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Professor Abdus Salam, Director of the International Centre for Theoretical Physics, Trieste, Italy, presenting the Special Dirac Medal to Mrs. Margit Dirac, on 24 July 1991, in the Main Lecture Hall of the ICTP. Prof. A. Zichichi, President of the World Laboratory, is on the left.

Contents

Galileo Galilei Celebration

"Abdus Salam has created in Trieste a centre which is unique in the world and prestigious for Italy. Not only I but also the Trieste citizens and the major officials of Italian institutions say so", said Prof. Antonino Zichichi, Director of the famous international school of physics in Erice and President of the World Federation of Scientists in Geneva, at the Galileo Celebrations which were inaugurated on Wednesday 24th July, 1991, in the Main Lecture Hall of ICTP in Trieste. The Celebrations, which will last three years, shall include a series of initiatives aiming at honouring Galileo Galilei on the 400th anniversary of the birth of modern science. The project will involve both Italian and foreign universities and research centres.

Prof. Zichichi spoke at length on the revolutionary influence of Galileo on human history. *"Before Galileo*, he said, *man had discovered techniques — for example, fire and the wheel — as well as numbers, geometry and the arts of sculpture and painting. Galileo's enormous contribution was the experimental method which caused a strong acceleration in the rhythm of invention"*.

He then added, *"Very often great scientific discoveries are abandoned and taken up again only for military purposes. Our civil technology is a fraction of military technology which is huge. This practice must change. Scientific discoveries must be followed immediately by the study of practical 'peaceful' uses."*

Before the speech by Prof. Zichichi, Professor Abdus Salam, Director of ICTP and President of TWAS, presented Ms. Margit Dirac, the widow of Nobel Laureate Paul Dirac, with the medal in memory of her husband — one of the major physicists this century who actively supported the establishment and early development of the ICTP. Ms. Margit Dirac, after receiving the award, said that being in Trieste again was like "a beautiful dream" to her.

After an introduction by Prof. Zichichi, the first item in the Galilei Celebrations was a lecture on the origin of the universe by the cosmologist Sir Fred Hoyle.

The origin of the universe is one of the most debated topics in science. Sir Fred is the major propounder of the 'theory of the stationary state' which is opposed to the so-called 'Big Bang' theory.

According to the latter, the universe was born about fifteen thousand million

years ago, after a big explosion which caused a gradual expansion of galaxies.

A few supporters of the Big Bang have claimed for some time that their beliefs have been proved incontrovertibly, but Sir Fred Hoyle was clear today: *"The problem is all but open"* — one more sign of that democracy which Galileo pioneered.

On the occasion of the Galileo Celebrations a message was sent to Prof. Zichichi by the Prime Minister of Italy. The message is given below:

Rome, 24 July 1991

To Prof. Antonino Zichichi
Director.
International School of Subnuclear Physics, Erice
and President,
World Federation of Scientists, Geneva

Dear Zichichi,

I wish to congratulate you heartfully on the joint initiative by the Galileo Galilei Foundation, World Federation of Scientists, Ettore Majorana Centre of Scientific Culture and the International Centre for Theoretical Physics aiming at duly celebrating Modern Science on the 400th anniversary since its birth.

While I wish to assure you of the patronage of the Prime Ministry to the series of such high-level initiatives, I would like to recall the effort being made by the World Lab to make research universal — which can only be achieved through Science.

I have been convinced for a long time that the exchange of ideas and experience is the foundation of progress. This holds true, in particular, for scientific progress, whose impact on the development of our societies is so important that it requires the widest and freest possible circulation of ideas as well as open and constructive debate on new projects. This new state of things, to which you have contributed so much through your passionate action in favour of a science without secrets or barriers, will also enable the study of the great potentialities of subnuclear physics to be oriented towards significative realizations, not only on a purely scientific level, but also in favour of industrial and social development. Specifically, I am referring to the project of a new very-high-energy machine whose construction in Sicily would mean a great asset for promoting at the highest level scientific activities in a region which has a right to enter the mainstream of European development.

The careful consideration of the developments which have been taking place in Erice and Comiso has led to the proposal to create a large scientific and technological laboratory, in the framework of which the project of the large collider Eloisatron can be included.

The deep interest of the scientific community on these new frontiers which open up a future extended alliance among industrialized and developing countries, makes the Erice-Comiso and Eloisatron projects very significative.

If we proceed jointly and in agreement at the international level, the studies which have been carried out on a large data processing centre in Erice and on the large ELN machine in Comiso will be enabled to enter the phase of concretization. Such would be a fine accomplishment on the occasion of the 400th anniversary of the birth of Modern Science!

On the basis of the above thoughts, I would start the Galilei Celebrations in Erice and Trieste. These Celebrations are started at a moment in which scientific and technological East-West-North-South collaboration is entering a new phase, thanks to the climate of peace which the Erice scientists have favoured and that we have been following since the difficult years when the danger of a nuclear holocaust was feared. In this new era of peace, my effort for supporting the Erice-Comiso projects shall be — as has ever been — sincere and convincing.

With best regards and wishes,
Giulio Andreotti ♦

Dirac Medal Award Ceremony

On August 7, 1991, Prof. Sidney R. Coleman (Harvard University, Cambridge, Ma., USA) received the 1990 Dirac Medal which had been awarded to him last year. Two such medals are awarded every year on the birthday of P.A.M. Dirac — 8th August.

The ceremony took place in the Main Lecture Hall of the ICTP, Trieste. Professor Abdus Salam, Director of the ICTP, presented the Medal and a cheque of US$ 5,000 to Professor Sidney R. Coleman.

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Professor Sidney R. Coleman is honoured for his contributions to quantum field theory and particle physics. His work on quantum field theories has greatly clarified their structure. This includes the classification of all possible bosonic symmetries of S-matrix (with J. Mandula) and the study of some fundamental properties of two-dimensional quantum field theories including, in particular, the absence of symmetry breaking and aspects of boson-fermion equivalence. His study (with E. Weinberg) of the quantum effective action and the phenomenon of dimensional transmutation has had an important influence on the development of the subject. This includes his work on the fate of false vacuum, on the discovery of Q-balls, and more recently, on the potentially far-reaching physical consequences of wormholes. These contributions are paralleled by the equally important one of teaching the younger generation of particle physicists the modern concepts in quantum field theories through very lucid lectures and papers.

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Prof. Coleman was born on 7 March 1937 in Chicago, Illinois, USA. He obtained his B.Sc. at the Illinois Institute of Technology in 1957 ad his Ph.D. at the California Institute of Technology in 1962. He started his career at Harvard University as a Corning Lecturer and Research Fellow in physics (1961-63). He then became Assistant Professor of Physics (1963-65), Alfred Sloan Fellow (1964-65), and Associate Professor of Physics from 1966 to 1968 at the same University. After spending one year at the University of Rome, Italy, as a Visiting Professor, he returned to Harvard where he was appointed as a

Professor Sidney R. Coleman, receiving the Dirac Medal of 1990 from Professor Abdus Salam, Director of the International Centre for Theoretical Physics and President of TWAS on Wednesday, 7 August 1991, in the Main Lecture Hall of the ICTP.

Professor of Physics in 1969. He was Visiting Professor one year at Princeton in 1973 and at Stanford in 1979-80. In 1980, he was appointed as a Donner Professor of Science at Harvard University. In 1989 he was again visiting Professor at Berkeley. Honors bestowed include the Boris Pregel Award from the New York Academy of Sciences; the Award for Lectures in Physics from the Centro Ettore Majorana (International School of Physics, Erice, Italy); J. Murray Lack Award for Scientific Reviewing given by the National Academy of Sciences; and the Distinguished Alumnus Award from the California Institute of Technology. Prof. Coleman is a Fellow of the American Physical Society, American Academy of Arts and Sciences and National Academy of Sciences. He is the author of 82 papers. ♦

Special Dirac Medal Ceremony

On Wednesday, 7th August, 1991, on the occasion of the Dirac Medal Ceremony, Professor Abdus Salam, Director, ICTP, presented a special Dirac Medal to Prof. Claudio Villi, in recognition for his contribution to the development of scientific activities of the national and international institutes in Trieste.

Professor Claudio Villi was born in Trieste in 1922. He obtained his degree in Physics at the University of Trieste in 1951. Appointed Full Professor of Theoretical Physics at the University of Parma in 1960, he is at present Full Professor at the University of Padua.

He has published over 100 scientific papers mainly on the nucleon-nucleon interaction, on nuclear matter, on mathematical methods of physics and lately on quantum field theory in curved space. His construction of a model of the electromagnetic structure of the proton, for which he received the Stanford-Battelle Prize, was widely used by Robert Hofstädter during his famous experiments. He has published books on Nuclear Physics and on Mathematical Methods in Physics. He is also author of a book and researcher on certain aspects of modern history. In 1988 he received the Gold Medal from the Centre for Scientific Culture "E. Majorana" in Erice.

He has been President of the Senate Commission on Ecology and Vice-President of the Interparliamentary Commission for the creation of the Research Area of Trieste, of the University of Udine and of the SISSA, as well as for the enforcement of the Treaty of Osimo. He is presently member of the Patavina Academy and of the Veneto Institute for Science, Literature and Art. He is also President of the Mittel-European Branch of the World Laboratory.

On the occasion of the Dirac and Special Dirac Medal Ceremony (from left to right), Prof. P. Budinich, Prof. S.R. Coleman, Professor Abdus Salam, Prof. S. Lundqvist and Prof. Claudio Villi, (recipient of Special Dirac Medal).

Professor Stig Lundqvist, Chairman of the Scientific Council of the ICTP, chaired the function and spoke about Prof. Villi's active contribution to the scientific field, ICTP and to Trieste. The following is the text of Prof. Lundqvist's speech on the occasion.

"Today the special Dirac Medal is being awarded to Professor Claudio Villi, a scientist, a politician, a member

of the Senate of the Italian Republic and a public administrator who has well earned his public merit in various fields complementary to each other.

Since the 1960's Sen. Prof. Claudio Villi has given his full backing to the scientific developments in Trieste. Together with Paolo Budinich, he promoted a Symposium on High Energy Physics, in which eminent Italian and foreign experts took part, and which inspired Professor Abdus Salam to propose to the IAEA the establishment of the ICTP.

In the years from 1970 to 1975, during his tenure as President of the INFN, he implemented the active participation of Italian scientists in the activities of the ICTP, and of scientists from Third World countries in research programmes in Italian laboratories.

From 1977 onwards, Prof. Villi has been the President of the Consortium for Physics of the University of Trieste. During his tenure the construction of the guest house named after Galileo Galilei was carried out, the Main Building was doubled and now the new ICTP administrative building is being built.

We can thus consider Prof. Claudio Villi fully deserving this special Dirac Medal for having contributed in different places and circumstances both to the birth and the development of the International Centre for Theoretical Physics, as well as to the scientific initiatives of Trieste". ♦

Visits to ICTP

Prof. Shing-Tung Yau

Prof. Shing-Tung Yau (Harvard University, Cambridge, MA., USA) lectured at ICTP on 16 July 1991 on "Compact Ricci flat manifolds".

Corrigendum
Minister Visit to ICTP

Please read "Minister" instead of "Ambassador" on Page 8 of the June/July issue of *News from ICTP*, under *Visits to ICTP: Swedish Ambassador to IAEA.* ♦

Dirac Medals 1991

The 1991 Dirac Medals of the International Centre for Theoretical Physics (ICTP), Trieste, Italy, have been awarded to Professor Jeffrey Goldstone (Massachusetts Institute of Technology, Cambridge, MA, USA) and Professor Stanley Mandelstam (University of California, Berkeley, USA).

Professor Jeffrey Goldstone is honoured *"for his fundamental clarification of the phenomenon of spontaneous symmetry violation in relativistic quantum field theory. This phenomenon has come to occupy a central role in our understanding of elementary particles, and Goldstone's work is now among the foundations of the standard model of fundamental interactions. The ensuing massless bosons, known as Goldstone bosons, have found crucial applications also in many spontaneous symmetry breaking processes in condensed matter physics."*

Professor Stanley Mandelstam is honoured *"in recognition of his contributions to the development of theoretical physics. His representation of the analytic properties of scattering amplitudes in the form of double dispersion relations (Mandelstam representation) is basic to the modern understanding of relativistic particle scattering and his seminal work on the quantization of string theories, exploiting their conformal properties, led to a more profound understanding of this subject. Mandelstam was among the first to apply path integral quantization methods to string theory. This work was generalized and extended by many others in the following years and now forms an in the following years and now forms an integral part of the modern formulations."*

The Dirac Medals of the International Centre for Theoretical Physics were instituted in 1985 in memory of Professor P.A.M. Dirac, an honoured guest and staunch friend of the ICTP. They are awarded every year on Dirac's birthday — 8th August — for contributions to theoretical physics. From 1990, the medalists will also receive a cheque of 10,000 US dollars.

In 1985, the 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 Professor 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, New Jersey, USA) and Prof. Efim Samoilovich Fradkin (Lebedev Physical Institute, Moscow, USSR). The 1989 Dirac Medals were awarded to John H. Schwarz (Caltech, Pasadena, USA) and Michael B. Green (Queen Mary College, University of London, UK). The recipients of the 1990 Dirac Medals were Prof Ludwig D. Faddeev (Steklov Mathematical Institute, Leningrad, USSR) and Prof. Sidney R. Coleman (Harvard University, Cambridge, USA).

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

International Conference on Solid State Science and Technology

The University Science Malaysia in collaboration with the Malaysian Solid State Science and Technology Society will be organising the International Conference on Solid State Science and Technology. The details are as follows:
Date: 18–20 August 1992.
Place: Penang, Malaysia.
Registration: US$ 200.00.
Contact person: Dr. K. Ibrahim, Conference Secretary, School of Physics, University Science Malaysia, 11800 USM, Penang, Malaysia.
Fax: (04) 875113
Telex: MA 40254
Tel: (04) 877888 Ext 3663 or 3200
Deadline for abstracts: 31st January 1992
Notice of acceptance: March 1992.

The Conference will be conducted in English. ♦

A Salute to Stig Lundqvist

by
Elias Burstein

Courtesy of
Solid State Communications,
Vol. 79, No. 6, August 1991.

It is with great pleasure that we inform our readers that Stig Lundqvist, a Member of the Board of Editors of *Solid State Communications* from its inception in 1963 until 1976 when he became a Member of the Editorial Policy Committee has been awarded the Dirac Medal of the International Centre for Theoretical Physics (ICTP), Trieste, Italy.

In August 11–13, 1990, a Symposium on "Frontiers in Condensed Matter Physics" honouring Stig Lundqvist was held at ICTP on the occasion of his 65th birthday (9 August) and his retirement from Chalmers University of Technology, Göteborg, Sweden. (...) During the ceremonial session, Lundqvist was presented with the Dirac Medal by Prof. Abdus Salam, the Director of ICTP, who also committed the sum of US$ 5,000 to establish a Lecture Series in Lundqvist's honour jointly at Chalmers University of Technology and at ICTP. Lundqvist was also presented with the Chalmers Medal by Prof. Anders Sjoberg, Rector of Chalmers University of Technology.

The Dirac Medals of the International Centre for Theoretical Physics were instituted in 1985 in memory of Prof. P.A.M. Dirac. They are awarded every year on Dirac's birthday — 8th August — for contributions to theoretical physics.

The citation for the Dirac Medal awarded to Lundqvist reads:

"Stig Olov Lundqvist is awarded the Dirac Medal of the ICTP for his outstanding contributions to Many-Body Theory: From Atoms to Condensed Matter. He has made fundamental advances in the areas of: (a) quantum mechanics of lattice vibrations in insulators: (b) collective excitations in atoms and molecules: (c) many-body correlations in electronic systems: (d) theory of electron and photon spectroscopy of solids; (e) electromagnetic response of metal surfaces. Moreover, Stig Lundqvist has played a crucial role in promoting scientific research and education in Sweden and worldwide. His dedication and his passion have been particularly instrumental in developing and nurturing condensed matter programmes at ICTP".

The Chalmers Medal was awarded to Lundqvist in recognition of *"the central role that he has played in theoretical physics"* in Göteborg in which he contributed both to the development of condensed matter physics and to the development of opportunities for young scientists.

We take this opportunity to congratulate Stig Lundqvist on receiving these noteworthy awards and to extend to him, on behalf of the Board of Editors and his many friends and colleagues, our very best wishes for continued success in all of his endeavours. ♦

Dirac Lecture

by
L.D. Faddeev,
Steklov Mathematical Institute,
St. Petersburg.

It is a great privilege and pleasure for me to be able to address this audience. I am grateful to Professor Abdus Salam and the Members of the Dirac Committee for giving me this opportunity.

I was too young to know Dirac personally. In fact, the only occasion when I was able to see him at short distance happened here during the inauguration of a new building of ICTP in 1968 — what a splendid month all of us had! Nevertheless, the influence of Dirac on my scientific life cannot be overestimated.

The curriculum of theoretical physics in our university was supervised by V.A. Fock. It is well known how spiritually close were Dirac and Fock. Thus Dirac's influence on me as an undergraduate student was through V.A. Fock.

Dirac's textbook on quantum mechanics with its stress on foundations together with Fock's lucid but not well known book of 1932 were the main sources which established my views of quantum theory.

Finally and most important, it was Dirac's as well as Feynman's influence which was the starting point of my own work on Quantum Field Theory.

I decided that I can do an original work in this field in the mid '60s after my successful work on the three body problem in quantum mechanics. It was time when QFT was out of fashion everywhere in the world. There were several reasons — the failure of the meson theory of nuclear force, Landau zero charge theorem in QED, the superficial success of S-matrix theory etc. And as always happens in my country, where every community tends to amplify and monopolize its influence, QFT became a forbidden area. The conceptual success of QFT in the end of the '20s and beginning of the '30s as well as quantitative achievement of QED in the late '40s and early '50s were brushed aside.

However, all this was not imperative for a nonconformist as myself. Apparently in Leningrad the collective wisdom was less influential, moreover as a mathematical physicist I was not obliged to follow the main line in physics. Thus I decided that I was able to begin to work on QFT.

Naturally, I was to choose a direction, or concrete model to work on. The simple models of self-interacting scalar field did not appeal to me. I wanted to deal with something really fundamental and natural. Electromagnetism and gravity are established cornerstones of the classical physics. Their geometric origins were unraveled by Einstein, Weyl and

Fock. QED already existed. Thus Quantum Gravity was a possible direction to work.

I began to read the literature on Quantum Gravity and finally two sources became my main stimulus: Dirac's papers of the end of the '50s on the Hamiltonian description of Einstein's Theory of Gravity and Feynman's lecture in Poland on quantization of gravity. The functional integral formulation of quantization of the gauge fields, found by me and Popov in the fall of 1966, was the outcome of the work in the direction shown by Dirac and Feynman.

Let us stress again, that the concentration on the fundamental questions, which is characteristic of all scientific life of Dirac, is a lesson to any young scientist, which hardly could be overestimated.

In the second part of my lecture I want to present some technical point in generalized Hamiltonian dynamics. Namely, I shall discuss a procedure of reducing the singular Lagrangian to the Hamiltonian form. Quite a general procedure for that was presented by Dirac in 1950. It was important for the problem of quantization of the gauge fields, because the corresponding Lagrangians are singular. My formulation was developed when I adapted Dirac's approach to Yang-Mills field and gravitational field in the form, suitable for the functional integral.

Following tradition I shall discuss the mechanical situation with finite number of degrees of freedom. The passage to the field theory is straightforward.

In the Lagrangian formulation of mechanics we begin with the Lagrange function $L\,(q,v)$ of $2n$ variables $q_i, v^i, i = 1, \ldots, n$. (I shall drop indices below whenever it do not lead to confusion).

The passage to the Hamiltonian form is based on the change of variables

$$(q, v) \to (q, p)\,,$$

where

$$p = \frac{\partial L}{\partial v}\,.$$

The Hamiltonian function then is constructed as

$$H = pv - L \Big|_{v = v\,(p,\,q)}\,.$$

The change of variables is well defined if

$$det \left\| \frac{\partial^2 L}{\partial v^i\, \partial v^k} \right\| \neq 0\,.$$

If this determinant vanishes identically we say that the Lagrangian is singular and passage to Hamiltonian form is to be modified. Exactly this was discussed by Dirac in 1950.

My simplification was based on the so-called first order formalism. Known in the '20s (Palatini formalism for gravity) and '30s (Kemmer-Duffin formalism for scalar fields) it was strongly advocated by Schwinger, from whom I adopted it for myself.

First order Lagrangian uses one sort of variables, call them ξ, and it is linear in the time derivatives of ξ,

$$\ell = f^a\,(\xi)\,\dot{\xi}_a - \phi\,(\xi),\ \ a = 1, \ldots, N\,.$$

The nonsingular Lagrangian $L\,(q, v)$ reduces to this form as follows

$$\ell = \frac{\partial L}{\partial v}\,(\dot{q} - v) + L$$

or in variables q, p

$$\ell = p\,\dot{q} - H$$

It is the last expression which enters the action functional needed for the functional integral quantization.

Of course, the Lagrangian ℓ considered as function of independent variables ξ and $\dot{\xi}$ is an example of the most singular Lagrangian: matrix $\partial^2\,\ell\,/\,\partial\dot{\xi}\,\partial\dot{\xi}$ is identically zero. However the proposed passage to Hamiltonian form will be different from the Dirac's one. In particular, I shall not introduce "momentum" variable, conjugated to ξ.

Let us consider the equations of motion, generated by variation of the action

$$A = \int \ell\, d\,t = \int f^a d\,\xi_a - \phi\, d\,t\,.$$

They look as follows

$$\left(\frac{\partial f^{\,a}}{\partial\,\xi^{\,b}} - \frac{\partial f^{\,b}}{\partial\,\xi^{\,a}} \right) \dot{\xi}_{\,b} + \frac{\partial\,\phi}{\partial\,\xi^a} = 0\,.$$

If the matrix

$$\Omega^{\,ab} = \frac{\partial\, f^{\,a}}{\partial\,\xi^{\,b}} - \frac{\partial\, f^{\,b}}{\partial\,\xi^{\,a}}$$

is nondegenerate, then these equations are already in Hamiltonian form; indeed, the inverse matrix Ω_{ab} defines the Poisson brackets

$$\{\xi_{\,a}\,,\,\xi_{\,b}\,\} = \Omega_{ab}$$

and equations of motion can be rewritten as follows

$$\dot{\xi} = \{\,H\,,\,\xi\,\}\,.$$

In general case $\Omega^{\,ab}$ is degenerate. We shall invoke the Darboux theorem, which states that there exists such a change of variables

$$\xi \to (p, q, z)\,,$$

that matrix $\Omega^{\,ab}$ acquires the form

$$\Omega = \left\| \begin{array}{ccc} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{array} \right\|\,.$$

The Lagrangian ℓ in new variables looks as follows

$$\ell = p\,\dot{q} - \phi(p, q, z) + \frac{\partial s}{\partial t},$$

where the last term can be discarded. The equations of motion

$$\dot{p} = -\frac{\partial \phi}{\partial q}; \quad \dot{q} = \frac{\partial \phi}{\partial p};$$

$$\frac{\partial \phi}{\partial t} = 0$$

are partly Hamiltonian, however there are extra variables z. Observe, that the last equations do not contain time derivatives. So one can use them to try to express variables z in terms of p and q. One can do it for all z but those which enter ϕ linearly. So after the elimination of those z, which could be expressed through p and q we end with the Lagrangian

$$\ell = p\,\dot{q} - H(p, q) - \lambda\,\varphi(p, q)$$

with canonical variables p, q and Lagrangian multipliers λ. The constraints

$$\varphi(p, q) = 0$$

allow us to express p and q through independent variables η

$$p = p(\eta); q = q(\eta),$$

and Lagrangian is transformed to the form

$$\ell = g^b(\eta)\dot{\eta}_b - \psi(\eta), \; b = 1, \ldots, M$$

— the same as we began with. The only difference is that the number of variables η is smaller than that of ξ; in the generic situation

$$M = N - m - 2n$$

where m is a number of excludable z and n is a number of Lagrangian multipliers λ.

We can repeat the same cycle until we finish with a

We can repeat the same cycle until we finish with a proper Hamiltonian formulation (no λ variables), or exhaust all variables to be able to claim, that the original Lagrangian was contradictory. And this is all. No notion of primary or secondary constraints is needed, the only nontrivial procedure is a realization of Darboux theorem.

It is useful to know, what property of constraints φ and generalized Hamiltonian H in the Lagrangian

$$\ell = p\,\dot{q} - H - \lambda\,\varphi$$

guarantee, that we get the canonical formulation after solving the constraints. Two cases are typical:

1. Constraints are of the first class (Dirac's terminology) and Hamiltonian commutes with them. This means, that all Poisson brackets

$$\{\varphi^\alpha, \varphi^\beta\}, \{H, \varphi^\alpha\}$$

vanish on the surface $\varphi^\alpha = 0$.

2. Constraints are of the second class (no condition on H). This means, that the matrix

$$\| \{\varphi^\alpha, \varphi^\beta\} \|$$

is nondegenerate.

In the first case the true number of canonical variables is equal to number of p, q but twice the number of constraints. In the second case constraints are to be counted only once.

The first situation is realized in the case of Yang-Mills field and Einstein gravity. In the case of Yang-Mills field one uses A_μ and $F_{\mu\nu}$ as independent variables. The Lagrangian

$$\ell = \frac{1}{4\gamma} tr\,[F_{\mu\nu}(\partial_\mu A_\nu - \partial_\nu A_\mu + [A_\mu, A_\nu]) - \frac{1}{2} F_{\mu\nu}^2]$$

is already in the generalized Hamiltonian form; indeed, using three-dimensional indices and notations

$$E_i = F_{oi}$$

we have

$$\ell = \frac{1}{2\gamma} tr\,[\partial_0 A_i E_i + \frac{1}{2} E_i^2]$$

$$\frac{1}{2} F_{ik}(\partial_i A_k - \partial_k A_i + [A_i, A_k]) - \frac{1}{4} F_{ik}^2 +$$

$$+ A_0(\partial_i E_i + [A_i, E_i])].$$

We see that F_{ik} could be excluded, A_k and E_k play the role of canonical variables, A_o is Lagrangian multiplier and Gauss law $G = \nabla_i E_i$ plays the role of constraint; the Hamiltonian H is given by

$$H = \frac{1}{4\gamma} tr\,(E_i^2 + B_i^2)$$

where $B_i = \varepsilon_{ik\ell} F_{k\ell}$. It is easy to check that G and H are of the first class

the first class.

In the case of gravity, one could start with the Palatini formulation with $g_{\mu\nu}$ and $\Gamma^\sigma_{\mu\nu}$ as independent variables; one immediately identifies Γ^σ_{00} as Lagrangian multipliers; however the corresponding constraints do not commute with the generalized Hamiltonian and one is to solve them exactly and begin the next cycle. The realization of the Darboux theorem on the second step is not completely trivial but can be achieved. The first and second quadratic forms q_{ik} and h^{ik} of the initial surface imbedded in the space time become canonical variables. One gets constraints, but now they are of the first class. This accomplishes the programme of the passage to the Hamiltonian form for the Einstein gravity, which was first done by Dirac in the mid '50s. And it is natural for me to stop here. ♦

Junior Associates 1991

NAME	COUNTRY	SCIENTIFIC FIELD
ACHARYA, B.L.	INDIA	MEDICAL PHYSICS
ADHIKARY, Dal Bahadur	NEPAL	MATHEMATICS
ADIGUZEL, Osman	TURKEY	CONDENSED MATTER PHYSICS
ADIMULA, Isaac A.	NIGERIA	COMMUNICATIONS PHYSICS
AFENYA, Evans	GHANA	MATHEMATICS
AHMED, Abubakar G.	NIGERIA	CONDENSED MATTER PHYSICS
AHMED, Laceque	GHANA	CONDENSED MATTER PHYSICS
AHMED, Omar M.	SOMALIA	CLIMATOLOGY
AKHTER, Javed	PAKISTAN	GEOPHYSICS
AKINLADE, Olatunde	NIGERIA	CONDENSED MATTER PHYSICS
AL-BAALI, Mehiddin	SYRIA	MATHEMATICS
ALAM, Jawaid	PAKISTAN	CONDENSED MATTER PHYSICS
ALI, Tariq	PAKISTAN	CONDENSED MATTER PHYSICS
ALLOTEY, Daniel F.K.	GHANA	SOIL PHYSICS
ALTSHULER, Ernesto	CUBA	CONDENSED MATTER PHYSICS
ALTUN, Ziya G.	TURKEY	COMMUNICATIONS /SOLAR ENERGY
AMADI, Rose U.	NIGERIA	NONCONVENTIONAL ENERGY
ANSARI, Nadeem A.	PAKISTAN	ATOMIC PHYSICS
ANTONIO, Jerome	GHANA	GEOPHYSICS
ARZI, Ezatollah	IRAN	CONDENSED MATTER PHYSICS
ASSELMAN, Adel	MOROCCO	PLASMA PHYSICS
AYOOLA, Ezekiel O.	NIGERIA	APPLIED MATHEMATICS
AYUB, Muhammad	PAKISTAN	HIGH ENERGY PHYSICS
BABAEI BROJENY, A.A.	IRAN	CONDENSED MATTER PHYSICS
BAFAYAD, Saeed	YEMEN	GEOPHYSICS
BAHRAMPOUR, Yosef	IRAN	MATHEMATICS
BAIMBA, Andrew A.	SIERRA LEONE	GEOPHYSICS
BAJRACHARYA, Shanti	NEPAL	MATHEMATICS
BAKCHICH, Abderrahim	MOROCCO	CONDENSED MATTER PHYSICS
BALUN, Lawong	PAPUA NEW GUINEA	MATHEMATICAL ECOLOGY
BANTIKASSEGN, Workalemahu	ETHIOPIA	PLASMA PHYSICS
BANTILAN, Feliciano T.	PHILIPPINES	CONDENSED MATTER PHYSICS
BARAL, Kedar	NEPAL	GEOPHYSICS
BARRETO ACEVEDO, Willians	VENEZUELA	PLASMA PHYSICS
BATHIEBO, Dieudonné	MALI/BURKINA FASO	NONCONVENTIONAL ENERGY
BAYOU, Tesfaye	ETHIOPIA	NONCONVENTIONAL ENERGY
BHARTEE, Shova	NEPAL	ATOMIC PHYSICS
BHUIYAN, Md. Abu Hashan	BANGLADESH	CONDENSED MATTER PHYSICS/SOLAR ENERGY
BREW-HAMMOND, Abeeku	GHANA	NONCONVENTIONAL ENERGY
BUI, Trong Tuyen	VIETNAM	COMMUNICATIONS PHYSCS/CLIMATOLOGY
CABALLERO BADILLO, Carlos	MEXICO	GEOPHYSICS
CARDENAS PONCE, Rolando	CUBA	CONDENSED MATTER PHYSICS
CEYLAN, Mehmet	TURKEY	CONDENSED MATTER PHYSICS
CHAURASIA, Prashad P.	NEPAL	BIO-/CONDENSED MATTER/ATOMIC/NUCLEAR PHYSICS
CHEFI, C.	TUNISIA	CONDENSED MATTER PHYSICS
CHIRWA, Max	ZAMBIA	CONDENSED MATTER PHYSICS
CHITAMU, Peter J.	TANZANIA	COMMUNICATIONS PHYSICS
CHUKWUMA, Victor U.	NIGERIA	COMMUNICATIONS PHYSICS
COMINETTI, Roberto M.	CHILE	APPLIED MATHEMATICS
COULIBALY, Ibrahima	CôTE D'IVOIRE	NONCONVENTIONAL ENERGY
DADSON, Andrew	GHANA	CONDENSED MATTER PHYSICS
DAFALLA, Abusufian	SUDAN	COMMUNICATIONS PHYSICS

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NAME	COUNTRY	SCIENTIFIC FIELD
DANSO, Kwaku	GHANA	CONDENSED MATTER PHYSICS
DOAN NHAT QUANG	VIETNAM	CONDENSED MATTER PHYSICS
ERUKU, Panny-Pancras	UGANDA	COMMUNICATIONS PHYSICS
FAROOQ, Muhammad S.	PAKISTAN	GEOPHYSICS
FWALING, Piragel	ZAIRE	APPLIED MATHEMATICS/MATHEMATICS
GABOW, Abdulkadir	SOMALIA	NONCONVENTIONAL ENERGY
GALLO, Carla	PERU	BIOPHYSICS
GBADAMASSI, Moussiliou	BENIN	NONCONVENTIONAL ENERGY
GISMALLA, Daffalla	SUDAN	MATHEMATICS
GONZALES, Raul	PERU	MEDICAL PHYSICS
GONZALEZ FELIPE, Ricardo	CUBA	HIGH ENERGY/PARTICLE PHYSICS/APPLIED MATHS.
GONZALEZ, Jorge	CUBA	COND. MATTER PHYS./APPLIED MATHS./CLIMATOLOGY
GUERMAZI, Samir	TUNISIA	CONDENSED MATTER PHYSICS/NONCONV. ENERGY
GUERRERO YANES, Luis	VENEZUELA	CONDENSED MATTER PHYSICS
HAILU, Getachew	ETHIOPIA	COMMUNICATIONS PHYSICS
HAKIM, Abdul	PAKISTAN	GEOPHYSICS
HALILOU, Amrane	ALGERIA	NUCLEAR PHYSICS
HERNANDEZ-GALEANA, Albino	MEXICO	HIGH ENERGY PHYSICS
HERSI, Osman	SOMALIA	GEOPHYSICS
HINDAWI, Ahmed	EGYPT	PLASMA PHYSICS
HOORANI, Hafeez	PAKISTAN	COMPUTATIONAL PHYSICS
HOSSAIN, Deloar	BANGLADESH	MEDICAL PHYSICS/BIOPHYSICS
HOSSAIN, Md. Mozaffor	BANGLADESH	CONDENSED MATTER PHYSICS
HOUNKONNOU, Mahouton	BENIN	PLASMA PHYSICS
IDREES AHMAD, M.	PAKISTAN	MICROPROCESSORS
ILEPERUMA, Oliver	SRI LANKA	CONDENSED MATTER PHYSICS
ISHIEKWENE, George	LIBERIA	PLASMA PHYSICS
ISHTIAQ, Ahmad	PAKISTAN	CONDENSED MATTER PHYSICS
ISLAM, M. Shafiqul	BANGLADESH	CONDENSED MATTER PHYSICS
ISLAM, Mir W.	BANGLADESH	MATHEMATICS
IYAYI, Sunday E.	NIGERIA	CONDENSED MATTER PHYSICS
JAHANGIR, Saleh Mahmud	BANGLADESH	BIOPHYSICS/MEDICAL PHYSICS
JAIN, Suman	ZAMBIA	MATHEMATICS
JASSIM, Asaad	IRAQ	ATOMIC PHYSICS
JAYARATNE, Kalu	SRI LANKA	CLIMATOLOGY
KABANDA, Madika	ZAIRE	COMMUNICATIONS PHYSICS/MATHEMATICS
KADEL, Abdul	CHINA	MATHEMATICS/GEOPHYSICS
KAINO, Luckson	TANZANIA	MATHEMATICS/GEOPHYSICS
KAINO, Luckson	TANZANIA	MATHEMATICS
KAJUNI, Asukile R.	TANZANIA	CLIMATOLOGY/MATHEMATICAL ECOLOGY
KALLEL, Ali	TUNISIA	CONDENSED MATTER PHYSICS
KAMARA, Sierrie	SIERRA LEONE	CLIMATOLOGY
KANSAKAR, Padma	NEPAL	CONDENSED MATTER PHYSICS
KANYINDA, Malu-Kabiena	ZAIRE	CONDENSED MATTER PHYSICS
KAONGA, Llolsten	MALAWI	MATHEMATICS
KARIM, A.N.M.M.	BANGLADESH	MICROPROCESSORS
KASHINJE, Stanslaus	TANZANIA	CONDENSED MATTER PHYSICS
KASSAHUN, Tsehaye	ETHIOPIA	CONDENSED MATTER/ATOMIC PHYSICS
KHAN, Nawazish	PAKISTAN	CONDENSED MATTER PHYSICS
KHATOON, Khalida	PAKISTAN	BIOPHYSICS
KIMAMBO, Cuthbert	TANZANIA	NONCONVENTIONAL ENERGY
KIVAISI, Rogath	TANZANIA	NONCONVENTIONAL ENERGY
KUMAR, Mahendra	FIJI	SOIL PHYSICS
LADELE, Emmanuel	NIGERIA	ATOMIC PHYSICS

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NAME	COUNTRY	SCIENTIFIC FIELD
LAOUINI, Nozha	TUNISIA	CONDENSED MATTER PHYSICS
LATIF, Abdul	PAKISTAN	MATHEMATICS
LE, Thi Cat Tuong	VIETNAM	COND. MATTER /COMMUNICATIONS/NUCLEAR PHYSICS
LIBATIQUE, Nathaniel	PHILIPPINES	COMMUNICATIONS PHYSICS
LOUIS MARTINEZ, Domingo	CUBA	HIGH ENERGY PHYSICS
LUFUNGULA, Nkwambiaya Ero	ZAIRE	NUCLEAR PHYSICS
MAHGOUB, Abdalla	SUDAN	CONDENSED MATTER PHYSICS
MAMMO, Yewondwossen	ETHIOPIA	CONDENSED MATTER PHYSICS
MANSOUR, Abdel	EGYPT	NUCLEAR PHYSICS
MASAIF, Noureddine	MOROCCO	CONDENSED MATTER PHYSICS
MATIN, Md. Abdul	INDIA	NUCLEAR PHYSICS
MBAGWU, Joe	NIGERIA	SOIL PHYSICS
MEIKHAIL, Mahrous	EGYPT	CONDENSED MATTER PHYSICS
MEZIANE, Belkacem	ALGERIA	CONDENSED MATTER PHYSICS
MILLER, Collie Roy E.	JAMAICA	MEDICAL/CONDENSED MATTER/BIOPHYSICS
MINA, Aziz	EGYPT	HIGH ENERGY PHYSICS
MKHWANAZI, Xolani	SWAZILAND	CONDENSED MATTER PHYSICS
MOLINA, Luis	CUBA	MICROPROCESSORS
MONDJALIS, Poto	ZAIRE	SOIL PHYSICS
MOUTAIROU, Kabirou	BENIN	BIOPHYSICS
MOYO, Thomas	ZAMBIA	CONDENSED MATTER PHYSICS
MUCKBIL, AbdulRehman	YEMEN	MATHEMATICS
MUNYAMARERE, Francois	RWANDA	MATHEMATICS
MUSENDA, Mark	UGANDA	COMMUNICATIONS PHYSICS
MUSTAFA, Fikria	SYRIA	BIOPHYSICS
MWAIPOPO, Oberth	TANZANIA	GEOPHYSICS
NGUYEN, Hung Son	VIETNAM	MATHEMATICS/HIGH ENERGY/COND. MATTER PHYSICS
NNABUDE, Peter	NIGERIA	SOIL PHYSICS
NSOWAH-NUAMAH, Nicholas	GHANA	MATHEMATICS
NTABUHASHE, Zahinda	RWANDA/ZAIRE	MATHEMATICS
NUBI, Olatunbosun	NIGERIA	NONCONVENTIONAL ENERGY
NWAGBO, Ejidike	NIGERIA	NONCONVENTIONAL ENERGY
NYONDO, Andrew	PAPUA NEW GUINEA/ZAMBIA	MATHEMATICS
NYONG, Anthony	NIGERIA	CLIMATOLOGY
OBENG, Paul	GHANA	ATOMIC/COMMUNICATIONS PHYSICS
ODONDO, Harrison	KENYA	MATHEMATICS
ODURO, Francis	GHANA	MATHEMATICS
OKAZ, Ali	EGYPT	CONDENSED MATTER PHYSICS
ODURO, Francis	GHANA	MATHEMATICS
OKAZ, Ali	EGYPT	CONDENSED MATTER PHYSICS
OKIO, Alex	ZAMBIA/UGANDA	COMMUNICATIONS PHYSICS
OMING'O, Dickson	KENYA	MICROPROCESSORS
ONWUAGBA, Beniah	NIGERIA	CONDENSED MATTER PHYSICS
ONYEDIM, Godwin	NIGERIA	GEOPHYSICS
OSINKOLU, Gabriel	NIGERIA	CONDENSED MATTER PHYSICS/NONCONV. ENERGY
OULD MAYIF, Mohamed	MAURITANIA	GEOPHYSICS/MATHEMATICAL PHYSICS
OZARA, Nino	NIGERIA	SOIL PHYSICS
PACHECHO-DOLL, Monica	CHILE	CONDENSED MATTER PHYSICS
PATEL, Birendra	INDIA	MATHEMATICS
PAVDYAL, Homnath	NEPAL	ATOMIC PHYSICS
PHAM, Thanh Tri	VIETNAM	MATHEMATICS
PICASSO ESCOBAR, Gino	PERU	CONDENSED MATTER PHYSICS
POLETTI, Giovanni	PERU	BIOPHYSICS
QADER, Mahnaz	PAKISTAN	HIGH ENERGY PHYSICS
RAHMAN, M.M.	BANGLADESH	CONDENSED MATTER PHYSICS

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NAME	COUNTRY	SCIENTIFIC FIELD
RAKOTOANDRAMANGA, Desire	MADAGASCAR	MICROPROCESSORS
RAMAKRISHNA MURTHY, M.	INDIA	CONDENSED MATTER PHYSICS
RAMOLA, Rakesh	INDIA	NUCLEAR PHYSICS/GEOPHYSICS
RANDRIANANDRAINA, Faneva	MADAGASCAR	NUCLEAR PHYSICS
RANDRIANASOLO, Léon	MADAGASCAR	GEOPHYSICS
RASAMOELA, Zaka	MADAGASCAR	MATHEMATICS
RAZA, Syed	PAKISTAN	CONDENSED MATTER PHYSICS
RIZVI, Syed	PAKISTAN	MICROPROCESSORS
SABER, Mohammed	MOROCCO	CONDENSED MATTER PHYSICS
SALAMIN, Yousef	WEST BANK	ATOMIC PHYSICS
SALAS ASENCIOS, Hernan	PERU	COMMUNICATIONS PHYSICS
SALAZAR RODRIGUEZ, Julio	PERU	ATOMIC PHYSICS
SALIMI, Muhammad	PAKISTAN	SOIL PHYSICS
SAMARAWEERA, Nihal	SRI LANKA	COMMUNICATIONS PHYSICS
SAMAVI, Shahrokh	IRAN	ATOMIC/COMMUNICATIONS PHYSICS
SANCHEZ, Joaquin T.	CUBA	CONDENSED MATTER PHYSICS
SARBISHAEI, Mohsen	IRAN	HIGH ENERGY PHYSICS
SARMAGO, Roland	PHILIPPINES	CONDENSED MATTER PHYSICS
SAVANE, Abdoul	GUINEA	CONDENSED MATTER PHYSICS
SEIFU, Dereje	ETHIOPIA	CONDENSED MATTER PHYSICS
SHAABAN, Maamoun	EGYPT	CONDENSED MATTER PHYSICS/SOLAR ENERGY
SHAHEEN, Naeem	GHANA	NONCONVENTIONAL ENERGY
SHRESTHA, Shankar	NEPAL	COND. MATTER/COMMUNIC. PHYS./NONCONV. EN.
SILES-ALVARADO, Hugo	BOLIVIA	CONDENSED MATTER PHYSICS
SILVA-CARDENAS, Carlos	PERU	COMMUNICATIONS PHYSICS
SINGH, Ramvir	INDIA	CONDENSED MATTER/COMMUNICATIONS/SOIL PHYS.
SMIDA, Abdallah	ALGERIA	HIGH ENERGY PHYSICS
SOLARI-AGUELA, Felipe	PERU	COMMUNICATIONS PHYSICS
SORO, Drissa	CôTE D'IVOIRE	COMMUNICATIONS PHYSICS
SRAKU-LARTEY, Kofi	GHANA	CONDENSED MATTER PHYSICS
SUBEDI, Lekha	NEPAL	GEOPHYSICS
SULTAN, Abdul	YEMEN	CONDENSED MATTER/COMMUNICATIONS PHYS.
TADROS, Sedhom	EGYPT	MATHEMATICS
TAFUR-SOTELO, Julio	PERU	BIOPHYSICS/COMMUNICATIONS PHYSICS
TAMBWE-LOLO, Kasong'a	ZAIRE	CONDENSED MATTER PHYSICS/SOLAR ENERGY
TECSON, Marlon	PHILIPPINES	MEDICAL PHYSICS
TENDEKU, Felix	LIBERIA	MICROPROCESSORS
TIMOUMI, Mohsen	TUNISIA	MATHEMATICS
TENDEKU, Felix	LIBERIA	MICROPROCESSORS
TIMOUMI, Mohsen	TUNISIA	MATHEMATICS
TSADIK, Samuel	ETHIOPIA	CONDENSED MATTER PHYSICS
TSHINANGA, Shimata	ZAIRE	MATHEMATICS
TUHUMWIRE, Z.N.	UGANDA	MATHEMATICS
TUMUHAIRWE, Joy	UGANDA	SOIL PHYSICS
UMOEFIK, Nkereuwem	NIGERIA	COMMUNICATIONS PHYSICS
VALDIVIA, Ramiro	PERU	GEOPHYSICS
VILLEGAS, Miguel	VENEZUELA	APPLIED MATHEMATICS
VYAS, Brij	INDIA	CLIMATOLOGY
WILLIAMS, Martin	GUYANA	COND. MATTER/ATOMIC/COMMUNICATIONS PHYS.
YEGO, Joel	KENYA	PLASMA PHYSICS
YOUSSEF, Haidar	SYRIA	COMMUNICATIONS PHYSICS/SOLAR ENERGY
ZANETTE, Damian	ARGENTINA	APPLIED MATHEMATICS

Activities at ICTP July-August 1991

Title: SUMMER SCHOOL IN HIGH ENERGY PHYSICS AND COSMOLOGY, 17 June – 9 August.

Organizers: Drs. E. Gava (University of Trieste, Italy), K.S. Narain (ICTP), S. Randjbar-Daemi (ICTP), E. Sezgin (Texas A&M University, College Station, USA) and Prof. Q. Shafi (Bartol Research Institute, Newark, USA).

Lectures: Introduction to functional methods in quantum field theory. Anomalies. Introduction to renormalization group and its application in the standard model. Instantons and vacua. The standard model and beyond. Zero modes. Neutrino physics. Perturbative QCD. Precision tests of the electroweak model. Beyond the standard model: origin of families and mass scales. Quark masses and mixings and CP violation. Phenomenological supersymmetry. Superstring model building. Standard big bang cosmology and nucleosynthesis. Inflationary universe models and cosmic strings. Recent developments in lattice gauge theories. Non-perturbative effects in electroweak theory. Electroweak symmetry breaking. Baryon number violating effects and related matters. The riddle of high energy baryon number violation. Aspects of N=2 supersymmetric theories. Conformal field theory and string field theory. 2 d gravity and random matrices. Topological field theory. W-algebras. Schwinger-Dyson equations and constraints in 2-d gravity. Continuum noncritical string theory. Review of developments in string theory. Large limit of Yang Mills theories. Quantum W_3 gravity. 1 dim. matrix models. Variations on Goldhaber's paradox. W_3 gravity. 1 dim. matrix models. Variations on Goldhaber's paradox.

Workshop on phenomenology in high energy physics and cosmology, 18–19 July: Implications of the 17 keV neutrino. Do weak interactions become strong at high energies? Heavy quark effective theory and weak decays. CP violation. Valley method for instanton-induced effects in quantum field theory. Electroweak aspects at LEP. Supersymmetry, supergravity grand unification and superstring phenomenology. Renormalization of (2+1)-dim. SUSY nonlinear sigma model in 1/N expansion. CDF experiment at Fermilab. Recent developments in dynamical symmetry breaking.

Workshop on superstrings and related topics, 8–9 August: N=2 strings. Topological and antitopological fusion. Stringy topological defects. Superspace WZW models and black holes. Super-W algebras. SL(∞ , R) symmetry of quantum W∞ gravity. Discrete linear systems and one-matrix models. Low energy behaviour of the four dimensional nonlinear sigma model. Schwinger-Dyson equations and constraints in 2-D gravity. Simplicial quantum gravity, theory and simulation. W∞ gauge theory formulation of d=1 matrix model: Ward identities and discrete states. Multiloop correlators for strings in discrete target space.

The School was attended by 249 lecturers and participants (183 from developing countries).

Title: INTERNATIONAL CONFERENCE ON COMPLEX SYSTEMS: FRACTALS, SPIN GLASSES AND NEURAL NETWORKS, 2 – 6 July.

Organizers: Professors H. Cerdeira (Universidad Estadual de Campinas, UNICAMP, Campinas, Brazil and ICTP, Trieste, Italy), S. Lundqvist (Chalmers University of Technology, Göteborg, Sweden), G. Parisi (Università di Roma "Tor Vergata", Rome, Italy), L. Pietronero (Università "La Sapienza", Rome, Italy) and M.A. Virasoro (Università "La Sapienza", Rome, Italy), with the co-sponsorship of the Commission of the European Communities.

Lectures: Adaptation to the edge of chaos. Fractal geometry of isoscalar surfaces in turbulence: theory and experiment. Some progress on the infinite range spin glass model. From spin glasses to growth problems. On the field theories of random systems. Recent progress on fractal dynamics. Categorization in neural network progress on fractal dynamics. Categorization in neural network models. The path integral for dendritic cables. Generalization error in perceptrons. Statistical mechanics of learning from examples. Dilute neural network for associative memory: some recent results. Tiling-like learning in the parity-machine. Exhaustive learning in the perceptron. Multiscaling in turbulence and dynamical systems. Wavelet analysis of turbulent flows. Universal hard multifractals and turbulent velocity and temperature fields. Growth models: scaling, cross-over and simulations. Fixed scale transformation approach to fractal growth. Self-organized criticality in geophysics, economics and biology. The burning process in the Abelian sandpile model. Surface growth models and self-organized criticality. Properties of growth probabilities in DLA. Fractals from random walks. Fractional diffusion equation for transport phenomena in random media. Wetting phenomena in the presence of disorder. Fractal dimensions of Potts clusters. Spin glass dynamics. Relaxation in glassy systems. Cluster approach to spin glasses. Irreversibility cross-over in a Cu:Mn spin glass in high magnetic fields — evidence for the Gabay-Toulouse transition. Proton and deuteron glasses. Short-range corrections to the order parameter and to the excitation spectrum of the Ising spin glass. Numerical simulations for spin glasses. Scaling of energy barriers in random field Ising systems. The random energy model for complex temperature and magnetic field. Multifractality of Ising models on hierarchical lattices: pure and spin glass cases. Self-avoiding surfaces and vescicles on the lattice. Statistical models of evolving populations. Replica symmetry breaking in neural networks. First-order transition to perfect generalization in a neural network with binary synapses. Learning in feed-forward neural networks by improving the performance. Basins of attraction in neural network models trained with external fields. On the capabilities of feed-forward neural networks. Exact learning and default rule governed behaviour. Pores and Hausdorff dimension in fractal site percolation systems. Noise distribution recovering from experimental data on surface roughening. The fractal structure of the universe.

The Conference was attended by 171 lecturers and participants (54 from developing countries).

Title: MINIWORKSHOP ON

Title: MINIWORKSHOP ON STRONGLY CORRELATED ELECTRON SYSTEMS, 8 July – 2 August.

Organizers: Professors G. Baskaran (Matscience Institute of Mathematical Science, Madras, India), A.E. Ruckenstein (Rutgers State University, Piscataway, USA), E. Tosatti (International School for Advanced Studies, ISAS-SISSA, and ICTP, Trieste, Italy) and Yu Lu (Academia Sinica, Beijing, P.R. China, and ICTP), with the co-sponsorship of the International School for Advanced Studies (ISAS-SISSA, Trieste, Italy), Fondazione IBM Italia and National Research Council (Consiglio Nazionale delle Ricerche, CNR, Italy).

Plenary Seminars: Introduction to the Chern-Simons-Ginzburg-Landau theory of the FQHE. Excitations in the high T_c materials: a phenomenological review. Orbital Kondo effect, mass enhancement and superconductivity. Introduction to integrable models of strongly correlated fermions. Open problems in strongly correlated systems. Two dimensional magnetism, a historical and experimental overview. Magnets as fluids. Normal state properties of the high T_c oxides: gauge theories. Collective excitations, spectral function and Hall effect in a strongly correlated Fermi liquid state of the t-J model. Foundations of Fermi liquid theory. Magnetic structure factor of the 2-D Hubbard model. Effects of the magnetic fields on the charge and spin density waves.

Informal Discussions: Problems in strongly correlated electron systems. Open problems in strongly correlated systems. The metal-to-insulator transition. Phenomenological models. Numerical methods.

From 9 to 12 July, the participants in the Miniworkshop attended the lectures of the Adriatico Research Conference on "Open problems in strongly interacting electron systems".

The Miniworkshop was attended by 65 lecturers and participants (36 from developing countries).

Title: ADRIATICO RESEARCH CONFERENCE ON "OPEN PROBLEMS IN STRONGLY INTERACTING ELECTRON SYSTEMS", 9 – 12 July.

Organizers: Professors G. Baskaran (Matscience Institute of Mathematical Science, Madras, India), A.E. Ruckenstein (Rutgers State University, Piscataway, USA), E. Tosatti (International School for Advanced Studies, ISAS-SISSA, and ICTP, Trieste, Italy) and Yu Lu (Academia Sinica, Beijing, P.R. China, and ICTP), with the co-sponsorship of the Commission of the European Communities, International School for Advanced Studies (ISAS-SISSA, Trieste, Italy), Fondazione IBM Italia and National Research Council (Consiglio Nazionale delle Ricerche, CNR, Italy).

Lectures: Overview of high T_c experiments. Open questions related with heavy electrons. Electron spectroscopy of strongly correlated systems. Single hole in 1D and 2D Hubbard model. Numerical studies of Hubbard and t-J models away from half-filling. Fermi surface and dynamics of the t-J model at moderate doing. Dynamical properties of strongly correlated electronic models. Surface acoustic wave studies of the FQHE. Chern-Simons-Landau-Ginzburg theory of the FQHE and its experimental prediction. On the Landau-Ginzburg theory of the singlet QHE and chiral spin liquid. What's really going on a $\nu=1/2$? Magnetic fluctuations in $La_{2-x}Sr_xCuO_4$. Organic superconductors: spectroscopic outlook. Normal state properties of high T_c materials — a slave boson approach. Single particle spectral function for the large U Hubbard model. Mean field theories for strongly correlated electrons: a controlled approach based on the limit of high dimensions. Strongly correlated systems in infinite dimensions and their zero-dimensional counterpart. Stable hc/e vortices in a gauge theory of superconductivity in strongly correlated systems. Renormalization group for interacting fermions in d>1. Structure, phase transitions and superconductivity in C_{60} and its derivatives. Ab-initio simulations of K_3C_{60} and K_6C_{60}. Electronic mechanism for superconductivity in doped C_{60}. Weakly correlated electrons: many questions and few answers. Static and dynamical analysis of the instabilities in the three-band extended Hubbard model of the CuO2 planes. Conference summary: experiment and theory.

Short Communications: Ward identity and β function in the Lattinger liquid. Non-perturbative results of few electrons in 2D Hubbard model. Transport and spectral properties of 1D multiphase Landau liquids. Does frustration describe doping in models for high-temperature superconductivity? Is there spin on the quasiparticles in the high T_c superconductors? — a comparison of the three-band Kondo Heisenberg and t-J models. Charge redistribution and properties of high temperature superconductors. A single pair state bound by exchange interactions: exact results. Local canonical transformations of fermions. Diamagnetism of fermions in the static spatially modulated magnetic fields and instability of uniform field anyone states. Exotic physics in barium bismuthates. Absence of holon condensation in 2D t-J model: some physical implications. Novel oscillation phenomena of strongly interacting electrons on a small ring in magnetic field. On some problems of the Fermi liquid phase of the t-J model. de Haas van Alphen in strongly correlated electrons in 2D. Mid-gap states in the slate-boson method.

The Conference was attended by 54 lecturers and participants (14 from developing countries).

Title: COURSE ON OCEAN-ATMOSPHERE INTERACTIONS IN THE TROPICS, 29 July – 17 August.

Organizers: Professors G. Furlan (University of Trieste and ICTP, Italy), A. Moura (Instituto de perquisas espaciais, INPE, São José dos Campos, Brazil), A. Navarra (Istituto per lo studio delle metodologie geofisiche ambientali, IMGA–CNR, Modena, Italy) and J. Shukla (University of Maryland, College Park, USA), with the co-sponsorship of the Direzione Generale per la Cooperazione allo Sviluppo (Ministry of

Course on ocean-atmosphere interactions in the Tropics, 29 July – 17 August.

Foreign Affairs, Rome, Italy) and National Research Council (CNR, Italy).

Lectures: El Niño. Observations: tropical climatology. Equations of motion. Design considerations for numerical ocean. Thermodynamic quantities. One and two-layer models of the ocean. How clouds heat. Influence of SST anomalies on atmospheric circulations. The ocean mixed layer. Convective boundary layer (flux-profile relationships). Coupled GCM's strategies and results. Vertical structure of the tropical atmosphere. Time mean and variability in the Atlantic ocean circulation. SST and surface fluxes. Thermal forcing (Reed and Recker; the Hadley circulation; Lindzen; Gill model). El Niño, La Niña and the Southern oscillations. Equatorial ocean dynamics: free waves. Air-sea interactions in the seasonal cycle. Equatorial ocean dynamics: adjustment. Predictability of the ocean-atmosphere system. ENSO observations: Tropics. Theories of ENSO: Bjerknes, Wyrtki, Busalacchi and O'Brien. Low frequency variability of the monsoons: observed characteristics. Results from a coupled ocean-atmosphere model: Cane and Zebiak. ENSO observations: global effect. Mechanisms of low frequency variability of the monsoons. Linear instability analysis of the coupled system: Hirst. Simple ENSO mechanisms. Prediction and predictability.

The Course was attended by 35 lecturers and participants (21 from developing countries).

Title: COLLEGE ON SINGULARITY THEORY, 19 August – 6 September.

Organizers: Professors V.I. Arnold (Steklov Mathematical Institute, Moscow, USSR), Lê Dung Tráng (Steklov Mathematical Institute, Moscow, USSR), Lê Dung Tráng (Université de Paris VII, France), K. Saito (Research Institute of Mathematical Sciences, Kyoto University, Japan) and B. Teissier (Ecole Normale Supérieure, Paris, France).

Lectures: Singularity of complex hypersurfaces. On the fundamental group of plane curves. Complex hypersurfaces with non-isolated singularities. Knot invariants. Topology, resolution and deformation of curve singularities. Duality "à la Poincaré". Introduction to singularities on topology. Curve flattening, Schubert cells and Weierstrass points bifurcation. Monodromy of non-isolated singularities. Computer experimentation singularities in the teaching of geometry. Dynkin graphs and singularity theory. Mixed Hodge structure, as geometric invariants on cohomology. Elementary study of singularities of analytic functions. Line arrangements in the complex projective plane and Galois branched coverings. Resolution of singularities of surfaces. Singularity problems in control theory. Geometric features of lattice point problems. Stratifications and determinacy. Real geometry of vanishing cycles. Introduction to jets and jet spaces. Space curves. Resolution of non-degenerate singularities and applications. More about intersection homology. Vanishing cycles in the resolution. Valuation theory and resolution of singularities. Stability and classification of smooth map singularities. Introduction to the theory of deformations. Apparent contour singularities of convex bodies. Singularities of projections. Puiseux theorem for differential equations. Introduction to De Rham theorem for singular varieties. Geometry of asymptotics of integrals. Quotient singularities in dimension 2. Singularities of maps of surfaces into the Euclidean space. Introduction to derived category perverse sheaves and vanishing cycles. Three-dimensional cusp singularities. Stratification theory. Extremal distributions of critical points and critical values. On Riemann-Hilbert's problems for Fuchsian linear systems on $\mathbb{C}P^1$. Polar varieties and maps $C^2 \to C^2$. The automorphism groups of Kummer branched covering spaces. Plurigenera of normal isolated singularities. Truncation of Taylor series. Topology of complements to discriminants of smooth maps. The Lê numbers of a hypersurface singularity. Reduction of singularities of holomorphic foliations by blowing-ups. Moduli of singularities and modules on singularities. Introduction to integral closure of ideals and modules. Codimension and discriminant Milnor numbers of singularities of mappings. Singularities of implicit ODE's and of PDE's of mixed type. Singularities of wave fronts in nonholonomic mechanics. Critical points of functions invariant under C*-action. The index of holomorphic vector field under blowing-up. Cremona transformations and foliations of $P^2(C)$. Introduction to periods of integrals. Unfolding of complex analytic foliation singularities. Real singularities and finite determinacy. Lefschetz theorems in the original style of Lefschetz. Vector fields on bifurcation varieties. Limit cycles of quadratic vector fields which are perturbations of Hamiltonian ones. A characterization of normal graded isolated singularities in terms of Pinkham-Demazure's construction. Separatrices for pseudogroups of diffeomorphisms. Applications of the integral closure of modules. Groups and special singularities. On complete ideals in 2-dimensional regular local rings. On invariant algebraic sets of foliations by curves. Topological triviality in versal unfoldings of space curve singularities. Introduction to gravitational instantons (after Kronheimer). Generalised Morse theory and homotopy type of Stein spaces. Milnor numbers in dynamical systems. Singularity at infinity of polynomials of two complex variables. The Chern characters of a hypersurface with singularities. Some global aspects

College on singularity theory, 19 August – 6 September.

of the complex analytic singular foliations. Multiplicity of filtered rings and simple K3 singularities. Lagrange and Legendre singularities in symplectic and contact geometry and mathematical physics. Affine varieties and Lefschetz theorems. On the De Rahm cohomology of algebraic varieties. The simple boundary singularities A_k, B_k, C_k, D_k, F_4 and the focal set of a surface with boundary in $\mathbb{R}^3$. Desingularization of Lagrangian varieties and systems of microdifferential equations. Jacobi inversion problem for simple and simple elliptic singularity. Affine polar quotients and irregularity at infinity of algebraic plane curve. Gauge theoretical construction of "simple elliptic" singularity. Legendrian and Lagrangian singularities. Lagrange and Legendre singularities in symplectic and contact geometry and mathematical physics. Resolution of singularities in various characteristics. Flat theta invariants and Jacobi forms. The principal part of vector fields on the plane with fixed Newton diagram. Symplectic quotient and group theoretic resolution of simple singularities. On the symmetric fronts and caustics. Singularities of Gauss maps. Special neighbourhoods for some subsets in complex spaces. Geometry and topology of real singularities. On the asymptotics of Green functions for parabolic equations. Invariants of 3-manifolds and surface singularities. Real geometry of algebraic curves. Which set of points in P2 are intersections of an irreducible space curve? On the theory of Lagrangian varieties. Area, Morse theory and an inverse problem for the heat equations.

The College was attended by 206 lecturers and participants (100 from developing countries).

Title: COURSE ON PATH INTEGRATION, 26 August – 2 September.

Organizers: Professors H. Cerdeira (Universidad Estadual de Campinas, UNICAMP, Campinas, Brazil and ICTP, Trieste, Italy), A. Ranfagni (Istituto di Ricerca sulle Onde Elettromagnetiche, IROE–CNR, Florence, Italy) and L.S. Schulman (Clarkson University, Potsdam, USA).

Lectures: Path integrals: introduction and selected topics, including semiclassical asymptotics and topological aspects. Path integrals and the theory of polymers. Quantum tunnelling and the path decomposition expansion. Path integrals in phase space. Feynman path integrals and the Feynman ordered operator calculus. Elimination of the phonon (or boson) bath. Thermodynamics and dynamics of quantum dissipative systems: the functional integral approach. Fractional statistics. Rigorous field theoretic bounds via stochastic quantization. Time dependent tunnelling via the classical paths (with application to ballistic tunnelling in 2D structures). Stochastic processes from the point of path integrals: elimination of variables through influence functional methods. Derivation of the path integral: a new view to an old problem. Critical properties of a superradiant model. Path integral simulations on superfluids and Coulomb systems. Some new techniques in path integration. Poisson path integrals. Path integral methods for complex liquids. Application of the path integral to the search of chaos in quantum systems. The class of paths in phase space path integral. Path integration in the Schwinger model on the torus. Stochastic processes on fibre bundles: their uses in path integration.

The Course was attended by 85 lecturers and participants (47 from developing countries). ♦

Course on path integration, 26 August – 2 September.

Calendar of Activities at ICTP in 1991

Working Party on surface phase transitions	2 – 13 September
Path integration and its applications (Adriatico Research Conference)	3 – 6 September
School on dynamical systems	9 – 27 September
Conference on recent developments in the phenomenology of particle physics	23 – 27 September
Workshop on stochastic and deterministic models	7 – 11 October
School on "Use of synchrotron radiation in science and technology"	14 October – 8 November
Workshop on composite materials	28 October – 8 November
Conference on major problems of the atmospheric system and the developing countries	11 – 16 November
School on materials for electronics: Growth, properties, and applications	18 November – 6 December
Second International Workshop on radon monitoring in radioprotection and earth science	25 November – 6 December
Workshop on non-linear dynamics and earthquake prediction	25 November – 13 December

Calendar of Activities at ICTP in 1992

Adriatico Research Conference on polarization dynamics in nuclear and particle physics ..... 7 – 10 January
Third Training college on physics and technology of lasers and optical fibres ..... 27 January – 21 February
Workshop on computation and analysis of nuclear data relevant to nuclear energy and safety ..... 10 February – 13 March
Topical Workshop on coherent atom-radiation interactions ..... 24 February – 6 March
College on neurophysics — Object recognition by man and machine ..... 17 February – 13 March
Spring School and Workshop on superstrings ..... 30 March – 10 April
The Essential role of science in technological progress and economic development ..... 22 – 24 April
Workshop on modelling of energy and environmental physics ..... 27 April – 15 May
Spring college on superconductivity ..... 27 April – 19 June
Experimental workshop on high T_c superconductivity (advanced activities) ..... 27 April – 19 June
Conference on chemical evolution and the origin of life ..... 4 – 8 May
Trieste Conference on quantum field theory and condensed matter physics ..... 11 – 15 May
Workshop on Mediterranean cyclones ..... 18 – 22 May
Workshop on dynamical systems ..... 18 May – 5 June
Seventh Trieste Semiconductor Symposium on: "Wide-band gap semiconductors" ..... 8 – 12 June
Miniworkshop on strongly correlated electron systems ..... 15 June – 10 July
Summer School on high energy physics and cosmology ..... 15 June – 14 August
Research Workshop on condensed matter, atomic and molecular physics ..... 22 June – 25 September
Adriatico Research Conference on clusters and cluster aggregates ..... 23 – 26 June
Miniworkshop on non-linearity: dynamics and surfaces in nonlinear physics ..... 13 – 24 July
Adriatico Research Conference on wrinkles of surfaces in nonlinear systems ..... 21 – 24 July
Adriatico Research Conference on synergetics in condensed matter ..... 4 – 7 August
Miniworkshop on methods of electronic structure calculations ..... 10 – 21 August
Workshop on climate variability and predictability ..... 17 – 21 August
Adriatico Research Conference on hydrogen atoms in intense electromagnetic fields ..... 18 – 21 August
Workshop on vegetation-climate interaction ..... 24 – 28 August
Course on two-dimensional quantum field theory for condensed matter physicists ..... 24 August – 4 September
College on medical physics: imaging and radiation protection ..... 31 August – 18 September
Workshop on arithmetic algebraic geometry ..... 31 August – 11 September
Workshop in commutative algebra ..... 14 – 25 September
Fourth International Conference on applications of physics in medicine and biology: advanced detectors for medical imaging ..... 21 – 25 September
College on methods and experimental techniques in biophysics ..... 28 September – 23 October
WMO Workshop on limited area modelling ..... 28 September – 2 October
Second College on microprocessor-based real-time control — Principles and applications in physics ..... 5 – 30 October
Second Trieste Conference on recent developments in the phenomenology of particle physics ..... 19 – 23 October
School on physical methods for the study of the upper and lower atmosphere system ..... 26 October – 6 November
Third Workshop on basic VLSI design techniques ..... 2 – 27 November
Second workshop on the applications of synchrotron radiation ..... 2 – 27 November
Fourth Autumn course on mathematical ecology ..... 2 – 20 November
Experimental Workshop on high T_c superconductivity (basic activities) ..... 16 November – 11 December
Workshop on three-dimensional modelling of seismic waves generation, propagation and their inversion ..... 30 November – 11 December

Workshop on three-dimensional modelling of seismic waves generation, propagation and their inversion ..... 30 November – 11 December

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

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