THE INSTITUTE OF MATHEMATICAL SCIENCES

ANNUAL REPORT 1988 - 89

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

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ANNUAL REPORT

April 1988 - March 1989

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CONTENTS

FOREWORD

The period under review has been another fruitful year of increased research output with more than forty research papers published and an equal number at different stages of publication. The members of the academic staff continue to be in the national stream with their active participation in both the national and international conferences and other scientific meetings.

During the Seventh Plan period, both the Tamil Nadu Government and the Department of Atomic Energy have substantially increased their support to the Institute, thanks to the efforts of Prof.E.C.G. Sudarshan, the Director of the Institute. A Nelco Force 20 (D) computer was acquired in September 1988 with further additions expected in the near future.

Much needed construction activities have started. The Foundation stone for a separate Library complex behind the existing Institute Building and a Hostel and Guest House complex was laid by Hon'ble Dr.K.R.Narayanan, Minister of State for Science and Technology, Government of India, on 13th January 1989. The Library Complex is to be completed by December 1989 and the Hostel and Guest House Complex by March 1990. Apart from the 4 acres of land in which the existing Institute building is situated, an additional 2.5 acres for the Hostel and Guest House Complex was also allotted to the Institute free of cost by the Government of Tamil Nadu. The Department of Atomic Energy is meeting the entire cost of construction.

The Plan outlay for the next five year plan was considered. The efforts of the Director-in-charge and the Registrar for the development programmes of the Institute were appreciated by the Officials of both Governments and resulted in a three fold increase over VII Plan allotment for which I am grateful to Chairman, Atomic Energy Commission, Joint Secretary to Government of India, and the Chairman of the Working Group of the Department of Atomic Energy. The Institute is poised for a massive expansion during VIII Plan period which will also enable the Institute to undertake, in addition, other training programmes for the development of mathematical sciences in our country.

I wish to place on record my appreciation to our Registrar, Dr.Varaprasada Rao, I.A.S who, with his administrative experience and scientific background, has shown remarkable patience and competence in the day-to-day administration of the Institute.

I am thankful to Prof.T.S.Santhanam, Dr.R.Jagannathan, Dr.H.Bhate, Dr.H.S.Sharatchandra and Dr.R.Sridhar for their valuable help in the preparation of this report.

September 1, 1989.

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Dr. M. SIVAKUMAR[8]	(Physics)

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[1] *Was at the Tata Institute of Fundamental Research, Bombay, during 21, Sept. '88 - 31, March '89 as Visiting Professor, on leave from the Institute.*

[2] *On lien from TIFR, Bombay*

[3] *On reemployment from 1, Dec. '86*

[4] *Was on leave from the Institute during 20, June '88 - 24, April '89, on academic assignments abroad*

[5] *Now with the Department of Mathematics, University of Florida, Gainsville, Florida, USA, on leave from the Institute*

[6] *On leave from TIFR, Bombay*

[7] *On leave from the Computer Science Department, Aarhus University, Denmark*

[8] *Whose tenure at the Institute was over in 88-89*

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[1] *Fellowship of the Council of Scientific and Industrial Research (CSIR)*

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

[3] *From TIFR, Bombay*

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RESEARCH WORK: SOME OUTLINES

PHYSICS

OPTICS, QUANTUM MECHANICS, FOUNDATIONS OF PHYSICS

Hamilton introduced an elegant way of describing SU (2) elements as equivalence classes of directed great circle arcs on a sphere, also called turns. The SU(2) multiplication is then correctly reproduced by a geometric composition of the turns. It has now been shown that the method of turns constitutes a powerful tool in polarization optics, and a new geometric representation for polarization optics wherein both the polarization states and the optical systems are handled geometrically is developed. The connection with geometric phases is brought out. The power of this new representation is demonstrated by application to some synthesis problems (SIMON and SUDARSHAN, with MUKUNDA)*.

The following question is raised and answered in the affirmative: Can we design a single universal gadget consisting of quarterwave plates and halfwave plates which can realize all SU(2) polarization transformations by simple adjustment of the plates?. It is shown that the universal gadget needs two halfwave plates (H,H') and two quarterwave plates (Q, Q') mounted coaxially in the configuration HQ H'Q'. The two quarterwave plates Q, Q' are rigidly coupled to disable relative rotation. Given an SU(2) element, the Euler angles are computed as α,β,γ and then the elements QQ', H and H' are rotated to the corresponding angular positions to realize the given SU(2) element (SIMON, with MUKUNDA).

The connection between optical phases and the symplectic group is clarified. The relevance of an idea due to Pancharatnam for the computation of optical phases is demonstrated by using it to compute the phase of a squeezed state wavefunction in the configuration representation as a function of time. It is shown that for a highly squeezed state the phase evolves in an almost discontinuous manner. An analogy between this phase evolution and the Guoy effect is established, thus showing that this new phenomenon may be considered as the Guoy effect for squeezed light. Finally, the Pancharatnam SU(2) phased is traced to the symplectic group by isolating the U(2) subgroup (the maximal compact subgroup) of Sp(4, R) (SIMON).

Optical experiments have played an important role in the context of geometric phases. However, there has been a tendency to ignore two important aspects leading to erroneous claims. The first one is the role of the dynamical phase in geometric phase experiments, and the second one is the connection between a group and its n-fold covering on the one hand and the corresponding geometric phases on the other. As an illustration of taking proper account of these two aspects, two recently proposed experiments (one by Jordan, and another by Jordan Chiao) are analysed in detail and it is shown that these experiments, if carried out, will give results totally differing from those predicted by the authors of these papers (SIMON).

Two representations for squeezed states and their unitary evolution have been derived. In the first one, squeezed states are represented as points on the positive branch of the

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

two-sheeted hyperboloid in a 2 + 1 dimensional Minkowski space. Evolution under general hermitian quadratic Hamiltonians then act as Lorentz rotation in this space. In the second one, squeezed states are represented as points on the lower half of a complex plane, with unitary evolution under quadratic Hamiltonians acting as Mobius transformations. The connection between these two representations is clarified (SIMON).

The Mukunda-Simon-Sudarshan theory for the passage from Scalar to Vector (Maxwell) wave optics in the case of paraxial systems is being generalized to treat even aberrating systems (JAGANNATHAN).

The quantum theory of solenoidal magnetic electron lenses developed entirely on the basis of the Dirac equation, for the first time, (Jagannathan, Simon, Sudarshan, and Mukunda) is being extended to cover the treatment of general electron lens systems such as axially symmetric electrostatic lenses, electrostatic quadrupole lenses, magnetic quadrupole lenses, etc., (JAGANNATHAN).

The generalized Heisenberg inequality and the entropic uncertainty relation of Deutsch provide measures of joint uncertainty rather than incompatibility for discrete variables. This distinction has been clarified and a measure of incompatibility applicable for both classical and quantum systems has been proposed based on the respective properties of joint probabilities for such systems (SANTHANAM, with HALL).

Quantum mechanics based on P-adic number systems has been discussed. In particular, the p-adic harmonic oscillator has been studied with different possibilities for its ground state (SANTHANAM).

Stochastic interpretation of quantum mechanics, including relativistic aspects, is being examined from a fresh view point through a rigorous study of the underlying stochastic field. As a bye-product variational methods in stochastic theory and allied ideas are being developed (VASUDEVAN).

The Witten index in supersymmetric quantum mechanics is an order parameter whose nonzero value implies unbroken symmetry. A systematic expansion in $\hbar$, a la Wigner-Kirkwood, for this index in one and two dimensions, reveals that the lowest order $\hbar$ - term is nonzero and all higher order corrections vanish. The original conjecture of Witten, that the result is β-independent (β = KT) atleast in two dimensions, is confirmed (MURTHY, with BHADURI and KHARE).

Work is in progress on the inequivalent quantizations for an O(3) invariant nonlinear σ - model on (arbitrary genus surface) x R. The strategy adopted in this work is to compute the zeroth and first homotopy (π_0 and π_1) groups of the classical configuration space and classify, if possible, the inequivalent, irreducible unitary, finite-dimensional representations of the fundamental group (DATE and SHANKAR, with GOVINDARAJAN).

It is demonstrated that the violation of Bell's inequalities stems from the negativeness of some of the underlying probabilities when calculated quantum mechanically (SUDARSHAN).

The question is posed whether quantum mechanics will continue to be valid in the downward journey undertaken by physicists in probing space-time down to the Planck length (10^{-33} cm). Possible points of departure from the present quantum mechanics, in the development of GUTs based on exceptional groups and in the pursuit of new ideas involved in super symmetry, supergravity, higher dimensional theories and super strings are discussed (RAJASEKARAN).

The work of MARIWALLA on the foundations of physics has been proceeding along the following lines. In 1970 Boulder lectures a twin programme of study of the conceptual framework underlying the intense developments of powerful calculational methods and formalisms to account for varied physical phenomena discovered during the past century, was proposed. One was to trace the logical and epistemological origins of varied current ideas using only the assumption that in a large local region space is absolute, 3-dimensional-euclidean, containing matter not further defined. It yields (1) the notion of time and Galilean mechanics - both classical and quantum; Quantum theory arising from the synthesis between two different concepts, of particles and fields, used in a physical description, and (2) the Special Relativity as a logical completion of Galilean mechanics, together with the notion of "interaction space-time" which is even dimensional and, except for gravitation, is larger than 4 with maximum of 10 or 26 dimensions. In place of one-parameter development there is a fundamental two-space, where a particle is represented by curve, with a geometry based on area, related to a Finsler metric. The other study was to understand varied transformation groups "in the large" leading to the "Principle of Relativity of Paths" - the set of all observers that see the same paths are equivalent. A first application was the "projective Einstein - Cartan" theory (1971) which predicts energy emission, with Plackian spectrum (1978) as in the Hawking effect (1975), from a spherically symmetric gravitational collapse. In mechanics and field theory it yields new conservation laws, based on second variation, hitherto considered as accidental (1975-78). Now, it has been shown that in special relativity the symmetry group of paths, containing the conformal and projective groups, is ∞ - dimensional and includes n(=4) rows of Virasaro algebras, besides graded towers of solvable and nilpotent algebras. Specialized to two dimensions, these generate quasiconformal transformations, underlying the "Teichmuller metric" which (has characteristics of negative curvature, and) is derivable from a Finsler metric. Thus one obtains much of the mathematical apparatus underlying both Gauge and String theories without additional notions of "Compactification" or "Strings".

STATISTICAL PHYSICS, CONDENSED MATTER PHYSICS

Recent trends in measurement theory develop models in which the environment of the open system plays a key role. The evolution of the system with one and two photon emission and absorption interacts with a heat bath either in the fully coupled situation or in the rotating wave approximation. Starting with initial density matrix in the squeezed state for the system the time evolution is obtained. Fluctuation dissipation relations showing new features are obtained. Also, the way in which equilibrium is reached is analysed to obtain the KMS condition (VASUDEVAN, with CHAKRABARTY).

Multiple productions are treated by Van Hove et. al. as due to processes leading to a negative binomial distribution of particles. This picture is reinterpreted as population processes with suitable immigration characteristics along with mainstream processes in the cavity radiation population with suitable parameters for birth and death eventualities (VASUDEVAN, with SRINIVASAN).

A microscopic theory of nonlinear dynamics of superfluid Helium-4 has been given using a pseudospin Hamiltonian on a lattice. The expectation value of the spin-flip operator in the spin-coherent state representation is taken to be the order parameter. Calculations are carried out in the continuum version. Besides reproducing several well known results in suitable approximation schemes, in the cylindrically symmetric case, a vortex core of finite thickness and a nonsingular vorticity is obtained. Unidirectional travelling wave solutions with velocity-dependent amplitude are shown to exist. For a specific choice of parameters a static-domain wall solution is also shown to exist (Radha BALAKRISHNAN, SRIDHAR and VASUDEVAN).

Based on a self-consistent theory to determine the excitation energy and the structure factor of liquid He-II, it has been shown that the phonon velocity is proportional to the square-root of the average kinetic energy per particle. This enables one to estimate the condensate fraction at T = 0 as 13.6% (SRIDHAR).

Application of the principles of gauge invariance and vortex flow in superfluid ^{4} He is being analysed (Radha BALAKRISHNAN, SRIDHAR and VASUDEVAN). The earlier work of the authors on pseudospin formalism of an interacting Bose gas started with a discrete lattice spin model and interesting results were obtained. In the continuum approximation it led to a continuity equation for the superfluid, from which one could infer that a velocity field **u**, called the depletion velocity is superimposed and its interaction with the superfluid was described by a coupling related to the mass of the helium atom. This naturally invites the application of the ideas of a gauge theory, **u** being the gauge field. Different representations of the spin-flip operators of the pseudospin formalism are being tried out to form a Lagrangian with canonically conjugate variables for the full exploitation of the gauge theoretic ideas.

BASKARAN and Collaborators have been studying the confinement aspects in the gauge theory of strongly correlated systems, chiral symmetry breaking in RVB states, and the relevance of RVB theory to actual high temperature superconductivity experiments. Studies on strongly correlated electron systems mainly by analytical means and also by numerical variational methods are being pursued.

A model for high temperature superconductivity has been presented based on the close relationship between structural phase transitions and accompanying lattice instabilities on the one hand and the high temperature superconductivity on the other. A novel explanation of the weak isotope effect has also been given (Radha BALAKRISHNAN and SRIDHAR, with CHATURVEDI and SRINIVASAN).

A brief review has been given of the theories of high temperature superconductivity with a BCS-like approach in which structural transformations play an important role. After discussing the relevant experimental data, Jahn-Teller effect mediated theories and attempts based on local structural instabilities have been discussed. After presenting some tight-binding models, a critical discussion of the available theories has been given (SRIDHAR).

Some other topics on which Radha BALAKRISHNAN has worked are: Theoretical interpretation of the dependence of third sound velocity on ^{4}He film thickness; On the integrability of the nonlinear evolution for the order parameter in superfluid ^{4}He; Soliton dynamics in the uniaxially anisotropic quantum ferromagnetic chain (with HOLYST and BISHOP); Nonlinear dynamics of a quantum ferromagnetic chain (with BISHOP)

FIELD THEORY, PARTICLE PHYSICS, NUCLEAR PHYSICS, ASTROPHYSICS

Certain aspects of the use of a nonlinear gauge fixing condition in SU(N) gauge field theories have been studied. The Faddeev - Popov ghost Lagrangian is obtained using two different methods. Feynman rules have been derived explicitly. The full Lagrangian is shown to be BRS - invariant. The Slavnov - Taylor identities have been derived (PARTHASARATHY).

Using auxiliary field for the field strength in the Minkowski functional integral, Saviddy's chromomagnetic vacuum for nonabelian theories has been reconsidered and shown to be stable for a range of coupling constant (ANISHETTY, BASU and PARTHASARATHY).

A perturbative chromoelectric vacuum for QCD has been constructed. Certain colour degrees of freedom for the gluons cease to exist as asymptotic states, providing an indication of confinement in QCD. This is a new mechanism for confinement of colour degrees of freedom (ANISHETTY, BASU and PARTHASARATHY). The infrared problem in the theory has also been addressed and it is found that if we resum the naive perturbation theory and consider only 1PI graphs there is considerable improvement in the infrared region. This offers a hope of ameliorating the IR problem in QCD. Work on inclusion of fermions in the theory is in progress.

Quantum effects in nonlinear sigma model compactification for $M_4 \times S^2$ have been evaluated a la Candelas and Weinberg and the stability of the classical solutions has been discussed (CHAKRABARTY AND PARTHASARATHY).

A dynamical compactification scheme using a generalized Robertson-Walker metric of the form $ds^2 = dt^2 - a^2(t)g_{mn}\,dx^m\,dx^n - b^2(t)g_{ij}\,dy^i\,dy^j$ for Kaluza-klein theory with nonlinear sigma field coupled to gravity has been proposed. Solutions for a (t) and b(t) have been obtained with the usual space expanding and the extra space contracting (CHAKRABARTY and PARTHASARTHY). Work is in progress on a possible approach to consider CP^2 manifold admitting generalized spin structure by coupling fermions to CP^2 instantons. This is used in the context of Kaluza-Klein theory for introducing chiral fermions in $M_4 \times CP^2$ spaces. The model admits spontaneous compactification.

Work is in progress on the issue of consistency of anamolous two dimensional gravity and the possibility of simplifying the analysis using chiral bosonization (DATE, HARI DASS and SUMITRA).

Work on the quantization of a gauge-invariant massive spin-3/2 theory with external interaction was completed. It has been shown that this theory, which was earlier found to have causal classical propagation modes, is also free from the problem of negative-norm states at the quantum level. This supports an earlier conjecture that gauge invariance can solve certain problems of higher-spin theories, and disproves a contention of some authors to the contrary (RINDANI). Work is in progress on extending this spin-3/2 theory to include a more general external interaction, while still preserving the gauge invariance. Preliminary results indicate that the theory is consistent at the classical as well as the quantum level.

A review has been carried out of possible searches of the standard model light Higgs boson in future experiments, as well as of existing results on the limits for the Higgs mass (RINDANI).

The possibility that $\theta(1720)$ and the recently reported $\zeta(1480)$ are suitable members of a 36 dimensional multiplet of $(Q^{-2}Q^2)$ mesons has been investigated. Decay modes to two pseudoscalars and to four pseudoscalars (via virtual vector-meson pairs) have been analysed. The proposed interpretation is found to have a fair chance of being correct. Further consequences of the model concerning a narrow isoscalar at 1930 MeV and the three doubly charged exotics have been presented (SUDARSHAN, with BOSE).

A factorization property relating the exchanges of the ordinary photon and the "heavy photon" (or the neutral weak boson) has been proved in the SU(2) X U(1) electroweak theory (RAJASEKARAN with LAKSHMIBALA).

The unusual events seen in the KGF proton decay detector have been interpreted as indicating the existence of a massive long-lived particle. The possibilities of identifying this new particle as a fourth-generation (massive) neutrino, or as a neutral fermionic member of the 27-plet of E_6-GUT, or as the SUSY partner of the neutrino have been studied (JOSHIPURA and RAJASEKARAN, with V.GUPTA and K.V.L.SHARMA).

It has been shown how the position and residue of the S-Matrix pole can remain stable under changes in the form of the parametrization of the matrix elements. A relation among the shifts in the Breit-Wigner resonance parameters under these changes has been derived and explicitly verified for the case of Δ (1232) (RAJASEKARAN, with VASAN).

It has been shown that the integrally charged quark model predicts an upward shift of W and Z masses by 3.3 and 3.7 GeV respectively, as compared to the fractionally charged quark model. When combined with radiative corrections and compared with experimental data on m_W and m_Z, a heavier top quark than in the fractionally charged quark model is implied (RAJASEKARAN, with DESHPANDE).

Renormalization of the SU(2) X U(1) electroweak theory and the calculation of the one loop radiative corrections to the formulae connecting the muon decay rate to the masses of W and Z have been treated in the context of the precision measurement of the mass of Z in the e^+e^- colliders LEP and SLC (RAJASEKARAN).

In the article on symmetry and unification in Physics (RAJASEKARAN) the role of symmetry in unifying the fundamental forces of Nature is elucidated. It is shown how symmetry has provided the guiding principle, first in the unification of electricity and magnetism, next in the electroweak unification, and finally in the possible (grand) unification of electroweak forces with the strong force. Current attempts on the total unification of all these forces with gravity revealing yet newer aspects of symmetry in Nature are also discussed.

A derivation of electroweak theory based on electroweak symmetry is given. The manifestation of electroweak symmetry is then studied through the following examples : cancellation of divergences due to electroweak symmetry, electroweak factorization in photon and "heavy photon" (Z) mediated processes, generalization of the equivalent photon approximation, the cure of the diseases of the massive charged vector bosons and the charge radius of the neutrino (RAJASEKARAN).

After an account of the fascinating story of Dirac's discovery of his famous equation, the following topics are discussed : modern view of holw theory, antimatter, self-conjugate fermions (Majorana particle), super symmetry, higher-spin fields, Dirac equation in the context of the standard model of high energy physics, Dirac equation as the gateway to quantum field theory, quantum gravity and superstring theory (RAJASEKARAN).

After an introduction and overview which describes free strings and string interactions and emphasizes the fact that every consistent string theory necessarily includes gravity, the quantum theories of bosonic strings, superstrings and heterotic strings are constructed. The treatment is kept at an elementary level so that anybody who knows quantization of the harmonic oscillator can understand string quantization (RAJASEKARAN).

In the article on Building up the Standard Gauge Model in High Energy Physics (RAJASEKARAN) the sandard model of particle physics based on the gauge group SU(3) X SU(2) X U(1) is carefully built up, step by step. Starting with the simplest notions of abelian gauge field theory and proceeding through the ideas on spontaneous breakdown of symmetry, nonabelian gauge fields, etc., the various strands making up the SU(2) X U(1) electroweak theory are collected together. Then the strong interaction sector is taken up and it is shown how deep-inelastic scattering, asymptotic freedom and colour lead upto QCD. The renormalization group equation is shown to provide the foundation for asymptotic freedom and the justification for QCD. Combining the electroweak and QCD sectors, the complete standard model is then constructed. Its strengths and weaknesses are analysed and some views beyond the standard model are presented.

In the article on superstrings (RAJASEKARAN), first, the quantum theories of bosonic strings, superstrings and heterotic strings are constructed at the level of free noninteracting strings. Then, interactions are introduced in terms of vertex operators and the construction of tree amplitudes as well as loop amplitudes is treated. Finally, string field theory in the light-cone gauge as well as recent attempts at constructing covariant string field theories are described.

Work is in progress along the following lines (RAJASEKARAN) :

1. A general study of the properties of shadow poles has been undertaken. Formulae for their positions and residues have been derived.
2. A number of tests have been devised to distinguish between atomic hadrons (quark bound states) and molecular hadrons (hadronic bound states).
3. Consequences of QCD with broken colour for Bhabha scattering experiments are being worked out.
4. The most general characterization of nongravitational long range forces (fifth force), if any, in terms of quantum numbers consistent with the standard model of high energy physics is being looked for.
5. New relationships between baryon number violation and possible fifth force (outside the framework of GUTs) is under investigation.
6. A crucial error in the existing treatments of the neutrino magnetic moment has been found. Possible ways of correcting this will be pursued.

Recent measurements from the deep inelastic scattering of polarized muons on polarized protons by the EMC (European Muon Collaboration) have raised some new questions regarding the spin structure of the proton. The naive parton model interpretation that quarks entirely account for the proton spin has been challenged by the data. In fact it turns out that gluons play an important role. Studies have been made on the possibility of measuring gluon spin dependent densities independently through a study of high p_T-photon and dimuon production in polarized p-p and $\bar{p}$-p scattering at high energies (INDUMATHI and MURTHY, with GUPTA).

The EMC data on the first moment of the polarized proton structure function also seem to violate the sum rules based on a theoretical analysis of an SU(3) quark model. A reanalysis was carried out using the method of QCD sum rules. Isocalar and isovector axial vector renormalization constants have been computed and using these the sum rules have been rederived in excellent agreement with the data, thus settling the controversy. The new results and their agreement with the data can be explained through a proper understanding of the role played by the anomoly in the singlet axial vector current. (MURTHY, with GUPTA and PASUPATHY)

Work is in progress on understanding the spin physics at high energies; new results are expected soon. The computation of the proton spin structure function using QCD sum rule is nearing completion (INDUMATHI and MURTHY, with PASUPATHY). Reconciling the new results from the EMC on the proton structure functions with the well known quark model results by accommodating the role played by the anomaly is also underway (MURTHY and RAVINDRAN).

It has been shown that the strong gravitational fields associated with neutron stars can induce helicity flip for massive neutrons. The effect is of comparable magnitude to that induced by neutral current weak interactions. It has also been shown that the limit on the gravitational parity violating coupling can be improved using well known ideas on the rate of cooling of hot neutron stars (CHOUDHURY, HARI DASS, and MURTHY).

Study of two dimensional quantum gravity and quantum supergravity are of interest in many diverse areas like superstring theories, statistical mechanics, theory of random surfaces, etc. The so called (1,0) quantum supergravity theory has been studied and it has been shown that it is exactly integrable in the light cone gauge (supersymmetric). An infinite dimensional graded affine SL(2,R) algebra has been shown to be symmetry algebra of the solutions (HARI DASS and SUMITRA). While the existence of a similar algebra in the purely bosonic theory had been established in the pioneering work of Polyakov, the precise origin of these symmetrics had remained obscure so far. Now, the above work of HARI DASS and SUMITRA establishes, in the broader context of supergravity, that these symmetrics arise out of motions along the gauge slice, and constitutes an explicit example of an exact symmetry being born out of an inexact (to be explicit, anamalous) symmetry due to dynamics.

A supernova explosion was sighted in the large Magellanic cloud in late February 1987. This led to intense activity both from points of view of Astrophysics as well as Particle Physics. As was anticipated, neutrino bursts from this supernova had been recorded in underground detectors all over the world. The work done at the Institute (Hari Dass, Indumathi, Joshipura and Murthy, 1987-88) was one of the first, even internationally, to make a detailed analysis of the neutrino events. This analysis established that the currently popular models of

supernovae were in remarkable agreement with the observations. Now, the analysis has been pursued (HARI DASS, JOSHIPURA and MURTHY) to clarify the impact of the observations on some of the most sought after questions in neutrino physics, namely, the neutrino mass, mixing angles, and lifetimes. While the data point tantalisingly towards a nonvanishing netutrino mass, the statistics is not good enough for clear predictions. HARI DASS, JOSHIPURA and MURTHY have been able to improve the limits on the neutrino lifetimes by several orders of magnitude. Work is in progress to make realistic predictions for the spectrum of neutrinos emitted by a supernova which would help in constructing scenarios for future supernova detections. This involves a careful integration of neutrino physics with various bulk effects like opacity with the astrophysical models.

A problem initiated in 1980 (Mariwalla) was to estimate the number of elementary entities of matter using information theoretic interpretation of black-hole entropy. A black-hole interior then makes sense and it was proposed that it is a compact (even of finite volume) 3-space of negative curvature; As phase-space of geodesics is then ergodic, the notion of time arises naturally and is consistent with Robertson - Walker metric. The interior consists of analogue of "Bohr orbits" of elementary entities (about exp (2π) in number) in this multiply connected space carrying very high entropy. Under suitable conditions a phase transition of some of the "orbits" to (ordinary) matter at high temperature can take place, in principle, leading to a structure akin to the observed universe. A sharpening of some of these and related results with application to the third law of thermodynamics, Casimir effect, and "fifth force conjecture" have been obtained (MARIWALLA).

Particles produced in high energy collissions in a supercollider lead to quark-gluon cascades leading to formation of hadrons. The cascade models based on probabilities of the processes computed on the basis of QCD have been described by Bellman - Harris type of branching equations. KNO scaling is shown to be a natural consequence and the similarities with population process with immigration, death and birth probabilities have been illustrated. Calculations are shown to be simplified by imbedding methods (VASUDEVAN, with SRINIVASAN).

A model of jet fragmentation and hadronization has been worked out which describes the quark-gluon cascades leading to hadron formation exploiting the product-density approach and energy-dependent cross sections. It is illustrated that these are connected with Field Feynman models. The expected number of hadrons have been computed (VASUDEVAN, with SRINIVASAN).

MATHEMATICAL PHYSICS, AND TOPICS IN OTHER MATHEMATICAL SCIENCES

It was shown that the triple sum series of Jucys and Bandzaitis for the 9-j coefficient can be identified with a formal hypergeometric series due to Lauricella-Saran-Srivastava (SRINIVASA RAO and RAJESWARI). This identification had immediately two consequences: (i) study of polynomial zeros of the 9-j coefficient (SRINIVASA RAO and RAJESWARI); (ii) development of a new Fortran program for the 9-j coefficient (SRINIVASA RAO and RAJESWARI, with CHIU). In the former it is shown that there exist polynomial (or nontrivial) zeros for the 9-j coefficient. A simple closed-form expressing for the polynomial zeros of degree one of the 9-j coefficient has been derived, and these polynomial zeros are then generated from either the closed-form expression or a set of parametric solutions of the

multiplicative Diophantine equations: xyz = uvw. The new Fortran program for the 9-j coefficient developed on the basis of the Jucy-Bandzaitis triple sum series has been shown to be computationally faster than the conventional and standard method based on expressing the 9-j coefficient as a single-sum over the product of three 6-j coefficients.

It has been established that the complete set of polynomial zeros of degree one of the Racah coefficients can be obtained only from the full eight-parameter solution of the multiplicative Diophantine equation xyz = uvw subject to the constraint z = x + y + u + v + w. All other parametric solutions, due to Bremmer, Brudno, louck, and others, have been shown to represent only proper subsets of the complete set of solutions (SRINIVASA RAO and RAJESWARI, with KING).

Simple algorithms based on the principle of factorization of an integer have been proposed to generate complete sets of polynominal zeros of degree 2 of the 3-j and the 6-j coefficients (SRINIVASA RAO, with CHIU).

The connection between the 3-j and the 6-j coefficients to a set of a six ${}_3F_2(1)$'s and a set of three (or, equivalently a set of four) ${}_4F_3(1)$'s, respectively, is used to obtain sets of Regge 3 x 3 and Bargmann - Shelepin 4 x 3 symbols. Closed-form expressions have been obtained for the polynominal zeros of degree n of these coefficients (SRINIVASA RAO and RAJESWARI).

The wigner, Racah, and Majumdar sets of ${}_3F_2$ (1)'s have been derived from the symmetric van der Waerden ser of ${}_3F_2(1)$'s for the 3-j coefficient, using a transformation due to Erdelyi and Weber, which is also used to relate the 3-j coefficient to a discrete orthogonal Hahn polynominal. The four recurrence relations (old and three new) obtained by Karlin and McGregor for the Hahn polynomial are used to derive recurrence relations for the 3-j coefficient, two of which have been shown to be useful in the exact recursive evaluation of the 3-j coefficients by Schulten and Gordon (RAJESWARI and SRINIVASA RAO)

The noncompact group $Sp(2,R) \simeq SU(1,1) \simeq SL(2,R)$ plays an important role in many areas of physics. Since SU(2) and SU(1,1) share the same complex extension, it is of interest to ask: Can we generalize Hamilton's method of turns for SU(2) to the noncompact group SU(1,1)? The answer to this question has been shown to be in the affirmative. The role of the unit sphere S^2 is now played by the single-sheeted hyperboloid Σ in a 2 + 1 - dimensional Minkowski space $M_{2,1}$ and that of great circles by the curves ξ through which planes passing through the origin in $M_{2,1}$ intersect Σ. Each Sp(2,R) elent is to be identified with an equivalence class of arcs on ξ. The Sp(2,R) composition then reduces to a geometric "addition" of these arcs. This generalization of Hamilton's method has been called the method of screws and its application to several problems has been outlined (SIMON and SUDARSHAN, with MUKUNDA).

Several questions arising in the context of the theory of screws for SU (1,1) have been analysed. Finite elements of SU(1,1) have been classified into timelike, spacelike and lightlike nonintersecting subsets with their union giving SU(1,1) and the importance of this new classification is emphasised. Attention is drawn to the fact that SU(1,1) is not a group of the exponential type, i.e., there are elements (in fact, a lot of elements) which do not lie on any one-parameter subgroup. Indeed, for every $U \in SU(1,1)$ with $t_r U \geq 2$ its negative

$-U \epsilon$ SU(1,1) cannot be written as exp(J) for any generator of SU(1,1). This nonexponential nature is geometrically interpreted and its relevance to the theory of screws is brought out. Finally, it is shown that every element of SU(1,1) can be written as a product of two timelike (compact) elements. This theorem is shown to be central to the theory of screws. (SIMON and SUDARSHAN, with MUKUNDA).

It is wellknown that composition of two boosts is not just a boost, but a boost followed by a rotation called the Wigner rotation. It is noted that the computation of SO(n,1) Wigner rotation for any n is basically an SO(2,1) problem. Exploiting the homomorphism between Sl(2,R) and SO(2,1) it has been shown that the computation of SO(n,1) Wigner rotation can be simply handled through 2 x 2 real matrices resulting in a substantial economy in the otherwise messy algebra (SIMON, with MUKUNDA).

Pursuing the work originally done in the seventies in relation to the translation operator on a finite interval (Mariwalla), applications to (1) determine the spectrum of sine and cosine operators; (2) understanding of propagation and conductivity in cellular periodic structures; and (3) aspects of representation of Virasaro algebra have been worked out (MARIWALLA).

Technique of using the generating functions has been developed for computing the Kostant partition functions for Kac-Moody algebras untwisted and twisted. The method makes use of some infinite product identities like Euler's, Jacobi's triple product, and Watson's quintuple identities. Comparison of these results with those of Kac and Peterson yield the well-known Tannery and Molk identity for A^1 and its generalization for A^1_2. The construction of the generating functions requires only the knowledge of the simple and positive roots (SANTHANAM, with CHAKRABARTI).

In Davydov's model for transportation of energy in biological molecules, a nonlinear differential equation is derived using the adiabatic approximation. This has led to some criticisms and discussions; and even the validity of the model has been seriously challenged. Now, using Feynman's methods developed for quantum electrodynamics, a more general nonlinear equation has been developed exhibiting time retardation effects; on the adiabatic limit the retardation effect vanishes and Davydov's nonlinear equation is recovered. (RADHAKRISHNAN, with CAMPBELL).

In one dimensional transport theory Rehheifer, taking a two-port model, obtained the differential equation for transmission (T_l , T_r) and reflection (R_l , R_r) functions. Now, a four-port model has been developed and operators are defined as transmission operators for the incident flux U_r (r = East, West, South, North) to come out as exiting fluxes V_r at the same face or other faces one has to define $T_{\phi'}$ transmission operators, $R_{\phi'}$ reflection operators $G_{\phi'}$ left-turn operators, and $D_{\phi'}$ right-turn operators, with ϕ suitably defined to represent the proper directions. The imbedding principle is enlarged and suitable small pieces of slabs are attached successively at each face. By particle counting methods nonlinear differential equations in x and y variables, more than sixteen in number, are obtained. The coefficients t_r, r_r, d_r and g_r, derivatives of T,R,D and G for small or zero slab thickness in the respective directions, can be solved for numerically, with suitable initial values and these are important in reactor theories (VASUDEVAN, with SETH).

A finite dam or storage model is treated as a barrier problem with random inputs, outputs, and exponential release. Equations have been written down to calculate the expected amount of overflow in a given time using imbedding methods (VASUDEVAN, with VITTAL).

MATHEMATICS

Let $g(n) = \prod_{p/n} g(p)$ be a strongly multiplicative function and $g_y(n) = \prod_{p/n,\, p<y} g(p)$ its truncation; p is prime. Let A be a set of positive integers satisfying certain sieve conditions, and $A(x) = A \cap [1,x]$. Then the sum $s_g(A(x),y) = \sum_{n \in A(x)} g_y(n)$ has been treated as a generalized sieve sum. The combinational sieve of Brun has been used to estimate $s_g(A(x),y)$ when $o \leq g \leq 1$, and applications have been sketched. The main result is that the Pure sieve of Brun can be employed to estimate $s_g(A(x), y)$ even when $-1 \leq g \leq 1$, provided $\log A(x) / \log y$ is not too small. This gives new results on the distribution of the number of restricted prime factors in a wide class of sets A (Krishnaswami ALLADI).

Let n be square-free and h a multiplicative function satisfying $0 \leq h(p) \leq 1/(k-1)$ for all primes p. Here $k \geq 2$ is an integer. Using a powerful result of Baranyai on hypergraphs it has been shown that $\sum_{d/n} h(d) \leq 2(k+o(1))) \sum_{d/n, d \leq n^{1/k}} h(d)$ for $k = 2,3,4,\ldots$, where o(1) is a quantity tending to zero as $\nu(n) = \sum_{p/n} 1 \to \infty$ Such results have applications in Probabilistic Number Theory (Krishnaswami ALLADI, with ERDOS and VAALER).

The celebrated results of Erdos-Kac and Kubilius in Probabilistic Number Theory dealing with the distribution of additive functions, were originally established using Brun's sieve and ideas from Probability Theory such as independent random variables, the central limit theorem and infinitely divisible distributions. By means of a new method involving Laplace transforms and a multiplicative generalization of the sieve, the Erdos-Kac-Kubilius theorems have been reproved, but in a wider setting. The new method has two advantages: (i) there is no necessity for using random variables and (ii) the underlying sieve enables a discussion of distribution in a wide class of sets (Krishnaswami ALLADI).

Probabilistic Number Theory has its origins in a paper of Hardy-Ramanujan (1917) on the distribution of the number of prime factors of integers, and blossomed into a subject with the fundamental work of Erdos-Kac (1939). Classical results in this area almost always deal with distribution in the set of all integers. In a survey paper the major results of Probabilistic Number Theory starting from Hardy-Ramanujan have been described and connections with a new method are illustrated. The new method described in this paper involves the sieve and Laplace transform and provides a unified approach to the distribution of additive functions in a large class of subsets of the positive integers (Krishnaswami ALLADI).

Work is in progress in pursuing the ideas on generalized sieve sums in greater depth and detail. In particular, one can define a multiplicative sieve dimension parameter K which turns out to be useful in estimating certain generalized sieve sums. It has been shown that the Kubilius class of functions in Probabilistic Number Theory is equivalent (in a certain sense)

to sieve dimension K--> 0. This intrinsically interesting result has the potential for several applications. As a first illustration, a new proof has been obtained for the result of Barban on the distribution of additive functions in the sequence of shifted primes {p + a}; it is hoped to apply these ideas to polynomial sequences as well. Work is in progress along these lines (Krishnaswami ALLADI).

If we define $\delta_k(n)$ to be the maximal divisor of n, which is coprime to k, it is an interesting problem to study the error term associated to the summatory function of $\delta_k(n)$. Even though good Ω – results are known in the special case when k is a prime, the general case was not known. Using the powerful method developed by Erdos and Shapiro to get a good Ω_+ result for the summatory function of Enler's totient function, called the averaging technique, a good Ω_+ result has been obtained for the summatory function of $\delta_k(n)$ (ADHIKARI and BALASUBRAMANIAN).

Even though on empirical grounds one can guess that $\sum_{nd(n) \leq 2x} 1 \sim 2 \sum_{nd(n) \leq x} 1$ the question was raised by Professor Erdos whether one could prove such a result rigorously. In an attempt to prove this result a stronger result has been obtained namely that for any multiplicative function g(n), such that g(p) is independent of the prime p and satisfying some mild growth conditions, it is true that $\sum_{ng(n) \leq 2x} 1 \sim 2 \sum_{ng(n) \leq x} 1$; this includes the divisor function as a special case. In fact, the method yields a much stronger result in the form of an asymptotic formula for $\sum_{ng(n) \leq 2x} 1$ with as good an error term as $O(x \exp(-c(\log x)^{3/5} (\log\log x)^{-1/5}))$. The coincidence of this error term with that occurring in the prime number theorem is not accidental (BALASUBRAMANIAN, with RAMACHANDRA).

An integer n is said to be k-full if all the prime factors of n appear with an index atleast k. One can now consider the summatory function of the k-full integers and seek Ω – results for the error function. Earlier, the results were known only for the case k=2, and in this case the Ω –result is a consequence of the singularities of the functions. In the general case, the Ω –result due to singularities gives a weak result. A stronger result could be obtained using the growth condition. Earlier in the literature Ω – results using growth conditions were known only for the functions having a pole on the real line like, for example, $\zeta^2(s)$. Now, for the first time Ω –results even for functions having more singularities have been proved using growth conditions. This includes as a special case, Ω – results for the k-full integers and various other functions (BALASUBRAMANIAN, with RAMACHANDRA and SUBBARAO).

A new proof of Hardy's first approximation theorem in the theory of Riemann Zeta function has been given. The advantage of this method is that it could be used to prove the analytic continuation of complicated functions such as

$$\sum_{n=1}^{\infty} (-1)^n \exp[(\log n)^{1/2}]/n^s$$

(BALASUBRAMANIAN,with RAMACHANDRA).

One is interested in the rate of growth of Zeta function on the critical line. Here the expected O-results are so deep that it seems impossible to prove them even under Riemann Hypothesis. On the other hand, the Ω –results look trackable. Here two methods are used in general; One method essentially due to Littlewood, is to raise Zeta function to a high power and get a lower bound for the high power of zeta function and deduce Ω –result. The other method, due to Montgomery, is to approximate $\log\zeta(s)$ by a finite Dirichlet series and apply Kronecker's theorem. These methods have their own advantages and a strong result by one method is not obtainable by the other method. Developing the powerful technique of Balasubramanian and Ramachandra in getting the lower bound of high power of Dirichlet series, it has been proved that $\zeta(\frac{1}{2}+it) = \Omega(\exp[\frac{3}{4}\{\log t)/\text{loglogt}\}^{1/2}])$. One can compare this with the result of Montgomery, who proved $\log e^{i\theta}\zeta(\frac{1}{2}+it) = \Omega_{\pm}(c(\log t)^{-\sigma}/(\text{loglogt})^{\sigma})$, with $c = c(\sigma)$. Here $C(\frac{1}{2}) = 1/20$ and for $\sigma = 1/2$ one needs Riemann Hypothesis (BALASUBRAMANIAN). On the other hand one would expect that $\log|\zeta(\alpha+it)|$ has an upper bound and lower bound of order $(\log t)^{1-\alpha}/(\text{loglogt})^{\alpha}$. Such a result is proved to be true if we omit a set of small measure in [T,2T] (BALASUBRAMANIAN and RAMACHANDRA).

The following question, known as Erdos - Woods conjecture, has an important application in mathematical logic. Does there exist an integer $k \geq 2$ such that for any two integers $x < y$ there exists an integer $j \leq k$ such that the prime factors of $(x + j)$ and the prime factors of $(y + j)$ are different. Using Baker's theory of linear form in logarithms a partial solution has been obtained for this problem (BALASUBRAMANIAN, with SHOREY and WALDSCHMIDT).

Let $r_4(n)$ be the number of representations of n as a sum of four squares. Then, using the method of Montgomery an Ω– result for the error term in the summatory function of $r_4(n)$ has been proved (ADHIKARI and BALASUBRAMANIAN, with SANKARANARAYANAN).

Generalizing the earlier result of Balasubramanian regarding the error term in the mean square of Riemann Zeta function it is shown, by sharpening a result of Tom Meurman, that similar results could be proved over short intervals for the Dirichlet L-function (BALASUBRAMANIAN, with RAMACHANDRA).

The question whether L-functions can have zeros on the real line is interesting. In particular, it is of interest to know whether $L(\frac{1}{2}, x)$ can be zero. The only known result in this direction is due to Balasubramanian who proved that of all the characters to the modulus q there are atleast $q/(\log q)^{100}$ characters which are such that $L(\frac{1}{2}, x) \neq O$. Improving this result (proof is given in case q is prime) it is proved that for a positive proportion of characters $L(\frac{1}{2}, x) \neq O$. These ideas are quite useful if they could be extended for L-functions associated to elliptic curves, after the recent results of Kolyvagin on Birch - Swinnerton Dyer conjectures (BALASUBRAMANIAN, with KUMAR MURTHY).

The inverse problem of the discrete, periodic, second order operator in more than two dimensions has been studied, and a method of solution in particular cases has been found. Extensions to higher order operators are being investigated (BHATE).

It has been shown that random potentials with certain types of band spectra are necessarily almost periodic functions. Here the spectral bands (contained in R^+) are required to grow in size at a certain rate (as one approaches ∞) (KRISHNA, M., with KOTANI). This work has been recently extended by W. Craig (Stanford University) to cover reflectionless potentials.

There is some progress in understanding the localization problem with Anderson Model (KRISHNA, M., with KOTANI). Also currently work is in progress on the random Boussinesq equation: The aim is to study the spectral properties of a differential operator of the form $H^\omega = i\frac{d^3}{dx^3} + (1/i)(q^\omega\frac{d}{dx} + \frac{d}{dx}q^\omega) + p^\omega$ where $\omega \in \Omega$. (Ω, β, P) is a probability space and (q^ω, p^ω) are random variables: $\Omega \dashrightarrow R$ (KRISHNA, M.).

The following theorem has been proved: Asymptotic completeness holds in $L^2(R)$ for $(h(p) + (1 + Q^2)^{-\epsilon}. h(p))$ for all $\epsilon > O$ when $(1 + |Q|)^{-1} (h(p) + i)^{-1}$ is compact. Here Q, P are the operators given by $(Qf)(x) = xf(x)$ and $(Pf)(x) = -if.(x)$. Further work is in progress (MUTHURAMALINGAM).

A necessary and sufficient condition, in terms of n and k, for a (real, complex or quaternionic) Grassmann manifold $G_{n,k}$ to be a boundary has been obtained, mainly using characteristic classes and a theorem of Conner and Floyd as the bordism of an almost complex manifold admitting a 'Conjugation' (SANKARAN).

A classical, result of R.D. Anderson is that under certain conditions on a space X, some homeomorphism groups of X are simple. This implies that the homeomorphism groups in question must have vanishing first homology. Now, it has been shown that a slight modification of Anderson's conditions leads to homeomorphism groups of X whose homology groups vanish in *all* dimensions greater than zero. Applications to the Cantor set, the rationals, and the irrationals have been given (SANKARAN, with VARADARAJAN).

The real Grassmann manifolds $G_{n,k}$ and the oriented Grassmann manifolds $\tilde{G}_{n,k}$ and the oriented Grassmann manifolds have been classified, save for a few exceptional cases, as to which of these admit almost or weakly almost complex structures (SANKARAN).

THEORETICAL COMPUTER SCIENCE

A logic which exactly captures the notion of a finite set of events occurring independent of each other at a state of a distributed system has been formulated and studied. A sound and complete axiomatization has been obtained. The logic has also been shown to be decidable (LODAYA, RAMANUJAM, and THIAGARAJAN).

A Petri net model has been formulated to capture a finite number of agents communicating with each other asynchronously via point-to-point unidirectional unbounded buffers. It has been shown that techniques that have so far worked in a very restricted setting can be extended to obtain a poset-based behavioural semanties based on event structures (MUKUND and THIAGARAJAN).

The major tools used for representing the behaviour of elementary net systems, the basic system model of net theory, have been investigated. It has been shown that tools advocated by different researchers such as nonsequential processes, trace languages, unfoldings, and event structures, yield essentially the same result when applied to elementary net systems (THIAGARAJAN, with NIELSEN and ROZENBERG).

The proof theory for exception handling in Ada programs has been revised and made more compact (LODAYA, with SHYAMSUNDAR).

Previous work on semantics of distributed logic programs has been extended to include a process model, where the operational semantics has been built using process histories and a translation has been provided from processes associated with distributed logic programs into programs in a TCSP - like language (RAMANUJAM).

Work is in progress to provide logics for reasoning about behaviours of asynchronously communicating systems and to introduce parallel composition operators into logics of programs (LODAYA, RAMANUJAM and THIAGARAJAN).

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R. SIMON and E.C.G. SUDARSHAN (with N. MUKUNDA)
Gaussian pure states in quantum mechanics and the symplectic group
Phys. Rev. A 37 (1988) 2028

R. SIMON and E.C.G. SUDARSHAN (with N. MUKUNDA)
Hamilton's theory of turns generalized to Sp(2, R)
Phys. Rev. Lett. 62 (1989) 1331

K. SRINIVASA RAO and V. RAJESWARI (with R.C. KING)
Solutions of Diophantine equations and degree one polynomial zeros of Racah coefficients
J. Phys. A (Math. Gen.) 21 (1988) 1959

K. SRINIVASA RAO and V. RAJESWARI
Polynomial zeros of the 9,-j coefficient,
J.Phys. A(Math. gen.) 21 (1988) 4255

E.C.G.SUDARSHAN (with G. MARMO, G. MORANDI and A. SIMONI)
Quasi-invariance and central extensions
Phys. Rev. D 37 (1988) 2196

E.C.G. SUDARSHAN (with Tom D. IMBO and T.R. GOVINDARAJAN)
Configuration space topology and quantum internal symmetries
Phys. Lett. B 213 (1988) 471

E.C.G. SUDARSHAN (with S.K. BOSE)
Spectrum of $J^P = 2^+$ mesons
Phys. Rev. Lett. 62 (1989) 1445

R. VASUDEVAN (with R. CHAKRABARTI)
Quantum Langevin equation for a harmonic oscillator with memory-dependent damping
J. Phys. A (Math. Gen.) 21 (1988)

IN PROCEEDINGS OF CONFERENCES/SYMPOSIA etc. and OTHER PUBLICATIONS

Radha BALAKRISHNAN and R. SRIDHAR (with S. CHATURVEDI and V. SRINIVASAN)
Strucural phase transition and high - T_c superconductivity
Progress in High Temperature Superconductivity, Vol. 16 (1988) 339
(Eds. A.K. Gupta, S.K. Joshi and C.N.R. Rao, World Scientific, Singapore)

Radha BALAKRISHNAN
Dependence of third sound velocity on ^{4}He film thickness: Theoretical interpretation
Proc. Solid State Physics Symposium (Department of Atomic Energy, India) (1988) 31

N.D. HARI DASS
Aspects of Unitarity in string theories
Proc. DST Workshop on Particle Physics : Superstring Theory,
Kanpur 1987, Eds. H.S. Mani and R. Ramachandran (World Scientific, Singapore, 1988)

N.D. HARI DASS
Observational cosmology
Proc. UGC Instructional Conference on "Gravitation, Quantum Fields and Superstrings"
Eds. P.M. Mathews, G. Rajasekaran, and M.S. Sriram
(World Scientific, Singapore, 1988)

M.V.N. MURTHY
Supernova 1987a and its implication to neutrino physics
Kodaikanal observatory bulletin (1988) (Ed. Kameswar Rao) (Based on an invited talk presented at the Topical Workshop on Supernova 1987a, Indian Institute of Astrophysics, Bangalore, Feb. 1988)

G. RAJASEKARAN
Introduction to string theories
In " Gravitation, Quantum Fields and Superstrings"
(World Scientific, Singapore, 1988) pp 333 - 393

G. RAJASEKARAN
Building up the standard gauge model of high energy physics
In "Gravitation, Gauge Theories and the Early Universe"
(Kluwer Academic Publishers, Dordrecht, 1989) pp 185 - 236

S.D. RINDANI
Coset space compactification in string theory
Proc. Workshop on Particle Physics : Superstring theory, Kanpur, 1987
(World Scientific, Singapore, 1988)

T.S. SANTHANAM
Kostant's partition functions in Kac-Moody algebras
Proc. Workshop on Particle Physics : Superstring theory, Kanpur, 1987
(World Scientific, Singapore, 1988) p. 457

H.S. SHARATCHANDRA
An overview of superstring theory
In "Gravitation, Gauge Theories and the Early Universe",
Eds. B.R. Iyer, N. Mukunda, and C. Vishveshwara (Kluwer) Academic Publishers, Dordrecht, 1989

K. SRINIVASA RAO
Multiplicative Diophantine equations and the quantum theory of angular momentum
Proc. Ramanujan Centennial International Conf., Annamalai Nagar, 1987,
Ramanujan Mathematical Society Publication #1, 141

To appear in
RESEARCH JOURNALS

Radha BALAKRISHNAN (with J. HOLYST and A.R. BISHOP)
Soliton dynamics in the uniaxially anisotropic quantum ferromagnetic chain, J. Physics C (Condensed Matter)

Radha BALAKRISHNAN (with A.R. BISHOP)
Nonlinear dynamics of a quantum ferromagnetic chain : Spin coherent State approach
Phys. Rev. B

S. GUPTA and M.V.N. MURTHY (with J. PASUPATHY)
The isoscalar axial vector renormalization constant and polarized proton structure function
Phys. Rev. D

D. CHOUDHURY, N.D. HARI DASS and M.V.N. MURTHY
Gravitational helicity flip for massive neutrions and SN 1987 a
J. Classical and Quantum Gravity

N.D. HARI DASS and R. SUMITRA
Symmetry reorganisation in exactly solvable two dimensional supergravity
Int. J. Mod. Phys.

A.S. JOSHIPURA and G. RAJASEKARAN (with V. GUPTA and K.V.L. SHARMA)
Interpretation of the recent Kolar events
Pramana

R. PARTHASARATHY
Gribov ambiguity in gauge theories
Pramana

G. RAJASEKARAN (with S.S. VASAN)
Stability of the S-matrix pole
Pramana

G. RAJASEKARAN (with N.G. DESHPANDE)
Mass shifts for the weak bosons in the integrally charged quark model
Mod. Phys. Lett. A

V. RAJESWARI and K. SRINIVASA RAO
Fours sets of ${}_3F_2(1)$s, Hahn polynomials and recurrence relations for the 3-j coefficients
J. Phys. A (Math. Gen.)

S.D. RINDANI
Quantum consistency of a gauge-invariant theory of a massive spin- 3/2 particle interesting with external fields
Mod. Phys. Lett. A

T.S. SANTHANAM (with R. CHAKRABARTI)
The Kostant partition functions in Kac-Moody algebras
J. Math. Phys.

T.S. SANTHANAM
The concept of maximum CP-nonconservation in arbitrary number of generations
J. Sci. Indust. Research (Delhi)

R. SIMON (with N. MUKUNDA)
Universal SU(2) gadget for polarization optics
Phys. Lett. A

R. SIMON and E.C.G. SUDARSHAN (with N. MUKUNDA)
The theory of screws : A new geometric representation for the group SU(1,1)
J. Math. Phys.

R. SIMON and E.C.G. SUDARSHAN (with N. MUKUNDA)
Hamilton's theory of turns and a new geometrical representation for polarization optics
Pramana

K. SRINIVASA RAO (with Charles B. CHIU)
Algorithms for the polynomial zeros of degree 2 of the 3-j and the 6-j coefficients
J. Phys. A (Math. Gen)

K. SRINIVASA RAO and V. RAJESWARI
A note on the triple sum series for the 9-j coefficient
J. Math. Phys.

K. SRINIVASA RAO and V. RAJESWARI
On the sets of generalised hypergeometric functions and the Regge, Bargmann - Shelepin arrays for the 3-j and the 6-j coefficients
Indian J. Pure and Appl. Math.

K. SRINIVASA RAO and V. RAJESWARI (with Charles B. CHIU)
A new Fotran program for the 9-j coefficient
Computer Phys. Communs.

To appear in
PROCEEDINGS OF CONFERENCES/SYMPOSIA etc, and OTHER PUBLICATIONS

Ramesh ANISHETTY
A fresh look at confinement in QCD
Proc. IX High Energy Physics Symposium, Madras 1988
(Eds. R. Parthasarathy and H.S. Sharatchandra)

Radha BALAKRISHNAN

The Chirikov-Taylor map
Proc. Workshop on Chaos, S.N. Bose Centre, Calcutta (1989)
(Eds. M.H. Engineer and C.K. Majumdar)

Radha BALAKRISHNAN
Spatial chaos in a classical Heisenberg chain
Proc. Workshop on chaos, S.N. Bose Centre, Calcutta (1989)
(Eds. M.H. Engineer and C.K. Majumdar)

Radha BALAKRISHNAN
On the nonlinear evolution for the order parameter in superfluid ^{4}He
Proc. NATO Advanced Study Institute on partially integrable nonlinear evolution equations and their physical applications, Les Houches, France (1989)
(Ed. Robert Conte, Kluwer publications)

Rahul BASU
Supersymmetry at nonzero temperatures
Proc. IX High Energy Physics Symposium, Madras 1988.
(Eds. R. Parthasarathy and H.S. Sharatchandra)

N.D. HARI DASS
SN 1987a and Neutrino Physics
Proc. DST Workshop on High Energy Physics Phenomenology
Bombay, 1989 (World Scientific, Singapore)

N.D. HARI DASS
Neutrino Physics relevant for supernovae
Proc. Workshop on sueprnovae and Stellar Evolution,
Goa, 1989 March

N.D. HARI DASS
Can exact symmetrics have their origins in inexact ones? to be published under the Theoretical Physics Seminar Circuit Programme

R. JAGANNATHAN
Dirac equation and electron optics
Proc. National Seminar on Sixty Years of the Dirac equation, Visva-Bharati, Santiniketan, (1989)

M.V.N.MURTHY
Spin structure of the proton to be published under the Theoretical Physics Seminar Circuit Programme

G.RAJASEKARAN
Is quantum mechanics for ever ?
In "Philosophical Foundations of Quantum Theory" (World Scientific, Singapore)

G.RAJASEKARAN
Electroweak radiative corrections and the masses of the weak bosons
In "High Energy Physics Phenomenology" (World Scientific, Singapore)

G.RAJASEKARAN
Symmetry and unification in physics
Proc. Symposium on Symmetry - A symmetry
(Max Muller Bhavan, Bombay)

G.RAJASEKARAN
Electroweak symmetry
In "Waves and Symmetry", Proc. Raman Centenary Symposium
(Raman Research Institute, Bangalore)

G.RAJASEKARAN
The discovery of the Dirac equation and its impact on present day Physics
Proc. of the National Seminar on Sixty Years of the Dirac Equation,
Calcutta (1989) (Wiley Eastern Pub.)

G RAJASEKARAN
Superstrings to be published by Wiley Eastern Ltd., under the SERC Schools Series

S.D. RINDANI
Search for the standard model light Higgs boson
Proc. DST Workshop on High Energy Physics Phenomenology
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T.S. SANTHANAM
p-adic quantum (mechanics)
Proc. Conf. on Philosophical Foundations of Quantum
Mechanics, NISTADS (Delhi) 1988 (World Scientific, Singapore)

R.SIMON
Geometric phases in optics
Proc.IX High Energy Physics Symposium, Madras, 1988
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R.SIMON
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Proc.Workshop on Quantum Optics, Goa
(Eds.G.S.Agarwal, S.V.Lavande and R.R.Puri,
World Scientific, Singapore, 1989)

R.SIMON
Optical phases and the Symplectic group
In "Waves and Symmetry", Proc. Raman Centenary
Symposium (Eds. S.Ramaseshan and G.Srinivasan,
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R.SIMON
Geometric representation for squeezing: The abcd-law
In "Coherence and Quantum Optics VI", (Eds.J.H. Eberly, L.Mandel and E.Wolf, Plenum, New York 1989)

R.SIMON
Geometric phases in optics: Some pedestrian considerations
In "Coherence and Quantum Optics VI", (Eds, J.H.Eberly,
L. Mandel and E.Wolf, Plenum, New York, 1989)

R.SIMON and E.C.G.SUDARSHAN (With N.MUKUNDA)
Lie methods in polarization optics
In "Lie Methods in Optics: second Workshop" (Ed.K.B.Wolf, Lecture Notes in Physics, Springer - Verlag, 1989)

R.SRIDHAR
BCS - like approach to high temperature superconductivity with emphasis on structural transformations
In "Recent Developments in High Temperature Superconductivity" (Ed.A.V.Narlikar, NOVA Science Pub., New York)

E.C.G.SUDARSHAN
Negative probabilities underlying the violation of Bell's inequalities
Proc.Conf. on Philosophical Foundations of Quantum Mechanics, NISTADS (Delhi), 1988
(World Scientific, Singapore)

R.VASUDEVAN (with D.L.SETH)
A set of differential equations for invariant imbedding in two spatial dimensions
Proc. Biannual Conf. on Transport Theory, Blacksburg,
Virginia Polytechnic Institute (U.S.A), 1989.

IN THE COURSE OF PUBLICATION

Ramesh ANISHETTY and R.VASUDEVAN
Analysis of neural dynamics and memory organization.

Ramesh ANISHETTY, Rahul BASU and R.PARTHASARATHY
Chromomagnetic Vacuam for non-abelian gauge theories

Ramesh ANISHETTY, Rahul BASU and R.PARTHASARATHY
Confinement of gluons in chromoelectric vacua

Radha BALAKRISHNAN (with A.R.BISHOP)
Nonlinear dynamics of a quantum ferromagnetic chain

Rahul BASU (with B. DATTA)
A chiral sigma model for nucleon matter and phase transition to quarks at high densities

B.CHAKRABORTY and R.PARTHASARATHY
Quantum effects in Kaluza-Klein theory

B.CHAKRABORTY and R.PARTHASARATHY
Dynamical compactification in Kaluza-Klein theory

M.V.N.MURTHY (with R.K.BHADURI and A.KHARE)
General results for the Witten index using Wigner - Kirkwood expansion

V.RADHAKRISHNAN (with D.K.CAMPBELL)
Nonadiabatic nonlinear equation for the Davydov model

T.S.SANTHANAM (with R.CHAKRABARTI)
Kostant's partition functions in twisted Kac-Moody algebras

R.SIMON (with N.MUKUNDA)
S0(n,1) Wigner rotation as an SL(2,R) problem

R.SIMON (with N.MUKUNDA)
Minimal three-component SU(2) gadget for polarization optics

R.SRIDHAR
Condensate fraction and phonon dispersion in liquid He II

K.SRINIVASA RAO, T.S. SANTHANAM and V.RAJESWARI
Multiplicative Diophantine equations

E.C.G. SUDARSAN (with Tom D.IMBO and Chandni S. IMBO)
Topological and algebraic aspects of quantization:
Symmetries and statistics

E.C.G.SUDARSAN (with Tom D. IMBO and Chandni S.IMBO)
Inequivalent quantizations and representation theory of discrete groups

E.C.G. SUDARSHAN (with Robert E.MARSHAK)
Conserved currents in weak interactions

E.C.G.SUDARSHAN
Conserved currents

E.C.G.SUDARSHAN (with I.DUCK and P.STEVENSON)
Can a measurement of a spin - 1/2 particle's spin component yield a value 100 ?

E.C.G.SUDARSHAN (with P.A.HORVATHY and G.MORANDI)
Inequivalent quantization in multiply - connected spaces

R.VASUDEVAN (with P.R.VITTAL)
Expected amount of overflow in a storage model in continuous time

PREPRINTS

Ramesh ANISHETTY, Rahul BASU and R.PARTHASARATHY
Chromomagnetic vacuum for non-Abelian gauge theories
IMSc. Preprint, 1988

Ramesh ANISHETTY, Rahul BASU and R.PARTHASARATHY
Confinement of gluons in chromoelectric vacua
IMSc. Preprint, 1989

Ramesh ANISHETTY and R.VASUDEVAN
Analysis of neural dynamics and memory organization
IMSc. Preprint, 1988

G.BASKARAN (with P.W.ANDERSON, S.JOHN, B.DOUCOT and S.LIANG)
Topological origin of fermions in 2-D spin - 1/2 quantum antiferromagnet
Princeton Preprint

Rahul BASU
Supersymmetry at nonzero temperature
IMSc. Preprint, 1988

S.D.RINDANI
Search for the standard model light Higgs boson
IMSc. Preprint, 1989

S.D.RINDANI
Quantum consistency of a gauge - invariant theory of a massive spin - 3/2 particle interacting with external fields
Preprint No.IC/89/35, ICTP, Trieste, Italy.

R.VASUDEVAN (with S.K.SRINIVASAN)
Multiplicity distribution and natural scaling
IMSc. Preprint, 1988

R.VASUDEVAN (with S.K.SRINIVASAN)
A model of jet fragmentation and hadronization
IIT Preprint, 1989

R.VASUDEVAN (with S.K.SRINIVASAN)
Multiple production and negative binomial distribution
IIT Preprint, 1989

SCIENTIFIC ARTICLES IN POPULAR MAGAZINES, AND OTHER SUCH PUBLICATIONS (PUBLISHED/IN THE COURSE OF PUBLICATION)

G.RAJASEKARAN
The future of high energy physics to appear in Physics News

K.SRINIVASA RAO
Review of three books on Sir C.V.RAMAN to appear in "Commemoration Volume on the occasion of the Raman Centenary",
Patriotic and People - oriented Science and Technology
(PPST) Foundation publication (Madras)

E.C.G.SUDARSHAN
Sweetness and light - Perspective on wisdom and knowledge
The Theosophist (1988) 307 (Lecture at the Annual Convention of the Theosophical Society, Madras 1988)

E.C.G.SUDARSHAN
The altered relation of man to the Universe
(Benjamin Bailey Alemorial Lecture, 1985) Pub.
George Sudarshan Centre, Kottayam, India, 1988

E.C.G.SUDARSHAN
Indian Metaphysics
(Talk at Cesna, Italy, May 1988)

PUBLICATIONS EDITED

G.RAJASEKARAN (With P.M.MATHEWS and M.S.SRIRAM)
Gravitation, Quantum Fields and Superstrings
(World Scientific, Singapore, 1988)

MATHEMATICS

S.D.ADHIKARI and R.BALASUBRAMANIAN
On an error term related to the greatest divisor of n which is prime to k
Indian J.Pure and Appl. Math. 19 (1988) 830

Krishnaswami ALLADI
Multiplicative functions and Brun's sieve
Acta Arithmetica 51 (1988) 201

Krishnaswami ALLADI (With P.ERDOS and J.D.VALLER)
Multiplicative functions and small divisors - II
J. Number Theory 31 (1989) 183

Krishnaswami ALLADI
Probabilistic number theory and Brun's sieve
Seminare de Theorie des Nombres, Paris (1986 - 87)
Progress in Mathematics (Birkhauser) 75 (1988) 1

R.BALASUBRAMANIAN (With K.RAMACHANDRA)
On the number of integers n such that $nd(n) \leq x$
Acta Arithmetica 49 (1988) 313

R. BALASUBRAMANIAN (with K. RAMACHANDRA)
On an analytic continuation of ζ (s)
Indian J. Pure and Appl. Math. (1987) 790

R.BALASAUBRAMANIAN (with K.RAMACHANDRA and M.V.SUBBARAO)
On the error function in the asymptotic formula for the counting function of k-full integers
Acta Arithmetica 50 (1988) 107

R.BALASUBRAMANIAN
On the frequency of Titchmarsh's phenomenon for ζ(s) - IV
Hardy-Ramanujan Journal Vol.9 (dated 1986) 1

R.BALASUBRAMANIAN (with K.RAMACHANDRA)
On the frequency of Titchmarsh's phenomenon for
ζ(s) - V
Arkiv fur Matematik 26 (1988) 13

M.KRISHNA (with S.KOTANI)
Almost periodicity of some random potentials
J.Functional Analysis 78 (1988) No.2

P.SANKARAN
Which Grassmamians bound?
Archiv der Math.50 (1989) 474

IN THE COURSE OF PUBLICATION

Krishnaswami ALLADI
The distribution of additive functions in special sets of integers
to appear in Proc. Number Theory Symposium,
Ramanujan Centennial Conference, Anna University, Madras 1987
Lecture Notes in Mathematics, Springer-Verlag, 1989 (Ed.K.Alladi)

R.BALASUBRAMANIAN (with T.N.SHOREY and M.WALDSCHMIDT)
On the maximal length of two sequences of consecutive integers with the same prime divisors to appear in Acta Math. Hungarica

S.D.ADHIKARI and R.BALASUBRAMANIAN
On an error term related to $r_4(n)$

R.BALASUBRAMANIAN (with K.RAMACHANDRA)
On squarefull integers

R.BALASUBRAMANIAN (with K.RAMACHANDRA)
Sharpening of a theorem of Tom Meurman

R.BALASUBRAMANIAN (with V.KUMAR MURTY)
Dirichlet's function at s = 1/2

R.BALASUBRAMANIAN (with A.SANKARANARAYNAN and D.SURYANARAYANA)
On the additive completion of squares - II

R.BALASUBRAMANIAN (with K.RAMACHANDRA and A.SANKARANARAYANAN)
On the frequency of Titchmarsh's phenomenon for
$\zeta(s)$ - VII

P.SANKARAN
Determination of Grassmann manifolds which are boundaries

P.SANKARAN
Nonexistence of almost complex structures on
Grassmann manifolds

P.SANKARAN (with K.VARADARAJAN)
Acyclicity of certain homeomorphism groups

THEORETICAL COMPUTER SCIENCE

K.LODAYA, R.RAMANUJAM and P.S.THIAGARAJAN
A logic for distributed transition systems
In "Linear Time, Branching Time and Partial Order in Logics and Models of Concurrency", Proceedings of the School/Workshop, Noordwijkerhout, the Netherlands, Lecture Notes in Computer Science,
(Springer-Verlag) 354 (1989) 508

P.S.THIAGARAJAN
Some behavioural aspects of net theory
In Proc. 15th International Colloquium on "Automata,
Languages and Programming", Tampere, Finland
Lecture Notes in Computer Science (Springer-Verlag) 317 (1988) 630

K.LODAYA (with R.K.SHYAMASUNDAR)
Proof theory for exception handling in Ada to appear in Acta Informatica

R.RAMANUJAM
Semantics of distributed definite clause programs to appear in Theoretical Computer Science

P.S.THIAGARAJAN
Some behavioural aspects of net theory to appear in a Special Issue of Theoretical Computer Science

P.S.THIAGARAJAN (with B.ROZOY)
An event structure representation of trace monoids
to appear in Theoretical Computer Science

Madhavan MUKUND and P.S.THIAGARAJAN
A Petri net model of asynchronously communicating sequential processes
to appear in "A Perspective in Theoretical Computer Science", A Commemoration volume to Gift Siromoney, Ed.R.Narashimhan, (World Scientific, Singapore, 1989)

P.S.THIAGARAJAN (with M.NIELSEN and G.ROZENBERG)
Behavioural notions for elementary net systems
(submitted for publication)

Preprint

Madhavan MUKUND and P.S.THIAGARAJAN
A Petri net model of asynchronously communicating sequential processes
MSc Preprint, 1989

PARTICIPATION IN CONFERENCES AND OTHER PROFESSIONAL ACTIVITIES OF THE ACADEMIC STAFF

Prof. E.C.G.SUDARSHAN

- inaugurated the IX High Energy Physics Symposium held at the Indian Institute of Technology, Madras, during 5-9, December'89, and organized jointly by the Institute of Mathematical Sciences and the I.I.T. under the auspices of the Department of Atomic Energy, Government of India.
- gave an invited talk on 'Coherence'in the Raman Centenary symposium on waves and Symmetry, Raman Research Institute, Bangalore (December '88).
- besides visiting many Institutions and Participating in Conferences in India and abroad and lecturing on various topics.

Prof. G.RAJASEKARAN

- gave the Prof.J.N.Mitra Memorial Lecture on "The Physics of the Subatomic World" at Delhi under the auspices of the Association of the Mathematics Teachers on 13, April '88.
- gave an invited talk on "Neutrinos from Supernovae" at a Workshop organized by the Periyar Centre for Science and Technology of the Government of Tamil Nadu, at the Birla Planetarium, Madras, on 4, July '88.
- gave an invited talk on "Symmetry and Unification in Physics" at the symposium on Symmetry - Asymmetry organised by the Max Muller Bhavan, Bombay, during 3-8, October '88.
- participated in the symposium on Physics Research and Education organised by the Indian Physics Assocation at Calcutta on 25, November '88 and gave an invited talk on "Problems of Physics Research in India".
- participated in the Annual Meeting of the Indian Academy of Sciences and the Raman Centenary Celebration at the Indian Association for the Cultivation of Sciences, Calcutta, during 31, October - 2, November '88.
- visited the Saha Institute of Nuclear Physics, Calcutta, and gave a seminar on "Stability of S - Matrix poles" on 9, December '88.
- participated in the Raman Centenary Symposium on Waves and Symmetry at Raman Research Institute, Bangalore, during 12-17, December '88 and gave an invited talk on "Electroweak Symmetry".
- participated in the DST Workshop on High Energy Physics Phenomenology, Bombay, during 2 -15, January '89 and gave an invited talk on "Electroweak Radiative Corrections and the Masses of the Weak Bosons".
- gave an invited talk on "The Discovery of the Dirac Equation and its Impact on Present Day Physics" at the National Seminar on Sixty Years of the Dirac Equation held at Santiniketan during 28-30, January '89.

- participated in the DST National Seminar on Thrust Areas in Physical Sciences held at Viswa Bharati University, Santiniketan, during 23-25, February '89
- participated in the Brain Storming Session on Indian Science and Technology Journals, held at I.I.T., Madras, by the PPST Foundation during 17-18, March '89 and presented an invited paper on Indian Physics Journals.
- was at the Tata Institute of Fundamental Research, Bombay, during 21, September '88 - 31, March '89 as Visiting Professor on an academic assignment.
- is the Chairman of the Organizing Committee of the Series of SERC Schools on Theoretical High Energy Physics conducted by the Department of Science and Technology (Government of India), every year, including the IV School held at Jaipur in October '88.
- was a member of the Organizing Committee of the Workshop on High Energy Physics Phenomenology (cosponsored by the Institute of Mathematical Sciences) held at Bombay in January '89.
- was a member of the Organizing Committee of the National Seminar on Sixty Years of the Dirac Equation held at Santiniketan in January '89.
- gave a Colloquium on the "Future of High Energy Physics" at TIFR, Bombay, on 8, February '89 and also a number of Seminars.

Prof.R.VASUDEVAN

- is serving as a member of the Board of studies of the Elite School of Optometry, a unit of the Medical Research Foundation, Madras.

Prof. N.D.HARI DASS

- was invited attendee at the Workshop on Anomalies held at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore (September'88).
- was invited speaker at the Tata Institute of Fundamental Research, Bombay, under the Theoretical Physics Seminar Circuit (TPSC) Programme and delivered a seminar on "Can exact symmetrics have their origins in inexact ones" (October '88).
- delivered a seminar under the TPSC programme at the Bhabha Atomic Research Centre, Bombay, on "Testing Parity and Time reversal violation in gravitation using cold neutrons" (October '88).
- delivered a Colloquium under the TPSC programme at the Department of Physics, University of Bombay, on "Supernovae" (October '88).
- gave an invited seminar at Jawaharlal Nehru University, New Delhi, on "Two dimensional quantum gravity and the critical behaviour of two dimensional statistical mechanical systems" (October '88).
- participated, as Guest Scientist, in the IV SERC School on Theoretical High Energy Physics held at Jaipur (October '88).
- delivered a seminar on "Testing θ-parameter of QCD" at the Annual Meeting of the TPSC conveners, held at TIFR, Bombay (November '88).
- delivered the invited talk on "SN 1987 a and neutrino physics" in the DST Workshop on High Energy Physics Phenomenology held at Bombay (January '89).

- gave an invited talk on "Neutrino physics relevant for supernovae" in the Workshop on Supernovae and Stellar Evolution held at Goa (March '89).

Prof. T.S. SANTHANAM

- was visiting Fellow at the Australian National University, Canberra, Australia for eight weeks during June - August '88.
- gave lecturers at the University of Queensland, Brisbane, and the University of Adelaide, Australia.
- was Visiting Professor at the Southern Illinois University, Carbondale, Illinois, USA during August - December '88.
- was consultant at the University of Texas at Austin, USA during Febraury '89.
- gave lectures at the Lawrence Radiation Laboratory, Berkeley, California and Parks College of the St. Louis University, Illinois, USA.
- gave lectures at the Imperial College of Science and Technology, London, and at the Technical University, Clausthal-zellerfeld, West Germany.
- was visiting Scientist at the International Center for Theoretical Physics, Trieste, Italy during March-April '89.
- delivered lectures at the Universities of Bari and Naples, Italy.

Prof. K.R. UNNI

- gave an invited talk on "Problems in Approximation Theory" at the Varahamihir Memorial National Seminar on Theory of Approximation and its Applications, VIKRAM UNIVERSITY, UJJAIN (10-14, February '89).

Dr. Krishnaswami ALLADI

- is currently a Professor in the Department of Mathematics, University of Florida, Gainsville, USA on leave of absence from the Institute.
- gave an half-hour talk entitled "On the distribution of the number of restricted prime factors in special sets" at the International Conference on Analytiche Zahlen-theorie, held in Mathematicches Forschungsinstitut, Oberwolfach, West Germany (September '88).
- gave an one-hour address on "The mathematical genius of Srinivasa Ramanujan" at the Suncoast Regional Meeting of the Mathematical Association of America in St. Petersburg, Florida (3 December '88).
- and gave the following one-hour Colloquium/Seminar talks: "Multiplicative generalization of Brun's sieve", Monthly Meeting of the Tamil Nadu Academy of Sciences, Madras (1, August '88). "Integers without large prime factors" (Two lectures) National University of Singapore, Singapore (10th and 11th, August '88).

"The Rogers - Ramanujan Identities and the Lost Notebook", History of Science Seminar, University of Florida (9, September '88).

Dr. R. BALASUBRAMANIAN

- delivered a series of invited talk for the "P. Kesava Menon Memorial Lectures" at the Calicut University.
- gave a popular talk on 'Number Theory' at the invitation of the Madras Chapter of the Indian National Science Academy (INSA).

Dr. G. BASKARAN

- gave an invited talk at the Einstein Centenary Celebration at Indore University (April '88).
- gave invited talks (five) at the Workshop on "Strongly correlated 2-d electron system" held at Beijing, China, under the auspices of the Academia Sinica, for two weeks in May - June '88.
- gave an invited talk on "Strongly correlated electronic systems" at the Nobel symposium in Sweden (June '88).
- gave an invited talk at the International Conference on Magnetism held in Paris (July '88).
- gave an invited talk at the International Conference on Strongly correlated systems held at the International Centre for Theoretical Physics (ICTP), Trieste, Italy ('88).
- gave an invited talk at the RVB Meeting at IBM Research Lab., YT Heights, New York, USA (September '88).
- gave an invited talk at the Workshop on high-T_c superconductivity held during the DAE symposium on solid state physics at Bhopal (December '88).
- gave invited lectures (seven) at the Workshop on "Strongly correlated systems" held in Puri (January '89).
- besides giving seminars at I.I.Sc. (Bangalore), PRL (Ahmedabad), I.I.T (Madras), Madras University, and Princeton University (Princeton, New Jersy, USA).

Dr. K.H. MARIWALLA

- was an invited participant in the Workshop on Geometrical Aspects of Relativity held at the Tata Institute of Fundamental Research, Bombay (20 - 22, January '89).
- was invited as a UGC (University Grants Commission) "Visiting Fellow" to Shivaji University, Kolhapur, Maharashtra, to deliver a lecture series on "Foundational Basis of Mechanics of Particles and Fields" (28, February - 14, March, '89).

Dr. R. PARTHASARATHY

- participated in the IX High Energy Physics Symposium held in Madras during 5-9, December '89 and was the Convenor of this Symposium.

Dr. R. SRIDHAR

- participated by invitation in the International Workshop on High Temperature Superconductivity organised by the Department of Science and Technology at Srinagar during 2-4 May '88.
- gave a series of lectures on "High Temperature Superconductivity" at the Physics Department, Cochin University of Science and Technology, Cochin, during 27-31, March '89.

Dr. K. SRINIVASA RAO

- was visiting Scientist at the Centre for Particle Theory of the University of Texas at Austin, USA for four months (April - July, '89).
- visited Los Alamos, New Mexico, and San Diego State University, San Diego.
- visited the State University of New York, Buffalo, and gave a seminar on his computer programs for angular momentum coefficients.
- was Visiting Scientist at the Center for Theoretical Studies, Indian Institute of Science, Bangalore (March '89), and participated in the Tutorial School on Quantum Chromodynamics conducted by the C.T.S.
- gave a lecture on "Topics in Quantum Theory of Angular Momentum" at the Department of Nuclear Physics, University of Madras under the auspices of the Tamil Nadu Academy of Sciences (November '88).
- visited the Bhabha Atomic Research Centre, Trombay, the Department of Physics, Indian Institute of Technology, Powai, Bombay, and the Tata Institute of Fundamental Research, Bombay, in December '88, and gave a seminar each at the Institutions on different aspects of his on-going research work on the quantum theory of angular momentum.

Dr. P. S. THIAGARAJAN

- Participated in the School/Workshop on "Linear Time, Branching Time and Partial Order in Logics and Models for Concurrency" held at Noordwijkerhout, the Netherlands, from 30, May to 3, June '88 and gave a talk on "A Logic for Distributed Transition Systems"; also, was a member of the Programme Committee of this School /Workshop.
- attended the Tutorial Part of the 9th European Workshop on "Applications and Theory of Petri Nets" held in Venice, Italy, from 19 to 23, June '88 and gave a tutorial talk on "Elementary Net Systems" for participants from Industry.
- participated and gave an invited talk entitled "Some Behavioural Aspects of Net Theory" in the 15th International Colloquium on "Automata, Languages and Programming" held at Tampere, Finland, from 11 to 15, July '88.
- served on the Programme Committee, attended and chaired a Session, at the 8th Conference on "Foundations of Software Technology and Theoretical Computer Science" held in Pune, from 21 to 23, December '88.
- visited the Gessellschaft fur Mathematik und Datenver arbeitung, St. Augustin, West Germany, for a week in March '89; gave a talk entitled "A Logical characterization of Prime Event Structures".

- Visited the Computer Science Department of Aarhus University, Denmark, for a week in March '89; gave a talk entitled "A Logical characterization of Prime Event structures".
- visited the Computer Science Department of the Leiden University for six weeks in March-April '89; gave a series of six lectures on the theory of event structures.
- has been made an editor of a new journal on Theoretical Computer Science, called "International Journal on Foundations of Computer Science", to be published by World Scientific Publishing Co., Singapore.

Dr. R. JAGANNATHAN

- participated in the National Seminar on "Sixty Years of the Dirac Equation" held at Visva-Bharati, Santiniketan, during 28-30 January '89 as a delegate of the Institute and gave an invited talk entitled "Dirac equation and electron optics".

Dr. S.D. RINDANI

- visited the International Center for Theoretical Physics, Trieste, Italy (June-September '88); also participated in the summer school on High Energy Physics and Cosmology, and the Conference on Phenomenology, both held at the ICTP (June-August '88).
- participated in the Workshop on High Energy Physics Phenomenology held at the Tata Institute of Fundamental Research, Bombay (3-15 January '89) and gave an invited talk on "Search for the standard model light Higgs boson".

Dr. Ramesh ANISHETTY

- participated in the IX High Enery Physics Symposium held at Madras in December '88 and gave an invited talk entitled "A fresh look at confinement in QCD".
- participated in formulating the UGC Summer School on Gravitation and Particle Physics at the Tata Institute of Fundamental Research, Bombay, upon invitation.

Dr. Radha BALAKRISHNAN

- visited School of Physical Sciences, Jawaharlal Nehru University, New Delhi, and gave two lectures on "Solitons" (17-28, May '88).
- was an invited speaker at the Workshop on "Chaos" held at the S.N. Bose Centre, Calcutta (7-17, February '89) and gave two lectures titled "The Chirikov-Taylor map" and "Spatial Chaos in a Classical Heisenberg Chain".
- presented a poster paper titled "On the nonlinear evolution equation for the order parameter in superfluid ^{4}He" at the NATO Advanced Study Institute on "Partially integrable nonlinear evolution equations and their physical applications", held at Les Houches, France (21-30, March '89).

Dr. Hemant BHATE

- gave two invited talks in the Department of Mathematics, Pondicherry University, during the Seminar on Integrable Dynamical Systems (7th and 8th, December '88).

Dr. G. DATE

- participated in the Workshop on "Anamolies" at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore (6-9, September '88); gave an informal talk on problems involving quantizations of general classical systems and briefly discussed various approaches followed in this area.

Dr. KRISHNA, Maddaly

- attended the "Summer School in Probability and Analysis" conducted during 9, May - 4, June '88 by the Indian Statistical Institute, Bangalore Centre, and taught part of the course on "Spectral theory and Schrodinger operators"; also lectured on "Random Schrodinger operators" for the mathematicians at the ISI, Bangalore Centre, during this period.

Dr. Kamal LODAYA

- gave a lecture on "Developing correct programs" in the Computer Science Seminar at Anna University, Madras (3, March '89).

Dr. M.V.N. MURTHY

- visited Tata Institute of Fundamental Research and Bhabha Atomic Research Centre, Bombay, and Physical Research Laboratory, Ahmedabad, under the Theoretical Physics Seminar Circuit Programme and gave talks on "Spin structure of the Proton" (September '88).
- participated in the Workshop and School on supernovae and Stellar Evolution held at Goa, during 10-17, March '89 (sponsored by TIFR, DST, IUCAA, IIA, INSA and NSF (USA);) was also a member of the Organizing Committee.
- participated in the National Seminar to Review and Update Thrust Areas in Physical Sciences held at Santiniketan, during 23-25, February '89, sponsored by the Department of Science and Technology.
- visited the Centre for Theoretical Studies, Indian Institute of Science, Bangalore (June-July '88).

Dr. R. RAMANUJAM

- gave a talk on "Logic Programming" in the Computer Science Seminar organized by the School of Computer Science and Engineering, Anna University (3, February '89).
- gave a course of eight lectures on "Logics of knowledge and Distributed Computing" at the Department of Mathematics, Madras Christian College, Tambaram (February '89).

Dr. H.S. SHARATCHANDRA

- gave an invited talk on "Anomalies in Lattice Gauge Theories" in the Workshop on Anomalies held at the Indian Institute of Science, Bangalore, during 7-9, September '88.
- served as Secretary and participated in the IX High Energy Physics symposium held at Madras during 5-9, December '88.
- gave a talk on 1988 Nobel Prize in Physics at the Indian National Science Academy (Madras Chapter) on 28, January '89.

Dr. R. SIMON

- participated in the Second Workshop on Lie Methods in Optics held in Cocoyoc, Mexico (July '88); was leader of the Session on Maxwell - Lie Optics, and gave an invited talk on "Lie Methods in Polarization Optics".
- was a Distinguished Visitor at IIMAS-UNAM, Mexico, and gave a Colloquium on "Topological Phases in Optics" (July - August '88).
- visited American College, Madurai and gave a talk on "Some recent experiments in polarization Optics" (September '88).
- visited Physics Department, Indian Institute of Science, Bangalore and gave a Colloquium on "Geometric phases in polarization Optics" under the Institute Theoretical Physics Programme (October '88).
- gave an invited talk in the Silver Jubilee Symposium on "Current Trends in Pure and Applied Physics" organized by the Physics Department, Cochin University of Science and Technology Cochin (October '88).
- gave a course of lecturers on "Canonical transformations in classical mechanics" in the UGC Refresher Course on Mathematical Physics and Classical Mechanics at the Academic Staff College, Bharathidasan University, Tiruchirapalli (November - December '88).
- gave a seminar on "A polarization effect for detuning lasers" at the Physics Department, Bharathidasan University, Tiruchirapalli (December '88).
- gave an invited talk on "Geometric phases in optics" in the IX High Energy Physics Symposium, Madras (December '88).
- gave an invited talk on "Optical phases and the symplectic group" in the Raman Centenary Symposium on Waves and Symmetry, Raman Research Institute, Bangalore (December '88).
- visited School of Physics, Central University of Hyderabad and gave a Colloquium (January '89).
- gave two lectures on "Quantum principles" in Women's Christian College, Madras (January, March '89).
- gave a course of lectures on "Time-dependent quantum problems" in the UGC Refresher Course on Quantum Mechanics, Relativity and Astrophysics at the Academic Staff College, Bharathidasan University, Tiruchirapalli (February - March '89).
- gave an invited talk in the Workshop on Quantum Optics held at Goa during March '89.

Dr. Rahul BASU

- participated in the IX High Energy Physics Symposium held at Madras during 5-9, December 1988, and gave an invited talk on "Supersymmetry at nonzero temperatures"; was also a member of the Scientific Programme Committee of the Symposium.
- participated in the "Tutorial School on QCD and Nuclear Physics" held at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore (8-21, March '89).

Dr. Parameswaran SANKARAN

- gave an invited Seminar talk at the Indian Institute of Technology, Madras, on "Cobordism of Grassmannians" (3, November '88).

Mr. Anand J. ANTONY

- attended a three-week Instructional Conference on "Ergodic Theory and Dynamical Systems" conducted by the National Board for Higher Mathematics at Bombay from 29 May to 20 June '88.
- visited the School of Mathematics, Tata Institute of Fundamental Research, Bombay (15, September - 30, December '88).

Mr. Madhavan MUKUND

- attended the Eighth Annual Conference on Foundations of Software Technology and Theoretical Computer Science, held at Pune, during 21-23, December '88.

Mr. V. RAVINDRAN

- attended the SERC School on theoretical high energy physics held at Jaipur during October '88.
- attended the School on QCD and Nuclear Physics held at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore, during March '89.

Mr. A.S. VYTHEESWARAN

- participated in the School on QCD and Nuclear Physics held at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore, during March '89.

OTHER NEWS

Awards and Honours

Prof. E.C.G. SUDARSHAN was honoured as a Distinguished Scientist by the Andhra Pradesh Academy of Sciences on the occasion of its Silver Jubilee Celebrations (December '88).

Dr. G. BASKARAN has been elected a Fellow of the Indian Academy of Sciences.

Dr. K. SRINIVASA RAO has been elected a Fellow of the Tamil Nadu Academy of Sciences.

Ph. D. Course Work

Physics

Ms. V. RAJESWARI submitted her Ph.D. Thesis entitled "Topics in Quantum Theory of Angular Momentum" to the University of Madras, in February, '89; The researh work leading to the Thesis was done under the guidance of Dr. K. SRINIVASA RAO.

Mathematics

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

Prof. C.S. SESHADRI	-	Construction of the Jacobians
Dr. R. BALASUBRAMANIAN	-	Topics in Number Theory
Dr. H. BHATE	-	The Sturm-Liouville Problem: An In troduction to Infinite Dimensional Geometry
Dr. P. SANKARAN	-	Singular Cohomology Theory

There was a Reading Course on Mathematical Analysis conducted by Dr. M. KRISHNA for the first year students.

Besides, there was a weekly "Mathematics Colloquium": the list of Mathematics Colloquium Lectures is given in the Appendix.

Theoretical Computer Science

Ph. D. Level Lecture Courses:

Dr. P.S. THIAGARAJAN	-	Introduction to the Theory of Petri Nets
Dr. R. RAMANUJAM	-	i) Domain Theory
		ii) Cartesian - closed categories and the λ - calculus

Conferences conducted/co-sponsored

High Energy Physics Symposium is an important national event held once in two years under the auspices of the Department of Atomic Energy, Government of India. The IX HEP Symposium was held in Madras during 5-9 December '89, jointly organized by the Institute of Mathematical Sciences and the Indian Institute of Technology, Madras. The Symposium was inaugurated by Prof. E.C.G. Sudarshan, and Prof. L.S. Srinath, Director, I.I.T. (Madras), chaired the inaugural function. About 200 delegates from various parts of the country participated. There were 25 invited lectures delivered by leading experts in Theoretical and Experimental High Energy Physics and 126 contributed papers presented by active workers in the field of High Energy Physics. Besides these lectures and discussions on current areas of research in High Energy Physics there was a panel discussion on "The Interaction between Universities and Research Institutions in High Energy Physics" by experts in this field. There was also an evening lecture on "Fifty Years of Cascade Theory", highlighting Prof. H.J. Bhabha's fundamental contributions to cascade theory, by Prof. Alladi Ramakrishnan, the Founder-Director of the Institute of Mathematical Sciences.

The Institute was also a cosponsor for the DST workshop on High Energy Physics Phenomenology held at Bombay during 2-15, January '89.

New Computer Facility

The new computer systems (Nelco Force 20 (D) mini-computer) installed at the Institute was inaugurated on 16th September '88 by Dr. H.B.N. Shetty, I.A.S., Special Commissioner and Secretary to the Government, Education Department, Government of Tamil Nadu, and Member, Board of Governors of the Institute. On this occasion, Sri C. Subramaniam, Patron of the Institute, presided over the inaugural function and unveiled the protrait of Prof. R.E. Marshak, the first Niels Bohr Visiting Professor to the Institute; Prof. Alladi Ramakrishnan (Founder-Director of the Institute), Prof. H.N. Mahabala (I.I.T., Madras), and Prof. N. Mukunda (Centre for Theoretical Studies, Indian Institute of Science, Bangalore), offered their felicitations.

The Nelco Force 20 (D) system was enhanced with a Dual processor in February, '89. The mini-Computer system is based on two Motorala 68020 microprocessors at 16.67 MHz each with its own 68881 Math. Co-processor. With the Dual processor, the system does 3.7 million instructions per second. It has 4 MB memory, an 86 MB Winchester drive and besides its console has 2 PC/XT Computers and one PC/AT Computer connected to it. The PC's can work independently or as dumb terminals (under UNIX operating system) of the Force 20 (D). A Godrej printer and a plotter are part of this system, in its present minimal configuration.

New Buildings

Foundation Stones were laid for Library Complex and Hostel Complex by Dr. K.R. Narayanan, Minister of State for Science and Technology, Government of India, on 13th January '89. Dr. A. Padmanabhan, I.A.S., Adviser to Governor of Tamil Nadu, and Chairman, Board of Governors of the Institute, presided over the function; Sri C. Subramaniam (Patron of the Institute), Prof. Alladi Ramakrishnan (Founder-Director of the Institute), and Dr. H.B.N. Shetty, I.A.S., (Special Commissioner and Secretary to the Government, Education Department, Government of Tamil Nadu, and Member, Board of Governors of the Institute) offered their felicitations on the occasion.

Research Projects Funded by DST

The following Research Projects at the Institute are being funded by the Department of Science and Technology (DST) :

"Computer Investigations of Lattice Gauge Theories and Guided Random Walks" (Principal investigator : Prof. N.D.HARI DASS ; co-investigator : Dr. M.V.N.MURTHY)

"Theoretical Studies in High Temperature Superconductivity" (Principal investigator : Dr.G.BASKARAN ; Co-investigator : Prof.N.D.HARI DASS)

Library

The Institute Library started with about 1500 Books and Journal Volumes in 1962 and today the total number of volumes in the Library is about 25,000. During 1988-89, 1337 books and bound volumes of periodicals were added to the collection. Most of the books and journals relate to Theoretical Physics, Pure and Applied Mathematics, and Theoretical Computer Science. A good portion of the budgeted expenditure of the Institute is spent towards equipping the Library. We are now getting about 215 journals by subscription most of which are internationally reputed journals.

Besides the subscribed journals, we are receiving several periodicals, Lecture Notes, and Preprints from about sixty research Institutions throughout the world in exchange for the Institute publications. These are well used by the members of the Academic staff and the students of the Institute. Also, we and the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, are exchanging the contents pages of journals not received by the respective libraries. The Inter-Library-Loan facility is available to the members of the Institute to borrow books from the neighbouring institutions as well as from other research centres like the Tata Institute of Fundamental Research (Bombay),IGCAR (Kalpakkam), etc.

A large number of research students and scientists working in and around Madras city make use of our Library. A register is maintained to evaluate the use of the Library by the users from other institutions.

The following table focuses the contents of the Library:

1.Total number of volumes as on 31.3.89 (Books and bound periodicals)	= 24947
2.Journals being subscribed currently	= 215
3.Number of journals, Lecture Notes etc., being received on exchange basis	= 55
4. Average number of Preprints received during a month from institutions in India and abroad	= 300
5. Number of Matscience Reports published upto March '89	= 112

During the current year the Institute Library received many valuable and useful Books/ Journal volumes as gratis from the following, and we would like to thank them:

Prof.G.Rajasekaran, Prof.N.R.Ranganathan, Dr.R.Ramanujam, and Mr.Madhavan Mukund(Matscience); Dr.T.R.Govindarajan(Loyola College, Madras); Dr.R.Ramamurthy(McGill University, Canada); Prof.G.E.Andrews(Pennsylvania State University, USA); Prof.A.Bohm (University of Texas at Austin, USA); Research Centre for Advanced Mathematics, Nagoya University, Japan.

VISITORS

D.HOME, Bose Institute, Calcutta (6-12, April 1988)
(Search for new tests of EPR Paradox from elementary particle physics)*

P.BHATTACHARJEE, Tata Institute of Fundamental Research, Bombay (12-14, April 1988)
(Cosmic Strings I and II)

BIKASH SINHA, VECC, Calcutta (14, April 1988)
(Overview of the latest development in the field of QGP)

S.N.BISWAS, (27-29, April 1988)
(Berry's phase)

JOSEPH, University of Paris, France (5, April 1988)

A.KUNDU, Saha Institute of Physics, Calcutta (12, April 1988)

R.VIJAYARAGHAVAN, Tata Institute of Fundamental Research, Bombay
(19, May 1988)
(On High Temperature Superconductivity)

P.MITRA, North Bengal University (23-25, May 1988)
(Anomalour Commutators in chiral Range theories)

V.LAKSHMIBAI, Mathematics Department, Northeastern University,
Boston, USA (6-18, June 1988, 10-July to 6, August 1988)

J.PASUPATHY, Indian Institute of Science, Bangalore (7,June 1988)
(23-29, Sept.1988)
(Chiral symmetry breaking in QCD)

BOSCO EMMANUEL, Regional Research, Trivandram (20-25, June 1988)

A.P.BALACHANDRAN, Syracuse University, USA (13-17, June 1988)

M.NERURKAR, Mathematics Department, Rutgers University, USA
(5, July 1988)
(Enveloping Semigroups in dynamical systems)

V.S.SUNDER, I.S.I. Bangalore Centre (14, July 1988)
(Braids, Knot invariants and II factors)

P.N.PANDITA, N.E.H.U., Shillong (12-July to 2-August 1988)
(Low Energy supersymmetry)

LEOPALD HALPERN, Florida State University, Tallahasse, USA
(9-July, 1988)

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

B.R.SRINIVASAN, Bharathidasan University, Tiruchi (23-26, July 1988)

M.WALDSCHMIDT, Institute Henri Poincare, Paris,France (25, Aug.1988)
(Transcedence Theory)

ASHOK DAS, Univ. of Rochester, N.Y. (3-11, August 1988)
(The Integrability condition for dynamical systems)

DEBASHISH GANGOPADHYAY, Inst. of Physics, Bhubaneshwar (9-Aug. 1988)

D.L.SETH, Los Alamos National Lab., USA (9-20, August 1988)

K.S.NAGARAJAN, Mathematics Department, Madurai Kamaraj University, Madurai (8 Sept.1988)
(Subalgebras of affine algebras)

S.SRINIVAS RAU, Univ. of Hyderabad, Hyderabad, A.P. (29-Sept. 1988)
(Determinats of Laplacians and zeta functions)

A.Beauville, France (23-27, Sept.1988)
(Schottky problem, Vector bundles on curves and θ divisors)

A.SUSLIN, (23-27,Sept. 1988)
(K-theory of fields, K-theory of local fields)

N.MUKUNDA, Indian Institute of Science, Bangalore (16-17, Sept. 1988)

Deepak Dhar, (16-19, Nov. 1988)
(Dynamic critical exponent at Lee-Yang edge singularity in two dimensions)

A.K.MISHRA, Allahabad (16 May - 15 Nov. 1988)

G.ZOGRAF, V.A. Steklov Mathematical Institute of the USSR Academy of Sciences, Leningrad (21-22 Dec. 1988)
(The Geometry of modular spaces)

A.SMIRNOV, V.A.Steklov Mathematical Institute, USSR academy of Sciences, Leningrac (22-28 Dec.1988)
(Completely integrable models in quantum field theory)

SAJEEV JOHN, Princeton University, USA (22-December, 1988)
(Localization of waves)

R.P.AGARWAL, Lucknow University (11-17, Dec.1988)
(Basic hypergeometric series and continued fractions - some recent developments - I, developments - II)

BHAMA SRINIVASAN, University of Illinois, USA (15-December 1988)
(Modular representation of finite chevalley groups)

M.BHASKARAN, Perth, Australia (22-December to 22-Jan. 1989)
(Some conjectures in number theory)

K.T.ARASU, Wright State University, USA (5-Jan 1989)
(Divisible difference sets with multiplier - I)

K.S.VISHWANATHAN, Simon Fraser University, Canada (16-Dec. '88 to 8-Jan. 1989)
(Fractional spin in 2+1 dimensions)

N.Sarma, Nuclear Physics Division, BARC, Bombay (16-19, January 1989)

P.E.HODGSON, Department of Physics, Oxford University, UK
(19-Jan. 1989)
(The unification of the Nuclear optical potential)

J.L.VERDIER, University of Paris VII, France (21-25, Jan. 1989)
(families of solutions of K'd V equations)

REMY Y.DENIS, Gorakhpur University, Gorakhpur (31-Dec.'88 to 6-Jan.'89)
(Generalization of certain continued fractions of Ramanujan)

V.SRINIVASAN, School of Physics, University of Hyderabad
(13-jan. 1989)

BOB JONGEJNS, NIKHEF, Amsterdam (3-Feb. 1989)
(Neutral current chiral coupling constant)

N.KOBLITZ. University of Washington, Seatle (1-Feb. 1989)
(Cryptography and Algebraic curves)

J.GOKHALE, Department of Maths, Pondicherry University (23-Feb. 89)
(Compactified picard variety)

S.KOTANI, University of Tokyo, Japan (27-Feb. to 2 April 1989)
(On spectrum of Schrodinger operators with almost periodic potentials)

J.L.COLLIOT THELENE, University of Orsay, Paris XI (26-29 March 1989)
(Rationality problems in fields of invariants)

K.RAMACHANDRA, TIFR, Bombay (some problems in analytical theory)
(9-March 1989)

F.GIANESSI, University of Pisa, Italy (16-March 1989)
(Lagrange multipliers)

VIKRAM SONI, University of Paris sud, Orsay (11-14, March 1989)

M.S.RAGHUNATHAN, TIFR, Bombay (2-March 1989)
(Principal Fibre Spaces over affine spaces)

APPENDIX

MATHEMATICS COLLOQUIUM LECTURES

C.S. Seshadri	:	Survery of moduli of vector bundles
V.S. Sunder	:	Braids, knot invariants and II factors
V. Lakshmibai	:	Towards a standard monomial for infinite dimensional flag varieties
R. Balasubramanian	:	Some problems in combinatorial number theory
M. Waldschmidt	:	Transcendence theory
P.S. Thiagarajan	:	Some behavioral aspects of the net theory A logic for regular sequential programme
P. Sankaran	:	On simplicity of certain homeomorphism group
M. Krishna	:	Random Schroedinger operators
K.S. Nagarajan	:	Subalgebras of affine algebras
S. Srinivas Rao	:	Determinants of Laplacians and zeta functions
V. Balaji	:	Cohomology of some moduli spaces Some criteria for rationality
S.D. Adhikari	:	Ramanujan and partition functions
Madhavan Mukund	:	Hilbert's 10th problem is undecidable
K. Lodaya	:	Developing correct programmes
S. Lobo	:	To find a real α such that 2α and 3α are integers
A. Smirnov	:	Completely integrable models in quantum field theory
Bhama Srinivasan	:	Modular representations of finite Chevalley groups
M. Bhaskaran	:	Some conjectures in number theory
K. T. Arasu	:	Divisible difference sets with multiplier
R. Simon	:	Hamilton's theory of turns for SU(2) and its generalisation to SL(2, R)

N. Koblitz	:	Cryptography and algebraic curves
J. Gokhale	:	Compactified Picard variety
S. Kotani	:	On the spectrum of Schroedinger operators with almost periodic potentials
J.L. Colliot-Thelene	:	On the Hasse Principle
K. Ramachandra	:	Some problems in analytic number theory
F. Gianessi	:	Lagrange multipliers
M.S. Raghunathan	:	Principal fibre bundles over affine spaces
R. Ramanujam	:	Semantics of logic programs
H. Bhate	:	The inverse problem for Hill's equation.

THE INSTITUTE OF MATHEMATICAL SCIENCES, MADRAS

Receipts and Charges for the year ending 31st March 1989

Receipts		Rs.	Charges	Rs
Opening Balance	- Cash	1,000.75		
	Bank	18,73,258.50	**Pay and Allowances**	
Department of Atomic Energy Grants			i) Academic Staff	18,93,174.00
Recurring (1988-89)		41,79,000.00	ii) Administrative staff/Supporting Staff	6,34,775.45
Non-Recurring (1988-89)		40,00,000.00	Post Doctoral Fellowship	1,66,977.00
Tamil Nadu Government Grants			Junior Research Fellowship	4,18,401.00
Recurring (1987-88)	6,99,000		Employer Contribution to CPF	66,079.00
Recurring (1988-89)	7,50,000		Pension Contribution	12,505.00
		14,49,000.00	Leave Salary Contribution	5,450.00
Other Grants			CPF Management Contribution to TIFR	-
NBHM Fellowship Grants		1,03,800.00	Gratuity Contribution to TIFR	-
CSIR Fellowship Grants		23,375.00	Overtime Allowance	8,372.00
Receipts/Refunds under Hosting of Scientific Con,/Summer Schools/ Symposium/Workshop.etc.		1,09,153.00	Gratuity to Staff	73,200.00
			Encashment of leave on Superannuation	-
DAE Grants for HEP Sym. for Pub.	5000		Library	18,22,866.20
DST Grants for HEP Sym.	20000		Visiting Scientists Programme	62,340.00
UGC Grants for HEP SYm.	45303			
Other receipts	11500		**Travelling Allowance**	
Refunds	27350		i) Board and Committee Members	16,052.75
			ii) Participation by acad. staff in Conference	6,031.00
Sale of IMSc, Reports		480.00		
Xeroxing Receipts		7,792.50		
Hostel and Guest House Rent		29,567.00		
		1,17,76,426.75		51,86,223.40

Receipts

B/F	1,17,76,426.75
Earnest Money Deposit	20,150.00
Pension Contribution from Staff	6,880.00
Pension Equivalent of Gratuity from Staff	9,330.00
Auction sale of scraps and unserviceable	810.00
Interest on Investment	1,09,945.20
Investment matured	10,00,000.00
Excess salary recovered from acad. staff	3,312.00
Recovery for official car use	500.00
Festival advance recovered	10,360.00
Temporary advance recovered	1,46,474.00
Recovery of excess amount transferred from Management to Provident Fund during 87-88	992.00
Recovery under the Head JRF	2,660.00
Recovery under the Head LTD to Staff	4,219.00
Recovery under the Head TA - others	4,170.00
Recovery under the Head Admn.Staff	4,594.00
Recovery under Furniture and fittings	100.00
Recovery under the Head Telephone Charges	11,349.10
GPF Recoveries	2,57,870.10
IT Recovered	2,09,247.00
PLI Recovered	7,301.20
Professional tax recovered	10,759.50
CTD recovered	600.00
HDFC loan recovered	7,138.00
GPF recovered from Registrar	720.00
	1,36,05,907.85

Charges

B/F	51,86,223.40
iii) Other official visits	28,507.00
iv) Candidates called for interview	-
v) LTC to Staff	28,558.40
vi) TA-Others	1,636.30
Hosting of Scientific Con./Summer School Sym./ Workshop. etc.	1,32,385.00
vi) For HEP Symposium 100885	
ii) Amount transfered to HEP Sym. to Sep.A/c.16500	
iii) Other Conf. Hosted by the Inst. 15000	
Accommodation for Director (Rent, Maintenance, Furniture and Fittings	32,647.75
Guest House Maintenance (Rent, Maintenance, Furniture and Fittings	1,35,775.70
	55,45,733.55

Receipts		Charges		
B/F	1,36,05,907.85	B/F		55,45,733.55
Motor Car advance recovered from Registrar	6,000.00	**Office Expenses**		
Group Insurance Scheme recovered from Registrar	480.00	i)	Building Maintenance	1,69,168.40
Family Benefit Fund recovered	18.00	ii)	Furnitures and Fittings (Repairs, Renewals, Purchases)	1,31,831.80
CPF recovered (for TIFR)	12,276.00	iii)	Stationery and Printing	61,271.20
Vehicle advance recovery	2,226.00	iv)	Postage	46,651.40
Leave salary contribution paid to DAE returned	62.00	v)	Contingent and Miscellaneous	32,690.60
Special advance recovery	50.00	vi)	Telephone charges	85,940.00
Sale of Tender document (including sales tax Rs.66)	1,266.00	vii)	Advertisement charges	32,565.00
Recoveries from the Construction of Library Building Head	30.00	viii)	Canteen facilities	3,366.10
Security deposit for Guest House and Hostel construction	50,000.00	ix)	Vehicle Maintenance	66,719.90
Security deposit for Library Building construction	24,694.00	x)	Petrol/Diesel for Vehicles	60,900.90
		xi)	Computer Stores/Charges/Maintenance	12,649.60
		xii)	Uniform to Staff	12,956.65
		xiii)	Water and Electricity Charges	16,914.00
		Advances paid		
		i)	House Building advance	-
		ii)	Purchase of vehicle	52,765.00
		iii)	Festival	11,200.00
		iv)	**Other advances/deposits**	
			Special advance	500.00
			Earnest Money deposit returned	50,150.00
	1,37,03,009.85			63,93,974.10

Receipts		Charges	
B/F	1,37,03,009.85	B/F	63,93,974.10
		Investment of non-recurring Grant	25,00,000.00
		Telephone deposits	15,000.00
		Temporary advance	1,94,362.00
		Other Welfare Measures	
		Ex-gratia payment in lieu of Bonus	23,267.00
		Health care scheme	10,207.15
		Pension	-
		Non-recurring items	
		Construction of Hostel and Guest House	8,09,419.00
		Construction of Library Building	2,57,956.00
		Mahindra Jeep	1,59,273.25
		New Service Connection for Electricity	70,150.00
		Computer installation	10,09,544.00
		Airconditioner and Furniture to the Computer room	50,155.00
		Others	
		NBHM Fellowship	93,494.05
		CSIR Fellowship	24,893.20
		TPSC	10,683.50
	1,37,03,009.85		1,16,22,378.25

Receipts		Charges	
B/F	1,37,03,009.85	B/F	1,16,22,378.25
		Ramanujam Centenary Symposium Account (Balance transfered to Separate a/c)	587.20
		CPF remittance	2,56,153.00
		IT remittance	2,08,961.00
		PLI remittance	7,301.20
		Professional tax remittance	10,759.50
		CTD remittance	600.00
		HDFC Loan remittance	7,138.00
		GPF remittance	720.00
		Motor Car advance	6,000.00
		Group Insurance Scheme remittance	480.00
		Family Benefit Fund remittance	18.00
		CPF remittance to TIFR	12,276.00
		Closing Balance - Cash	16,650.00
		Bank	15,52,987.70
	1,37,03,009.85		1,37,03,009.85

Sd/-
INSPECTOR OF L.F.ACCOUNTS

Sd/-
Registrar

PROVIDENT FUND ACCOUNT

RECEIPTS AND CHARGES FOR 1988-'89

Receipts	Rs. P.	Charges	Rs.P.
Opening Balance as on 1.4.88	3,62,300.36	Advance from fund	64,465.00
Subscription/Refund	2,56,153.00	Part final withdrawals	22,000.00
Management Contribution for 88-89	66,079.00	Excess interest credited by bank in Oct.86 recovered by Bank	20.25
Interest earned through investments	86,277.80	Transfer of excess amount credited in CPF A/c to Management	992.00
Investment matured	65,000.00	Bank charges	94.00
Bank clearing charges remitted by bank	30.00	Closing Balance as on 31.3.89	7,48,268.91
	8,35,840.16		8,35,840.16

Sd/-
INSPECTOR OF L.F.ACCOUNTS

Sd/-
Admn./Accts.Officer
IMSc., Madras

NBHM LIBRARY GRANT ACCOUNT for 1988 - 89

Opening Balance as on 1.4.88	Rs.	2,800.26
Add : Grants received during 88-89	Rs.	3,00,000.00
Add : Savings Bank Interest	Rs.	1,499.15
Total	Rs.	3,04,299.41
Amount spent	Rs.	2,28,748.00
Unspent Balance	Rs.	75,551.41

Sd/
Admn./Accts.Officer
IMSc., Madras

Sd/.
INSPECTOR OF L.F.ACCOUNTS