrara.

The Spring Workshop had a duration of 2 and a half days. There were 16 talks given by invited speakers and 11 short talks by participants as follows:

S. MUKHI (Tata Inst., Bombay) – *C=1 as a topological string theory.*

G. MOORE (Yale and Rutgers Univ., Piscataway) – *Symmetries of the bosonic string S-matrix.*

D. ZANON (Univ. of Milan) – *Kähler potentials and renormalization group flows in N=2 Landau Ginzburg models.*

A. MIGDAL (Princeton University) – *Large N QCD at low energy.*

S. SHATASHVILI (IAS, Princeton) – *Exceptional magic.*

E. ADI (Hebrew Univ. of Jerusalem) – *Figure-8 solution to the Wheeler-DeWitt equation in 2D quantum gravity.*

S. RANDJBAR-DAEMI (ICTP) – *Low energy Yang-Mills systems from a class of Ising type models.*

A. LOSEV (ITEP, Moscow) – *K. Saito theory in Landau-Ginzburg topological gravity.*

Y. OZ (Tel Aviv University) – *Topological and integrable structures of 2D string theory.*

N. OBERS (Ecole Poltychnique, Palaiseau) – *Plane gravitational waves in string theory.*

P. FRE' (SISSA) – *Constrained 2D topological gravity.*

B. ZWIEBACH (MIT, Cambridge) – *On the background independence of string theory.*

S. MUKHERJI (ICTP) – *2-D black hole with finite matter.*

S. FERRARA (CERN) – *On the stability of scale hierarchies in effective supergravity theories.*

C. KOUNNAS (Ecole Normale Sup., Paris, and CERN) – *The spectrum of string excitation in a wormhole background.*

Y. SHAMIR (Weizmann Inst., Rehovot) – *Dynamical-space regular-time lattice and quantum gravity.*

L. THORLACIUS (Univ. of California, S. Barbara) – *Boundary conformal field theory.*

E. KIRITSIS (CERN) – *Time dependent topology change in string theory.*

E. KIRITSIS (CERN) – *Time dependent topology change in string theory.*

I. AREFEVA (Steklov Inst. of Maths., Moscow) – *High energy QCD and 2-d lattice models.*

S. GOVINDARAJAN (Tata, Bombay) – *A proposal for the geometry of Wn-strings.*

F. BASTIANELLI (Niels Bohr Inst., Copenhagen) – *A hierarchy of superstrings.*

I. ANTONIADIS (Ecole Polytechnique, Palaiseau) – *Effective μ-term in string theory.*

B. ZWIEBACH – *On the background independence of string theory.*

J. ZANELLI (Univ. of Chile and CECS) – *Higher (and somewhat lower) dimensional black holes.*

C. IMBIMBO (CERN) – *Lagrangian treatment of 2-D topological gravity.*

D. BOULATOV (Univ. of Copenhagen) – *QCD on a tree.*

M. BLAU (ICTP) – *Equivariant Kähler geometry and localization in the G/G model.*

The total number of visitors (including speakers and organizers) was 154.

The Directors

Title: Workshop on Nuclear Reactors — Physics, Design and Safety, 11 April – 13 May.

Co-sponsors: Ente per le Nuove tecnologie, l'Energia e l'Ambiente (ENEA, Rome, Italy) and International Atomic Energy Agency (IAEA, Vienna, Austria).

Organizers: Professors D.E. Cullen (Lawrence Livermore National Laboratory, USA), H.R. Dalafi (ICTP), L. Fonda (University of Trieste and ICTP), A. Gandini (ENEA), S. Ganesan (IAEA) and J.J. Schmidt (formerly IAEA).

Report: The main objective of the Workshop was to train scientists and engineers from developing countries in the modern methods for the computation of nuclear reactors, with particular emphasis on reactor physics, design and safety in order to make nuclear reactors a fully available and economic source of energy, within widely accepted constraints of safety and environmental protection.

Currently, out of 304 research reactors which are operating in 59 countries, 91 reactors are in 40 developing countries. There is a steady increase in the number of research reactors as more developing countries embark on nuclear technology related

reactors as more developing countries embark on nuclear technology related

programmes. The importance of research reactors for developing countries lies in the fact that they are multidisciplinary facilities with utilization for basic and applied research, commercial services and industrial applications. There are also around 400 power reactors in the world in operation in 16 advanced countries and in 10 developing countries. There are many power reactors under construction. This is due to the fact that in many developed and developing countries nuclear power has become a significant source for the production of energy. Nuclear power reactors have now become commercially available in many countries.

Workshop on Nuclear Reactors — Physics, Design and Safety, 11 April – 13 May.

The Workshop was organized in a series of high quality lectures to familiarize the participants from the developing countries with all the different aspects of nuclear reactors.

An important part of the Workshop was the practical use of selected nuclear model computer codes by the participants with particular concern on reactor physics, design and safety.

There were 26 lecturers mostly from Europe. Some special lectures were also delivered by IAEA scientific staff. There were 55 participants from 24 developing countries and several participants, who came at their own cost, from advanced countries and several participants, who came at their own cost, from advanced countries.

Lectures were usually held in the mornings, on a 5-day working week; the afternoons were mostly dedicated to computer code exercises. The lectures covered the following topics:

- Evaluated nuclear data processing and classification.
- Lattice cell calculations, slowing down theory.
- Thermal reactor physics and safety.
- Types, effective utilization and safety features of research reactors.
- Research reactor core calculations.
- Core design and management.
- The WIMS computer code.
- TRIGA and CORD-2 packages.
- Reactor physics models for PWR reactors.
- Fast reactors.
- Principles of nuclear safety.
- Safety analysis and translation of safety criteria into design constraints.
- Economy of nuclear power — fuel cycle strategy.
- Reactor operation control strategy.
- Space dynamics methods.

The fifth week of the Workshop, a group of 14 selected participants was hosted at ENEA, Bologna (Italy), to be exposed to nuclear reactors laboratory work and computations.

work and computations.

H. Dalafi, L. Fonda

Title: Spring College in Condensed Matter on Quantum Phases, 3 May – 10 June.

Organizers: Professors G. Baskaran (Institute of Mathematical Sciences, Madras, India), R. Bhatt (Princeton University, NJ, USA), A. Georges (Ecole Normale Supérieure, Paris, France), S. Sachdev (Yale University, New Haven, CT, USA) and Yu Lu (ICTP).

Report: The Spring College in Condensed Matter on Quantum Phases which ran for a period of six weeks, consisted of an average of three 90-minute lectures a day (89 in all) given by 22 distinguished active research scientists from a number of different countries (USA, France, UK, Germany, Russia and Finland). In addition there was one seminar on average per week, and five to six 30-minute presentations by the participants of the School every week.

In the estimation of the Organizers, the lecturers and the participants, the College was a great success. ICTP has provided a unique opportunity to get together experts in a very active field of condensed matter science, to expose participants from Third World countries to a newly emerging and burgeoning field to a newly emerging and burgeoning field which requires a combination of techniques, background and talents.

The School began with lectures at a graduate level by Prof. Wolfle on Fermi liquid theory and BCS instability giving rise to superconducting/superfluid phases, something most participants would have been exposed to. A new formalism to look at that was provided by Prof. R. Shankar, using the modern renormalization group approach. The subject of infrared singularities was covered by Prof. Nozieres, followed by implementation of the Kondo problem using the numerical RG technique by Dr. Jones. Simultaneously, the effect of disorder and the phenomenon of Anderson localization was covered by

Prof. Kravtsov, as a prelude to the issue of metal-insulator transitions in Fermionic systems.

In a parallel series, the general topic of quantum phases and transitions was started by Prof. Sachdev, using spin systems as a paradigm. This was complemented by lectures of Prof. Jolicoeur on quantum antiferromagnets and conformal field theory methods, by Prof. Singh on series expansion techniques, and experimental systems were covered in the lectures by Prof. Lonzarich. In the fourth week, this discussion was extended to include disorder and randomness by Prof. Daniel Fisher, which tied into the lectures by Prof. Bhatt.

The subject of the superconductor-insulator transition in disordered two dimensional films was covered in the lectures of Prof. Girvin, with experimental aspects covered in a lecture by Prof. Paalanen. This consisted of transitions involving only charge degrees of freedom, and complemented the subject of quantum spin systems which involved only spin degrees of freedom, and helped make clear why the problem of fermion localization in the presence of electron interactions (the venerable metal-insulator transition problem) has such a long history without any solution that incorporates all aspects.

During the fifth and sixth weeks, the issue of quantum phase transitions in fermionic systems with both spin and charge degrees of freedom were covered in lectures by Profs. Georges, Kotliar and Bhatt. Prof. Georges gave the general formulation for the infinite dimension approach (mean-field theory) for the Mott transition with electron approach (mean-field theory) for the Mott transition with electron interactions, which was further amplified and extended to include disorder at a simple level by Prof. Kotliar. Prof. Kotliar also discussed the various long-wave length approaches to the problem of metal-insulator transition in disordered electronic systems, their current status and their inadequacies. Prof. Bhatt's lectures covered the issue of magnetic and thermodynamic properties near a metal-insulator transition, and how spin degrees of freedom dominate at low temperatures (this tied into random quantum spin models discussed by Prof. Fisher). Experimental aspects of the metal-insulator transitions in doped semiconductors, metal-insulator mixtures, vanadium oxide, as well as high temperature superconducting oxides were covered by Dr. Thomas and Prof. Paalanen. In parallel with these 2, 3 or infinite-dimensional theories, a set of lectures on use of bosonization techniques to study both fermionic and bosonic problems with interactions and disorder were covered in the lectures by Dr. Giamarchi.

The final major topic covered was the quantum Hall effect, both integral and fractional, where lectures were given by Prof. MacDonald and Prof. Read (theoretical aspects), Prof. Chalker (numerical methods) and Prof. Shayegan (experimental aspects). These were supplemented by lectures by Profs. Girvin and Bhatt, which made contact with relation to spin systems, and random matrices and localization, respectively. This system of two dimensional electrons in a large perpendicular magnetic field with a plethora of quantum phases and transition between them provided an ideal example of the richness and variety of the subject of the Spring College.

The lectures involved a number of techniques of general applicability in various fields. These included analytical approaches (RG: Shankar, Nozieres, etc.; large d and large N methods: Georges, Kotliar, Sachdev; diagrammatic methods: Kravtsov, Wolfle; field theoretic methods: Jolicoeur, Read — to name a few), as well as numerical techniques (RG: Jones, White, Bhatt; transfer matrix methods and other matrix techniques: Chalker, Bhatt; series expansion methods: Singh; Monte Carlo techniques: Girvin, etc.).

On the whole, student participation was remarkably good: they were On the whole, student participation was remarkably good: they were motivated, interested, and active. The idea of having a few students from the Western world appeared to be successful in allowing an interchange at a level that is not possible between lecturer and students. However, the School was quite intense with 4.5 hours of lectures/day in addition to seminars/student discussions. Also the duration was somewhat long, and students were getting saturated towards the end. It is recommended that future schools be limited to 3-4 weeks, with no more than 4.5 hours of total planned activity (lectures and seminars/discussions) per day. The duration of each lecture (90 minutes including questions) was deemed appropriate because with shorter lectures there is a tendency to cram stuff in the shorter time and that is not beneficial to the students. Also use of board instead of viewgraphs wherever possible is recommended to slow down the pace of lecturers and make the subject matter more understandable to the students. In this aspect, the current School was vary successful.

Ravin Bhatt

Title: WORKSHOP ON COMMUTATIVE ALGEBRA AND ITS RELATION TO COMBINATORICS AND COMPUTER ALGEBRA (EUROCONFERENCE), 16 – 27 May.

Co-sponsor: European Commission (Brussels, Belgium).

Organizers: Professors N. Mohan Kumar (Tata Institute of Fundamental Research, Bombay, India, and Washington University, St. Louis, MO, USA), A. Simis (Universidade Federal da Bahia, S. Salvador, Bahia, Brazil), and G. Valla (University of Genoa, Italy).

Report:

Objectives. The Workshop had in mind a mixed audience of experts that included scientists from developing countries, young researchers and Ph.D. students nearing their degree. Seemingly, this sort of gathering ought to be very efficient in order to bring up an atmosphere of discussions and to foster new ideas in the field.

The main body of the lectures was devoted to themes of recent interest in the area so as to induce the audience into picking up some of the most important topics among the current subjects in commutative algebra, as well as the applications thereof to combinatorics and computer algebra. A secondary nonetheless vital purpose envisaged by computer algebra. A secondary nonetheless vital purpose envisaged by the Directors was the provision of slots for short talks to be delivered by participants, with particular stress on announcements by young scientists from developing countries and Ph.D. students from both developing and developed countries.

Structure and organization. The main structure of the Workshop consisted of series of lectures by known experts in a fairly representative spectrum of the area. As pointed out above, besides these lectures, there were 16 half-hour talks by participants. Also a number of 50-minute addresses was delivered to the audience with the purpose of giving a survey look at certain topics that have witnessed recent significant advances.

The organization of the activities followed the general principle of having 4 main lectures every day (2 in the morning and 2 in the afternoon), leaving some free time for interchange of ideas and group discussions by participants.

Scientific achievements. The scientific achievements of this Workshop can only be measured vis-à-vis the preceding Workshop held in September 1992. The idea of inducing younger people in the field to actively participate by means of delivering talks, mixing with other groups and holding intense discussions in the free time, seemed to have impact on the overall state-of-the-art of a number of research themes. In fact, since then one could notice a clearer delineation of frontier problems and a crystallization of groups of researchers around such problems. As a consequence, several significant achievements were attained in themes such as blowup algebras and Hilbert functions with combinatorial advances thereof.

In the present Workshop, the chosen scientific program reflected in a peculiar manner the advances just mentioned, intensifying the gathering and combination of partial results, through a friendly collaboration among the various groups and individuals. The establishment of links between groups of researchers in order to share preliminary results can be considered a major contribution of this Workshop.

The overall achievement obtained by making a precise selection of themes and not solely a mere geographical choice of topics seems to be having an important bearing on scientists from developing countries who thus find reassurance in continuing or changing their research work back in their home countries.

General information on participants. The total number of participants was 115, distributed among 28 countries. Of these, 45 were young mathematicians from European countries supported either by EEC, Euroconference Program or by other sources.

Suggestions and proposals. One of the most important lessons provided by the Workshop was that no matter how one plans and organizes a gathering of this nature, a certain number of themes will overwhelm the activities and show a natural direction for emphasizing and fostering future guidelines for the area.

This is, to our view, a capital insight into the phenomenology of meetings, pointing the tip of an iceberg. To wit, as the means of outlet for the current scientific literature becomes increasingly meager and slow (this is not strictly exact, varying from field to field, as there is an increasing number of periodicals and series that try to revert this trend), one sees the intensity of workshop organization as a true alternative for the fast interchange among scientists.

This suggests the making of such organization more intense, with intervals of at most 2 years, perhaps at the cost of decreasing the number of paid participants. Since one of the main purposes of the meetings in ICTP is to produce a continuing force of active scientists in developing countries, ultimately a proper balance has to be achieved.

At the point where we see things now, it is crucial that the line of resources now provided for workshops in the area of commutative algebra and its ever growing relationship to other fields of mathematics and science, including its growing intimacy with computational algebra, do not undergo a long intermission lest the partial achievement obtained so far fail to catch up with its present strength.

The Directors

Calendar of Activities at ICTP in 1994-95

1994

SMR	Activity	Dates
751	Follow-up to the Workshop on preparation of radiomaritime master plans for English-speaking African countries	14-18 February
752	Winter College on quantum optics	14 February – 4 March
753	Workshop on study of atmospheric interactions by remote sensing	21 February – 4 March
755	Workshop on fluid mechanics	7 – 25 March
754	Workshop on science and technology of thin films	7 – 25 March
803	Training Course on dosimetry and dose reduction techniques in diagnostic radiology	16 – 25 March
756	Spring School and Workshop on string theory, gauge theory and quantum gravity	11 – 22 April
757	Workshop on nuclear reactors — physics, design and safety	11 April – 13 May

758 Spring College in condensed matter on quantum phases ... 3 May – 10 June

759 International Conference on monsoon variability and prediction ... 9 – 13 May

761 Workshop on commutative algebra and its relation to combinatorics and computer algebra ... 16 – 27 May

760 College on atmospheric boundary layer and air pollution modelling ... 16 May – 3 June

766 Workshop on submicron quantum dynamics ... 13 June – 1 July

762 Summer School in high energy physics and cosmology ... 13 June – 29 July

including

Workshop on perspectives in theoretical and experimental particle physics ... 7 – 8 July

Workshop on strings, gravity and related topics ... 28 – 29 July

764 Research Workshop on condensed matter physics ... 13 June – 19 August

including

Miniworkshop on nonlinear time series analysis ... 8 – 12 August

Working Group on disordered alloys ... 8 – 19 August

765 Quantum transport in nanostructures (Adriatico Research Conference) ... 20 – 24 June

767 Miniworkshop on strong correlations and quantum critical phenomena ... 4 – 22 July

814 Electronic and geometric structure of solids and surfaces (Adriatico Research Conference) ... 12 – 15 July

768 Cooperative effects in many-electron systems and their response to external fields

(Adriatico Research Conference) ... 26 – 29 July

769 Workshop on non-linear electromagnetic interactions in semiconductors ... 1 – 10 August

806 Lasers in surface science (Adriatico Research Conference) ... 9 – 12 August

770 Advanced Workshop on algebraic geometry ... 15 – 26 August

771 Conference on the structure and model of the first cell ... 29 August – 2 September

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

772 International Workshop on parallel processing and its applications in physics,

chemistry and materials science ... 5 – 23 September

775 College in biophysics: experimental and theoretical aspects of biomolecules ... 26 September – 14 October

774 Third College on microprocessor-based real-time control —

774 Third College on microprocessor-based real-time control —

principles and applications in physics ... 26 September – 21 October

777 3rd Trieste Conference on recent developments in the phenomenology of particle physics ... 3 – 7 October

779 Workshop on variational and local methods in the study of Hamiltonian systems ... 10 – 28 October

750 College on advanced techniques in archaeometry and conservation of works of art ... 17 – 28 October

780 Fourth Autumn Course on mathematical ecology ... 24 October – 11 November

781 Suivi de l'atelier sur la préparation des plans directeurs radio-maritimes

pour les pays africains francophones ... 7 – 11 November

782 Second Workshop on three-dimensional modelling of seismic waves generation,

propagation and their inversion ... 7 – 18 November

748 ICTP-UNU-Microprocessor Lab: Third Course on basic VLSI techniques ... 21 November – 16 December

804 Ultrafast phenomena and applications (Adriatico Research Conference) ... 6 – 9 December

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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:

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.

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

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For further information please write to
SCS-Scientific Computing Section, International Centre for Theoretical Physics,
P.O. Box 586, 34100 Trieste, Italy

1995

SMR

838 **Seventh international workshop on computational condensed matter physics: total energy and force methods....................11 - 15 January**

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**

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....................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**

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**

852 **Conference on 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 physical and mathematical implications of mirror symmetry....................5 - 9 June**

865 **Workshop on computational methods in material science and engineering....................12 - 25 June**

865 **Workshop on computational methods in material science and engineering....................12 - 25 June**

858 **Summer school in high energy physics and cosmology....................12 June - 28 July**

including

864 **Workshop on the search for new elementary particles....................27 - 29 July**

859 **Research workshop on condensed matter physics....................12 June - 18 August**

860 **Adriatico research conference on physics of sliding friction....................20 - 23 June**

862 **Workshop on biological models (tentative)....................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 **School on non-accelerator particle astrophysics....................17 - 28 July**

861 Adriatico research conference on chaos in atomic and molecular systems.......... 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

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 systems.......... 29 August - 1 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 Workshop on topical subject in plasma physics.......... 16 - 20 October

888 Conference on oceanography: "Antonio Michelato" memorial.......... 23 - 27 October

880 International conference on ultrafast processes in spectroscopy (UPS '95).......... 30 October - 4 November

877 School on synchrotron radiation in science and technology.......... 30 October - 1 December

878 Experimental training course on chemistry and physics of oxide materials:

high T_c superconductors, to be held in Bangalore, India.......... 3 weeks in October/November

879 Third workshop on non-linear dynamics and earthquake prediction.......... 6 - 17 November

News from ICTP is also available on Gopher server.

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