International Centre for Theoretical Physics

News from ICTP

No. 24/25
July/August 1989

ICTP Dirac Medals and Yukawa Prize

Professor Efim Samoilovich Fradkin, winner of the ICTP Dirac Medal 1988, was awarded the prize at ICTP on 11 July 1989. The citation reads: *"for his many fruitful contributions to the development of quantum field theory and statistics. Among these are his early work on functional methods including his formal solution to the Schwinger-Dyson equations for the Green's functions of interacting systems. This result has become a standard part of modern quantum field theory. Independently of Takahashi he discovered the generalized Ward identitites for electrodynamics. These identities and their generalization for non-Abelian gauge theories are basic to the understanding of local symmetries. In his work on the Schwinger-Dyson equations, Fradkin drew attention to the zero-charge problem, a potential inconsistency in Abelian gauge theories whose later resolution in the non-Abelian theories led to the discovery of asymptotic freedom. At the same time as Schwinger and Nakano, Fradkin constructed a Euclidean formulation of quantum field theory, a development which was to have far-reaching implications for the development of statistical physics and string theory. His contributions to the quantization of relativistic systems with constraints are widely recongized. This work culminated in the Baalin-Fradkin-Wilkovisky quantization method which is used both in quantum field theory and in the theory of extended objects such as strings and membranes".*

The other 1988 Dirac Medal was awarded to Prof. David Gross (Princeton University, New Jersey, USA) on 10 April 1989.

Michael B. Green from Queen Mary College, London, UK, and John H. Schwarz from the California Institute of Technology, Pasadena, USA, are the recipients of the Dirac Medals of the International Centre for Theoretical Physics 1989, *"for their basic contributions to the development of superstring theory. Most significant was their discovery that chiral gauge anomalies are absent for a class of ten dimensional superstring theories. This provided a strong indication that superstring theory with a specific gauge symmetry may provide a consistent unified quantum theory of the fundamental forces including gravity. It led to an explosion of interest in string theory which has already spurred remarkable advances both in mathematical physics and in pure mathematics".*

The Medals will be presented to the awardees later on.

Professor Abdus Salam, Director of ICTP and President of TWAS, reading the citation for the 198 Dirac Medal awarded to Prof. Efim S. Fradkin. From left to right: Prof. H. Dalafi, Executive Secretary of the World Laboratory Branch in Trieste, Prof. A. Zichichi, President of the World Laboratory and Member of the Scientific Council of the ICTP, Prof. Abdus Salam, Director of the ICTP, and President of the Third World Academy of Sciences, and Prof. E.S. Fradkin (USSR), ICTP Dirac Medal 1988.

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This was announced, as every year since 1985, on 8 August, birthday of the late Paul Adrien Maurice Dirac – Nobel Prize for Physics 1933 – on the same day of the award ceremony of the ICTP Prize in honour, this year, of the late Hideki Yukawa, the great Japanese physicist who won the Nobel Prize in 1949. Dr. Ashoke Sen from the Tata Institute of Fundamental Research, Bombay, India, is the recipient of the Yukawa Prize *"for his contributions to string theory, and in particular for the application of the sigma model approach to the heterotic string theory. He has contributed to the development of techniques of superstring perturbation theory at higher genus which have enhanced the string theory understanding of space-time supersymmetry non-renormalization theorems. He has also studied the implications of modular invariance in the problem of the classification of rational conformal field theories in 2 dimensions"*.

The Ceremony took place in the Main Lecture Hall of the ICTP. Professor Abdus Salam, Director of the International Centre for Theoretical Physics, read the citation for both awards, and presented the medal, diploma and US$1,000 cheque for the Yukawa Prize.

Two ICTP Medals were also presented to Mr. S. Coloni, Member of the Italian Parliament, and Mr. M. Rossetti, Member of the European Parliament, in appreciation of their work for the progress of science in Trieste.

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The Dirac Medals of the International Centre for Theoretical Physics were instituted in 1985 in memory of Prof. P.A.M. Dirac, a honoured guest at and a staunch friend of the ICTP. The Medals are awarded yearly for contributions to theoretical physics.

From left to right: Dr. Ashoke Sen, awardee of the Hideki Yukawa Prize, Professor Abdus Salam and Prof. P. Budinich (International School for Advanced Studies).

The 1985 Dirac Medals were awarded to Professor Yakov Zeldovich (Institute for Space Research, Moscow, USSR) and Prof. Edward Witten (Princeton University, USA) and in 1986 to Prof. Yoichiro Nambu (Enrico Fermi Institute for Nuclear Studies, Chicago University, USA) and Prof. Alexander Polyakov (Landau Institute for Theoretical Physics, Moscow, USSR). In 1987, they were awarded to Prof. Bryce DeWitt (University of Texas at Austin, USA) and Prof. Bruno Zumino (University of California at Berkeley, USA). The recipients of the 1988 Medals were Prof. David J. Gross (Princeton University, USA) and Prof. Efim S. Fradkin (Lebedev Physical Institute, Moscow, USSR).

The Selection Committee includes Professors S. Lundqvist, R. Marshak, J. Schwinger, S. Weinberg, Abdus Salam and others. The Dirac Medals of the ICTP are not awarded to Nobel Laureates or Wolf Foundation Prize winners.

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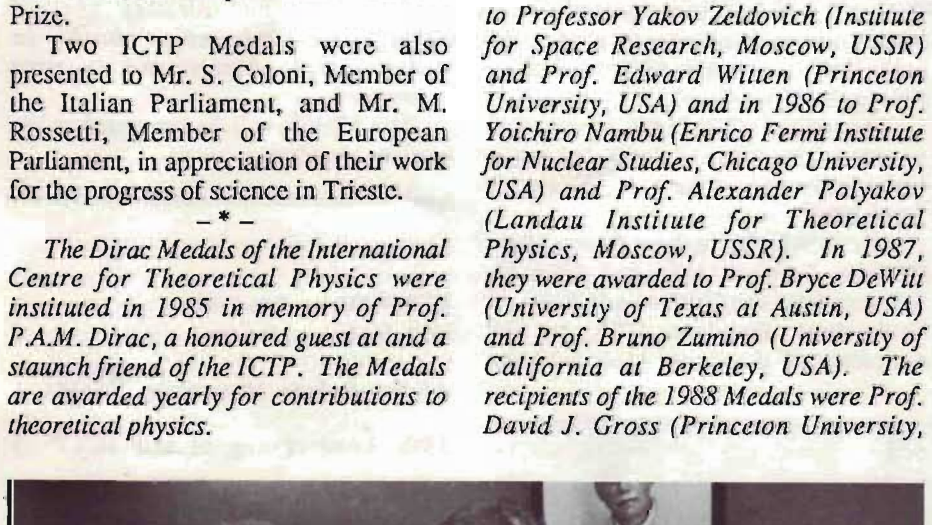
One ICTP Prize is awarded yearly for outstanding and original contributions within an announced field, to a scientist under 40 years of age, national of a developing country, working and living in a developing country. The winner of the Prize is selected by an International Committee, from among the most outstanding scientists in the announced field.

field.



Prof. A. Zichichi presenting the Dirac Medal to Prof. E.S. Fradkin.

Abdus Salam Honorary Knight

Courtesy of The Times Thur, 3 Aug 1989

Professor Abdus Salam, professor of theoretical physics at Imperial College, London, and the inspiration behind the foundation of the International Centre for Theoretical Physics at Trieste, has been appointed an honorary Knight Commander of the Order of the British Empire.

The scientists and staff of the ICTP join in congratulating Professor Abdus

Salam on his appointment.

25th Anniversary of the ICTP

A quarter of a century has passed since Abdus Salam opened the Seminar on Plasma Physics, the inaugural activity of the ICTP which had just been created. Since then, from US$350,000, the annual budget has gone to 20 million, 28,000 scientists from developing countries have passed through Trieste out of a total of 40,000, there are about forty-five different activities each year, the Centre now occupies four large buildings, and 4,300 preprints have been produced.

All these achievements are due to the far-sighted and energetic guidance of Abdus Salam, Nobel Laureate for Physics 1979 and Director since the ICTP's inception, the patronage of the IAEA and UNESCO, the generous contribution from the Government of Italy and of many others. The 25th Anniversary will be celebrated on 31 October 1989. The ceremony will be honoured by the presence of the President of Italy, Mr. F. Cossiga, and of many other distinguished guests from the international, scientific and political world. The official part of the ceremony will be followed by a three-day scientific meeting.

Frontiers of Informatics: Artificial Intelligence and Parallel Machines

by
Ṭahir Shah

Courtesy of
TWAS Newsletter

The origin of informatics lies deep within the abstract studies of symbolic logic and the foundations of mathematics. David Hilbert, one of the most versatile and brilliant mathematicians of this century, formulated a proof theory in which the truth of mathematical formulae is decidable mechanically by a finite number of steps. This was a remarkable idea. The decision theoretical part of his formalism, the famous "Entscheidungs-problem", led the British mathematician Allan Turing to devise a model of computing machines. All computers are based on the Turing-machines model. The proof theoretical part of Hilbert's program led to the foundations of Artificial Intelligence. Two most widely used symbolic computer languages, LISP and PROLOG, owe their existence to two sub-branches of symbolic logic — Church's lambda calculus and Horn Clause logic, respectively. Without such theoretical studies perhaps even the birth of information technology would not have been possible.

Artificial Intelligence has progressed from a laboratory science to an expanding technology over the last few years. Since the announcement by the Japanese of their Fifth Generation computer project in 1981, there has been a plethora of activity in this field from all corners of the globe. In his recent book "Infinite in All Directions", theoretical physicist Freeman J. Dyson named three technologies which will revolutionize our future. These are (a) genetic engineering, (b) artificial intelligence, and (c) space science. According to him, "The second technological revolution is artificial intelligence. This revolution has already begun with the rapid development and proliferation of computers..." However, despite mass-media attention, there is a confusion as to the nature of A.I., even among scientists who are not specialists or actively involved in A.I.

Quite often "expert systems" are considered synonymous with A.I. In other cases, it is confused with the study of neural models only.

One of the points that requires clarification at the outset, therefore, is the commonly conceived myth that expert systems constitute the total scope of Artificial Intelligence. Expert systems are not all there is to A.I. and rule-based systems are not all there is to the field of expert systems.

Devised in the mid-70s, rule-based expert systems were one of the first commercially developed packages. Due to the availability of comparatively weak computing power at that time, it is understandable that expert systems were designed using the simplest knowledge representation schemes. So-called production rules are very similar to the if-then statements being used for procedural programming languages. Procedural programming languages use algorithmic procedures to solve a problem. Most of the well-known commercially used languages (e.g. Cobol, Fortran and Pascal) are of this variety.

In the field of A.I., however, one rarely uses procedural languages because they are inappropriate for symbolic and descriptive programming style. To illustrate the complexity and interdisciplinary nature of A.I., some technical details of an intelligent system would not be out of context here.

Intelligence

Over the centuries, philosophers and other intellectuals have tried to define intelligence. Intuitively, it is the ability to solve problems, learn from experience, infer facts from other facts and so on. In computational studies of intelligence we take for granted that machine intelligence must deal with these capabilities. Complex intelligent behaviour involves the synergy of a number of minor subsystems.

Over the last two decades, research into A.I. and related cognitive sciences has led to the conclusion that computational studies of intelligence deal with two basic problems: (1) How to represent knowledge, i.e. the study of knowledge representation schemes; (2) How to manipulate knowledge through inferential techniques such as deduction, induction, property inheritance, etc. (Inference is a form of knowledge manipulation relating one piece of knowledge with another).

Intelligence itself, more specifically, is defined as a problem-solving skill in the broadest sense imaginable and includes speech, natural language and other perceptual processes such as reasoning, abstraction, acquisition and manipulation of knowledge. Thus, to make a machine intelligent, we need to represent acquired knowledge in a convenient, concise and consistent form. This study of representation is a central problem in the field of A.I. research. The difficulty is in developing sufficiently precise notation with which to represent knowledge. A specific description of knowledge is called a knowledge representation scheme (KRS).

For practical purposes, we can consider a knowledge base as a model of the physical world. Typically, the world around us is made up of a collection of objects. The collection of all of these objects and their relationships to one another at any moment in time constitute a state. There can also be state transformations resulting in creation, destruction or change in these relationships.

There are many well-established knowledge representation schemes, however, these four are used most often:

Logic: Symbolic logic dates back to ancient Indian and Greek philosophers. It was only at the end of the 19th century that a formal approach was started by George Boole (known for his Boolean logic, used in the field of electrical engineering), Gottlob Frege, Bertrand Russell and others. Today, one of the most promising A.I. languages, called PROLOG (PROgramming in LOGic) is based on symbolic logic. In this KRS, true assertions about states are stored in a knowledge base.

Production Rules: This is the most widely used representation scheme by industrial/commercial expert system designers. The knowledge base consists of a set of *if...then* rules, i.e. "if a condition is true, then activate a procedure". In this scheme, the rules are actually state transformations between world states.

Frames: In this representation scheme, facts are represented as contextual structures with slots which are to be filled for details, For instance, identical names can fill different frames without confusion, because the system does not confuse different meanings of the same word in different contexts.

Semantic Net: This is a network of conceptual objects connected to each other through relations. A semantic net is a collection of individuals and relationships arranged in a suitable network.

Inference

The inference engine is the part of an intelligent system that relates one piece of knowledge (assertion or fact) to another. It is the component of an expert of knowledge (assertion or fact) to another. It is the component of an expert system that controls its operation by selecting the rules to use, accessing and executing those rules, and determining when an acceptable solution has been found. This component is sometimes called the control structure or the rule interpreter.

Expert systems are therefore special types of knowledge-based systems. In these systems, an expert's knowledge from a narrow domain is stored in the knowledge base. Typically, a commercial expert system is designed using production rules and is targeted at either diagnostic or decision support tasks.

In applying A.I. to the field of robotics, we find that although the problem robots encounter are simple and intuitive, they do represent major difficulties in the plan generation domain. A plan is an essential step towards solving any problem. A simple definition of a plan would be an ordered sequence of actions to reach the solution of a problem. A plan can also be defined as the representation of a course of action listing sub-goals in some ordered fashion. There are four distinct planning approaches: hierarchical, non-hierarchical, script-based and opportunist.

A hierarchical planner, for example, generates a hierarchy of plan representations wherein the highest is a simplification of the plan and the lowest is a detailed plan. The robot controller's knowledge would contain commands for its mechanical motion, the perception of the world around it, the formulation of an action plan and the monitoring and execution of that plan.

One project on the leading edge of robotics and A.I. is in space-related automation projects, specifically NASA's Space Station design and development. The applications in this area include: teleoperation and robotics for physical object manipulation; expert systems to aid in monitoring, diagnosis and maintenance; planning, to schedule space station resources and to determine what action should be performed by autonomous robots; data management systems; and man-machine interfaces.

With the further addition of intelligence, autonomous robots with self-contained vision, planning and control, will be able to perceive and manipulate objects. With such capabilities, the robots will be able to move around within the space station to carry out the crew's orders. Applications move around within the space station to carry out the crew's orders. Applications in the manufacturing arena on earth would be forthcoming as a result of these innovations. All this is expected to happen by the year 2005.

On the expert system side, the ultimate objective is to have a space manufacturing system that is capable of quality control, process control and maintenance. This is to be achieved in three phases. The first during 1991-1992, the second 1993-1995, and the third from 2000-2005.

On the planning side, robots are expected to function very much like human beings. By the end of 2005, it is thought that these robots, all of them independent and autonomous, will move around from one location to another and work cooperatively with other robots. They will be able to achieve such tasks as planning complex maintenance and repair operations for manufacturing equipment and subsystems.

Massively parallel machines

In October 1987, I made a projection about parallel computers published in *Canadian Electronic Engineering* [February 1988] that by the mid-nineties we expect to see a widespread use of parallel machines in image processing, graphics, and some large CAD systems. Towards the end of the next decade, micro and mini size parallel machines will be as popular as we see microcomputers today. A recent issue of *Byte* magazine (USA) dedicated to personal parallel machines suggests that my prediction was correct.

In the late seventies, when LISP machines entered the computer market and later on, when the Japanese Fifth Generation computer project was announced, most felt that specialized machines like LISP machines and "to be developed inference machines" would dominate the market of the late eighties and onwards. This was due to the fact that there were great expectations from the newly publicized Artificial Intelligence. Despite the apparent popularity of Artificial Intelligence in recent years, specialized machines like LISP or Inference machines are used only for either rapid proto-typing or research and development. The general purpose single CPU machine still is the work horse of a large segment of the computing industry.

For some sectors of computing, such as image and radar signal processing, complex fluid dynamics and environmental model calculations and complex fluid dynamics and environmental model calculations and other similar demanding applications, the successful use of parallel machines indicates their feasibility and eventual large scale usage. In fact, for many problems, a single processor is no longer good enough. For example, consider an image processing system which can recognize and describe a picture. An ordinary television picture with 1000 x 1000 pixels (picture elements) may take a processing time of 10 to 20 hours on such machines as DEC PDP-10 (where each pixel is an 8-bit-element). In comparison, a parallel machine, such as MPP (Massively Parallel Processor) built by Goodyear Aerospace for NASA, can process 7123.5 million pixels per second for gray scale thresholding. The gray scale is a measure of blackness for a black and white picture. This machine contains 16,384 processors interconnected in a 128 x 128 configuration with a basic cycle rate of 100 nano-seconds.

There is a demand for more and more processing power as new kinds of software systems, such as natural language processing, are coming into greater use for industrial and commercial applications. Although the price for a single VLSI processor is decreasing, single processor machines do not satisfy many large scale application requirements. Some experimental systems were built recently to take care of this need.

One would typically extrapolate three factors to determine the future trend. These are: (a) economic feasibility, (b) limits on existing technology, and (c) scientific breakthroughs. To analyze systematically the influence of these three factors, the hardware technologies can be classified in terms of distinct areas for improvement, namely:

Conventional electronics: (a) VSLI improvements based on production technologies, such as surface mount components, gate arrays, programmable array logic, etc.; (b) New semiconductors such as GaAs; (c) Specialized chips such as the LISP machine chip.

New physical principles: (a) Optical gates and eventually optical VLSI; (b) Bio-chemical chips.

New design principles: (a) Innovative non Turing-Von Neumann machines; (b) Data flow machines; (c) Fixed and variable topology parallel machines.

Parallel machines are in the latter category because these machines can be built using either conventional or exotic technologies, so let us see why parallel
built using either conventional or exotic technologies, so let us see why parallel
machines are going to dominate our future.

Parallel dominance

Since the first LSI chip in the early seventies, the density of active elements, i.e. number of the transistors per square centimetre, is increasing continuously. More and more transistors are being squeezed into a smaller and smaller chip. In 1959 only one transistor would fit on a chip and in 1987 the number surpassed a million. But there are limitations on such increases. The internal circuits of a chip are wired using a very fine line of conducting material and are referred to as the "lines". These lines are very thin, almost one millionth of a centimetre or less wide. The line width has reached now almost near molecular dimensions and the laws of physics suggest that we can not narrow it down significantly any further. There are other reasons besides this, however. New processing and lithographic techniques may make it possible in the near future to manufacture VLSI with ten or a hundred million transistors. The argument against such an unbounded increase in the size and the density of VLSI is that mere possibilities inherent in large scale integration do not themselves create adequate ways of exploiting this technology efficiently.

Hardware alternatives

The other hardware alternatives are to build optical processing elements or move into biochip manufacturing. Both these technologies are neither mature nor economically feasible at the present time. So we are still left with good old electronics and VLSI — cheap and functional. Also, one does not expect that any new discovery will expedite development of optical or biochemical gates. In both cases the physical principles are well understood. However, the problem is not the physics or chemistry behind the idea but the maturity of the technology which makes it economically feasible. This is what is lacking in optical and biochemical chip development. It takes a full two decades to mature a technology from its infancy to a robust and usable stage. Conclusively, the natural direction would be to develop parallel machines further.

The other factors are of a theoretical nature but nevertheless of fundamental importance. For example, we know that the Japanese Fifth Generation program
importance. For example, we know that the Japanese Fifth Generation program
emphasizes the development of new machines based on some principles other than the abstract model of Allan Turing and John Von Neumann.

All computers that exist today are based on this abstract computation model. Unfortunately, there are no known computational models which are shown to be more powerful than Allan Turing's abstract machine. On the other hand, there is significant evidence that natural information processing systems, i.e. human and animal brains, are massively parallel systems consisting of simple processing units. Research in the human thinking process will eventually lead A.I. into the parallel computation domain to a greater extent than today. Regarding the innovative theoretical models of the computer, we do not know how cost effective their implementation will be. In any case, it is not something that we will see in the near future.

New Centre for Theoretical Research in Bangalore

by K.S. Jayaraman

Courtesy of Nature, Vol 339, 22 June 1989

A Centre for advanced scientific research is to be set up in Bangalore and named after Jawaharial Nehru, India's first prime minister, whose centenary is being celebrated this year. The $16 million centre will be structured along the lines of the international institute for theoretical physics at Trieste in Italy.

Professor C.N.R. Rao, director of the Indian Institute of Science (IIS), also in Bangalore, is to act as president of the Nehru Centre which, he says, "will be devoted to scientific research at the highest level in frontier areas". It will set up its own facilities for theoretical work and will have access to the workshop and laboratories of IIS for experimental work.

The centre has been registered as a non-profit society with the primary objective of providing an excellent climate for research and acting as a national and international forum for free exchange of ideas through workshops, seminars and summer schools. It will have a full-time faculty as well as honorary and visiting positions. Rao hopes the new centre will attract Indian intellectuals now drawn to Trieste.
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Book review from IAEA

IAEA Yearbook 1989
Publication date: August 1989. Price: Austrian Schillings 560,-. Code: STI/PUB/832.
Summary: The Yearbook provides descriptions of the IAEA's major programmes, with articles on particular projects and areas of activity, together with reports of particular current interest and general information about the IAEA. The Yearbook presents the work of the IAEA in the context of scientific, technical and economic developments worldwide.

Contents: Foreword by the Director General; the IAEA's Contribution to Sustainable Development: Part A – Transfer of Nuclear Technology; Part B – Applications of Nuclear Techniques; Part C – Nuclear Power and Fuel Cycle: Status and Trends; Part D – Nuclear Safety Review; Part E – IAEA Safeguards; Part F – The IAEA.
Parts A, B, C and D are also available separately.

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P.O. Box 100
A-1400 Vienna
Austria

Activities at ICTP February - June 1989

Title: MINIWORKSHOP ON STRONGLY CORRELATED ELECTRON SYSTEMS IN CONDENSED MATTER, 19 June - 21 July.

Organizers: Professors G. Baskaran (Indian Institute of Mathematical Sciences, Madras, India), A.E. Ruckenstein (University of California, La Jolla, USA), E. Tosatti (International School for Advanced Studies, ISAS-SISSA, and ICTP, Trieste, Italy) and Yu Lu (P.R. China/ICTP), with the co-sponsorship of the International School for Advanced Studies (ISAS-SISSA, Trieste, Italy).

Lectures: Introduction to metal-insulator transition and the strong correlation problem. Some results in fermion mean field theories of the large U Hubbard model. Itinerant vs. localized AF of CuO_2 layers within a slave boson [illegible] AF of CuO_2 layers within a slave boson approach. Gauge theory of dimer phase with holes. Kondo effect: a saga of strongly interacting fermions. Instability of the ferromagnetic state in the large U limit of the Hubbard model. Novel local symmetries and chiral symmetry broken phases. Variational study of the pair hopping model. Exact diagonalization studies of small correlated systems. Two quantum liquids. Quantum spin systems and flux phases for pedestrians.

The Miniworkshop was attended by 67 lecturers and participants (23 from developing countries).

Title: SUMMER SCHOOL IN HIGH ENERGY PHYSICS AND COSMOLOGY, 26 June - 18 August, including the Workshop on superstrings (12 - 14 July) and the Workshop on phenomenology in high energy physics and cosmology (16 - 18 August).

Organizers: Professors G. Ellis (International School for Advanced Studies, ISAS-SISSA, Trieste, Italy), J.C. Pati (University of Maryland, College Park, USA), S. Randjbar-Daemi (Iran/ICTP, Trieste, Italy), E. Sezgin (Turkey/ICTP, Trieste, Italy) and Q. Shafi (University of Delaware, Newark, USA), in collaboration with the International School for Advanced Studies (ISAS-SISSA) and the Italian Institute for Nuclear Physics (INFN).

Lectures: *Part I:* Introduction to strings and conformal field theory. Multi-loop amplitudes in superstring theory. Coulomb gas approach to rational conformal field theories. String theory and 2-dim. quantum gravity. Landau-Ginzburg approach to N=2 superconformal field theory. Conformal field theory. N=2 string theory.

Part II: Physics of the early universe. Perturbative QCD. Probing the standard electroweak model. Inflation. Lattice QCD. Superphysics. QCD with dynamical quarks. To grand unification and beyond. Flavour physics. Superphysics. Scalar particle searches. Towards a unification of mass scales. Gauge theories and integrable models. Triviality and Higgs mass bound: a status report. Inflation and quantum cosmology. Interacting higher-spin actions from strings. Cosmological constant. Highlights of GR12. The surface tension in hadron nucleation and other first order phase transitions. Stellar structure, evolution and the solar neutrino problem (SNP). Microwave Background radiation and large scale structure of the universe. WIMPs and the Background radiation and large scale structure of the universe. WIMPs and the SNP. Current status of the strong CP problem. Three generation superstring models. Conformal field theory in the upper half plane. WIMPs and the solar pulsation problem (SPP). WIMPs in other stars: predictions and observations. 4-dim. superstring models. Application of conformal field theory to string field theory.

Workshop on superstrings: Fundamental length scale in string theory. The quartic effective action of the heterotic string and supersymmetry. Heterotic superstrings vacua based on non-compact current algebras. Topology of singularities and phase diagram on N=2 superconformal field theories. Contour integral representation of characters and supercharacters in rational conformal field theories. Real weight B-C systems and conformal field theory in higher genus. Massless and massive spinning superparticles. Duality and quantum groups. Minimal model in higher genus. Fusion and braiding in W-algebra extended and coset conformal theories. Deforming the Veneziano model ("q-strings"). The role of 2-dim. quantum gravity in string theory. General SU(2) Coset models and products of Virasoro models. BRS – invariance in unusual settings. Anomalies of the heterotic sigma models in a curved (1,0) superspace. Topological aspects of Calabi-Yau compactifications. Landau-Ginzburg Hamiltonians, expansions and N=2 superconformal models. Hidden symmetries in string theories. Non-perturbative aspects and exact results for N=2 Landau-Ginzburg theories. Integrating out Kaluza-Klein modes in string compactifications. Quantization of dynamical systems in curved phase space. Quantization of general gauge theories in curved phase space. Uq[sl(2)] invariant operators and minimal theories fusion matrices.

Workshop on phenomenology in high energy physics and cosmology: Experimental status of heavy flavour physics. Proton spin. The status on CP violation. Physics from the Mark II Detector and the SLC. Overview of three generation Calabi-Yau models. Strings at high temperature. The cosmological constant with or without wormholes. A natural connection between the origin of inflation and the hierarchy in mass-scales. Physics at LEP. 4-dim. superstring models. Physics at the Fermilab Tevatron collider.

The School was attended by 239

The School was attended by 239 lecturers and participants (162 from developing countries).

Title: QUASICRYSTALS, 4 - 7 July.

Organizers: Professors M.V. Jarić (Texas A. & M. University, College Station, USA) and S.O. Lundqvist (Chalmers University of Technology, Göteborg, Sweden), with the co-sponsorship of the International School for Advanced Studies (ISAS-SISSA, Trieste, Italy).

Lectures: Recent developments in the study of quasicrystals. Superlattice, microquasicrystals and approximants. Quasicrystal structure determination – Al-Cu-Li. The structure of quasicrystals:

advantages and limits of a neutron diffraction approach. Icosahedral alloys without phason disorder. Microcrystalline state of pseudo-icosahedral symmetry, crystalline to quasicrystalline phase transformation in the Al-Cu-Li and Al-Cu-Li and Al-Cu-Fe systems. Octagonal and dodecagonal quasicrystals. Quasiperiodic arrays in thin films of Al-Mn. On the symmetry of tilings and quasicrystals. Characterizations of order in aperiodic structures and arithmetical properties. Entropically stabilized quasicrystals. Tetracoordinated quasicrystals. A new algorithm for the generation of quasicrystals. Quasicrystals, approximations and dynamical systems. Simple quasicrystalline tilings. Quasicrystals versus modulated crystals. Topology of atomic surfaces in icosahedral quasicrystals. Modelling quasicrystal growth. Phason elasticity and surface roughening. Quasicrystal grain boundaries from the entropic and density-wave viewpoints. Soft mode crystallization. Why only quadratic irrationals are observed in quasicrystals? Kinetic roughening of quasicrystals. Defective vertex configurations in quasicrystals. Displacive mappings from quasiperiodic to periodic patterns. Dislocations in decagonal Al-Cu-Co alloy. Multifractal analysis of localization problem in quasiperiodic systems. Real space renormalization and critical properties of Fibonacci potentials. Electronic structure of quasicrystals. On the electronic properties of a three-dimensional quasicrystal with weak potential. Diamagnetism in quasicrystalline superconductors. Algebraic symmetries in quasicrystal scattering data. Crossover behaviour from 'extended' to chaotic in quasicrystal scattering data. Crossover behaviour from 'extended' to chaotic wavefunctions in 1d quasicrystals. Quasiperiodic Hume-Rothery stable alloys in 1d: an exact solution. Where and how large are the gaps in spectra of deterministic aperiodic systems? Novel transition between critical and localized states in a 1d quasiperiodic system. Thermal properties of a classical model of a 2d quasicrystal. Vibrational properties of Fibonacci chains without and with defects.

The Conference was attended by 62 lecturers and participants (12 from developing countries).

Title: TRIESTE CONFERENCE ON SUPERMEMBRANES AND PHYSICS IN 2+1 DIMENSIONS, 17 - 21 July 1989.

Organizers: Professors M. Duff (Texas A&M University, USA), C. Pope (Texas A&M University, USA) and E. Sezgin (Turkey/ICTP, Trieste, Italy).

Lectures: Membranes, extended objects and infinite-component wave equations. Supermembranes: a review. Towards a conformal field theory for higher spins. Infinite dimensional membrane symmetries that generalize the conformal symmetry of the string. Evolution equation of strings and membranes. Singleton and doubleton supermultiplets of spacetime supergroups and infinite spin superalgebras. Worldvolume supersymmetry from spacetime supersymmetry. Braiding matrices, modular transformations and topological field theory in 2+1 dimensions. New symmetries in 2+1 dimensions. Quantum topologically massive gravity. Topology and 3-dimensional field theories. Area-preserving algebras and membrane topology. Geometry and topology of 3-manifolds. Non-Abelian Chern-Simons theory, conformal field theory and knot polynomials. Covariant canonical quantization of superparticles. The light cone gauge. 2+1 topological terms, anyons and their possible physical application in high T_c superconductivity. The supermembrane mass spectrum. New directions in supermembranes. Strings from membranes: the origin of conformal invariance. New spacetime superalgebras and their Kac-Moody extension. Consistent dynamics of higher spin gauge fields. Comments on integrability in 2+1. The large N limit of extended conformal symmetries. Area-preserving diffeomorphisms and of extended conformal symmetries. Area-preserving diffeomorphisms and supermembrane Lorentz invariance. The E9 current of d=2, N=16 supergravity. Super Yang-Mills quantum mechanics and supermembrane spectrum. Trigonometrical structure constant for the classical Lie algebras and the vacuum states SU(∞) Yang-Mills theory. On the covariant quantization of gauge theories including supermembranes. BRST quantization of the Green-Schwarz superstring. Chern-Simons supergravity. Chern-Simon theories of symplectic super-diffeomorphisms. Structure of SDiff, the weather forecast and solar activity. Virasoro algebra and a membrane symmetry. Gauge theory of singletons: results and perspectives. Teal tunnelling geometries and the large scale topology of the universe. Generalized sigma models and the index theorem. Weyl-invariance of membranes. Harmonic superspace in supersymmetry and beyond. Supermembranes on black holes. Generic curved space supermembrane theories. Concluding remarks.

The Conference was attended by 35 lecturers and participants (6 from developing countries).

Title: STRONGLY CORRELATED ELECTRON SYSTEMS, 18 - 21 July.

Organizers: Professors A. Ruckenstein (University of California, San Diego-La Jolla, USA), E. Tosatti (International School for Advanced Studies, ISAS-SISSA, Trieste, Italy) and Yu Lu (ICTP), with the co-sponsorship of the International School for Advanced Studies (ISAS-SISSA, Trieste, Italy).

Lectures: Phenomenological constraints on theories of high T_c superconductors. Strong correlation and novel superconducting states. Theory of metal-insulator transition. The spiral phase and superconductivity in the doped Heisenberg model. Quasiparticles in doped planar antiferromagnet. Self-consistent renormalized motion of holes in a quantum antiferromagnet. Numerical studies of the t-J model: exact ground state and flux phases. Finite size calculations on the 2D Hubbard model. Fermion quantum Monte Carlo and Hubbard model. Preliminary group theory analysis of a 4x4 two-dimensional Hubbard model. Properties of two-dimensional systems with fractional statistics. Anyons on a lattice. Superfluidity of the anyon gas. Spin singlet fractional quantized Hall states. A Superfluidity of the anyon gas. Spin singlet fractional quantized Hall states. A model for orbital antiferromagnetism. Twisted superconductors and twisted magnets. Magnetism (+ superconductivity?) in the 2D Hubbard model. Intersite correlation in variational wave functions. New exactly tractable limit for correlated lattice electrons. Correlated fermions on a lattice in high dimensions. Heavy fermions: past, present and future. Understanding of NMR in high T_c materials. Slave boson approach to the Hubbard model. Itinerant vs. localized AF of CuO_2 layers within a slave boson approach. Instability of the ferromagnetic state in the large U limit of the Hubbard model. Strongly correlated, quasi-one-dimensional bands: group states, optics, and phonons. Nematic and dimer states in low dimensional magnets. Raman spectra and strong O-O fluctuations in $YBa_2Cu_3O_7$. Topological statistics transmutation and superconductivity. Treatment of strong correlations by projection techniques. Pairing theory in two-dimensions. Importance of spin-flip processes in quantum antiferromagnets. One loop corrections to the Gutzwiller approximation (within the slave boson approach). Quasiparticles and photoemission spectra in correlated electron systems. Binding of holons in the chiral spin states. The supersymmetric Hubbard model and high T_c superconductivity. The effect of topological excitations in the two-dimensional quantum Heisenberg antiferromagnet. $4K_F$ correlations in 1D systems revisited. $U=\infty$ Hubbard model: towards the exact solution in $d=\infty$.

The Course was attended by 79 lecturers and participants (22 from developing countries).

Title: INTERNATIONAL SYMPOSIUM ON HIGHLIGHTS IN CONDENSED MATTER PHYSICS (dedicated to Prof. K.S. Singwi on the occasion of his 70th birthday in recognition of his extensive and pioneering work in the field), 1 - 3 August.

Organizers: Professors P. Yena (Virginia Commonwealth University, Richmond, USA), R. Kalia (Argonne National Laboratory, Argonne, USA), M.P. Tosi (University of Trieste and ICTP, Italy) and P. Vashishta (Argonne National Laboratory, Argonne, USA).

Lectures: Local field effects in weakly to strongly interacting Fermi systems. Applicability of the local field concept for the electron gas. Dynamic susceptibility of a free electron gas in D dimensions and its analytic properties. Hubbard corrections in a 2-D electron gas. A novel approach to correlation effects in electron spectroscopies. On dynamic correlations in uniform electron liquid. The puzzling neutrinos. Dynamics of classical and quantum liquids from neutron scattering experiments. Relaxations in supercooled Lennard-Jones systems. Dynamical correlation function and transport coefficients of dense fluids. The structure and dynamics of intercalated ternary systems. Interatomic potential energy. Electron correlations and dielectric screening in a layered electron gas. Impurity problem in metals. Polaron gas in low dimensional structures. A cold start to the Universe? Density functional theory of superconductors. Ground-state energy of the one-and two-component Hubbard model calculated by the method of Singwi, Tosi, Land and Sjölander. Superconducting correlations in the new high T_c superconductors from a study of dynamic response function. Hydrogen in metals. Density wave theory of Wigner crystallization. Electron-hole liquids and many-body theories.

The Symposium was attended by 26 lecturers and participants (5 from developing countries).

Future Activities at ICTP in 1989

Computations in Physics and and Physics in Computation (Anniversary Adriatico Research Conference)	5 - 8 September
Adriatico Working Party on Condensed Matter Properties of Neutron Stars	11 - 29 September
Workshop on Materials Science and Physics of Nonconventional Energy Sources	11 - 29 September
Conference on Lasers in Chemistry	18 - 22 September
Workshop on Interaction between Physics and Architecture in Environment Conscious Design	25 - 29 September
Trieste Conference on Recent Developments in Conformal Field Theories	2 - 4 October
Fifth College on Microprocessors: Technology and Applications in Physics	2 - 27 October
Workshop on Soil Physics / Fifth College on Microprocessors: Technology and Applications in Physics	9 - 27 October / 2 - 27 October
Workshop on Soil Physics	9 - 27 October
College on Differential Geometry	30 October - 1 December
25th Anniversary Conference on "Frontiers in Physics, High Technology and Mathematics"	31 October - 3 November
Workshop on Telematics	6 - 24 November
ICTP & INFN Course on Basic VLSI Design Techniques	6 November - 1 December
Third Autumn Workshop on "Atmospheric Radiation and Cloud Physics"	27 November -15 December

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

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