INSTITUTE OF MATHEMATICAL SCIENCES

ANNUAL REPORT 1987 - 88

C. I. T. Campus, Tharamani
Madras-600 113, India

INSTITUTE OF MATHEMATICAL SCIENCES

ANNUAL REPORT

April 1987 - March 1988

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FOREWORD

The past year has been a year of increased research activity in the Institute. During this period about sixty research papers were completed which are listed later in this Report. From the composition and authorship of the papers it must be clear that there has been substantial improvement in the quality, depth and breadth of the papers. While there are cyclic variations in the productivity of scientists, a strong overall pattern of creative work has emerged. This 'momentum of growth' was specially appreciated by the Board of Governors in the Press release issued after their meeting in July 88.

The increase in the faculty strength was small but significant; it would have been larger were the physical facilities of the Institute more adequate; these would substantially improve once the new Library Building is completed with a much needed lecture room and new study areas in the library. The Board of Governors gave final approval for this building as well as the Hostel-Guest House Complex at their July meeting. Construction is under way.

During the year E.C.G.Sudarshan was elected a Fellow of the International Academy for the Philosophy of Science, a body which has by statute only seventy five living members at any time. C.S.Seshadri was elected a Fellow of the Royal Society of London. D.Sc.(Honoris Causa) was conferred on E.C.G.Sudarshan by the University of Madras.

One of the research papers, "Evolving geometric phase and its dynamical manifestation as a frequency shift: An optical experiment" by R.Simon, H.J.Kimble and E.C.G.Sudarshan, published in the July 4,1988 issue of Physical Review Letters was specially recognized for its originality: Mr.John Maddox, the Editor of "Nature" wrote a special report in the July 14, 1988 issue of that prestigious magazine with the title "Turning phases into frequencies". The promise made in the Introduction to last year's Report "The Institute is poised to make outstanding research contributions and this potential must be realized in the next few years" is beginning to be redeemed.

Our major assets are our students and the promise of that future creative scientific output. We must, and we shall, make every effort to facilitate this and remove every obstacle from their path.

The generous financial assistance from the two Governments is appreciated. A new Nelco Force 20 Computer was inaugurated in September by Dr.H.B.N.Shetty, Ph.D.,I.A.S.

We are happy to welcome Dr.V.Varaprasada Rao, Ph.D.,I.A.S. as our Registrar; he brings to the Institute proven administrative ability augmented by his scientific background.

I wish to record my appreciation to Dr.R.Jagannathan for his effort and care in bringing out this Report.

E.C.G.Sudarshan
Director

1988 September

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Sri. C.SUBRAMANIAM

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+ On lien from Tata Institute of Fundamental Research, Bombay.

* On reemployment from 1, Dec. '86.

δ Now with the Department of Mathematics, University of Florida, Gainsville, Florida, USA, on leave from the Institute.

o On leave from TIFR, Bombay.

++ On leave from the Computer Science Department, Aarhus University, Denmark.

** Whose tenure at the Institute was over in 87-88.

STUDENTS

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Ms.A.SHANTHI +o	(Physics)

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Mr.M.VENKATA SATYANARAYANA **	(Physics)

\+ Fellowship of the Council of Scientific and Industrial Research (CSIR)

* Fellowship of the National Board for Higher Mathematics (NBHM)

δ From TIFR, Bombay.

** Temporary Fellowship (March-April, '87)

O Whose tenure at the Institute was over in 87-88.

ADMINISTRATIVE STAFF

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Mr.M.G.RADHAKRISHNAN NAIR	Personal Attendant to the Director
Mr.A.RAVINDRAN	Hostel-cum-Guest House Cook
Mr.N.RAVICHANDRAN	Helper (Guest House)

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* Was on deputation from the Department of Atomic Energy, Bombay, and relieved on 23, Feb.88. Prof. K.R. UNNI, took change on 29, Feb.88 as Registrar Pro-tem.

\+ Resigned in May, 87.

RESEARCH WORK : SOME OUTLINES

PHYSICS

OPTICS, QUANTUM MECHANICS

The behaviour of width and angular divergence of an arbitrary partially coherent light beam under the action of first order systems has been clarifed. The transformation of these beam parameters has been reduced to a generalized abcd-law, and Kogelnik's abcd-law for Gaussian beams has been shown to be a special case of the generalized law (SIMON and SUDARSHAN, with MUKUNDA)*

Gaussian pure states (of which the coherent states and squeezed coherent states are special cases) of a system with m degrees of freedom and their evolution under quadratic Hamiltonians have been studied. The role played by a special orbit in the Lie algebra of SP(2n,R) in this class of problems has been exhibited using the Wigner distribution method. A matrix generalization of the Mobius transformation which completely describes this evolution has been derived. It has been further shown that this quantum symplectic evolution of Gaussian pure states can be given an elegant classical Poisson bracket description on this special orbit (SIMON and SUDARSHAN, with MUKUNDA).

A generalized ray description of the entire hierarchy of correlation fucntions of a radiation field has been formulated for the first time. The 'Bose statistics' has been shown to manifest itself as a special kind of symplectically invariant nonlocal ray-ray correlation. The difference between the classical and quantum ray-ray correlations has been clarified (SUDARSHAN and SIMON, with MUKUNDA).

The Pancharatnam phase which is an early example of the Berry-Aharanov-Anandan phase has been measured for a whole range of closed circuits on the Poincare sphere covering the entire 4π solid angle range, the polarization transformation along the circuits having been effected by the unitary action of quarter-wave plates alone (SIMON with CHYBA, WANG and MANDEL).

Situations where the topological Berry-Aharanov-Anandan phase could evolve in time have been analysed. Clearly, if this evolution is linear in time then it should result in a frequency shift. An optical experiment wherein such an evolving geometric phase manifests itself dynamically as a frequency shift has been performed (SIMON and SUDARSHAN, with KIMBLE).

Nonspecular phenomena in partially coherent beams reflected by multilayered structures have been studied for the first time. While these involve lateral, focal and angular shifts of the beam axis and a magnification of the beam width, it has been shown that only the angular

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* Throughout the Report external collaborators are mentioned as (with....)

shift is affected by the lack of coherence. A particular combination of the beam parameters has been shown to be an invariant of the reflection process (SIMON, with TAMIR).

The (diagonal) density matrix evolution corresponding to the Scully-Lamb approach has been analysed as a Markov process, which describes a population point process of branching type with emigration as well as immigration. With coarse graining averaging, the statistics of the counting processes has been obtained above and below the threshold (VASUDEVAN, with SRINIVASAN).

Quantum theory of magnetic electron lenses based on a convenient formulation of the Dirac theory has been obtained. It has been shown that the passage from conventional scalar theory to the spinor theory can be accomplished through a simple algebraic rule in analogy with the passage from scalar to vector light optics (JAGANNATHAN, SIMON and SUDARSHAN, with MUKUNDA).

When the first homotopy group of the configuration space is nonabelian it is possible to conceive of a generalized quantum theory with multiple components. Such "Vector quantum mechanics" has been studied and related to a new kind of internal symmetry (SUDARSHAN, with GOVINDARAJAN and TOM IMBO).

The treatment of identical particles in quantum theory leads to multiply connnected configuration spaces and different "Statistics" going beyond the usual Bose and Fermi statistics. This is related closely to the Artin braid groups. These are investigated for the simpler cases of three particles on R^3 and S^3 (SUDARSHAN, with CHANDNI SHAH IMBO and TOM IMBO).

When a system with one degree of freedom described by the quantum Hamiltonian $H(\hat{q},\hat{p})$ is transported adiabatically as $\hat{q}\to\hat{q}+q_o(t)$, $\hat{p}\to\hat{p}+p_o(t)$, where $(q_o(t), p_o(t))$ are shlowly varying c-number parameters forming a closed circuit in phase space, it is shown that the state of the system picks up a Berry phase which is equal to the area of the circuit and is independent of the state or the Hamiltonian under consideration. If the parameter space closed circuit becomes time dependent and is traversed repetitively, the state picks up a time dependent geometric phase leading to a frequency spread. A concrete situation where such a spread can be physically realized has been analysed (SIMON, with KUMAR).

CONDENSED MATTER PHYSICS

Some applications of soliton theory in condensed matter physics have been reviewed with examples from nonlinear lattice dynamics, magnetism and superfluid ^{4}He (RADHA BALAKRISHNAN).

Considering an isotropic Heisenberg chain with an external magnetic field in the X-Y plane, an area-preserving map relating spins at neighboring sites has been derived. For a certain range of weak magnetic fields it has been shown numerically that the spin profiles display spatial chaos (RADHA BALAKRISHNAN, with ANANTHAKRISHNA and HAO BAI-LIN).

A nonlinear evolution equation has been derived for the order parameter in superfluid ^{4}He using a pseudo-spin model for a system of hard-core bosons with an attracive nearest-neighbor interaction using the spin cohernt state representation. Exact solution of this equation yields: a nonsingular spatial dependence of the vorticity; a periodic travelling wave solution with a velocity dependent amplitude for the condensate density (valid for all $t < T_\lambda$) and a domain wall structure for this quantity (RADHA BALAKRISHNAN, SRIDHAR and VASUDEVAN).

Motivated by the observed structural phase-transition and the accompanying lattice instabilities, a model for High-T_c superconductivity has been proposed. The lattice is described by a Goldstone model. The lattice instability inherent in this model is shown to effectively reduce the Debye frequency of the lattice. Incorporating this, and the coupling of electrons with the soft made associated with the model, an expression, for T_c has been obtained using a modified BCS formalism; A novel explanation for the observed weak isotope-effect has been given (RADHA BALAKRISHNAN and SRIDHAR, with CHATURVEDI and SRINIVASAN).

Superconductivity in the strongly correlated electronic systems described by the Hubbard model for slightly less than half-filled band has been shown to arise from the condensation of charge + e holons which are bosons. The holon effective mass is found to be very close to that of the band electrons and they have a strong nearest neighbour repulsion induced by the spin fluctuations. They interact with an U(1) part of the collective SU(2) guage field (named S-guage field) of the spin system. This results in spontaneous symmetry breaking of a holon field and the appearance of the Anderson-Higgs phenomenon. The interesting possibility of the SU(2) - gauge field-spinon coupled system retaining some gapless excitation spectrum inspite of the spontaneous symmetry breaking in the holon field has been pointed out (BASKARAN).

The doped Mott insulator has, under some conditions, qualitatively different behaviour as compared to an ordinary Fermi liquid conductor. This difference has been brought out by a simple renormalization group analysis as well as reinterpreting the known canonical transformation method and other results. It has been argued that there exists a separate fixed point, different from the Fermi-liquid fixed point, which governs the long wavelength and long-time scale behaviour of an RVB conductor. Also, the disordered local moment phase of the Hubbard model (for non-half-filling) has been identified with the RVB metal phase and the phase boundary between the two phases has been located. A recent

construction of Anderson has been studied in detail and it has been shown that the novel quasi-particles of the RVB conductor, namely, holons and spinons are respectively bosons and fermions (BASKARAN).

The 'confinement' approach to metal-insulator transition and RVB state is being investigated (BASKARAN and SHANKAR). Also under investigation are the topological aspects of RVB state in Heisenberg insulator (BASKARAN, SHANKAR and HARI DASS, with WADIA).

The excitation spectrum of dilute solutions of ^{3}He in superfluid ^{4}He has been evaluated by solving the evolution equation of a suitably constructed excitation operator under the random-phase-approximation. The spectrum has two branches. By assuming that the first few moments of the dynamic form factor are saturated by these two branches alone, an integral equation is obtained for the structure factor. The structure factor thus obtained is shown to exhibit the existence of some recently observed fixed points, besides the usual features (SRIDHAR and SHANTHI).

FIELD THEORY, PARTICLE PHYSICS, NUCLEAR PHYSICS, COSMOLOGY

SUSY at nonzero temperature is being discussed in the literature for nearly a decade with confusing and contradictory results. The issues have been reanalysed and put under proper perspective with regard which are general expectations and which are provable results. In the course of the analysis it has been established that spontaneous symmetry breaking a la O'Rafierteigh mechanism is a generic phenomenon(ANISHETTY, BASU and SHARATCHANDRA).

A Hamiltonian formulation of the free guage invariant theory of a massive spin-3/2 particle has been presented and the absence of negative-norm states has been verified (RINDANI and SIVAKUMAR). The structure of guage invariant massive higher-spin theories of arbitrary spin (integral and half integral) obtained by dimensional reduction from one higher dimension has been studied. The constraints and the system of auxiliary fields have been identified (RINDANI and SIVAKUMAR, with SAHDEV). The theory of massive spin-3/2 particles derived by dimensional reduction from one higher dimension by some authors has been re-examined and shown to contain no results that were not obtained twenty five years ago (SUDARSHAN, with HAGEN).

It has been shown that some of the known consistent interacting massive spin-one theories have gague invariance associated with them. They are obtained by Kaluza-Klein reduction of massless spin-one theories from five dimensions (SIVAKUMAR).

Work is in progress on the issue of checking perturbative unitarity of string S-matrix amplitudes defined a la the Polyakov prescription (DATE).

In the case of the compactification of the $E_8 \times E_8$ heterotic string theory on coset spaces considered earlier, a harmonic expansion of the spin-1/2 fields on the space SU(3)/U(1) x U(1) has been carried out and the transformation properties of the four-dimensional zero modes under the isometry group SU(3) have been obtained. (JOSHIPURA, RINDANI and SARKAR, with GOVINDARAJAN).

Three generation superstring models require intermediate mass scales to be consistent with perturbative unification. The problem of neutrino masses in these theories has been studied (SARKAR, with MANN).

It has been shown that combining Peccei-Quinn symmetry and horizontal symmetry could lead to testable predictions on neutrino masses and mixing in grand unified models like SO(10) (JOSHIPURA).

It has been observed that the Kobayashi-Maskawa mixing matrix for three generations for maximal CP-noninvariance is nothig other than the finite Fourier transform matrix. This idea has been extended to arbitrary generations (SANTHANAM).

A factorization property has been proved relating the photon exchange, the Z-boson exchange and the electroweak interference terms of the differential cross section for the process of fermion-anti-fermion annihilation into bosons. The conditions on the polarizations have been deduced. Many examples of factorization in the standard electroweak theory as well as its extensions and modifications have been worked out (RAJASEKARAN, with LAKSHMIBALA).

Some unusual events seen in the KGF proton decay detector suggest the existence of a particle of mass $\geq$ 1.8 GeV and life time $\leq 10^{-8}$ sec. Possible interpretations of such a particle within the standard model as well as schemes going beyond the standard model have been considered (RAJASEKARAN and JOSHIPURA, with GUPTA and SARMA).

It has been shown that dimension five nonrenormalizable interactions can produce light Dirac neutrinos, in an extension of the minimal SU(5) GUT (JOSHIPURA and SARKAR).

A general analysis of resonant amplification of neutrinos in case of three generations was done and has been shown to have significantly different consequences than the correspondng two generation analysis (JOSHIPURA and MURTHY).

The nuclear dependence of quark and gluon densities has been investigated using various hard-scattering mechanisms (GUPTA with SRIDHAR). The relation in large -N QCD between the quark and soliton pictures of baryons has been obtained (GUPTA and SHANKAR). A particular signal of quark-gluon plasma formation in relativistic heavy ion

collissions has been investigated (GUPTA with SUKANT SARAN). The possibility of observing top quarks in the mass range from 80 to 200 GeV at the Tevatron has been found to be optimistic (GUPTA with ROY).

Transition from nucleon (neutron) matter to quark matter within the framework of $SU(2)_L \times SU(2)_R$ sigma model has been studied. The results have been used to study the possibility of such a transition taking place in cold dense matter viz. in the interior of neutron stars (BASU, with DATTA).

It has been proposed that the various models which claim to explain the EMC effect can be distinguished through a moments analysis of the structure functions (GUPTA and MURTHY).

Branching equations for gluon-quark cascade models relating to hard collissions of hadrons have been derived by imbedding methods and multiplicity distributions are found. Scaling comes out as a natural consequence. General quark-gluon cascades with hadron formation in a modified version of cascade theory leads to interesting results and circumvents divergencies (VASUDEVAN, with SRINIVASAN).

In the high energy colliders hard processes take place between (e^+ e) or (γ,p) etc. producing in the first stage quarks and gluons, and in the second stage rapid fragmentation takes place. Leaning on Feynman-field energy dependent cross sections for fragmentation, multiplicity distributions of hadrons produced are computed using product density techniques (VASUDEVAN, with SRINIVASAN).

Towards the end of February 1987 several detectors reported observation of neutrinos from the supernova 1987a. The group at I.M.Sc were among the first to make detailed analysis of this data for their implications to particle physics and astrophysics. This analysis supports the models of Wilson, Lattimer and Applegate for neutrino emission from supernovae. The masses and mixings of neutrinos could not be determined unambiguously (HARI DASS, INDUMATHI, JOSHIPURA and MURTHY). On the basis of non-observation of delayed (compared to supernova signal) signals in Kamioka detector constraints on mixing of ν_e with a heavy ($\geq$ 1MeV) neutrino were derived. These were found to be better than obtained in the laboratory experiments (HARI DASS, JOSHIPURA and MURTHY).

Three related programmes pertaining to the foundations of physics have been pursued as follows: (1) In an epistemological study of the foundations starting with the notion of euclidean 3-space containing matter, not further defined, classical and quantum systems are obtained as a formal twin. Next, special relativity arises as a logical completion of mechanics. Attempts at constructing relativistic dynamics lead to General Relativity and Gauge fields on the one hand and to a fundamental two space of maximum dimension 26 or 10 when metricised. Supersymmetry arises from the invariance structure of Bose and Fermi

commutators as an essential part of the dynamics. These need to be woven together. (2) A model of a black hole interior as a compact space of negative curvature given earlier has been refined (3) Since parameters of the observed universe are consistent with it being a black hole, and the singularity theorems are transcended if one admits that binding energy cannot exceed the masses bound, it is proposed that the universe is a space of negative curvature of finite volume. this curvature implies short range departure from 1/r law and is ascribed to Casimir effect. The universe is antemundane, but has a beginning in the sense that a 'material universe' like ours results from a phase transition inside a black hole. Our universe may be inside a suprauniverse, with embryonic universes in the process of formation (MARIWALLA).

MATHEMATICAL METHODS IN PHYSICS AND OTHER SCIENCES

The weight multiplicities in classical Lie algebras are determined using Freudenthal's recursive algorithm or Kostant's formula which involves partition functions. In the sixties the method of generating functions was developed (Santhanam) to compute the partition functions for the Lie algebras and applied to many classical Lie algebras including the exceptional algebra G_2. A similar programme has been carried out for the infinite dimensional Lie algebras of Kac-Moody type. In this scheme use has been made of Euler's identity, Jacobi's triple product, the quintuple identity and the identity of Tennery and Molk to obtain Carlitz-type relations leading to explicit evaluation of partition functions. Work is in progress to obtain Rogers-Ramanujan like explicit analytic forumale for such partition functions making use of the circle method of Ramunujan (SANTHANAM, with CHAKRABARTI).

Recently p-adic numbers are being tried in understanding some aspects of string theories. Work is in progress to analyse quantum mechanics based on p-adic number system, particularly in finite-dimensional version based on Weyl's form of Heisenberg's canonical communication relations (SANTHANAM and JAGANNATHAN).

The most general solutions for the seven types of multiplicative Diophantine equations studied by E.T.Bell (1933) have been reanalysed without recourse to the reciprocal arrays. A simpler and straightforward proof of a fundamental theorem of Bell has been provided to establish the minimum number of parameters necessary and sufficient for obtaining the most general solutions of the homogeneous multiplicative Diophantine equation of degree n: $x_1 x_2 \ldots\ldots x_n = u_1 u_2 \ldots\ldots u_n$, $n > 1$.

This theorem became the basis for the study of the other types of multiplicative Diophantine equations (SRINIVASA RAO, SANTHANAM and RAJESWARI). The theorem was also applied to the study of the problem of polynomial zeroes of degree one of the Racah coefficient and after analysing the many results obtained so far by various authors, this approach has been brought to completion (SRINIVASA RAO and RAJESWARI, with KING).

The triple sum series of Jucys and Bandzaitis for the 9-j coefficient has been identified with a formal triple hypergeometric series due to Lauricella-Saran-Srivastava. A new FORTRAN program based on the folded triple-sum series has been found to be efficient, time-wise when compared to the conventional single sum over the product of three 6-j coefficients (SRINIVASA RAO and RAJESWARI).

The polynomial zeroes of the 9-j coefficient have been shown for the first time, to exist and a simple closed form expression for the polynomial zeros of degree one of the 9-j coefficient has been derived from the triple sum series referred to above. Numerical work to generate the polynomial zeroes of degree one of the 9-j coefficient using the closed form expression and, alternatively, using the multiplicative Diophantine equations approach, is in progress (SRINIVASA RAO and RAJESWARI).

One dimensional Fokker-Planck equation subjected to Feller's natural boundary conditions at both ends, appears in the study of multiplicative noise in many systems. Treating the problem as a boundary value problem Schenzle and Brand have obtained results differing from the conclusions of Suzuki et.al. who also treat the problem in the same way but using a different method. It has been shown that the correct way to pose the problem is to treat it as a Cauchy initial value problem and the unique solution has been obtained by constructing the regular Green's function for the prblem. The result supports the conclusions of Suzuki et.al. This method of solving the one dimensional Fokker-Planck equation subjected to Feller's natural boundary conditions at both ends, as a cauchy initial value problem, has been applied to the Ornstein-Unlenbeck process (RADHAKRISHNAN, with SCHIEVE).

Concepts relating the Stratanovich and Ito integrals have been employed to analyse the modification warranted in the fist and second type of fluctuation-dissipation relations (VASUDEVAN, with SRINIVASAN).

Analysis of neural network dynamics with special reference to memory organisation leading to Hebb's hypothesis and corresponding synaptic connection matrix have been carried out. Aciton functions relating to Caianiello-type equations lead to globally stable equilibrium (configurations which are unique for each input. These ideas relate to) only short term memory (ANISHETTY and VASUDEVAN).

MATHEMATICS

Using the Erdos-Shapiro method of averaging over arithemetic progressions certain inequalities have been proved in connection with the error terms related to the greatest divisor of n which is prime to a square free k. (ADHIKARI and BALASUBRAMANIAN, with SANKARANARAYANAN). This problem orignates from the work of Joshi and Vaidya, and Maxsein

and Herzog have also independently announced this result, around the sametime as the authors, using a different method. Using the same technique of Erdos and Shapiro, ADHIKARI and SANKARANARAYANAN have also studied an error term related to the Jordan totient function. Some results related to the sums of Fourier coefficients of cusp forms have also been obtained by ADHIKARI.

Krishnaswami ALLADI has been working on a long project since 1981 exploring the connections between probabilistic number theory and sieve methods. In the first phase of this project a new method was discovered which enabled the extension of the work of Erdos - Kac and Turan-Kubilius. Following this, deeper and more subtle connections are being studied currently involving multiplicative functions over 'small divisors' and the asymptotic behaviour of multiplicative functions which oscillate in sign. Some of these results have been obtained in collaboration with PAUL ERDOS and JEFF VAALER while many others are in the papers of ALLADI.

Besides the paper with ADHIKARI and SANKARANARAYANAN mentioned above, the work of BALASUBRAMANIAN deals with the following topics: A theorem of Erdos, Sarkozy and Sos; Additive completion of squares; Frequency of Titchmarsh's phenomenon for $\zeta(s)$; Number of square full integers (with RAMACHANDRA); Number of integers n such that $nd(n) \leq N$ (with RAMACHANDRA); Number of k-full integers (with RAMACHANDRA and SUBBARAO); Extension of earlier work on additive completion of squares (with SANKARANARAYANAN and SURYARAMANA); Maximal length of two sequences of consecutive integers with the same prime divisors (with SHOREY and WALDSCHMIDT); Dirichlet's function at $s = 1/2$ (with KUMAR MURTHY).

The class of equations that can be solved by the discrete inverse scattering transform has been extended and shown to contain a new class of nonlinear differential difference evolution equations (BHATE).

The spectral transform and the inverse spectral transform for the discrete, periodic, laplacian in more than one dimensions has been investigated. The Green's function has been explicitly calculated and there has been some progress in the characteriazation problem in particular cases (BHATE).

Aparna DAR's research is related to Intersection Whitehead torsion and S-cobordism theorem for pseudo-manifolds.

Krishna MADDALY has been working on localization problems in the theory of random Schrodinger Operators.

Partial results have been obtained on which of the Grassmannians bound. A result due to Rohlin and Wall has been generalized to obtain relations among the cobordism classes of real, complex, and quaternionic flag manifolds (SANKARAN).

SESHADRI and BALAJI have been able to compute about two thirds of the cohomology groups of the desingularisation variety of the moduli space of vector bundles of rank two and degree zero associated to an algebraic curve and the detailed paper is in preparation.

Work is in progress on the problem of finding the Hilbert polynomial of the singularities of Schubert varieties (SESHADRI, with LAKSHMIBAI).

THEORETICAL COMPUTER SCIENCE

A decidability result has been obtained for a temporal logic designed to reason about asynchronously communicating agents (THIAGARAJAN and LODAYA).

A representation result linking labelled event structures to trace languages has been proved (THIAGARAJAN, with ROZOY).

A least fixed-point characterization has been obtained for Horn-clause programs distributed over a fixed finite set of sites (RAMANUJAM).

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P.S.THIAGARAJAN (with B.ROZOY)
Event structures and trace monoids
Internal Report 87-47, Informatique Theoretique et. Programmation, Universites Paris, VI et VII (1987)

PARTICIPATION IN CONFERENCES AND OTHER PROFESSIONAL ACTIVITIES OF THE ACADEMIC STAFF

Prof. E.C.G.SUDARSHAN

-delivered the Convocation Address entitled "Education towards reshaping destiny " at the 130th Convocation of the Madras University (30th Sept.87)

-with the Keynote Address "Creativity and Disorder" inaugurated the Workshop "Chaos-Order-Catastroph", organized by Alliance Francaise, Max Mueller Bhavans, National Centre for the Performing Arts and Tata Institute of Fundamental Research, jointly at the National Centre for the Performing Arts, Bombay, during 5-10, Oct.87.

-gave an invited talk at the Symposium, "The Optical Field: A symposium on Coherence, Propagation and Fluctuations of Light:, held in honour of Profs. Mandel and Wolf at the University of Rochester on Oct.24, 87. Title of the talk: "Coherence, propagation and fluctuations of light - a generalized ray approach".

-gave an invited talk "The life and work of Erwin Schrodinger", at the Schrodinger Centenary Symposium at I.I.T., Madras, on Dec.21,87.

-inaugurated the Colloquium on Number Theory held in honour of Srinivasa Ramanujan during 27, Dec.87-1,Jan.88 at the Instutute of Fundamental Studies, Kandy, Sri Lanka, and gave a special talk on Berry Phase.

-gave the Banquet talk at the International Conference on Quark-Gluon Plasma, Bombay, Feb.88.

besides visiting many Institutions in India and abroad and lecturing on various topics.

Prof.G.RAJASEKARAN

-gave a talk on "Supernova 1987a" at the Astronomical Club of the Anna University on Aug.1, 87.

-gave an invited colloquium on "Neutrinos in physics and astrophysics" in the Theoretical Physics Programme of the Indian Institute of Science, Bangalore, on Aug.19, 87.

participated in the International Conference on High Energy Physics and Astrophysics held at Srinagar, Kashmir during Sept.9-16, 87 and gave an invited talk on "Recent developments in neutrino physics and astrophysics".

-gave a course of lectures on "High energy physics" in the Scrodinger Birth Centenary Refresher Course in Theoretical Physics held at Indore University during Nov.9-18, 87.

-participated in the Department of Science and Technology sponsored Workshop in Particle Physics (Superstring theory) at I.I.T., Kanpur, during Dec.13-24, 87.

-participated and chaired a session in the International Conference on the Physics and Astrophysics of Quark-Gluon Plasma, Bombay, Feb.8-12, 88.

-participated in the NISTADS meeting on "Philosophical Foundations of Quantum Theory" held at Delhi, March 24-26,88 and gave an invited talk entitled "Is quantum mechanics forever?".

Prof. N.D.HARI DASS

-participated and gave lectures at the III SERC School on Theoretical High Energy Physics at Shantiniketan (Oct-Nov.1987) and the DST Workshop on superstring Theory at I.I.T., Kanpur (Dec.87).

Prof.N.R.RANGANATHAN

-visited the Department of Mathematical Physics, University of Adelaide, Australia, for a period of ten weeks from 14th April 87 and gave a few lectures on some aspects of Clifford Analysis during his stay there. He also spent a week with the Department of Mathematics at the University of Queensland, Brisbane, Australia.

Prof.T.S.SANTHANAN

-gave an invited talk on "CP-nonconservation" in the International conference on High Energy Physics and Astrophysics held at Srinagar, in Sept.87.

-gave an invited talk in the DST Workshop on Superstring Theory, I.I.T., Kanpur, in Dec.87.

-gave an invited talk on "P-adic quantum mechanics" in the meeting on "Philosophical Foundations of Quantum Mechanics "at New Delhi, in March

88, organised by the National Institute of Science, Technology and Development Studies. At the meeting he also presented the paper by Prof.E.C.G.Sudarshan on "Negative probabilities underlying the violation of Bell's inequalities".

Prof. K.R.UNNI

-gave the key-note address on "Problems of approximation" at the National Summer Institute on Computer Oriented Approximation and Operations Research Techniques held at the Ramanujan Institute for Advanced Study in Mathematics, Madras, during May 25-June 23, 87.

-gave an invited talk on "Multiplier pairs" at the Varahamihir Memorial National Seminar on Fourier Analysis and its Applications held at the School of Studies in Mathematics, Vikram University, Ujjain, during Jan.23-27, 88.

Dr.Krishnaswami ALLADI

-is currently with the Dept. of Mathematics, University of Florida, Gainsville, USA, on leave of absence from the Institute. He has given the following invited talks during 87-88: "Sieve methods and probabilistic number theory", (colloquium, Temple University, Philadelphia, April 87); "Multiplicative functions and small divisors" (Number Theory Seminar, Temple University, Philadelphia, April 87); "Legendre polynomials and irrational numbers " (colloquium University of New Hampshire, Durham, Oct.87), "Srinivasa Ramanujan and prime numbers", (Invited Adress, Conference on Ramanujan and Science in the Third World, Framingham State University, Massachussetts, Oct.87); "The Erdos-Kac theorem ", (colloquium, Dept. of Statistics, University of Florida, Gainsville, Oct.87); "Srinivasa Ramanujan and prime numbers" (University of Hawai, Honolulu, Dec.87); "Sieve methods and probabilistic number theory" (colloquium, National University of Singapore, Dec.87); "Srinivasa Ramanujan and probabilistic number theory" (Invited Address at the International Conference in Mathematics, Anna University, Madras,Dec.87); "Srinivasa Ramanujan and prime numbers" (Tamil Nadu Academy of Sciences, Jan. 88); "The mathematical genius of Srinivasa Ramanujan" (Invited Address, Mathematical Association of America, Regional Meeting, Florida, March 88).

-organised a one-day Symposium on "Number Theory" at the International Conference on Mathematics for Ramanujan Birth Centennial, at the Anna University, on 21 Dec.87.

-Reviewed Ramanujan's Lost Note-Book for "The Hindu", (Jan.88).

Dr.R.BALASUBRAMANIAN

-participated and gave lectures in the Ramanujan Birth Centenary Celebrations arranged by : Indian Academy of Sciences, Indian Institute of Science, Bangalore (16-9-87); Indian National Science Academy, in I.I.T., Delhi (Nov.87); Madurai Kamaraj University (5-9,Oct.87); Bharathiyar University, Coimbatore (Aug.87); Association of Mathematics Teachers of India, in Kumbakonam.

-was in the Organising Committee, and gave a lecture, in the Ramanujan Birth Centenary Celebrations organized at Maddras, during 22-26, Dec.87, by the National Board for Higher Mathematics (NBHM) in collaboration with the Institute, I.I.T.(Madras), Anna University, and the University of Madras.

-participated and gave lectures in the Annual Conferences of the Indian Academy of Sciences (Hyderabad, 7-9, Nov.87) and Indian Mathematical Society (Gorakhpur, Dec.29-Jan 1, 88).

-conducted a Workshop on behalf of the National Board for Higher Mathematics and Pondicherry University on "Circle Method", in Pondicherry University, for three weeks from 21-9-87.

-participated in the Annual Colloquium of T.I.F.R., Bombay.

-participated and delivered lectures in the conferences on "Number Theory" at the University of Laval, Canada, and Janos Bolyai Mathematical Society, Budapest, Hundary, during July 87.

Dr.G.BASKARAN

-was invited to give talks on the theory of high T_c-superconductivity in

the following meetings:
Annual Meeting of the Indian Academy of Sciences, Hyderabad (Nov.87)
DAE Symposium on Solid State Physics, BARC, Bombay (Dec.87)
Winter School Commemorating Schrodinger's Birth Centenary, Indore (Nov.87)

Discussion Meeting on High-T_c Superconductivity, I.I.Sc., Bangalore

(Feb.88)

Dr.K.H.MARIWALLA

-participated in the International Conference on High Energy Physics and Astrophysics held at the University of Kashmir, Srinagar, during Sept. 9-16, 87 and gave an invited talk on "A model of the Universe as a black hole".

-participated in the Advanced-level Institute in Relativity and Gravitation at the Mathematics Department, Nagpur University, during 12-19, Oct.87 and gave a course of lectures on "Foundational basis of mechanics of particles and fields".

-gave an invited talk on "Model of the universe as a black hole" in the Global Conference on Mathematical Physics: Centenary Celebration of Niels Bohr and Hermann Weyl, at Nagpur University (Oct.20-26,87).

Dr.R.PARTHASARATHY

-participated as an invited speaker in the International conference on High Energy Physics and Astrophysics held at the University of Kashmir, Srinagar, during Sept.9-16, 87 and gave a talk on "Kaluza-Klein theory".

Dr.R.SRIDHAR

-gave an invited talk in the Workshop on Theoretical Aspects of High Temperature Superconductors held at BARC, Bombay, during 23-25, July 87.

-participated in the Solid State Physics Symposium held at BARC,Bombay, during Dec.27-31, 87.

-participated and gave an invited talk in the Discussion Meeting on High Temperature Superconductivity organized under the theoretical Physics Programme of I.I.Sc., Bangalore (Feb.2-4, 88).

-Visited the School of Physics, University of Hyderabad, Hyderabad, and gave a seminar on "A new model for high T_c superconductivity" (Feb.29-

March 3, 88)

Dr.K.SRINIVASA RAO

-participated and gave talks in the following:
Workshop on Special Functions, Mt.Abu, Rajasthan, May 15-June 5, 87 (Three Lectures on "Series-product identities" and "Racah-Wigner algebra, hypergeometric functions and orthogonal polynomials"); U.G.C. Summer School on "Computer-Oriented Approximation and Operations Research Techniques" at the Ramanujan Institute for Advanced Study in Mathematics, University of Madras, June 87 (Four lectures on "Some aspects of computers, arithmetic and architecture"); Ramanujan Centennial Conference, sponsored by the Ramanujan Mathematical Society

at Annamalai University, Dec.15-18, 87 (Invited talk on "Multiplicative Diophantine equations"); International Conference on Mathematics held at the Anna University, Madras, Dec.18-21, 87 (prsented a paper on "New continued fraction representations for ${}_3\Phi_2$ functions"); Colloquium on Number theory in honour of Srinivasa Ramanujan, held at the Institute of Fundamental Studies, Kandy, Sri Lanka, Dec.27, 87 - Jan. 1, 88) (Two invited talks: "The life and work of Srinivasa Ramanujan" and "Quantum theory of angular momemtum, hypergeometric functions and multiplicative Diophantine equations").

-visited the Dept. of Mathematics of the University of Roorkee, Roorkee, in March 88, for a week and delivered lectures on "Quantum theory of angular momentum".

-became a Life Member of the Ramanujan Mathematical Society.

Dr.P.S.THIAGARAJAN

-gave an invited talk entitled "Toward a theory of message-passing systems" at the 8th European Workshop on Applications and Theory of Petri Nets held at Universitad de Zaragoza, Spain, in June 87.

-was a visiting scientist at the Dept. of Applied Mathematics and Computer Science, University of Leiden, The Netherlands, for a month (June, 87) and gave a talk on "An event structure representation of trace languages".

-was a visiting scientist at the Gesellschaft fur Mathematik und Daten ver arbeitung, St.Augustin, West Germany, for a month (July, 87) and gave a talk on "A modal logic for a subclass of event structures".

-presented a paper on "A modal logic for a subclass of event structures" at the 14th International Colloquium on Automata, Languages and Programming held at Karlsruhe, West Germany, in July 87.

-returned to the Computer Science Department of Aarhus University, Denmark, from which he is on leave, during Aug. 87 and gave a talk on "A hierarchy of behavioural notions for elementary net systems".

-gave a talk on "The Enrenfeucht conjecture" at the National Conference on Algebra held at the Ramanujan Institute, Madras, in Nov.87.

-was a visiting scientist for one week at the Gesellschaft fur Mathematik und Daten ver·arbeitung, St.Augustin, West Germany, in Feb. 88 and gave a talk on "A temporal logic for distributed transition systems".

-again returned to the Computer Science Department of Aarhus University, Denmark, for three weeks in Feb-march 88 and gave a talk on "A temporal logic for distributed transition systems".

Dr.S.D.RINDANI

-visited the Centre for Theoretical Studies, I.I.Sc., Bangalore, for four weeks during May 87 and gave a talk.

-participated in the DST Workshop on "Superstring Theory" during Dec. 13-24, 87 and gave an invited talk on "Coset space compactification in string theory"

Dr.Ramesh ANISHETTY

-participated in the International Conference on Physics and Astrophysics of Quark-Gluon Plasma held at Bombay, during Feb.88.

Dr.Radha BALAKRISHNAN

-gave an invited talk titled "Solitons in magnetic chains" at the meeting on Chaos and Nonlinear Dynamics held at the Indian Institute of Science, Bangalore, during June-July, 87.

-participated in the Summer School on Chaotic Phenomena in Nonlinear Systems held at the Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing, China, during 17-26, Aug. 87.

-attended the International Conference on Quasicrystals held at Beijing, China, during 30 Aug. - 5 Sept. 87.

-gave an invited talk titled "Role of lattice instability and structural phase-transitions in high T_c -superconductors" at the Discussion Meeting on High T_c superconductivity held at I.I.Sc., Bangalore from Feb. 2 to Feb 4, 88.

-visited School of Physics, University of Hyderabad, Hyderabad, during Feb.29 - March 4, 88 and gave a seminar on "A model for high T_c superconductors".

Dr.G.DATE

-participated in the DST Workshop on Superstring Theory at I.I.T., Kanpur, Dec. 13-24, 87.

-participated in the Tutorial Course on String Theories conducted by the Centre for Theoretical Studies, I.I.Sc., Bangalore, during Feb.22 - March 17, 88, as a Principal speaker and an organizer of the course material.

Dr.A.S.JOSHIPURA

-participated in the Europhysics Conference at Uppsala University, Sweden, during June 25-July 1, 87.

-participated in the Workshop on Particle Physics and Cosmology at the International Centre for Theoretical Physics, Trieste, Italy, during 1 July -10 Aug. 87.

-visited the Theory Group at DESY, Hamburg, West Germany, during 10-23, Aug. 87.

Dr. M.V.N.MURTHY

-was a visiting scientist at the Dept. of Physics, McMaster University, Hamilton, Ontario, Canada, during June-Sept. 87.

-was a visiting Professor at the Dept. of Physics, Aligarh Muslim University, Aligarh, during March 8-22, 88, under the DSA Program.

-visited the Indira Gandhi Centre for Atomic Research, Kalpakkam, in Dec. 87 and lectured on "Supernova 1987a".

-gave an invited talk at the DAE Symposium on Nuclear and Solid State Physics, on "Neutrinos from SN 1987a".

-gave an invited talk at the Topical Meeting on SN 1987a, on "Neutrinos from SN 1987a".

Dr.P1.MUTHURAMALINGAM

-visited and gave lectures at the Pondicherry University in Jan. 88.

Dr.R.RAMANUJAM

-gave a talk on "Semantics of distributed logic programs" in the 7th Conference on Foundations of Software Technology and Theoretical Computer Science, Pune (Dec. 87).

-gave a course of ten lectures on "Theory of logic programming" at the National Centre for Software Technology, Bombay (Aug.87).

-gave a course of eight lectures on "Semantics of logic programs" at Christian College, Tambaram, Madras (Sept.87).

Dr.H.S.SHARATCHANDRA

-gave a colloquium on "Phase transitions and critical phenomena" for the Research Scholars' Association, Physics Department, I.I.T., Madras.

-participated as a senior physicist contributing to discussions at the III SERC School in Theoretical High Energy Physics, Santiniketan (Oct. - Nov.87).

-gave two lectures on Superstring theory and two lectures on Critical phenomena at the Physics Department, North Bengal University, Darjeeling (Nov.87).

-gave a course of lectures on "Operator formalism in string theories" at the Tutorial School on String Theory, C.T.S., I.I.Sc., Bangalore (Feb-March,88).

-was a speaker under the Theoretical Physics Seminar Circuit Program for 87-88.

Dr.R.SIMON

-participated in the Seminar on "Foundations of Quantum Mechanics" held at I.I.Sc., Bangalore (Sept. 87).

-participated in the Annual Meeting of the Optical Society of America held at Rochester (Oct.87) and presented two papers (i) "Synthesis of SP(4,R) first order systems using thin cylindrical lenses" by R.Simon, E.C.G.Sudarshan, and N.Mukunda (ii) "Gaussian Schell-model beams in square-law media: A generalized ray approach" by R.Simon, E.C.G.Sudarshan, and N.Mukunda.

-participated in the Meeting held in honour of Profs. Mandel and Wolf, "The Optical Field : A symposium on Coherence, Propagation and Fluctuations of Light" at the University of Rochester (Oct. 87).

-gave a talk on "Pancharatnam phase: Proposal for some experiments" at the University of Rochester (Oct.87).

-gave a seminar on "Berry phase and some optical experiments " at the University of Arkansas (Nov. 87).

-visited the Polytechnic University, Brooklyn, in Oct. 87 and the University of Texas at Austin in Nov. 87.

-gave a talk on "Schrodinger coherent states and squeezed coherent states" at the Schrodinger Centenary Symposium held at I.I.T., Madras (Dec. 87).

Dr.Rahul BASU

-participated in the International Conference on the Physics and Astrophysics of Quark-Gluon Plasma held at Bombay (Feb.88).

Dr.Aparna DAR

-participated in the UGC National Conference on Algebraic and Differential Topology held at Allahabad during 8-28, Feb. 88 and gave a talk on "Intersection R-torsion and analytic torsion for pseudomanifolds.

Dr.Sourendu GUPTA

-attended the Workshop on Quark-Gluon Plasma, held in Jaipur during 1-5, Feb. 88 and the International Conference on the Physics and Astrophysics of Quark-Gluon Plasma, held in Bombay during 8-13, Feb. 88.

Dr.Kamal LODAYA

-participated in the 7th Conference on Foundations of Software Technology and Theoretical Computer Science, Pune (Dec.87).

Dr.Parameswaran SANKARAN

-attended the UGC National Conference on Algebraic and Differential Topology held in Feb. 88 at the University of Allahabad, Allahabad.

Dr.M.SIVAKUMAR

-participated in the DST Workshop on Superstring Theory at I.I.T. Kanpur (Dec. 13-24, 87).

-participated in the Tutorial School on String Theory held at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore (Feb. -March,88)

-visited the Hyderabad University and I.I.T. -Kanpur, and gave seminars on "Kaluza-Klein approach to higher spin problems", under the Theoretical Physics Seminar Circuit Program.

Mr.S.D.ADHIKARI

-attended the Schools on Modular Forms and Circle Methods held respectively at Bombay (May 87) and Pondicherry (Sept-Oct.87) and gave some talks. Also attended the International Conference on Mathematics held at T.I.F.R., Bombay (Jan. 88).

Mr.C.S.YOGANANDA

-attended the Instructional Conference on Modular Forms held at I.I.T., Bombay (May 4-24, 87) and gave talks on (i) Poincare series and Rankin's trick (ii) Modular forms of half-integer weight at the congruent number problem.

-attended the Workshop on Circle method held at the Pondicherry University (Sept.21-Oct.9, 87) and gave talks on Waring's problems.

-attended the Ramanujan Centenary colloquium at T.I.F.R., Bombay (4-11 Jan. 88).

OTHER NEWS

AWARDS AND HONOURS

Prof. E.C.G.SUDARSHAN has been elected Full Member of L'Academie Internationale de Philosophie des Sciences. Also, the University of Madras conferred on him the Degree of Doctor of Science (Honoris causa).

Prof. C.S.SESHADRI has been elected Fellow of the Royal Society of London.

Prof.T.S.SANTHANAM and Dr.R.SRIDHAR have been elected Fellows of the Tamil Nadu Academy of Sciences.

Dr.R.BALASUBRAMANIAN has been elected Fellow of the Indian National Science Academy.

RESEARCH WORK OF INSTITUTE SCIENTISTS IN THE NEWS

In a full page article entitled ***"The battle of the biquadrates"*** in the NEWS AND VIEWS section of NATURE 328 (1987) p.384 Ian Stewart of the Mathematics Institute of the University of Warwick, UK, Writes:

ADVANCES in mathematics take many forms. Entire new subjects can arise from a single brilliant idea. At the other extreme long standing problems can crumble under a sufficiently powerful attack. The metaphor is apt: research and war have much in common. Some problems are stromed by force of arms and superior generalship, some are devastated by new weaponry, some exist in a permanent state of siege. And some surrender only after a lengthy war of attrition.

Waring's problem (see my News and Views article in Nature 323 (1986) 674) falls into this last category. In his Meditations Algebraicae of 1770, Edward Waring stated without proof that every positive integer is a sum of at most 9 cubes, 19 biquadrates "and so on". One case of Waring's problem, that for biquadrates-fourth powers - has been finally resolved by the colloborative work of Ramachandran Balasubramanian at the Institute of Mathematical Sciences, Madras and Jean-Marc Deshouillers and Francois Dress at the University of Bordeaux. In two short notes (C.r. Acad. hebd Seanc. Sci., Paris 303, 85-88; 1986 and 303, 161-163; 1986) they show that, for fourth powers, Waring was right.....

Judging the work of SIMON and SUDARSHAN, with KIMBLE, demonstrating the dynamical manifestation of the evolving geometric phase as a frequency shift through an optical experiment, to be of sufficient interest NATURE has a full page expose written by its Editor. In this article in the NEWS AND VIEWS section (Nature 334 (1988) 99), entitled ***"Turning phases into frequencies"*** John Maddox writes:

The concept of geometrical phase, hitherto largely an academic issue, seems unexpectedly to have led to a novel means of fine-tuning the frequency of a laser.

It cannot be often that brooding about the basis of quantum mechanics leads people to the invention of a practical device, but this is what appears to have happened to R.Simon (from the Institute of Mathematical Sciences at Madras) and H.J.Kimble and E.C.G.Sudarshan from the University of Texas at Austin. They have been seeking a more general understanding of 'Berry's phase' or geometrical phase as M.V.Berry from the University of Bristol would modestly prefer it to be known, and have hit on a scheme for fine-tuning the frequency of a laser (Phys. Rev. Lett. 61 (1988) 19).....

COURSES FOR Ph.D. STUDENTS

PHYSICS

For students in Physics the course work preparatory to research leading to the Ph.D. Thesis aims at guiding them to study deeply the Foundation subjects and Specialized Topics. During 87-88, the Faculty Members in-charge of the various courses were as follows:

(Sept. 87 - Jan.88)

Classical Mechanics	-Dr.R.JAGANNATHAN
Quantum Mechanics	-Dr.R.ANISHETTY and Dr.R.SIMON
Classical Theory of Fields	-Dr.A.S.JOSHIPURA and -Dr.R.SRIDHAR
Mathematical Physics	-Dr.G.DATE and -Dr.H.S.SHARATCHANDRA

(Feb. - Aug.88)

Quantum Field Theory	-Dr.R.PARTHASARATHY and -Prof. G.RAJASEKARAN
Condensed Matter Physics	-Dr.H.S.SHARATCHANDRA and Dr.R.SRIDHAR
High Energy Physics	-Dr.A.S.JOSHIPURA and Dr.M.V.N.MURTHY
Numerical Methods and Computer Programming	-Dr.K.SRINIVASA RAO

Advanced Level Lectures in Particle Physics (Jan. - May 88)

Perturbative QCD	-Dr.Rahul BASU
Nonperturbative aspects of QCD	-Dr.M.V.N.MURTHY
Standard model and beyond	-Dr.S.D.RINDANI
Supersymmetry and Supergravity	-Dr.A.S.JOSHIPURA

MATHEMATICS

Extensive courses of lectures were given for the benefit of Ph.D. students in Mathematics both by the Faculty Members of the Institute and the Visitors. The list of Lecture Courses is as follows:

Prof.C.S.SESHADRI	-Representations of GL(n) Algebraic groups Geometry of G/P
Dr.R.BALASUBRAMANIAN	-Analytic number theory Elliptic curves and cryptology
Dr.P1.MUTHURAMALINGAM	-Complex analysis
Dr.P.SANKARAN	-Introduction to algebraic topology
Dr.V.KUMAR MURTHY University of Toronto Canada	-Complex multiplication
Prof.H.KNORRER University of Bonn, West Germany	-Cohen-Macaulay modules Fermi curves and density of states
Prof.BHAMA SRINIVASAN University of Illinois Chicago, USA	-Representations of Chevalley groups
Prof.JEAN-MARC DREZET CNRS, Paris,France	-Vector bundles on the projective plane
Prof.T.ODA Tohoku University Sendai, Japan	-Introduction to singularities
Prof.M.ARTIN Massachussetts Institute of Technology, Cambridge, USA	-Brauer groups
Prof.K.VARADARAJAN University of Calgary Calgary, Alberta, Canada	-Characteristic classes

Ph.D.-Level Lecture Courses

Dr.P.S.THIAGARAJAN	-Introduction to Logic
Dr.R.RAMANUJAM	-Computability theory
Dr.Kamal LODAYA	-Communicating sequential processes

PH.D.'s FROM THE INSTITUTE

Dr.M.VENKATA SATYANARAYANA received the Ph.D. Degree of the University of Madras. He had submitted his Thesis entitled "Some Studies in coherent states and squeezed coherent states" last year under the guidance of Prof. T.S.SANTHANAM.

Dr.A.SHANTHI received the Ph.D. Degree of the University of Madras. She had submitted her Thesis entitled "Study of two-particle excitations in Super-fluid Helium-4", last year under the guidance of Dr. R.SRIDHAR.

Mr.S.MADIVANANE has submitted his Ph.D. Thesis entitled "Some studies in matrix theory and applications to generalized cliffford algebras and representation of Lie groups" to the University of Madras under the guidance of Prof. T.S.SANTHANAM.

CONFERENCES CONDUCTED/CO-SPONSORED BY THE INSTITUTE

The Institute celebrated the Birth Centennial of Srinivasa Ramanujan in collaboration with the Hinduja Foundation, and Smt. Janaki Ammal Ramanujan was presented a Purse with the funds provided by the Hinduja Foundation, on 13th August 87 at the premises of the Institute.

The National Board for Higher Mathematics organised in Madras an International Symposium to commemorate the Birth Centenary of Srinivasa Ramanujan during 22-26, Dec.87 in collaboration with the Institute, I.I.T., (Madras), Anna University, and the University of Madras.

The Institute was a co-sponsor for the following conferences:

Department of Science and Technology Workshop in
"PARTICLE PHYSICS -SUPERSTRING THEORY"
at I.I.T., Kanpur (13-24, Dec.87)

"INTERNATIONAL CONFERENCE ON PHYSICS AND
ASTROPHYSICS OF QUARK -GLUON PLASMA"
at T.I.F.R., Bombay (8-12, Feb.88)

LIBRARY

During April 87-March 88, 1271 new books and bound volumes of periodicals were added and this brings the total number of volumes in the Library to 23610. With the addition of twenty journals this year, we are now getting 211 journals by subscription. The number of journals and Lecture Notes received on exchange for the Institute Reports is 55. Preprints are received from all major Institutions/Laboratories in the world. Inter-Library Loan Facility is available as usual for the members of the Institute to borrow books from the neighbouring institutions.

During this year we received many useful books/journal -volumes as gratis from the following and we would like to thank them: Institute for Advanced Study, Princeton, USA; Dr.R.Balasubramanian, I.M.Sc.; Dr.T.Dray, Oregon State University, USA; Dr.M.Nori, TIFR, Bombay; Prof. T. Oda, Tohoku University Japan; Dr. M.V.Satyanarayana University of Arkansas, USA; Dr. A.Shanthi, I.M.Sc.; Dr. B.K.Shivamoggi, University of Central Florida, USA.

VISITORS

RAMESH KAUL, Centre for Theoretical Studies, Indian Institute of Science, Bangalore (1-10, April 87)
(Multiloop calculation in superstring theories)*

J.V.NARLIKAR, Tata Institute of Fundamental Research, Bombay
(2, April 87)
(Space-time singularities and quantum cosmology)

SERGE PLATTARD, Deputy Counsellor, French Embassy
(Nuclear Physicist) New Delhi (21, April 87)

N.MUKUNDA, Centre for Theoretical Studies, Indian Institute of Science, Bangalore (25, April 87)
(Relativistic objects with internal structure)

N.DADICH, Mathematics Department, Poona University, Poona (27, April 87)
(Ashtekar variables for general relativity-Energy extraction from black holes)

P.JOTHILINGAM, Mathematics Department, Pondicherry University, Pondicherry, (29, April 87)
(Testing for regularity)

M.S.RAGHUNATHAN, School of Mathematics, Tata Institute of Fundamental Research, Bombay (1, May 87)
(Devenport's conjecture)

C.MUSILI, Mathematics Department, University of Hyderabad, Hyderabad
(5-22, May 87)
(Seminar on G/B and representation theory)

R.R.SINHA, School of Mathematics, Tata Institute of Fundamental Research Bombay (6, May 87)
(Uniformisation theorem)

G.S.AGARWAL, School of Physics, University of Hyderabad, Hyderabad
(8, May 87)
(Quantum Properties of pair coherent states and experimental generation of such states)

(....) * Topic(s) of formal seminar(s)/lecture course(s) given, if any, apart from informal discussions and lectures.

DINAKAR RAMAKRISHNAN, Department of Mathematics, Cornell University Ithaca, USA (7, May - 8, June 87)

KUMAR MURTHY, Department of Mathematics, Concordia University, Qubec, Canada (10, May-27, June 87)
(complex multiplications)

N.GUPTE, Poona University, Poona (20, May 87)
(Introduction to characterization of chaos)

SOURENDU GUPTA, Tata Institute of Fundamental Research, Bombay (20-31, May 87)

RAMADAS, Tata Institute of Fundamental Research, Bombay (1, June 87)
(Wilson renormalization group approach to nonlinear model)

K.P.SINHA, Indian Institute of Science, Bangalore (2, June 87)
(Possible mechanisms of high T_c superconductivity)

MANFRED FINK, Department of Physics, University of Texas, Austin, USA (2-3, June 87)
(New experiments to measure the neutrino mass)

K.RAMACHANDRA, School of Mathematics, Tata Institute of Fundamental Research, Bombay (4, June 87)
(Some problems in analytic number theory)

HEMA MURTHY, University of Toronto, Canada (26, June 87)
(Transonic aerodynamics)

M.V.BERRY, Bristol University, UK (30, June - 1, July 87)
(Adiabatic anholonomy in quantum phases - Fractals and chaos in the renormalisation of curlicues)

A.P.BALACHANDRAN, Department of Physics, Syracuse University, USA (29, June - 17, July 87)
(Topological aspects of quantum gravity)

L.HALPERN, Department of Physics, Florida State University, Tallahasse, USA (6-9,July 87)

B.P.DAS, Physics Department, State University of Colorado, Fort Collins, USA (7, July 87)
(Present status of parity violation in atoms)

P.K.RAMAN, Mathematics Department, Birla Institute of Technology. and Science, Pilani (7, July 87)
(On karmarkar's algorithm)

S.G.KAMATH, Indian Institute of Technology, Madras (21,July 87)
(Radiation from charged particle moving along a brachistochrone)

ARUN VERMA, Mathematics Department, University of Roorkee, Roorkee (July 87)
(Identities of the Rogers-Ramanujan type)

H.BANERJEE, Saha Institute of Nuclear Physics, Calcutta (14, July 87)
(Invariance of fermion determinant under large gauge transformation)

JEEVA S.ANANDAN University of South Carolina , USA 17-28, July 87)
(Nonintegrable geometric phase in quantum mechanics-Entropy of black holes)

K.RAGHUNATHAN, Department of Theoretical Physics, University of Madras (22, July 87)
(Semiclassical approximation for N-SUSY quantum mechanics)

T.DRAY, Oregon State University USA (July-Sept. 87)
(Lectures on Quantum Field Theory in curved space-time)

C.MANOGUE, Oregon State University USA (July-Sept. 87)
(Lectures on Quantum Field Theory in curved space-time)

A.J.PARAMESWARAN, Tata Institute of Fundamental Research, Bombay (18, Aug. - 8, Sept. 87)

SIDDHARTHA SAHI, Department of Mathematics, Princeton University, Princeton, USA (3-9, Aug. 87)
(Representation theory of semisimple Lie groups)

RAVI SHANKAR, State University of New York, New Paltz, USA (3, Aug.87)
(Derivation of reactor diffusion equations in the hydrodynamic limit)

H.KNORRER, Mathematics Institute, University of Bonn, West Germany (6, Aug. - 3, Sept. 87)
(Fermi curves and density of states -Cohen-Macaulay modules)

D.SAHDEV, Tata Institute of Fundamental Research, Bombay (12-19, Aug.87)
(Physics issues at the various upcoming accelerator facilities)

BHAMA SRINIVASAN, Department of Mathematics, University of Illinois, Chicago, USA (7,11, 17-18, Aug.87)
(Representations of Chevalley groups)

K.R.RAJAGOPAL, Mathematics Department, University of Pittsburg, USA (21, Aug.87)
(Uniquencess and stability of nonlinear fluids)

O.MATHIEU, C.N.R.S, France (24-29, Aug.87)
(Weyl character formula)

S.RAMADURAI, Indian Institute of Science, Bangalore (29, Aug.87)
(Supernova 1987a)

SHIVASHANKAR, TIFR Centre, Indian Institute of Science, Bangalore
31, Aug. - 10, Sept. 87)
(singular differential equations)

R.SHANKAR, Tata Institute of Fundamental Research, Bombay (1, Sept.87)
(Large N Nambu-Jona Lasanio model)

SACHIDANANDA NAIK, Institute of Physics, Bhuvaneswar (1-15, Sept.87)
(Nonperturbative studies of interacting superstrings)

REMY Y.DENIS, Department of Mathematics, Gorakhpur University,
Gorakhpur (10-13, Sept.87)
(Generalized and basic hypergeometric functions)

M.SITARAMAYYA, School of Mathematics, University of Hyderabad,
Hyderabad (15, Sept. 87)
(Some remarks on Hironaka's and Granert's examples of non-Kahler
Moishenyon spaces)

P.N.SRIKANTH, TIFR Centre, Indian Institute of Science, Bangalore
(7-11, Sept.87)

VARUN SAHNI, University of Toronto, Canada (17-22, Sept.87)
(Anisotropic cosmology and inflation)

C.L.BHATT, Nuclear Research Laboratory, Srinagar (25-26, Sept.87)
(Recent highlights in gamma-ray astronomy)

J.M.DREZET, C.N.R.S, France (22, Sept. - 12, Oct. 87)
(Vector bundles on the projective plane)

G.BHATTACHARYA, Saha Institute of Nuclear Physics, Calcutta
(23, Sept. 87)
(Relativistic 2d QFT's of action-angle type)

A.N.MITRA, Department of Physics, University of Delhi, Delhi
(26, Sept. 87)
(From spectroscopy to partons unified Bethe-Salpeter view)

G.V.SUBBARAO, Indian Institute of Technology, Madras (1, Oct.87)
(Recent developments in high T_c superconductivity)

AVIJIT MUKHERJEE, Calcutta University, Calcutta (6-20, Oct.87)

VIKRAM SONI, University of Regensburg, West Germany (7-11, Oct.87)
(Strongly Yukawa coupled fermion in the standard model-implications
for SSC)

M.S.RAGHUNATHAN, School of Mathematics, Tata Institute of Fundamental
Research (14-15, Oct.87)
(Compact forms of hyperbolic spaces)

R.SRINIVASAN, Department of Physics, Indian Institute of Technology, Madras (15, oct.87)
(Experimental studies of high T_c -superconductivity)

RANI SIROMONEY, Department of Mathematics, Madras Christian College, Madras (17, Oct.87)
(Public-key cryptosystems based on unsolvability of world problems)

A.ARVIND, Indian Institute of Technology, Madras (17, Oct.87)
(Kernel constructible languages)

C.G.KHATRI, Gujarath University, Ahmedabad (26, Oct.87)
(Use of matrix algebra in linear models)

C.S.AULAKH, Indian Institute of Science, Bangalore (29, Oct.87)
(Higher spin fields with mixed symmetry)

M.D.SRINIVAS, Department of Theoretical Physics, University of Madras, Madras (3,6, Nov.87)
(Quantum theory of successive measurements)

S.MAJUMUDAR, National Chemical Laboratory, Pune (23-27, Nov.87)
(Superconductivity in strongly correlated systems-High T_c oxides and

low T_c organic compounds)

MACFARLANE, Cambridge University, UK (27-29, Nov.87)
(Point-particle in relativity used to illustrate some ideas in string theory and supergravity)

T.ARASU, Mathematics Department, Wright State University, Ohio, USA (1, Dec. 87)
(Recent results on difference sets)

N.SARMA, Bhabha Atomic Research Centre, Bombay (8, Nov. - 7, Dec.87)
(Heavy ion collissions and quark-gluon plasma)

R.RAGHAVAN, Computer Scientist, Lockheed Research and Development Division, Palo Alto, California, USA (7, Dec. 87)
(An algebra of finite window transformation with application to parallel processing)

K.RAMACHANDRA, School of Mathematics, Tata Institute of Fundamental Research, Bombay (7, Dec.87)
(some famous problems in analytic theory of numbers)

H.B.NIELSEN, Niels Bohr Institute, Copenhagen University, Denmark (6-9, Dec. 87)
(Random dynamics : are laws of Nature complicated? Yes! - Confusing the E_8 's of the heterotic string twisting to avoid the shadow world)

S.WEINTRAUB, Lousiana State University, USA (9, Dec.87)
(Topology of Siegel modular varieties)

T.ODA, Mathematical Institute, Tohoku University, Sendai, Japan
(1, Dec. 87 - 11, Jan.88)
(Introduction to singularities)

J.C.PARIKH, Physical Research Laboratory, Ahmedabad (21-23, Dec.87)
(Colour correlation in QCD plasma)

R.PARIKH, City University of New York, USA (21-28, Dec.87)

PAUL KRASUCKI, Graduate Centre of the City University of New York, USA (23, Dec.87 -15, Jan.88)
(Same decision based on different knowldege - Levels of knowledge in distributed computing)

J.J.SEIDEL, Technical University, Eindhoven,Netherlands (23, Dec.87)
(Integral lattices, particularly of Witt and Leech)

V.S.VARADARAJAN, Mathematics Department, University of California, Los Angeles, USA (21, Dec.87)
(Recent progress in differential equations in the complex domain)

HIROSHI OOGURI, Department of Physics, University of Tokyo, Japan
(23-31, Dec. 87)
(Soliton equations and free fermions on Riemann surfaces)

M.ARTIN, Mathematics Department, Massachussetts Institute of Technology, Cambridge, USA (26, Dec.87 - 26, Jan 88)

V.VAZIRANI, Computer Science Department, Cornell University, USA
(31, Dec.87 -4, Jan 88)
(Pfeffin orientation, 0/1 permanents and even cycles in directed graphs)

A.BOHM, Department of Physics, University of Texas at Austin, Austin, USA (21, Dec. - 27, Dec.87)
(Group strings and relativistic extended objects)

P.CANDELAS, Department of Physics, University of Texas at Austin, Austin, USA (1-3, Jan.88)

K.VARADARAJAN, Mathematics Department, University of Calgary, Alberta, Canada (1-31, Jan.88)
(Course of lectures on characteristic classes)

RAJIV RANJAN PRASAD SINGH, University of Maryland, USA (11-14, Jan.88)
(Thermodynamics and shapes of two-dimensional vesicles)

S.R.S.VARADHAN, Mathematics Department, Courant Institute of New york University, New York, USA (18, Jan 88)
(Application of large deviations)

N.MUKUNDA, Centre for Theoretical Studies, Indian Institute of Science, Bangalore (21, Jan-88)

M.BHASKARAN, Australia (30, Jan.88)
(A new proof of Kronecker-Weber theorem)

I.SATAKE, Mathematics Institute, Tohoku University, Sendai, Japan (Jan.88)
(Zeta functions associated to self-dual cones)

J.L.VERDIER, University of Paris, France (Jan.88)
(Harmonic maps-Elliptic solitons - Quantum groups)

K.S.NARAIN, CERN, Geneva, Switzerland (Jan.88)
(Orbifolds-conformal field theory and punctured Riemann surfaces)

T.JAYARAMAN, ICTP, Trieste, Italy (Jan.88)
(Gluing procedures for holomorphic conformal field theories on Riemann surcaces)

S.MALLIK, Saha Institute of Nuclear Physics, Calcutta (5-8, Feb.88)
(Field theory in de-Sitter space)

B.K.PAL, Department of Physics, Himachal Pradesh University, Simla (2-11, Feb.88)
(Light neutrino masses in GUTs and quark - lepton mass relations)

D.SPERBER, Rensselaer Polytechnic Institute, USA (3-4, Feb.88)
(Heavy ion fusion and collective motion of large nuclei - Temperature dependence of nuclear surface energy)

K.SRIDHAR, Physics Department, Bombay University, Bombay (19-24, Feb.88)
(Direct photon production and the EMC effect)

S.M.ALLADIN, Centre for Advanced Study in Astronomy, Osmania University, Hyderabad (25, Feb.88)
(Interaction among galaxies)

R.GANGOLLI, Department of Mathematics, University of Washington, Seattle, USA (2, March - 88)
(Harmonic analysis on Lie groups)

S.FRIEDBERG, Department of Mathematics, University of California, Santa Barbara, USA (1-3, March, 88)
(Analytic continuation of Dirichlet series- Automorphic forms and the Shimura correspondence)

S.N.BEHERA, Institute of Physics, Bhubaneshwar (13-17, March 88)
(Charge and spin density wave superconductors)

R.S.BHALERAO, Tata Institute of Fundamental Research, Bombay (23-26, March 88)
(A new approach to relativistic two-body problem)

SPENTA WADIA, Tata Institute of Fundamental Research, Bombay
(21-26, March 88)
(Conformal field theory approach to strings - an overview)

I.V.VOLOVICH, Steklov Institute of Mathematics, Moscow, USSR
(21-22, March 88)
(String model with torsion on the world sheet - P-adic strings)

JOSEPH OESTERIE, University of Paris, France, (30, March-5, April 88)
(Szpiro's conjecture)