THE INSTITUTE OF MATHEMATICAL SCIENCES

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ANNUAL REPORT

August 1998 – July 1999

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Foreword

As we prepare ourselves for the next millennium, I record, for the last time, the foreword to the Annual Report of the Institute for the academic year 1998-99. I am pleased that it has been an eventful year with many accomplishments.

As we approach the middle of the Ninth Five Year plan, the extension to the Guest House that provides space for 30 more visitors is complete and we have just commenced the construction of the new three storey academic building that will add more office space, lecture halls, computing stations and a state of the art auditorium. In about two years time, we should be able to find necessary space to relieve the current space crunch and look forward to adding new activities for the next millennium. It is, hence the right time now to review the progress Institute has made over the decade and draw up concrete plans of action for the next decade. It may be useful to look for a body of external experts to join us in such a task, so that we may derive vital objective input to supplement our experiences and aspirations.

During the year under review, we organized, on behalf of the High Energy Physics Community, the Third Puri Workshop on Quantum Field Theory, Quantum Gravity and Strings at Toshali Sands, Puri, during December 9 - 19, 1998. This series has become an important national effort to project activities in this area in the format of a significant workshop with wide international participation. Similarly the 18th Meeting of the FST & TCS (Foundation of Software Technology and Theoretical Computer Science), that was hosted by us turned out to be an yet another successful annual International Conference of the research community of Theoretical Computer Scientists in the country. The report also includes other topical meetings that were hosted at the Institute to serve the needs of research community in the Institute and our colleagues elsewhere in the country.

The Institute conducted for UNESCO an International Conference to serve the needs of training of teachers in Mathematics of the developing countries in our neighbourhood. And our TCS faculty conducted a highly appreciated orientational course on foundational aspects of TCS for local college teachers. We continue to foster international research collaboration through programmes with ICTP (International Centre for Theoretical Physics), TWAS (Third World Academy of Sciences) and joint projects such as Ulm-IMSc Joint Project in Theoretical Computer Science supported by DST-DAAD.

Among the laurels won by members of the Institute, I must highlight that of S. Nag, who won the coveted Shanti Swarup Bhatnagar Prize for 1998. However, he is no more with us, as he succumbed to a massive heart attack on December 22, 1998. We propose to hold an annual event to remember him, particularly his infectious enthusiasm for quality mathematics.

We are proud to have the bust of Professor S. Chandrasekhar adorn the foyer of the Institute. It is nice to recall that Professor Chandrasekhar formally inaugurated this Institute, and was an Honorary Professor of the Institute in the formative years.

Shri Sethuraman completed his tenure as Chief Administrative Officer of the Institute during this year, and I am very pleased to record our gratitude for his forthright and dedicated service during the period of development of the Institute.

This Annual Report has been compiled through the efforts of a committee that consists of R. Sridhar, G. Date, T.R. Govindarajan, S. Kesavan, Venkatesh Raman, R. Simon and K. S. Santhanagopalan and to all of them I owe my gratitude.

We look forward to approach the next millennium for many laurels to our credit.

R. RAMACHANDRAN

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Chapter 1

The Institute

PATRON Shri **C. Subramaniam**

1.1 Board

Thiru **K. Anbazhagan**, Minister for Education, Government of Tamil Nadu, Chennai
(**Chairman**)

Dr. **R. Chidambaram**, Chairman, Atomic Energy Commission and Secretary to Government of India, Department of Atomic Energy, Mumbai
(**Vice Chairman**)

Prof. **R.M. Vasagam**, Vice Chancellor, Anna University, Chennai
(**Member**)

Prof. **S.S. Jha**, Director, Tata Institute of Fundamental Research, Mumbai
(**Member**)

Prof. **C.S. Seshadri**, Director, Chennai Mathematical Institute, Chennai
(**Member**)

Prof. **H.S. Mani**, Director, Mehta Research Institute of Mathematics and Mathematical Physics, Allahabad
(**Member**)

Dr. **J. K. Bhattacharjee**, Department of Theoretical Physics, Indian Association for the Cultivation of Science, Jadavpur, Calcutta
(**Member**)

Smt **Sudha Bhave**, I.A.S., Joint Secretary to Government of India, Department of Atomic Energy, Mumbai
(**Member**)

Shri **S.P. Elangovan**, I.A.S., Secretary to Government of Tamil Nadu, Education, Science

and Technology Department, Fort St. George, Chennai
(**Member**) (up to August 1998)

Shri **P. Selvam**, I.A.S., Secretary to Government of Tamil Nadu, Higher Education Department, Fort St. George, Chennai
(**Member**) (from September 1998)

Prof. **R. Ramachandran**, Director, The Institute of Mathematical Sciences, Chennai
(Member Secretary)

1.2 Executive Council

Dr. **R. Chidambaram**, Chairman, Atomic Energy Commission and Secretary to Government of India, Department of Atomic Energy, Mumbai
(**Chairman**) (up to April 1999)

Prof. **S.K. Joshi**, Chairman, Recruitment & Assessment Centre, Defence Research and Development Organisation (DRDO), Lucknow Road, Timarpur, Delhi
(**Chairman**) (from May 1999 onwards)

Prof. **C.S. Seshadri**, Director, Chennai Mathematical Institute, Chennai
(**Member**)

Prof. **H.S. Mani**, Director, Mehta Research Institute of Mathematics and Mathematical Physics, Allahabad
(**Member**)

Dr. **J. K. Bhattacharjee**, Department of Theoretical Physics, Indian Association for the Cultivation of Science, Jadavpur, Calcutta
(**Member**)

Smt **Sudha Bhave**, I.A.S., Joint Secretary to Government of India, Department of Atomic Energy, Mumbai
(**Member**)

Shri **S.P. Elangovan**, I.A.S., Secretary to Government of Tamil Nadu, Education, Science and Technology Department, Fort St. George, Chennai
(**Member**) (up to August 1998)

Shri **P. Selvam**, I.A.S., Secretary to Government of Tamil Nadu, Higher Education Department, Fort St. George, Chennai
(**Member**) (from September 1998 onwards)

Prof. **R. Ramachandran**, Director, The Institute of Mathematical Sciences, Chennai
(Member Secretary)

1.3 Faculty

email: user-id@imsc.ernet.in

Name	*User-id*	*Res. Phone No*
MATHEMATICS		
Balasubramanian, R.	balu	245 3926
Inamdar, S.P.[1]		
Kesavan, S.	kesh	641 2839
Kodiyalam, Vijay	vijay	490 2041
Krishna, M.	krishna	492 8499
Nag, S.[2]		
Nagaraj, D.S.	dsn	448 1260
Paranjape, Kapil H.	kapil	492 7243
Srinivas, K.	srini	448 1259
Sunder, V.S.	sunder	858 3343
PHYSICS		
Anishetty, R.	ramesha	496 0586
Balakrishnan, Radha	radha	445 9653
Baskaran, G.	baskaran	492 7304
Basu, Rahul	rahul	245 4794, 245 3297
Chakraborty, Tapash	tapash	
Date, G.	shyam	245 6148
Govindarajan, T.R.	trg	492 7309
Hari Dass, N.D.	dass	442 2767
Indumathi, D.	indu	492 8138
Jagannathan, R.	jagan	2401546
Jayaraman, T.	jayaram	492 9527
Kaul, Romesh	kaul	441 3264
Majumdar, Parthasarathi	partha	448 0793
Menon, Gautam I.	menon	
Mishra, A.K.	mishra	
Murthy, M.V.N.	murthy	235 2652
Parthasarathy, R.	sarathy	442 2201
Rajasekaran, G.	graj	441 3395
Rama, S. Kalyana	krama	

[1] Resigned on May 17, 1999
[2] Deceased.

Name	*User-id*	*Res. Phone No*
Ramachandran, R. (Director)	rr, director	442 0387
Rao, Madan	madan	
Ray, Purusattam	ray	492 8251
Sathiapalan, Balachandran	bala	492 7832
Shankar, R.	shankar	235 0436
Sharatchandra, H.S.	sharat	441 8059
Simon, R.	simon	441 3270
Sinha, Rahul	sinha	
Sinha, Sudeshna	sudeshna	492 7243
Sridhar, R.	sridhar	441 9145
Srinivasa Rao, K.	rao	441 1347
THEORETICAL COMPUTER SCIENCE		
Arvind, V.	arvind	235 2556
Lodaya, Kamal	kamal	445 3312
Mahajan, Meena	meena	441 3403
Raman, Venkatesh	vraman	492 9845
Ramanujam, R.	jam	492 8138
Seth, Anil	seth	492 7647
SCIENTIFIC OFFICER		
Subramoniam, G.	gsmoni	237 9520

1.4 Post-Doctoral Fellows

Name	*User-id*
MATHEMATICS	
Biswas, Jishnu Gupta	jishnu
Chakraborty, Kalyan[1]	
Gendron, Tim	gendron
PHYSICS	
Adhikari, Rathin	rathin
Arun Kumar, S.	arun
Dutta, Gautam	gdutta
Ghosh, P.K.	pijush
Kar Gupta, Abhijit[2]	
Mehta, Mitaxi	mitaxi
Nakkeeran, K.	naks
Seshadri, S	sesh
Sinha, Nita[3]	
THEORETICAL COMPUTER SCIENCE	
Kamakoti, V.[1]	
Roy, Suman[4]	

[1] Resigned on 30. 4. 1999.
[2] Resigned on 1. 2. 1999
[3] Term ended on 30. 11. 1998
[4] Resigned on 30. 4. 1999

1.5 Ph.D. Students

Name	*User-id*
MATHEMATICS	
Das, Paramita	pdas
Ghosh, Shamindra Kumar	shami
Gyan Prakash	gyan
Mukherjee, Kunal	kunal
Rajesh, M.	rajesh
Ramana, D. Surya	suri
Ravindra, G.V.	ravindra
Sabu, N.	sabu
Uma, V.	uma
PHYSICS	
Babu, Dutta Sreedhar	sbdutta
Bal, Subrata	subrata
Balaji, K.R.S.	balaji
Chaudhuri, Sarasij Ray[1]	
Das, Jayajit[2]	jayajit
Das, Saurya	saurya
Dasgupta, Arundhati	dasgupta
Ghosh, Tarun Kanti	tkghosh
Madhu, K.	mad
Majumdar, Pushan	pushan
Manoj, G.	manoj
Mishra, Anup Kumar	anup
Murugesh, S.	mgesh
Santosh Kumar	sant
Sarkar, Tapobrata	sarkar
Sinha, Subhasis	subhasis
Sumithra, S.R.	sumithra
Surendran, Naveen	naveen
Varadarajan, Suneetha	suneeta
Vathsan, Radhika	radhika

[1] Fellowship discontinued from January 1999
[2] Fellowship discontinued from February 1999.

Name	*User-id*
THEORETICAL COMPUTER SCIENCE	
Madhusudan, P.	madhu
Meenakshi, B	bmeena
Nagaraj, S.V.	svn
Srinivasa Rao, S.	ssrao
Suresh, S.P	spsuresh
Vinodchandran, N.V[1]	

[1] Fellowship ended in February 1999

1.6 Administrative Staff

Sethuraman G.	Chief Administrative Officer (till October 1998) (Administrative Consultant from November 1, 1998 to January 31, 1999)
Manja, Ramakrishna	Chief Administrative Officer (from December 1998)
Jayaraman, R.	Administrative Officer
Krishnan, S.	Accounts Officer
Santhanagopalan, K.S.	Librarian

Amulraj, D.
Ashfack Ahmed, G.
Balakrishnan, A.R.
Balakrishnan, J.
Elumalai, G.
Ganapathi, R.
Gayatri, E.
Geetha, M.
Indra, R.
Janakiraman, J.
Moorthy, E.
Munuswamy, N.
Munuswamy, M.
Muthukrishnan, M.
Muthusigamani, S.
Nithyanandam, G.
Parijatham, S.M.
Parthiban, V.
Radhakrishnan, M.G.
Rajasekaran, N.
Rajendran, C.
Ramesh, M.
Ravichandran, N.
Ravindran, A.
Rizwan Shariff, H.
Sampath, N.S.
Sankaran, K.P.
Selvaraj, M.
Tamil Mani, M.
Usha Devi, P.
Usha Otheeswaran
Vasudevan, T.V.
Varadaraj, M.
Venkatesan, G.
Venugopal, T.

Chapter 2

Academic Activities

2.1 Summary of Research

The next three subsections summarize the research done during the report period in the three disciplines. Any cross reference marked [M:**], [P:**] or [T:**] refers to the corresponding publication listed under Mathematics, Physics and Theoretical Computer Science respectively in the next section.

2.1.1 Mathematics

Algebra

A very simple proof of the existence of bases with good specialization properties has been given for Kac-Moody algebras of rank two [M:Ko]. This is done by translating the basis problem into one of linear algebra over a finite dimensional vector space and then solving this problem in the rank two case.

An approach towards proving lower bounds for Betti numbers of certain finite length modules over regular local rings is being investigated. This relies on explicitly resolving certain modules associated to matrices of 'Koszul type' over polynomial rings and using the Euler-Poincaré characteristic to compute their rank. These resolutions themselves may be of independent interest.

Algebraic Geometry

The compactification of the moduli space of vector bundles on a nodal curve has been studied further [M:Na1]. Let X_o be a projective curve whose singularity is one ordinary double point. A birational model $G(n,d)$ of the moduli space $U(n,d)$ of stable torsion free sheaves has been constructed in the case $(n,d)=1$ such that $G(n,d)$ has normal crossing singularities and behaves well under specialization; if a smooth projective curve specializes to X_o, then the moduli space of stable vector bundles of rank n and degree d on X specializes to $G(n,d)$. This generalizes an earlier work of Gieseker in the rank two case.

The moduli spaces of principal bundles with parabolic structure over a projective manifold have also been studied [M:Na2]. Various aspects of G- bundles have been generalized to parabolic G- bundles. These include establishing a relationship between unitary flat connections and parabolic polystable G- bundles and also the construction of moduli spaces.

The theory of *Motives* was proposed by Grothendieck as an ideal cohomological theory for varieties and schemes. Recent work by Levine, Suslin and Voevodsky gives a construction of an *almost final* version of this theory. Another such construction has been given by Nori. One problem is proving the equivalence of these constructions. Another way of approaching this is to demonstrate the Hard Lefschetz Theorem for these theories.

A study of these and related problems has been undertaken. An alternative construction of the category of motives, which will possibly be easier to compute with, since certain infinite towers of constructions have been replaced by finite ones, is being developed. These constructions also generalise to the singular varieties in positive characteristic; this is not possible with the earlier methods.

Various problems connected with the cohomology classes of cycles on singular projective varieties are being investigated. One of them could be thought of as the analogue of the Tate Conjecture for divisors for normal projective varieties.

In continuation of an earlier work on spectral sequences, a study of Categorical methods in Algebraic Topology and Geometry was undertaken.

Combinatorics

In the search for a proof of some conjectured inequalities regarding the eigenvalues of Laplacian matrices of graphs, some partial results were obtained. For instance, it was shown that the spectrum of the Laplacian of an amalgamation of two graphs is always 'majorised' by the spectrum of the Laplacian of their disjoint union.

Complex Analysis

The isotropy subgroup of any point of the universal Teichmuller space for the action of the universal modular group has been computed [M:N3]. The isotropy group turns out to be the commensurator of the Fuchsian group. It has been shown that the subgroup that fixes pointwise the stratum of the universal Teichmuller space, given by a fixed finite dimensional Teichmuller space, is the fundamental group of a surface in the stratum. It has also been shown that the action of an isotropy subgroup on the corresponding solenoidal surface is ergodic if and only if the Fuchsian group is arithmetic.

A new approach towards the resolution of the Ehrenpreis Conjecture is being considered. It consists of a generalization of Thurston's theory of simple closed curves and measured laminations to Riemann surface solenoids. The main point is to replace simple closed curves by their solenoid counterpart, simple compact 1-dimensional solenoids. Thus a space of 'projective measured foliations' has been constructed and shown to be an infinite dimensional sphere, yet compact with respect to Thurston's topology. The conjecture has been reformulated in this setting and is being studied.

Differential Equations

Work on the lower dimensional approximation of eigenvalue problems in shell theory was continued . The cases of flexural and membrane shells were studied [M:KeS]. These differ

by a geometric condition on the middle surface of the shell. If a certain function space were non- trivial, one gets the flexural shell in the limit and in the case it is trivial and a technical condition of ellipticity were satisfied, a membrane shell is obtained.

If the non-trivial space of inextensional displacements were infinite dimensional, complete results have been obtained. It has been shown that the eigenvalues are of the order of the square of the thickness of the shell and that the scaled eigenvalues converge to those of the two-dimensional flexural shell model. If this space is finite dimensional, then as many eigenvalues as that dimension exhibit the above mentioned behaviour. All the eigenvalues of the limit problem are shown to be accounted for in this manner. In the finite dimensional case, it is shown that the higher order eigenvalues are bounded and that they either converge to eigenvalues of the membrane model or the eigenvectors converge weakly to zero. It is, however, not known if there are examples of shells where the space mentioned above is finite dimensional. This is being investigated.

In case of the membrane shells, the limit problem involves a non-compact operator and the spectrum consists of an essential spectrum as well. It is shown that the eigenvalues are bounded uniformly with respect to the thickness but that their limits form a bounded set. Since the limit problem is known to have an increasing sequence of eigenvalues, not all eigenvalues of the limit problem can be captured as limits of eigenvalues of the three dimensional problems. It is shown that the eigenvalues either converge to the membrane shell eigenvalues or the eigenvectors converge weakly to zero.

Work continued in the study of the homogenization of optimal control problems. A systematic abstract study of this problem was done and its relationship to Γ - convergence was established. A natural description of the homogenized coefficients appearing in the cost functional was obtained. In fact, the homogenized matrix turns out to be the limit of an appropriate sequence of matrices constructed from the original sequence and a sequence of corrector matrices. An upper bound for this matrix was obtained, thus settling a question open hitherto. A uniqueness result for the matrix was also proved.

A list of problems involving low cost control, *i.e.* where the cost of the control in the objective functional also goes to zero, is being studied. Some of these have been completely settled.

Corrector results have been obtained for the homogenization of flow in a partially fissured medium [M:Ra].

Mathematical Physics

The spectral theory of random Schrödinger operators with random potentials coming from a family of wavelets and random point interactions is considered and is being worked out.

The partial sums of the Riemann zeta function are being studied in the critical strip in terms of some inverse spectral curves.

Number Theory

Some progress was made in the estimation of exponential sums, particularly in connection with a problem of Ramachandra of finding the largest prime factor of the product of the

square root of n consecutive integers starting with n.

It was proved that a product of translates of (positive or negative) integral powers of zeta functions, if it has a denominator, has the property that imaginary parts of poles tend to infinity.

Some progress was made in the problem of Erdös of finding the maximum possible values of c such that $n!$ can be written as a product of n integers all of them being bigger than cn.

The problem of finding a good upper bound for the ordinates of the zeros of zeta functions of a ray class of quadratic fields is being attempted.

Operator Algebras

Some effort was expended in a search for proofs (of acceptable rigour) of various assertions that have been made by Ocneanu regarding: (a) the (2+1)-dimensional Topological Quantum Field Theory associated with a finite depth subfactor, as well as (b) the standard invariant of the 'asymptotic inclusion' of a finite-depth hyperfinite subfactor. Some progress has been made with regard to (a) above. (It is agreed by a large number of the experts in the area that the existing 'proofs' leave a lot to be desired.)

2.1.2 Physics

Classical Mechanics, Mathematical Physics and Quantum Mechanics

Integrability and Nonlinear Dynamics

The system of anyons is analysed at the classical and the semiclassical level. In the classical analysis the meaning of pseudo-integrability is elaborated and corresponding loss of symmetry is shown. The semiclassical analysis shows evidence for the elusive non-linearly interpolating eigenvalues. The ambiguous role of additional "reflecting" classical orbits is discussed [P:Dat2].

For general boundary conditions, it was shown that the energy H of a two-dimensional curved ferromagnetic film satisfies the inequality $H \geq |\Gamma|$, where Γ is a certain anholonomy associated with the spin vector field. For a wide class of curved films, local energy minima were found to be solutions of a sine-Gordon equation with a geometry-dependent parameter appearing in it. Using soliton-lattice solutions it was seen that both the energy and the geometric phase develop a two-branch structure, which was physically interpreted [P:Ba1].

After identifying two types of local geometric phases associated with the evolution of a space curve, it was shown that the time-dependent Schrödinger equation of a particle in a potential $V(s)$ can be interpreted geometrically as a moving curve whose Fermi-Walker geometric phase density is $-(dV/ds)$. Examples of simple potentials were discussed [P:Ba2].

The Belavin-Polyakov equation for a unit vector field has been shown to describe a wide class of moving space curves. A hierarchy of multi-twist solutions were obtained for this equation and applications were discussed [P:Ba4].

The Banerjea-Taylor map is a model for helical polymers and ferro- magnets. It was shown using analytical arguments that the dimensionality of the phase-space survivors for the map is integer with the possible exception of the boundary of the allowed phase-space where the dimensionality may be fractional at some parameter values [P:Me1].

Adaptive control algorithms, whereby a spatially extended nonlinear system can be steered to a target state with desired spatio-temporal characteristics, were proposed. Specifically the control was implemented on a two dimensional coupled map lattice, where it successfully directed the system to desired targets ranging from spatio-temporal fixed points and regular spatial patterns to spatio-temporal chaos. The proposed methodology entailed monitoring the local neighborhood of only one (arbitrary) site in order to regulate the entire lattice. Further, knowledge of the system's governing equations was not required, and so these methods are expected to be very relevant in experimental implementations. The utility of the technique in so-called "smart matter" applications was specifically demonstrated [P:Sinh4], [P:Sinh7].

The capacity of a lattice of threshold coupled chaotic elements to perform computations was demonstrated [P:Sinh3]. (*This work was cited as one of the top Physics stories for 1998 by AIP Physics News Update 409 dated January 5, 1999.*) Such systems were shown to emulate logic gates, encode numbers and perform specific arithmetic operations, such as addition and multiplication, as well yield more specialised operations such as the calculation of the least common multiplier of a sequence of numbers. It was evident that this computing principle had potential and flexibility, arising from the wide range of behaviours each module is capable of, through the variation of a single ("programmable") parameter. That is, the chaotic elements presented a range of possibilities with the same collection of elements (i.e. using the same "hardware") by simply changing threshold (which is fed in as input, and is part of the "software"). The applicability of this computing paradigm was demonstrated for a system of coupled chaotic lasers, and for a system of coupled neurons (with individually chaotic responses) [P:Sinh2], [P:Sinh5].

Mathematical Physics

The study of two parameter deformations in the context of basic hypergeometric series and their transformations is in progress.

The relevance of fractal dimensions to curves such as those occuring in ECGs is being investigated.

It is shown that K. S. Krishnan's main result is essentially equivalent to the sampling theorem of Shannon that appeared a little later. While conventional wisdom viewed the sampling theorem as a powerful engineering tool in signal processing, Krishnan saw in his main result a rich source of deep mathematical identities [P:S3].

It is shown that a $N \times N$ real symmetric [complex hermitian] positive definite matrix V is congruent to a diagonal matrix modulo a pseudo-orthogonal [pseudo-unitary] x in $SO(m,n)$ [$SU(m,n)$], for any choice of partition $N = m + n$. It is further shown that this method of proof can easily be adapted to obtain a rather simple proof of Williamson's theorem which states that if N is even, then V is congruent also to a diagonal matrix modulo a symplectic matrix in $Sp(N,\mathcal{R})$ $[Sp(N,\mathcal{C})]$. These results yield a generalization of the Schweinler-

Wigner method of 'orthogonalization based on an extremum principle' to construct pseudo-orthogonal and symplectic bases from a given set of linearly independent vectors [P:S4].

Optics

The polarisation transformations due to the action of Half Wave Plates (HWP) and Quarter Wave Plates (QWP) and their elegant geometrical representations as Hamilton's turns on the surface a unit sphere was studied. Explicit geometric constructions have been given using HWP and QWP to establish various identities useful in the synthesis of various optical elements [P:Ar3].

The statistics of atoms coming out of a micromaser cavity after interacting with the field inside the cavity was studied. The relationship between the cavity field statistics and the detected atomic statistics in the steady state was investigated by developing a theoretical formulation taking explicit account of the discrete input of atoms into the maser cavity. Correlations between the detected atoms have also been studied [P:Ar1], [P:Ar2].

A general unified approach for finding the coherent states of polynomially deformed algebras such as the quadratic algebra and the Higgs algebra has been presented. This is relevant for the study of various multiphoton processes in quantum optics and explicit constructions of coherent states associated with several quantum optical systems have been given [P:J3].

Two six-parameter families of anisotropic Gaussian Schell-model beams that propagate in a shape-invariant manner, with the intensity distribution continuously twisting about the beam axis, are exhibited. The two families differ in the sense or helicity of this beam twist. The propagation characteristics of shape-invariant beams are studied, and the restrictions on the beams arising out of the optical uncertainty principle are brought out. Shape-invariance is traced to a fundamental dynamical symmetry underlying these beams. This symmetry is the product of spatial rotation and fractional Fourier transformation [P:S1].

A generalisation of the well-known connection between quantum mechanical Bargmann invariants and geometric phases is developed. The key notion is that of null phase curves in quantum mechanical ray and Hilbert spaces. Theory of such curves are developed, and differential geometric aspects of null phases are briefly explored [P:S6].

It is known that vortices in a light beam degrades the beam quality. Single-valuedness of the wave amplitude requires the intensity to vanish at the eye of the vortex. The contribution to beam quality degradation arising at a hole (localized zero of the intensity) without vortex is studied [P:S7]. Within the set of paraxial optical systems, which constitute the group manifold of symplectic matrices, the origin of the metaplectic phase and inherent limitations for optical map fractionalization are analysed. Geometric and wave optic implementations of image girator and a cross-girators are developed [P:S8].

Quantum Measurement Theory

The use of cold atoms for experimentally testing earlier proposals for possible discrete symmetry violations in gravity as well as for the so called protective measurements in Quantum Mechanics was investigated.

After work on protective measurements in Quantum Mechanics the problem of quantum measurements was pursued. Work under progress includes investigations of whether protective measurements make sense without adiabaticity, comparisons between the quantum measurement problem and foundations of quantum statistical mechanics [P:H1].

In recent times there has been an explosion of interest in quantum on and quantum information theory. Entanglement is the single notion that distinguishes these emerging areas from their classical counterparts. It is shown that, for general(pure or mixed) Gaussian bipartite states, the notions of elementary and nonclassicality become exactly identical, and that Peres condition as the necessary and sufficient condition for entanglement [P:S9].

Condensed Matter Physics and Statistical Mechanics

High T_c Superconductivity

Recent experiments indicate clearly that one layer cuprates have a finite superconducting T_c, challenging the interlayer pair tunneling mechanism. An unified presentation of the interlayer pair tunneling mechanism and an inlayer mechanism through the notions of kinetic energy frustration and degree of failure of Fermi liquid state is made [P:Bas4].

By looking at various experimental results the notion of intrinsic T_c of a single layer cuprate is introduced. Families of single layer cuprates are shown to posses T_c much less than the intrinsic T_c because of charge stripe tendencies. Some important predictions including the possibility of increasing the T_c of LSCO from 38 K to 98 K are made.

Magnetism

A one dimensional quantum anti-ferromagnetic model which shares many properties with the two dimensional Kagome lattice anti-ferromagnet was studied. All its infinitely degenerate classical ground states were explicitly parameterised, and the spin wave spectrum computed.

Many Body Systems

Work on particle clusters in two dimensions was continued. Inclusion of a particular class of three-body interactions was shown to lead to a novel classical ground state. Whenever the three-body interaction dominates the two-body interaction, all the particles align themselves on a line with positions determined uniquely by the zeroes of the Hermite polynomials. The result is exact and valid for any dimensions [P:Dat1].

The density of states of a quantum many body system may be represented as a series known as the Weyl series and is usually smooth. Yet another way of obtaining the semiclassical expansion of the density of states is by using the Thomas-Fermi method which gives the smooth part and the oscillating part is usually obtained by using Periodic Orbit Theory. Naively adding the oscillating terms obtained from POT to the Weyl series leads to over counting. A prescription for adding them by avoiding this over counting is derived. Several examples are worked out to show how the method works [P:Mu1].

Fractional exclusion statistics was proposed by Haldane a few years ago as a generalisation of Pauli principle. The constraints on the occupation probabilities in such a system are de-

rived. This resolves the problem of the appearance of negative probabilities in these systems. [P:Mu2].

Following Anderson's suggestion of the failure of Fermi liquid theory in 2d Hubbard model, the singular Landau parameter was calculated using Landau's prescription to calculate the forward scattering amplitude. Subtleties of the singular forward scattering were brought out [P:Bas1].

The remarkable experiment in which the linear tri-atomic molecule COS (carbon-oxygen-sulphur) exhibits coherent rotational state when immersed inside a superfluid state was studied by many body theory in several ways. Some interesting predictions regarding the structure of liquid ^4He around the diatomic molecule are made.

Nanophysics

The electronic properties of quantum rings populated with few electrons and no disorder were studied earlier. Very recently, experimentalists have reported creation of *self-assembled quantum rings* for the first time. Their work on far-infra-red spectroscopy revealed the energy spectrum, that is in very good qualitative agreement with theoretical formulations.

Collective excitations of large quantum dot at zero temperature and in zero magnetic field has been investigated within sum-rule approach. Analytical results are obtained for the multipole modes and breathing mode [P:Sin1], [P:Sin2].

Collective properties of quantum dot in the presence of strong magnetic field are under investigation. Dispersion relations of magnetoplasmon excitations are also studied.

Quantum Hall Systems

A coherent state basis was developed for the Chern-Simons field theory and its properties investigated. These were used to construct variational states for vortices and skyrmions in quantum Hall systems.

The skyrmion lattice problem was further investigated. In particular, face centered lattices with spiral orientational order were studied.

Fractional exclusion statistics was proposed by Haldane a few years ago as a generalisation of Pauli principle. We have derived the constraints on the occupation probabilities in such a system. This resolves the problem of the appearance of negative probabilities in these systems [P:Mu2].

A two dimensional model which is an example of exclusion statistics system at least to the leading order was proposed.

A theory has been developed to study electron correlations at half-filled Landau level using a many-body theory originally developed by Singwi, Tosi, Land and Sjölander (STLS). It is extended to double-layer electron-electron and electron-hole systems in order to understand Coulomb drag in those systems [P:C3].

The recently reported measurements of spin polarizations of various fractional quantum Hall states are understood and the unexpected features are partially explained [P:C1].

The puzzling experimental results indicated that spin transition at filling factor $\nu = \frac{2}{3}$ might be of first-order type. Results of pronounced hysteresis around this filling factor strongly supports earlier theoretical work predicting spin transitions at this filling factor.

Statistical Mechanics

A model for the properties of interacting Brownian motors was studied. A mean-field analysis done suggests that boundary driven phase transitions in molecular motor systems may be relevant as a possible mechanism of biological control [P:Men2].

Studies of the replica symmetry breaking transition in disordered liquids with application to the glass transition in type-II superconductors were carried out. [P:Men3].

The development of fracture in a material with defects as it generally happens in real samples was studies. It was shown that the growth and coalescence of micro-fractures have lots of similarity with the nucleation and growth process in the spinodal region of a first order phase transition. These results, which are supported by the experiments on the precursor effect of fracture, may enable us to detect early and prevent fracture [P:Ray1], [P:Ray3].

Crystallization in a size-dispersed system was studied in a two-dimensional system by molecular dynamics simulation. It was shown that size-mismatch gives rise to topological defects like dislocations and disclinations strong enough to melt the system and characterise the melting caused merely by increasing the size mismatch [P:Ray2].

Non-trivial strong correlations were shown to exist in the spatial distribution of persistent (inactive) sites in spatially extended systems undergoing time evolution. This distribution has a fractal nature, and the effective fractal dimension was shown to be sensitive to initial conditions [P:Ma1].

The dynamics of ordering of the nonconserved and conserved Heisenberg magnet was studied. The dynamics consists of two parts − an irreversible dissipation into a heat bath and a reversible precession induced by a torque due to the local molecular field. For quenches to zero temperature, we show, both numerically and analytically (approximate closure scheme due to Mazenko), that the torque is irrelevant at late times for the nonconserved dynamics but relevant for the conserved case. The Mazenko closure scheme was subjected to systematic numerical tests both for nonconserved and conserved cases and shown that the closure scheme performs respectably well for the nonconserved dynamics but is inconsistent with the conserved dynamics. For quenches to T_c we show, to $\mathcal{O}\epsilon^2$), that the torque is irrelevant for nonconserved case and relevant for the conserved model, driving the system to a new stable fixed point [P:D1], [P:D2].

Strongly Correlated Electronic Systems

A theoretical framework was proposed to describe the N-chain Hubbard ladder systems. The single-particle Green's function for any number of coupled chains is obtained by solving self-consistently a system of coupled integral equations in the composite operator method.

Preliminary numerical results have been obtained for the chemical potential as a function of the ratio $\tau = t_y/t_x$ for the two leg ladder system. The sharp feature around $\tau = 0.55$ could indicate the onset of some spin ordering related to the increasing of frustration in the spin coupling channel due to the appearance of an additional exchange interaction along the rungs [P:Sr1].

The electronic structure details of an electrochemical interface is yet an unexplored area. In continuation of earliar investigations, appropriate theoretical models based on generalized Anderson Hamiltonian and coherent potential approximation has been constructed and applied to the chemisorption phenomenon [P:Mi2].

Particle Physics/Phenomenology

Neutrino Physics and CP violation

In neutrino physics, the effect of flavour mixing and consequent neutrino oscillations on the signatures of neutrinos from stellar collapse has been worked out using the already known constraints from a full three generation analysis of solar and atmospheric neutrino problems. Detailed analyses of the dramatic changes in the signatures that may occur in a water Cerenkov detector like Super Kamiokande detector if neutrino oscillation is present, are given [P:I3].

A global phenomenological analysis has been performed of a wide-range of observations in neutrino physics and this has resulted in a broad synthesis. By combining the inputs from the neutrino-less double beta decay and the fits of cosmological models of dark matter with solar and atmospheric neutrino data, constraints have been obtained on two of the mixing angles of Majorana neutrinos, which become stronger when coupled with the reactor neutrino data. These constraints are strong enough to rule out Majorana neutrinos if the small angle solution is borne out for the solar neutrinos [P:A1].

The scenario that neutrinos having degenerate mass can exist in the R-parity violating Supersymmetric Model is explored. Study of the degeneracy of neutrino masses is important as the present neutrino oscillation data together with the consideration of neutrinos as hot dark matter indicate such a possibility.

The role of CP violation in neutrino oscillation has been studied. It is shown that the upper bound on the mixing angle ϕ coming from the reactor neutrino experiment is independent of CP violation. Consequently the effect of CP violation is suppressed in all neutrino oscillation phenomena [P:R2].

The CP violating asymmetries in the penguin $B \to K^* \ell^+ \ell^-$, where the K^* decays to $K\pi$. I that due to the existence of multiple partial waves in the final e it was possible to construct CP violating asymmetries using Dalitz–plot asymmetries in the angular variables, by adding B and $\bar{B}$ events. The advantage of such asymmetries is that it they not require flavor or time tagging, nor is the presence of strong phases needed. The interference term between the CP even and CP odd partial wave switches sign when comparing a B and a $\bar{B}$. Summing B and $\bar{B}$ thus produces a net null unless CP is violated. Such asymmetries allow efficient use of the large numbers of B mesons produced at hadron colliders to study this rare mode. The asymmetries derived here are valid in additional such as $B \to \rho \ell^+ \ell^-$ and $B \to \phi \ell^+ \ell^-$.

The exhaustive angular analysis was done and the full range of CP violating asymmetries were considered [P:Si1], [P:Si2], [P:Si4].

The rich kinematics of the decays of B to two vector mesons (VV) can provide a large number of observables if the time dependent study can be combined with a complete angular analysis. One may then expect to have enough information to determine the weak phases and to estimate the tree and penguin amplitudes along with their respective strong phases. The prospect of such a proposal was examined. It was shown that the complete set of observables constructed by combining a time dependent analysis with an angular analyis are not independent, as there exist several relations between them. The maximum number of independent observables cannot enable a complete solution to the host of theoretical parameters required to describe the decay. An isospin analysis, for example in $\rho\rho$ final states, will not provide any additional information. Several other proposals are also examined. These exmaples show that the phase of the penguin can never be measured without some theoretical input. Also examined was the theoretcial input that can allow the measurement of the penguin phase [P:Si3].

Dynamical breaking of electroweak symmetry has been studied. An approximate solution of the Ward-Takahashi identities and the Dyson-Schwinger equations of $SU(2) \times U(1)$ gauge theory without elementary scalar bosons leads to the following results : (a) $M_w^2 = M_z^2 \cos^2\theta_w$; (b) m_{top} is of the same order as M_w ; (c) $m_\nu = 0$ naturally, even after the breaking of $SU(2) \times U(1)$ [P:I3].

An important addition to the earlier neutrino eclipse work has been made by calculating the actual time-profile of the neutrino flux during the solar eclipse [P:R2].

QCD

The scheme of computing for QCD with string tension mentioned earlier is now extended to computing meson and baryon wave functions in a Lorentz covariant scheme.

An application of the ideas of double scaling not in the usual scenario of Deep Inelastic Scattering but in Drell Yan process, has been attempted for the first time. Due to the constraints on the kinematic region for the validity of double scaling, double scaling may be observed in the Drell-Yan process at the Tevatron and in the ALICE detector at the Large Hadron Collider in a window of masses. In the double scaling limit of the cross section, the higher order QCD corrections are quite large, and are driven by the rise in gluon densities in the double scaling regime [P:Basu2], [P:Basu5].

The data available on the reduced cross-section in deeply inelastic e-p scattering from the H1 collaboration at HERA is used along with available data on the longitudinal structure function to deduce the nature of $dF_2/dlnQ^2$ at different Q^2 for fixed values of x near $x \sim 10^{-4}$. The results are presented in a manner which effectively isolates possible higher twist effects in the structure function F_2 [P:Basu1].

Other areas of work are inclusive hadroproduction at colliders and a study of fragmentation functions of heavy hadrons [P:I1], [P:I2].

The question of where the spin resides on a nucleon is addressed. The answer to this depends

on how one views the nucleon. Three, not necessarily mutually exclusive possibilities are discussed: apart from quarks as carriers of spin polarisation, nontrivial quantum of polarisation resides in gluons as well, and there arises a topological component that can not be measured in a deep inelastic scattering experiment. Possible experimental signatures to support each view are discussed [P:Ra1].

Quantum Field Theory, Quantum Gravity, Black Holes

A new quantum field theory is constructed, with the operation of charge conjugation drastically modified. In this new theory, the one-to-one correspondence between particle and antiparticle is replaced by a many-to-one correspondence.

Work has been done on the problem of numerically simulating lattice gauge theories in the dual formulation. After succeeding in finding efficient algorithms that are also ergodic, there is still a problem with the occurrence of configurations with negative weights. Recently a way out of this has been found and large scale simulations are beginning to be made [P:H3].

Conventional discretizations of quantum fields on a manifold M replace the latter by a lattice of points. An alternative discretization which leads to fuzzy physics treats M as a phase space and quantizes it. M is thereby altered to a 'fuzzy' manifold M_F. Using such an approach to lattice regularisation we have a fermionic field theory without the conventional doubling problem.

Arguments presented in an earlier paper, demonstrating the breakdown of global supersymmetry in Hawking radiation from a generic four dimensional black hole h in-falling massless scalar and spinor particles, are reexamined. Careful handling of the Grassmann-valued spinorial supersymmetry parameter is shown to lead to a situation wherein supersymmetry may not actually break, provided certain commutators vanish. A comparative analysis in flat spacetime at finite temperature is also presented [P:M3].

Superconformal symmetry in two-dimensional many-particle systems has been studied. It has been shown that a well known model, which describes the low energy dynamics of the $2+1$ dimensional Yang-Mills theory and has connection to different planar condensed matter systems, possess extended $N = 2$ superconformal symmetry. The spectrum as well as the underlying algebra of this model has been studied in detail. Search for similar models with extended superconformal symmetry in other dimensions is the subject of present investigation [P:G1].

The existence of ring like and knotted solitons in O(3) non-linear sigma model is analysed. The role of isotopy of knots/links in classifying such solitons is pointed out. Appearance of torus knot solitons is seen [P:Go1].

Gauge field configurations appropriate for the infrared region of QCD are proposed in a sub-manifold of $SU(3)$. Some properties of the sub-manifold are studied. Using the usual action for QCD in the absence of quarks, confinement of these configurations is realized as in the London theory of Meissner effect. Inclusion of quarks is made and confinement of quarks is realized in a similar manner. Monopole configurations, without Higg's scalar, are realized and their crucial role is elucidated. By choosing a representation for the monopole field strength, a string action corresponding to the effective gauge theory in the infrared region, is

obtained. This confining string action contains besides the Nambu-Goto area term, extrinsic curvature action and the Euler characteristic of the world sheet. Work towards realizing chiral fermions is in progress [P:P3].

A manifestly gauge invariant formulation of the coupling of the Maxwell theory th an Einstein Cartan geometry is given, where the space time torsion originates from a massless Kalb-Ramond field augmented by suitable $U(1)$ Chern Simons terms. We focus on the situation where the torsion violates parity, and relate it to proposals for gravitational parity violation [P:M4].

The entropy of the BTZ black hole is computed in the Ponzano-Regge formulation of three-dimensional lattice gravity. It is seen that the correct semi-classical behaviour of entropy is reproduced by states that correspond to all possible triangulations of the Euclidean black hole. The maximum contribution to the entropy comes from states at the horizon [P:Su1].

The study of scalar field propagation in the background of Reissner-Nordstrom (RN) black hole and the 2 dimensional dilaton black hole in the near horizon limit shows that the Hamiltonian for the evolution of the scalar field is generically non-self adjoint, but admits self adjoint extensions. These extensions can be interpreted as degrees of freedom living on the horizon of the black hole. This gives new insights in black hole physics.

The information theoretic basis of Bekenstein's formulation is briefly surveyed, and compared with Hawking's approach. The issue of calculating the entropy by actual counting of microstates is taken up next, within two currently popular approaches to quantum gravity, viz., superstring theory and canonical quantum gravity. The treatment of the former is confined to a few remarks, mainly of a critical nature, while some computational techniques of the latter approach are presented [P:Ka1], [P:M2].

Radiation from 2+1 dimensional rotating black holes (BTZ), which are solutions of 2+1 dimensional gravity with a negative cosmological constant is studied. These black holes are described by a 1+1 dimensional conformal field theory (CFT). We find that the radiation rate for fermions have a structure which can indeed be described by such a CFT. Moreover the radiation rate for fermions is exactly the same as that from a five dimensional black hole, whose near horizon geometry is the BTZ black hole [P:Da1], [P:Da2].

Scalar, fermion and vector particles propagating on a five dimensional black hole, a solution of $N = 8$ supergravity is analysed. On lifting this solution to six dimensions, it's near horizon geometry splits into a product of 2+1 dimensional BTZ black hole and a compact manifold. Near horizon geometry is probed through plane waves and the absorption coefficient of the black hole for all partial waves of the particles is determined. Using a recent conjecture, it is shown that the near horizon geometry can be replaced by a CFT. A quantum mechanical calculation, similar to that of absorption/emission of radiation by atoms is done by exciting the CFT with plane waves, and this yields the same answer for the absorption coefficient. The above results point to a microscopic structure for the black hole, encoded in a 1+1 CFT, which lies on the boundary of its near horizon geometry. This is signature of a 'holographic principle'.

The description of Schwarzschild black holes, of entropy S, within matrix theory in the regime $N \gtrsim S \gg 1$ is studied. The most general matrix theory equation of state is obtained

by requiring that black holes admit a description within this theory. It has a recognisable form in various cases. In some cases a D dimensional black hole can plausibly be thought of as a $\tilde{D} = D + 1$ dimensional black hole, described by another auxiliary matrix theory, but in its $\tilde{N} \sim S$ regime. It is found that what appears to be a matrix theory generalisation to higher dynamical branes of the normalisation of dynamical string tension, seen in other contexts. A further possible generalisation of the matrix theory equation of state is discussed. In a special case, it is governed by N^3 dynamical degrees of freedom [P:K1].

The possible gauge dependence in Matrix models of Superstrings has been investigated. This work was motivated by the findings of Kawai et al whereby they found block-block interactions in IIB Matrix models to be in agreement with IIB supergravity theories.But these being off-shell quantities depend on gauge choice in general.The general problem of gauge dependence was studied by establishing Nielsen-like Identities.The issue of gauge independent actions within these models has also been studied.Currently issues related to the measure of integration are being investigated.

String Theory

A model of (3+1) QCD was studied in an effort to understand the confinement -deconfinement transition. It has been earlier argued, based on the matrix model that the Hagedorn transition is very similar to the deconfinement transition in QCD. The new duality between Yang Mills and string, it would seem should allow a more direct comparison. It had already been shown that a confinement- deconfinement transition in N=4 supersymmetric Yang Mills could be related to the Hawking Page transition of black holes in AdS background. An analogous connection for non-supersymmetric Yang Mills should exist. It was shown that if we take the AdS_7 model and compactify on two supersymmetry breaking S^1's rather than on one supersymmetric S^1 and one supersymmetry breaking S^1 as had been done earlier we end up with a model of finite temperature QCD. Furthermore a Hagedorn-like transition in the bulk takes place at a temperature that in the boundary theory (QCD) corresponds to the string tension scale. This is the expected temperature for a confinement deconfinement transition. Thus it supports the hypothesis that the two are related. Furthermore it was found that that the actual transition takes place when the radii of the two S^1's become equal and then their roles get interchanged. Thus there is a topology changing transition in the bulk corresponding to deconfinement in the boundary theory, just as in the supersymmetric case, but the nature of the transition is different [P:K1].

At the moment there is also an effort to understand processes like black hole formation using this duality. In particular one has to understand the horizon and Hawking radiation in gauge theory terms [P:K2].

Geometrically induced flat $SO(3)$ connections on a string world sheet are used to construct a self-dual Chern-Simons system for minimal and constant mean curvature surfaces immersed in R^3. Instanton-type solutions are shown to correspond to vortex configurations. Inclusion of the third fundamental form is studied [P:P1].

By adding the Dirac action on the world sheet, an effective action is obtained by integrating over the four-dimensional fermions pulled back to the world sheet. This action consists of the Nambu-Goto area term with the right dimensionful constant in front, extrinsic curvature action, and the topological Euler characteristic term. The divergent coefficients in front

of these terms are absorbed in the rigid string action without fermions. Thus it has been shown that the inclusion of fermions will not drastically change the structure of the rigid string action except for a redefinition of the couplings. Also, the importance of inclusion of the extrinsic curvature action is realized [P:P2].

In earlier work, some aspects of finite temperature string theory using matrix models and also the AdS-CFT connection were brought out. Pursuing this theme the question arose whether one could say something concrete about the high temperature limit of matrix models. The idea is that at high temperature there is effectively a dimensional reduction (for equilibrium phenomena) as the radius of the Euclideanized and compactified time coordinate is $1/T$. Thus the BFSS matrix model which is (0+1)-dimensional becomes similar to the (0+0)-dimensional IKKT model (but without supersymmetry). The SU(2) IKKT model is known to be exactly solvable. Thus one could hope to solve the BFSS model for two D-0-branes in the high temperature limit. It was shown that it is indeed possible to solve it to get the leading behaviour of the partition function, potential and mean distance between two D-0-branes. The important point being that the result is exact in g_s, the string coupling. This result shows a confining potential between the D-0-branes [P:K4].

The loop variable approach to string theory is being pursued following earlier work. One of the physical motivations there was to relate gauge invariance in string theory to a local scale symmetry or renormalization group symmetry. It was also suggested there that a new space-time coordinate that had to be formally introduced in order to understand gauge invariance could be interpreted as the *scale* of space-time. In the AdS-CFT correspondence the radial coordinate has precisely such an interpretation! Thus there is additional motivation to pursue this approach.

The study of D-branes wrapped around supersymmetric cycles in Calabi-Yau manifolds begun earlier was continued. A N=2 supersymmetric Landau-Ginzburg model on a world-sheet with boundary was shown to give a description of D-branes wrapped on supersymmetric cycles. The appropriate boundary conditions on the LG fields for different geometric situations were identified. In the case of middle-dimensional cycles a more detailed comparison showed that the LG description was equivalent to a description in terms of a boundary conformal field theory constructed from a tensor product of boundary N=2 superconformal minimal models. The case of compactifications on a 2-torus was used as a toy model for studying such constructions in detail. For closed strings Witten showed that the LG description was equivalent to a non-linear sigma model formulation strings on Calabi-Yau manifolds when the Kahler class was continued to negative values. This description was extended to the case of D0-branes, i.e. when all the LG fields obeyed Dirichlet boundary conditions [P:Ja1].

The holographic principle is applied during the inflationary stage of our universe. Where necessary, the analysis in the case of new and extended inflation which, together, typify generic models of inflation, is investigated. It is found that in the models of extended inflation type, and perhaps of new inflation type also, the holographic principle leads to a lower bound on the density fluctuations [P:K3].

The holographic principle, applied to cosmology according to the Fischler-Susskind proposal, appears to rule out closed universes as being inconsistent; or, requires that a new behaviour must set in. This issue is studied by considering the closed universes which in reality contains more than one type of matter. It is found that the closed universe is indeed consistent with

the holographic principle if it includes "quintessence" (matter with negative pressure, about which there has recently been an enormous interest due to the discovery that the universe is accelerating at present), and if the total density at present is close to the critical density [P:K4].

2.1.3 Theoretical Computer Science

Algorithms and Complexity Theory

A combinatorial algorithm for computing the pfaffian of a skew-symmetric integer matrix was discovered. This algorithm lies in the complexity class GapL, improving the earlier known containment in NC. Also, it was shown that given reasonable encodings of planar graphs, a pfaffian orientation can be found in logspace. This then implies that counting the number of perfect matchings in a planar graph is in GapL [T:M2].

Program checking using constant-depth (i.e. AC^0) circuits as checkers, which essentially model constant time parallel checkers, was studied. The focus was on *query complexity*, i.e. the number of queries made by the checker to the program being checked for the given problem. The query complexity of deterministic and randomized AC^0 checkers for complete problems for P and NC^1 were studied and it is shown that for input size n and for each $\epsilon > 0$, $\Omega(n^{1-\epsilon})$ lower bounds the query complexity of deterministic AC^0 checkers. It is also shown that these problems have randomized AC^0 checkers of constant query complexity. The latter results are proved using techniques from the proof of the PCP theorem.

Data Structures

The succinct representation (reported in an earlier report) for binary trees is extended in several directions. Several space efficient representations for suffix trees (for a text of length n over a fixed alphabet) were obtained resulting in a structure that takes $\frac{n}{2}\lg n + O(n)$ bits, and another structure taking $n\lceil\lg n\rceil + o(n)$ bits while supporting searches for a pattern of length m in $O(m)$ time. A structure that takes $o(n \lg n)$ bits that can simply answer the decision question of whether or not a pattern exists in the text in $O(m)$ time is also obtained [T:RS].

A succinct representation for an ordered m-ary tree taking $2n + n\lceil\lg m\rceil + o(n)$ bits in which all navigational operations at a node except 'to go to a node labeled i' can be performed in constant time is obtained. At any node, visiting the node labeled i if exists, for any i, can be performed in $O(\lg \lg m)$ time in the structure [T:R1].

Distributed Systems - Automata and Logics

The earlier study of regular languages over series-parallel posets is continued. A new parallel iteration operation gave the proof of a Kleene theorem. It is also shown that recognizability is strictly weaker than regularity [T:L].

Some progress has been made in understanding the problem of automatic synthesis of controllers for discrete event systems, with regard to branching time specifications. The natural extension is to try and extend our work to handle specifications written in branching-time

logics such as CTL and CTL^*. This question has been answered using automata-theoretic methods.

Some progress has been made in the other direction of the distributed controller synthesis problem. A reasonable formalization of the problem and a framework to discuss this problem have been proposed.

A detailed study of product spaces and different classes of languages over them was undertaken.

A notion of *view-based knowledge* has been proposed, referring to knowledge which is computed by an agent in a distributed system with partial visibility of system states. In the associated logic, each formula is interpreted over a class of Kripke structures, and hence the model checking algorithm for the logic needs to work with many sub-models of a given model. The logic has been shown to be elementarily decidable [T:Rm1], and a complete axiomatization of the valid formulas has been obtained [T:Rm2].

Finite Model Theory

The result that, on a class of finite structures LFP admits unbounded induction if and only if $L^{\omega}_{\infty,\omega} = FO$ on this class, is known as McColm's second conjecture in the finite model theory literature. We show that McColm's second conjecture does not hold in the presence of arbitrary generalized quantifiers. Further, there is a PTIME quantifier for which this conjecture does not hold. The same construction shows that the notions of boundedness and uniform boundedness are different for $IFP^2(Q)$, the two variable fragment of $IFP(Q)$. It also follows from the same construction that a ramified version of the McColm's first conjecture does not hold with generalized quantifiers. More technically our results can be stated as follows. There is a class C of finite structures and a PTIME quantifier Q such that

1. $IFP(Q)$ is bounded on C but $L^{\omega}_{\infty,\omega}(Q) \neq FO(Q)$ over C.
2. For all $k \geq 2$, $IFP^k(Q)$ is bounded but not uniformly bounded over C.
3. For all $k \geq 2$, $IFP^k(Q)$ is not uniformly bounded over C but $IFP^k(Q) = L^k(Q)$ over C.

On the other hand, we show that the ramified version of McColm's second conjecture does hold with arbitrary finitely many generalized quantifiers also.

A study on "Semi-deterministic extensions of fixed point logic" was carried out.

2.2 Publications

The following conventions have been adopted in the following list of publications: firstly, names of (co)authors who are not members of the Institute have been marked with a superscript *; secondly, in order to facilitate cross-referencing between this list and the 'summary of research' in §2.1, all entries in this list have been given a label and finally, the entries are listed according to the alphabetical order of their labels.

2.2.1 Mathematics

[**M:Ba1**]
Arasu, K. T.*, **Balasubramanian, R. and Evans, A. B.***
A new family of nested row column designs,
J. Comb. Maths. and Comb. Computing, **29** (1999), 139 - 144.

[**M:Ba2**]
Balasubramanian, R. and Ponnusamy, S.*
Applications of duality principle to integral transforms of analytic functions,
Complex Variables, **38** (1999), 289 - 305.

[**M:B1**]
Biswas, J. and Srinivas, V.*
The Chow ring of a singular surface,
Proc. Acad. Sci. Math. Sci, **108**, No. 3 (1998), 227 - 249.

[**M:B2**]
Biswas, J. and Srinivas, V.*
Roitman's theorem for singular varieties.
To appear in *Compositio Mathematica*.

[**M:B3**]
Biswas, J. and Srinivas, V.*
A Lefschetz (1,1) theorem for normal projective complex varities.
To appear in *Duke Mathematical Journal*.

[**M:Ke1**]
Kesavan, S.
Listening to the shape of a drum: I. The mathematics of vibrating drums,
Resonance, **3**, No. 9 (1998), 26 - 34.

[**M:Ke2**]
Kesavan, S.
Listening to the shape of a drum: II. You cannot hear the shape of a drum,
Resonance, **3**, No. 10 (1998), 49 - 57.

[M:Ke3]
Kesavan, S.
Isoperimetric inequalities in partial differential equations.
To appear in the Proceedings of the National Academy of Sciences, Allahabad.

[M:Ke4]
Grossi, M.*, Kesavan, S., Pacella, F.* and Ramaswamy, M.*
Symmetry of positive solutions of some nonlinear equations,
Topological methods in Nonlinear Analysis, **12** (1998), 47 - 59.

[M:Ke5]
Kesavan, S. and Pacella, F.*
Symmetry of solutions of a system of semilinear elliptic equations,
Advances in Mathematical Sciences and Applications, **9**, No. 1 (1999), 361 - 369.

[M:Ke6]
Kesavan, S. and Saint Jean Paulin, J.*
Optimal control on perforated domains,
J. Math. Anal. Appl., **229** (1999), pp. 563 - 586.

[M:KeS]
Kesavan, S. and Sabu, N.
Two- dimensional approximation of eigenvalue problems in shell theory: Flexural Shells.
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2.3 Conferences/Workshops Held at IMSc

2.3.1 Nobel Lectures

A mini-symposium was held in the Chandrasekhar Hall of IMSc on November 2, 1998 to describe this year's Nobel Prize winning work in the fields of Physics, Chemistry and Medical Sciences. The following were the talks in the mini-symposium.

- **M.S. Gopinathan**, Indian Institute of Technology, Madras
  On the Density Functional Theory and Computational Methods in Quantum Chemistry.
- **A. Namasivayam**, Dr. A.L.M. PG Inst. for Basic Medical Sciences
  On the Role of Nitric Oxide as a signaling Molecule in the Cardiovascular System.
- **G. Baskaran**, Institute of Mathematical Sciences, Chennai.
  On the Discovery of a New Form of Quantum Fluid with Fractionally Charged Excitations.

D. Indumathi coordinated the talks of the mini-symposium.

2.3.2 UNESCO Training Program in Mathematics

As part of their efforts to support higher education in the areas of science in developing countries, UNESCO requested IMSc to conduct a training programme in Mathematics for college teachers from the South Central Asian Region. Accordingly such a programme was conducted at the Institute from November 9 to 21, 1998. This programme was coordinated by M. Krishna (IMSc).

Out of the 19 participants selected for this programme, 8 were from outside India, 2 were from Chennai and the rest were from India, outside Chennai. Some of the participants also could not come owing to last minute workload at their respective university departments.

The inaugural session of the programme was held on the November 9, 1998. The programme began with a welcome of the participants by Prof. G. Bhaskaran on behalf of the Director. The programme was inaugurated by Prof. P. T. Manoharan, Vice Chancellor of the University of Madras.

Academic Programme : Main Lectures

There were four lecture courses taught by the Faculty of the Institute of Mathematical Sciences. These were

- *Differential Geometry*
  K. Paranjape
- *Differential Equations*
  M. Krishna
- *Algebra*
  D. S. Nagaraj

- *Number Theory*
  R. Balasubramanian

In addition to the lectures cited above, K. Srinivas of IMSc conducted a few problem sessions in Number Theory for the benefit of the participants.

The participants were given the following books in the above subjects.

- *Differential Equations,* by Martin Brown, Springer-Verlag.
- *Differential Geometry,* by Nirmala Prakash, Tata McGraw Hill
- *Number Theory,* by T. Apostol, Springer-Verlag.
- *Algebra,* by M. Artin, Prentice Hall India.

Special Lectures

There were special lectures in the afternoon of each day and the speakers were chosen from the Universities and Institutes other than IMSc in Chennai. Listed below are the titles of those talks.

- *Divergent Series*
  M. S. Rangachari, (Retired) Ramanujam Institute of Advanced Study, Chennai
- *Time Series Analysis*
  M. Srinivasan, Anna University, Chennai
- *Ill Posed Problems and Their Regularization*
  M. Tamban Nair, Indian Institute of Technology, Chennai
- *Exact Solutions of Non-Linear Evolution Equations*
  R. Sahadevan, Ramanujam Institute of Advanced Study, Chennai
- *Discrete Dynamics and Applications to Neural Networks*
  K. Viswanath, Central University of Hyderabad, Hyderabad
- *Composition Algebras*
  S. Sribala, Ramanujam Institute of Advanced Study, Chennai
- *Chebyshev Polynomials*
  V. Kannan, Central University of Hyderabad, Hyderabad
- *Countably Infinite Simple Groups*
  P. Sankaran, Chennai Mathematical Institute, Chennai
- *Galois Theory*
  T. Soundararajan, Madurai Kamaraj University, Madurai
- *Heisenberg Group*
  V. Muruganandam, Pondicherry University, Pondicherry

The participants also had unlimited use of the library and computing facilities of the Institute and they could Xerox some research and teaching material that they needed from the library.

There was a brief valedictory function at 11:30 am on November 21, 1998, when the Director of IMSc, Prof. R. Ramachandran, presented participation certificates to the participants of the programme.

2.3.3 QCD Meeting at IMSc

IMSc hosted QCD'98 Workshop in Chennai from November 30 to December 8, 1998. It was organised by Ramesh Anishetty (convener), Rahul Basu, N. D. Hari Dass, D. Indumathi, M.V.N. Murthy, R. Parthasarathy, G. Rajasekaran, R. Ramachandran, and H. S. Sharatchandra.

Every person who either contributed or was interested in contributing to research in QCD in India was invited. About 65 candidates participated including about 20 post-doctoral fellows and students. All major activities in the country were covered at a level which could appeal to active post-doctoral fellows. The discussions were intense and the pace was sufficiently slow so that people appreciated the efforts of their colleagues in a more critical manner. Many students and post doctoral fellows expressed their thanks for having been exposed to so many varying theoretical ideas in a meaningful manner. The organizers compiled the transparencies of all the talks (plenary and parallel) and bound them into three volumes. This is available at the Institute library.

The talks at this workshop were divided into three broad categories, namely, structure functions and deep inelastic scattering, formal QCD including non-perturbative techniques and finite temperature field theory and quark gluon plasma. The talks are listed below.

- *Recent advances in light–front QCD*
  A. Harindranath, SINP
- *Role of orbital angular momentum in nucleonic spin structure*
  Rajen Kundu, SINP
- *Twist-four longitudinal structure function in light-front QCD*
  Asmita Mukherjee, SINP
- *Nucleon structure functions*
  V. Devanathan, Madras Univ. (Retd).
- *Deep inelastic scattering: an overview*
  D. Indumathi, IMSc
- *Nonsinglet structure functions at high Q^2 and low x and ν scattering*
  Atri Deshmukhya, Gauhati Univ.
- *A solution of DGLAP Equation for gluons at low x*
  Paban Kr. Sahariah, Gauhati Univ.
- *Nonleptonic Λ_b decays in HQET*
  Rukmani Mohanta, Panjab Univ.

- *Nonleptonic B decays into p-wave charmed mesons*
  Anjan Kumar Giri, Panjab Univ.

- *Dispersive bounds on the shape of $\Lambda_b \to \Lambda_c l \bar{\nu}_l$ form factors*
  Debrupa Chakraverty, SINP

- *A QCD approach to determination of heavy meson masses*
  J. P. Singh, MS Univ., Baroda

- *Isgur-Wise functions in a QCD-inspired quark model*
  Namita Bordoloi, Gauhati Univ.

- *Local duality and isotopic mass splittings in non-leptonic B-decays*
  S. Arunagiri, Madras Univ.

- *QCD strings and extrinsic geometry*
  R. Parthasarathy, IMSc

- *QCD from string theory*
  Balachandran Sathiapalan, IMSc

- *Perturbative QCD with string tension*
  Ramesh Anishetty, IMSc

- *Topological centres and computation of confinement properties*
  H.S.Sharatchandra, IMSc

- *Dual gluons and monopoles in 2+1 Yang Mills theory*
  Pushan Majumdar, IMSc

- *Novel abelian projection in QCD*
  Manu Mathur, SN Bose Centre

- *Heavy flavour baryons in chiral soliton models*
  M.S. Sriram, Madras Univ.

- *Chiral perturbation theory and pi–pi scattering: review and recent results*
  B. Anantanarayan, CTS, IISc

- *Two topics in SU(2) heavy baryon chiral perturbation theory*
  Aalok Misra, IIT (Kanpur)

- *Compositeness and elementarity in strong interactions: Can a non-asymptotically free field theory become asymptotically free ?*
  Vikram Soni

- *Aspects of cohomology in non-abelian gauge theory*
  Rudra Prakash Malik, SN Bose Centre

- *The structure of finite temperature QCD*
  Sourendu Gupta, TIFR

- *J/ψ suppression in nuclear collisions*
  Rajiv Gavai, TIFR

- *Properties and signals of QGP: Current trends*
  C.P. Singh, BHU
- *Thermal QCD Sum Rules*
  S. Mallik
- *Thermal QCD sum rules: an estimate of the temperature dependence of the resonance parameters in the vector meson channel*
  Krishnendu Mukherjee, SINP
- *Are there quark stars ?*
  Jishnu Dey, Maulana Azad College, Calcutta
- *Phase transitions in lattice gauge theories*
  Srinath Cheluvaraja, TIFR
- *Hadron properties in medium and extreme conditions*
  J. Pasupathy, CTS, IISc
- *Chiral symmetry and lattice fermions*
  Asit K. De, SINP
- *Phenomenology from Lattice QCD*
  Rajan Gupta
- *Perturbative color transparency*
  Bijoy Kundu, IIT (Kanpur)
- *Rho-omega mixing in the hot and dense medium*
  Abhijit Bhattacharyya, VECC

2.3.4 FST&TCS

FST & TCS (Foundations of Software Technology and Theoretical Computer Science) is an annual international conference organized by the research community in theoretical computer science (TCS) in India. The 18^{th} conference in this series was held at Chennai from December 17 to 19, 1998 and was organized by IMSc. V. Arvind and R. Ramanujam co-chaired the Programme Committee and Meena Mahajan co-chaired the Organizing Committee (with Madhavan Mukund, Chennai Mathematical Institute).

The conference had 93 submissions (from 25 countries), which were evaluated by at least three reviewers for each paper, and an international programme committee finally selected 28 papers (from 11 countries) for presentation at the conference. In addition, the conference had two *theme sessions*, on Model checking and on Quantum computation. Rajeev Alur (Univ. of Pennsylvania, USA), Neil Immerman (Univ of Massachusetts, USA), Kenneth L. McMillan (Cadence Berkeley Labs, USA), John H. Reif (Duke Univ, USA), Erik Meineche Schmidt (University of Aarhus, Denmark) and Umesh Vazirani (Univ. of California at Berkeley, USA) gave invited plenary talks. The conference had a total of 144 registered participants, out of whom 43 were from outside India, and 56 were graduate students.

The conference included satellite events in the form of two pre-conference workshops, one on Molecular Computation (IIT, Madras, December 14 and 15, 1998), and one on Finite model

theory (IMSc, December 15 and 16, 1998), which had 65 and 72 participants, respectively. (A separate report gives details of the Finite model theory workshop.)

2.3.5 School on Finite Model Theory

This school, supported by the NBHM, was conducted at the Institute of Mathematical Sciences, Chennai, on the 15th and 16th of December 1998. It was jointly organized by Anil Seth (IMSc) and Anuj Dawar (University of Cambridge, UK). The School was a satellite event to the conference FST&TCS 1998 and depended heavily for its local arrangements on local organizers of the conference.

A total of 72 participants attended the School including 31 students, with 17 of the participants from outside India.

There were seven invited talks in the School given by eminent scientists from all over the world. All the invited speakers contributed write-ups which formed the basis of their talks. These were collated into Notes for the School, and the Notes were distributed to all participants.

The talks given were as follows:

- *Introduction to Finite Model Theory*
  Anil Seth , Institute of Mathematical Sciences, Chennai

- *Logics that Capture Complexity Classes*
  Neil Immerman, University of Massachusetts at Amherst

- *Finite Variable Logics*
  Anuj Dawar, University of Wales, Swansea

- *Graph Structure Theory and Descriptive Complexity*
  Martin Grohe, University of Freiburg

- *Monadic Logic and Finite-state Acceptors over Finite Graphs*
  Wolfgang Thomas, University of Aachen

- *Temporal Logic – Finite-Model Theory vs. Automata Theory*
  Moshe Vardi, Rice University, Texas

- *Databases and Finite-Model Theory*
  Victor Vianu, University of California, San Diego

- *Panel Discussion: New Applications of Finite-Model Theory*
  Moderator: Anuj Dawar, University of Wales, Swansea

Overall, the response has been quite heartening, and the feedback received from the participants points to the School having served a useful and much-required role.

2.3.6 Fields Medal Lectures

A mini-symposium was held at the Institute on January 21, 1999 to present the mathematical work of the Fields Medallists of 1998. The following lectures were delivered:

- *The work of R. E. Borcherds* by **P. Sankaran**, CMI, Chennai
- *The work of M. Kontsevich* by **K. H. Paranjape**, IMSc, Chennai
- *The work of C. T. McMullen* by **P. A. Gastesi**, TIFR, Mumbai
- *The work of W. T. Gowers* by **S. Kesavan**, IMSc, Chennai

Each lecture was about 40 minutes' duration and was aimed at presenting the work in a manner understandable to a general scientific audience. R. Balasubramanian coordinated the talks of the mini-symposium.

2.3.7 Annual Seminar Week

The Annual Seminar Meeting involving all the academic members of the Institute was held from February 15 to 19, 1999. The purpose of such a meeting was to provide a forum where people from all the disciplines could get an idea of what their colleagues are working on. A total of 42 talks were given by 27 faculty members, 6 post-doctoral fellows and 9 students (Physics 25, Mathematics 9, Theoretical Computer Science 7, and general 1). To promote greater interaction between disciplines each session had talks from all disciplines. All the talks were well attended. This year, Meena Mahajan coordinated the meeting. The following is a list of talks during the three days.

- **G. Rajasekaran**
  Neutrino physics: an overview
- **M. Krishna**
  Some random self-adjoint operators
- **V. Arvind**
  De-randomizing Arthur-Merlin games
- **Ghanashyam Date**
  Particle clusters in two dimensions
- **Purusattam Ray**
  2D Potts model: In the presence of random fields
- **Shreedhar P. Inamdar**
  Cycles in smooth quadrics
- **Gautam I. Menon**
  Molecular Brownian motors
- **N. D. Hari Dass**
  Gauge invariant effective actions

- **V. Kamakoti**
  Computational geometry

- **Mitaxi Mehta**
  Phase-space survivors in some area preserving maps

- **M. Rajesh**
  A result in the homogenization of an optimal control problem

- **Anil Seth**
  Ordering finite variable types with generalized quantifiers

- **Arundhati Dasgupta**
  Black holes in string theory

- **Suneeta Vardarajan**
  Understanding black hole entropy in lower dimensions

- **N. Sabu**
  Two dimensional approximation of eigenvalue problem in flexural shell theory

- **R. Sridhar**
  Superfluidity in Helium-4 clusters

- **K. Srinivasa Rao**
  Group theory of transformations

- **S. V. Nagaraj**
  Algorithmic number theory

- **D. Suryaramana**
  An elementary proof of Atkin's theorem on psuedosquares

- **K. Srinivas**
  On the difference between consecutive zeroes of the zeta functions

- **R. Ramanujam**
  Assigning meanings to messages

- **T. Jayaraman**
  String theory solitons in curved spaces – I

- **Tapobrata Sarkar**
  String theory solitons in curved spaces – II

- **Parthasarathi Majumdar**
  Aspects of supersymmetry breaking

- **S. Kesavan**
  Geometric properties of solutions of PDE

- **Kamal Lodaya**
  Non-associativity, or counting with your fingers

- **Rahul Sinha**
  CP violation: new physics with beauty
- **Nita Sinha**
  Mesons from correlated $B^0\overline{B^0}$ pairs
- **Venkatesh Raman**
  Space efficient suffix trees
- **Jishnu Biswas**
  Algebraic cycles - a theorem of Roitman
- **Rahul Basu and D. Indumathi**
  Three quarks for Muster Mark (An overview of perturbative QCD)
- **G. Manoj**
  Dynamic scaling in the spatial distribution of persistent sites
- **V. Kamakoti**
  Economic high performance computing initiative at IMSc
- **R. Parthasarathy**
  Infrared region of QCD and confinement
- **H. S. Sharatchandra**
  Topological centres of gauge fields and quark confinement
- **Vijay Kodiyalam**
  Bases for representations of semi-simple Lie algebras
- **R. Jagannathan**
  A Brief introduction to quantum groups
- **Subhasis Sinha**
  Collective excitations in Bose-Einstein condensate
- **Radha Balakrishnan**
  Spatial chaos in a spin chain
- **Kalyana Rama**
  Holographic principle and cosmology
- **Rathin Adhikari**
  Neutrino oscillation experiments and supersymmetry

2.3.8 National Science Day

National Science Day is observed on 28th February. At IMSc, the day was marked by a series of programmes targeted at students pursuing Bachelor's and Master's degrees in any of the science disciplines. An informative and fun-filled scientific programme for the day was planned. The programme was attended by about 60 students from science colleges in the city, and by several members of the Institute. This year, the programme was coordinated by V. Kamakoti, S. Kesavan and M. V. N. Murthy.

A major highlight of the programme was the **Science Quiz**. This quiz, which has become an annual feature of the National Science Day programme at IMSc, challenges the participants to find the scientific explanations behind phenomena we observe routinely in day-to-day life. It also probes their mathematical understanding and examines their appreciation of the bio-sciences. Some 23 teams (of two each) from local science colleges in Chennai participated in the Science Quiz. The first prize was won by the team from The Chennai Mathematical Institute (CMI).

Another exciting event of the day was the slide show/ lecture by Prof. N. D. Hari Dass (IMSc) on the "Birth and Death of stars". In another session, members of the Institute described briefly the research work pursued at IMSc. D. Indumathi talked on 'How does the Sun burn ?', B. Meenakshi talked about the Verification of finite state programs and K. Srinivas gave a talk on Number Theory and Cryptography. There was also a demonstration of how computers and the Internet provide an exciting and indispensable tool in research and education. The students visited an exhibition of posters depicting the various aspects of work done in the Institute and also posters on the life and works of the mathematician, Srinivasa Ramanujan.

The programme concluded with a special lecture by Prof. C. R. Muthukrishnan, Deputy Director of the IIT Chennai, on *Paradigms in Computing*. Prof. Muthukrishnan then gave away the prizes to the winners of the science quiz.

2.3.9 Orientation Course in Theoretical Computer Science

An *orientation course* on Foundational Aspects of Computer Science for College/University Teachers was organized at IMSc by the TCS group from May 24, 1999 to June 12, 1999. It was attended by 31 participants, 24 of whom were teachers from Universities and Colleges, largely from Tamil Nadu and Andhra Pradesh. The course included lectures in Data structures and algorithms, Automata theory and computability, Principles of programming languages, and Principles of parallel and distributed computing. R. Ramanujam coordinated the activities. Apart from IMSc faculty members, Prof. S. Arun-Kumar (IIT, Delhi), Dr. V. Kamakoti (ATI Research, Chennai) and Dr. K.V. Subrahmanyam (CMI, Chennai) gave lectures in the course. Participants attended lectures and solved assigned problems as well as worked on projects in groups.

2.3.10 Cluster Supercomputer Meeting

A meeting of interested persons from various institutes was organised from July 17 to 21, 1999 to discuss ways and means of making the use of our cluster supercomputer more efficient and user-friendly. Participants came from RRI, IISc, SINP, TIFR, Pune University and locally from Anna University and IIT Madras. A set of lectures was organised for the participants for the first two days. These were meant to familiarise them with our cluster as well as introduce them to relevant parallelising software like MPI, LAM, etc. and were delivered by Dr. V. Kamakoti (AIT Research) and G. Date. The rest of the time was spent by the participants in attempting to parallelise and run their programs on our cluster.

The meeting was beneficial both for the Institute as well as for the participants. It provided the participants a forum to experiment with parallelising programs and running them and it gave the Institute an opportunity to clean up various small bugs, and make the cluster more

efficient and usable for the general user, based on the input received from the participants.

It is expected that we would have more such informal meetings in the future to enable more interested participants to come and gain experience in parallel computing. In particular, participants from BARC, Mumbai and IGCAR, Kalpakkam, who have expressed a lot of interest in this cluster but who could not make it to this meeting due to prior commitments, would come and use the cluster for their purposes.

2.4 Other Conferences/Workshops Organized by IMSc

2.4.1 QCD Meet

IMSc organized a QCD meeting at Ooty from September 26 to October 4, 1998. This meeting was coordinated by R. Anishetty and H. Sharatchandra. All active researchers in India were invited to discuss current issues of their interest in greater depth. About ten people from IMSc and IISc participated in the meeting. NCRA was responsible for the hospitality of the participants at their Radio Astronomy centre in Ooty. In this session, the organizational issues for QCD 98 and other proposed meetings in the country were also discussed.

2.4.2 III Puri Workshop on Quantum Field Theory, Quantum Gravity and Strings

This workshop, held from December 9 to 19, 1998, was the third in an ongoing series of workshops held every two years at Puri, Orissa, India on fundamental issues in particle physics and quantum gravity. It is jointly organised by five premier research institutes of the country viz., Mehta Research Institute, Allahabad, Institute of Physics, Bhubaneswar, Saha Institute for Nuclear Physics, Calcutta, Institute of Mathematical Sciences, Chennai and Tata Institute of Fundamental Research, Mumbai.

The workshop was also partially supported by The Abdus Salam International center for Theoretical Physics, Trieste and Sir Dorabjee Tata Trust, Mumbai.

The National Organising Committee consisted of D. Jatkar and S. Panda from MRI, Allahabad, A. Khare and J. Maharana (Secretary) from IOP, Bhubaneshwar, P. Mitra and B. Sinha from SINP, Calcutta, T.R. Govindarajan, R. Kaul (Convenor) and B. Sathiapalan from IMSc. Chennai and S. Das, S. Mukhi and S. Wadia from TIFR, Mumbai.

The purpose of this series of workshops is to bring together eminent theoretical physicists to discuss important subjects of contemporary research interest. A large number of active researchers from various research institutes and the universities are also invited to participate in these workshops. The first two workshops held at Puri in December 1994 and December 1996 have been extremely successful. Many well known theoretical physicists from within the country and abroad attended these workshops and presented their works.

The third workshop focused on issues in the following frontier areas: *supersymmetry and supergravity, strings, branes, M-F theory, quantum gravity, black hole physics, cosmology, stringy phenomenology and non-commutative geometry.*

2.4.3 Discussion Meeting on Spatiotemporal Physics

A discussion meeting on spatiotemporal physics, with accent on problems of control and synchronisation in complex systems, was hosted by IMSc at the Radio Astronomy Centre of Ooty, from February 25 to 27, 1999. The participants included active researchers in the field from Chennai (with three participants from IMSc, three from IIT and one from Anna University), IISc/JNC Bangalore, JNU Delhi and PRL Ahmedabad. The meeting was organized by Sudeshna Sinha (IMSc) and Neelima Gupte (IIT Chennai).
The topics included: small-world networks, neural network models for apparent chaotic behavior of brain slices, parameter estimations using synchronization and adaptive control, signal transmission applications using compound chaotic signal, synchronization and control in strange non-chaotic systems, chaotic dynamics in excitatory-inhibitory neural networks and its applications in sensory information processing, spirals in excitable media, defibrillation strategies in a model of cardiac arrest, spatial chaos in the classical spin chain, phase-space survivors in area preserving maps and quantum revivals and classical recurrences. The talks are listed below.

- *Small-world networks*
  R.E. Amritkar
- *Relaxation oscillations, mixed mode oscillations and incomplete approach to homoclinicity*
  G. Ananthakrishna
- *Field-induced transitions and spatial chaos in the classical XY spin chain*
  Radha Balakrishnan
- *Quantum revivals and classical recurrences*
  S. Seshadri, S. Lakshmibala and V. Balakrishnan
- *A Stochastic neural network model for apparent chaotic behavior of brain slices*
  C. Dasgupta
- *Parameter estimation from a time series by synchronization and adaptive control*
  Anil Maybhate
- *Phase-space survivors in some area preserving maps and their physical implications*
  Mitaxi Mehta
- *Signal transmission applications using compound chaotic signal*
  K. Murali
- *Spirals in excitable media*
  Ashwin Pande and Rahul Pandit
- *Synchronization and control in strange non-chaotic systems*
  Ramakrishna Ramaswamy
- *Chaotic dynamics in excitatory-inhibitory neural networks and its applications in sensory information processing*
  Sitabhra Sinha
- *Death and the (Iron) Maiden: defibrillation strategies in a model of cardiac arrest*
  Ashwin Pande, Sitabhra Sinha and Rahul Pandit

2.5 Participation in ISC'99

After the Institute of Mathematical Sciences came into being, in 1962, the Indian Science Congress came to the city of Chennai for the first time this year, after a gap of 41 years. Following is a report of the Institute's participation in the 86th Indian Science Congress, January 3 to 7, 1999 (ISC'99) and Indian Science Congress Exhibition, January 3 to 8, 1999 (ISCE'99).

86th Indian Science Congress (ISC'99)

The Programme of the Indian Science Congress consisted of Symposiums, Special Lectures and Invited Lectures. The Focal Theme of the 86th ISC'99 was *New Biosciences: Opportunities and challenges as we move into the next millennium.* There were several sections, and the late Subhashis Nag of IMSc was the Local Sectional Secretary for the Mathematics Section, and he had contributed to the organization of the Academic Programme. K. Srinivasa Rao of IMSc was one of the local Sectional Secretaries. Kapil Paranjape and K. Srinivasa Rao gave special invited lectures. Several faculty and students of IMSc participated in some of the sectional meetings.

Indian Science Congress Exhibition (ISCE'99)

The Exhibitions are an addition to the annual ISC meetings for the past few years and have been a source of major attraction to the public. There were in all about 100 exhibitors and IMSc had three stalls in the ISCE'99 and these were:

- The Institute of Mathematical Sciences
- πie Pavilion and Pilot CD on Ramanujan
- Ramanujan Museum (Replica of the one at Royapuram)

The Institute of Mathematical Sciences

Around 40 posters explaining in detail, the areas of research in all the three disciplines (Mathematics, Physics and Theoretical Computer Science) occupied the IMSc stall in the exhibition. The posters were expository in nature and they attracted several school and college students.

πie Pavilion and Pilot CD on Ramanujan

This project was born out of an idea mooted by K. Srinivasa Rao. of having a π-Room, like the one in Paris, in a Museum, to house the original Notebooks of Srinivasa Ramanujan This project supported by the Department of Science and Technology, had K. Srinivasa Rao and R. Jagannathan as its coordinators. A 12 ft. diameter, 2 ft. deep, wooden, cylindrical structure was designed to display on its inside surface about 404 digits of the transcendental number π. The cylinder made was erected on four wooden pillars, and about 40 posters depicting the story of π and e, related through the equation: $e^{i\pi} + 1 = 0$ and a brief history of π, i and e were put up in the stall. The largest poster was one that depicted the first 2000 digits of the transcendental number e. The contributions of the Indian mathematicians, Euler, Gauss, Jacobi and the several formulae of Ramanujan including his 17 infinite series

representations were highlighted. Two posters of the Gateway Arch of St. Louis exemplified the catenary. The punch line of the Pavilion was *Never Say,* $\pi = 22/7$*, Never Again*!

The coordinators were assisted by the Library staff, in particular, and G. Subramoniam of the Institute. Two students: K. Madhu and Santhosh Kumar of IMSc helped in the making of a few posters. Volunteers to explain to the teeming visitors were organized by K. Srinivasa Rao and they were students of Anna University and teachers of Kavi Bharathi Vidyalaya.

The Pilot CD on Srinivasa Ramanujan was a multimedia presentation of a brief history of the life of Ramanujan, with some of the available pictures. The story of the taxi cab number and animated presentation of the nested roots formula for the number 3, were added to the interactive narration of the life of the mathematical genius. The preparation of the text for this from Chapter 1 of the book of K. Srinivasa Rao was first made in html files and the former mathematics student I. Suresh of the Institute helped in this project. The final multimedia presentation for the CD was made with the help of a team of professionals at NIIT, Delhi, coordinated by Dr. S.N. Uma of NIIT, Chennai.

Ramanujan Museum (Replica)

A Ramanujan Museum was created in 1993 in the premises of the Avvai Academy by the dedicated mathematics teacher Mr. P.K. Srinivasan. The idea of making a replica of this Museum was included as a part of the DST Project by K. Srinivasa Rao and R. Jagannathan. The posters depict mostly the number patterns observed/discovered by Ramanujan and contained in his famous Notebooks. The Replica recreates these posters as laminated photo enlargements of the originals. Thanks to Mr. W. Narayanan – foster son of the late Mrs. Janakiammal Ramanujan – a copy of the bronze bust of Ramanujan made by the renowned sculptor Paul Granlund presented in 1984 to Mrs. Ramanujan and the original passport of Ramanujan were displayed, in specially made display cabinets, along with the Notebooks (facsimile editions) of Ramanujan.

The enthusiastic and whole-hearted cooperation of Mr. P.K. Srinivasan, as a Resource Person and a volunteer to the NCSC'98 and the ISCE'99 contributed to the success of the whole project. Mr. A.T.B. Bose, Secretary of the Avvai Academy, organised the preparation and erection of the banners for the ISCE'99. Ms. Nirmala took part in the NCSC'98 and displayed the publications of the Mathematics Education Center of the Avvai Academy, especially during the NCSC'98.

Several dignitaries visited the πie Pavilion and the project received wide appreciation.

The PIE Pavilion and the Ramanujan Museum (Replica) were fused into a Ramanujan Gallery, by K. Srinivasa Rao, after the ISCE'99 and the Gallery was inaugurated by Ms. C.K. Gariyali, I.A.S., Vice Chairperson, Science City and dedicated to the public at the Periyar Science and Technology Center, in Kotturpuram, Chennai, on Science Day, February. 28, 1999. This brief function was presided over by Prof. R. Ramachandran, Director, IMSc.

The DST further provided funds (Rs. 50,000/-) to set up a Ramanujan Photo Gallery by the side of the Ramanujan Gallery in the PSTC. Work on this Photo Gallery, which consists of about 110 laminated photographs pertaining to the life and work of Ramanujan, was com-

pleted by K. Srinivasa Rao, with the help of Mr. A.T.B. Bose of the Ramanujan Museum, Royapuram, and opened to the public from the end of June 1999.

ISC'99 was preceded by the National Children's Science Congress (NCSC) at Anna University, in which the πie pavilion and the replica of Ramanujan Museum described earlier were exhibited. Several faculty members and students from IMSc participated in NCSC, as reviewers of children's projects, or as speakers in science lecture sessions.

2.6 Seminars

Seminars held at IMSc during 1998-99

Date	Speaker Affiliation	Title
3-8-1998	Balaji Raghavachari University of Texas at Dallas	The Clustered Travelling Salesman Problem
3-8-1998	Jaikumar Radhakrishnan TIFR Mumbai	Density Versus Entropy in Graphs
5-8-1998	Balachandran Sathiapalan IMSc	The Hagedorn Transition and the Matrix Model for Strings
12-8-1998	Nita Parekh CCMB Hyderabad	Targetting Spatiotemporal Dynamical States in Coupled Map Lattices
19-8-1998	Kamalesh Kar SINP Calcutta	Oscillation Effects on Supernova Neutrinos
20-8-1998	K B Wolf Applied Mathematics Institute, Mexico	Discrete Optical Systems on Phase Space
2-9-1998	Rahul Sinha IMSc	Summary of ICHEP 1998
10-9-1998	S Sinha IMSc	Computing with Chaos
24-9-1998	G. Baskaran IMSc	Strong Correlations at ICTP: Workshop Summary
8-10-1998	Jaya Iyer University of Bombay	Projective Normality of Abelian Surfaces
27-10-1998	D. Choudhury MRI Allahabad	Rare B Decays
29-10-1998	Krishna Kumar ISI, Calcutta	Dissipative Structures in Parametrically Forced Systems
5-11-1998	N. Chandramowliswaran Vellore Engg. College	Test Words in Free groups

6-11-1998	P. Ravindran Uppsala University, Sweden	Applications of Density Functional Theory
18-11-1998	Sushan Konar IUCAA Pune	Magnetic Fields of Neutron Stars
23-11-1998	M. Lakshmanan Bharatidasan University, Tiruchi	Spatio-temporal Patterns in Nonlinear Systems
23-11-1998	Malliavin University of Paris VI, Paris	Minimal Injective Resolutions
25-11-1998	Arundhati Dasgupta IMSc	Near Horizon Geometry and Emission from String Black Holes
9-12-1998	Samir Mallik SINP, Calcutta	Density Fluctuation from Inflationary Scenario
10-12-1998	Satya Majumdar TIFR Mumbai	Persistence in Nonequilibrium Systems
10-12-1998	S. Srinivasa Rao IMSc	Skipping the Skips
17-12-1998	Maneesh Thakur TIFR Mumbai	Exceptional Algebraic Groups and Related Structures
21-12-1998	Milind Sohoni IIT Bombay	Geometric Complexity
22-12-1998	L V Satyanarayana Loyola University, Chicago	Degree vs Sensitivity of Boolean Formulas
23-12-1998	S Venkatesh TIFR Mumbai	Communication Complexity of Pointer Chasing
1-1-1999	Ramesh Narayan Harvard University, USA	Searching for Black Holes
1-1-1999	H.E. Stanley Boston University, USA	Can Statistical Physics contribute to the Science of Economics?
5-1-1999	Antonio Siconolfi University of Rome, La Sapienza, Italy	Discontinuous Solutions of a Hamilton-Jacobi equation

6-1-1999	Prabodh Shukla NEHU Shillong	Patterns of Relaxation in Random Field Ising Model
7-1-1999	V Kamakoti IMSc	Introduction to Message Passing Interface
7-1-1999	Filomena Pacella University of Rome, La Sapienza	Symmetry of Solutions of Nonlinear Elliptic Equations
8-1-1999	Raj Gandhi MRI Allahabad	Neutrino Physics: Present Status and Future Directions
13-1-1999	Gautam Menon IMSc	Muon Spin Rotation in High-T_c Superconductors: Solving the Linewidth Puzzle
14-1-1999	J. Batt University of Munich, Germany	A Mathematical Study of Systems of Nonlinear PDE Governing The Evolution of Gravitational and Charged Matter
14-1-1999	Bindu Bambah Panjab University, Chandigarh	Non-equilibrium Phase Transitions in Particle Physics
14-1-1999	M.Rammurty Queens University, Canada	Some Remarks on Riemann Hypothesis
19-1-1999	Rahul Pandit IISc Bangalore	Multiscaling in Fluid Turbulence: Some New Results
19-1-1999	H.J. Schmitt IHFT, RWTH, Aachen, Germany	Brain Research with Optical Sensors
21-1-1999	Ashwin Vishwanath Princeton University, USA	Luttinger Liquid Physics in the Superconducting Vortex Core
22-1-1999	Elizabeth Gasparim UFPE, Recife, Brazil	Moduli Spaces of Instantons for Physicists
22-1-1999	G. Suryan IISc Bangalore	Full Implications of the Quantum Theory and their Relevance to the Understanding of the Universal Gravitation
28-1-1999	Bruno Kahn Institut de Mathématiques de Jussieu, Université de Paris VI, Paris	The Chern classes of the Regular Representation of a Reductive Algebraic Group

28-1-1999	Elizabeth Gasparim UFPE, Brazil	Sheaf Cohomology for Physicists (2nd talk)
28-1-1999	Loic Merel Univesity of Paris,France	A Question about Dirichlet Characters and its Relation to Modular Forms
29-1-1999	Joseph Oesterle IHP, Paris	Galois representations
2-2-1999	Elizabeth Gasparim Brazil	Moduli Spaces on Instantons
3-2-1999	Ayse Erzan Istanbul Technical University, Turkey	q-Derivatives, Noncommutativity and Irreversibility
4-2-1999	Fernando Moraes Federal Univ. of Pernambuco, Recife, Brazil	A Gravity-like Approach to Defects in Solids
5-2-1999	Godefroy University of Paris VI	Lipschitz Isomorphisms between Banach Spaces
9-2-1999	Dr Mahendiran University of Zaragosa, Spain	Charge Melting and Structural Instability in Colossal Magnetoresistive Oxides
10-2-1999	N V Vinodchandran IMSc	Counting Complexity and Computational Group Theory
10-2-1999	N. Plakida	Charge and Spin Dynamics in the t-J model
11-2-1999	Bruce C. Berndt University of Illinois	The Incomplete Elliptic Integrals in Ramanujan's 'Lost' Notebooks
12-2-1999	Parongama Sen SINP, Calcutta	Nonlocality in the Conservation of Coupling Fields: Critical Dynamics
12-2-1999	Jaydeb Chakrabarti MSD, IGCAR, Kalpakkam	Nematics in a Porous Medium
17-2-1999	Gunther von Gehlen Univerity of Bonn, Germany	Commensurate and Incommensurate Phase Transitions and Superintegrability

22-2-1999	Peter Bro Miltersen BRICS, University of Aarhus, Denmark	Constant width Planar Computation: Three New Characterizations of AC^0
23-2-1999	Lalit Sehgal RWTH, Aachen, Germany	New Evidence for Violation of Time-Reversal Invariance in K^0 Decay
23-2-1999	S Ramakrishna Hahn Meitner Institute, Berlin, Germany	Pump Probe Spectroscopy of Interfacial Charge Injection
25-2-1999	Corrado De Concini University of Rome, La Sapienza, Italy	Models of Compliment of Subspaces
25-2-1999	Fabrice Thalmann LEPES, Grenoble and JNCASR, Bangalore	Phase Diagram for Disordered Fluids
1-3-1999	Dietrich Meyer Humboldt University, Berlin, Germany	Ferromagnetism in the Periodic Anderson Model; a Dynamical Mean-Field Approach
2-3-1999	Loic Merel University of Paris VII	Invisible Elements in Tate-Shaferevich Group
3-3-1999	J Ravi Prakash IIT Madras	Molecular Rheology of Polymer Solutions
4-3-1999	Biswajit Chakraborty SN Bose, Calcutta	Effect of Gauging on Symplectic Structure and Fractional Spin involving Hopf and Chern-Simons Term
16-3-1999	H.G.Matthies TU,Braunschweig, Germany	Stochastic PDE-Numerical Methods
19-3-1999	S. Ganesan BARC Bombay	Interesting Problems and Challenges for a Nuclear Reactor Physicist in the Coming Century
22-3-1999	P. Ramadevi MRI Allahabad	Three Manifold Invariants using Chern-Simons Theory
23-3-1999	Rossen Dandoloff Univ. de Cergy-Pontoise, Paris	(2+1) Dimensional Quantum Antiferromagnets and Hopf Term

26-3-1999	Ajay Sood IISc Bangalore	Generation of Coherent and Squeezed Phonon Fields using Femtosecond Laser Pulses
30-3-1999	Meena Mahajan IMSc	Arithmetic Complexity, Kleene Closure, and Formal Power Series
30-3-1999	P. Poulose TIFR Bombay	CP violating Z-γ-γ and Top Quark Dipole Couplings at Photon Linear Colliders
31-3-1999	Kamal Lodaya IMSc	Decidability of Bisimulation for Pushdown Automata
7-4-1999	Srinath Cheluvaraja TIFR Bombay	A Lattice Model with a Theta Term in Three Dimensions
8-4-1999	Arindama Singh IIT Madras	Computing Prime Implicants
12-4-1999	Varun Sahni IUCAA Pune	Large scale Structure of the Universe
13-4-1999	Varun Sahni IUCAA Pune	Cosmological Constant, Revisited
20-4-1999	Paritosh Pandya TIFR Mumbai	Modelchecking Duration Calculus Using DC-VALID
21-4-1999	Bikash C Gupta IIT Chennai	Formation of Localized States Due to Discrete Nonlinear Schrödinger Equation
22-4-1999	S. Seshadri IIT Chennai	Isospectral Oscillators, Geometric Phases and Revivals
29-4-1999	Timothy Gonsalves IIT Madras	Affordable Internet Access
30-4-1999	Meena Mahajan IMSc	A Combinatorial Algorithm for Pfaffians
7-5-1999	Subrata Bal IMSc	High Temperature limits of $N = 2$ Matrix Model
26-5-1999	V. Lakshminarayanan Univ. of Missouri, St. Louis, USA	Some Applications of Wavelets

10-6-1999	Tim Gendron IMSc	Zeta Functions: Arithmetic, Algebro-geometric, Differential Geometric, Dynamical
15-6-1999	Shiva Shankar IIT Mumbai	Density of Solutions of Systems of PDE
23-6-1999	J. Mossino Ecole Normale Supérieure de Cachan	Reinforcement by a Thin Layer of Nonhomogeneous Material
30-6-1999	Tim Gendron IMSc	Number Theory as Non-dissipative Quantum Chaos
1-7-1999	M. Rajesh IMSc	Green, Brown and Probability
6-7-1999	G. Manoj IMSc	Random walks in rough terrains
8-7-1999	V.Kumar Murty University of Toronto, Toronto, Canada	Class numbers and zeros of L-functions
14-7-1999	T. Chakraborty IMSc	Dynamical correlations in a half-filled Landau level
14-7-1999	P. Madhusudan IMSc	Complementation of Buchi Automata Revisited
15-7-1999	Pablo Ares Gastesi TIFR, Mumbai	Conformal Dynamical Systems
19-7-1999	Mihir Chakraborty Dept of Pure Math, University of Calcutta	Consistency – Inconsistency
21-7-1999	M. Muthukumar U. Massachusetts, Amherst	Polymer translocation through a hole in a membrane
22-7-1999	K.Srinivas IMSc	Lattice Point Problem for Triangles
23-7-1999	Mihir Chakraborty Dept of Pure Math, Univ of Calcutta	Consistency – Inconsistency

26-7-1999	Rajaram Nityananda RRI, Bangalore	Tops, monopoles, and the depolarisation of fluorescence
29-7-1999	S. Srinivasan MRI, Allahabad	Vertex Models
30-7-1999	S.P. Suresh IMSc	Semi-deterministic extensions of fixed point logic

2.7 Student Programmes

2.7.1 Institute JRFs

The following students of the Institute have received the Ph.D degree during 1998-99 from Madras University:

Physics

Name	:	**D. Shubashree**
Thesis Title	:	Field Theory of Frustrated Antiferromagnets: An Approach to the Kagome Lattice Model
Supervisor	:	R. Shankar

Name	:	**Mohan Narayan**
Thesis Title	:	Phenomenological Consequences of Neutrino Oscillations
Supervisor	:	M. V. N. Murthy

Name	:	**K. Sundar**
Thesis Title	:	Amplitude Squeezed States of the Radiation Field
Supervisor	:	R. Simon

Mathematics

Name	:	**Manisha V. Kulkarni**
Thesis Title	:	Explicit Integral Galois Module Structure for Low Degree Abelian Extensions
Supervisor	:	R. Balasubramanian

Theoretical Computer Science

Name	:	**N.V. Vinodchandran**
Thesis Title	:	Counting Complexity and Computational Group Theory
Supervisor	:	V. Arvind

Name	:	**Swarup Kumar Mohalik**
Thesis Title	:	Local presentations for finite state distributed systems
Supervisor	:	R. Ramanujam

The following Ph.D. theses have been submitted during 1998-99.

Physics

Name	:	**Saurya Das**
Thesis Title	:	Aspects of Gravitational Scattering at Planckian Energies
Supervisor	:	Parthasarathi Majumdar
University	:	Anna University

Name	:	**Radhika Vathsan**
Thesis Title	:	Studies in Quantization: Methods for Constrained Systems and Semiclassical Spectra of Many-Body Systems
Supervisor	:	G. Date
University	:	University of Madras

Name	:	**Mary Elizabeth Selvadoray**
Thesis Title	:	Nonclassicality and Photon Number Distributions in Quantum Optics
Supervisor	:	R. Simon
University	:	University of Madras

Mathematics

Name	:	**N. Sabu**
Thesis Title	:	Eigenvalue Problems in Shell Theory
Supervisor	:	S. Kesavan.
University	:	University of Madras

Theoretical Computer Science

Name	:	**S.V. Nagaraj**
Thesis Title	:	Problems in Algorithmic Number Theory
Supervisor	:	Venkatesh Raman
University	:	University of Madras

The following student submitted his M.Sc. thesis to Anna University in May 1999.

Name	:	**S.P. Suresh**
Thesis Title	:	Semi-Deterministic Extensions of Fixed Point Logic
Supervisor	:	Anil Seth

The following lecture courses were offered during the last academic year.

Course Title	Period	Lecturer
Mathematics		
Analysis	Aug-Nov, 1998	Krishna Maddaly
Topology	Aug-Nov, 1998	D. S. Nagaraj
Algebra	Aug-Nov, 1998	R. Balasubramanian
Functional Analysis and PDE	Jan-May, 1999	S. Kesavan
Algebra	Jan-May, 1999	Vijay Kodiyalam
Topology	Jan-May, 1999	Kapil Paranjape
TQFT from Subfactors	July 1999 -	V.S. Sunder
Physics		
Classical Mechanics	Aug-Dec, 1998	Sudeshna Sinha
Classical Electromagnetism	Aug-Dec, 1998	S. Kalyana Rama
Quantum Mechanics	Aug-Dec, 1998	R. Parthasarathy
Mathematical Methods	Aug-Dec, 1998	K. Srinivasa Rao
Many-Body Theory and Advanced Statistical Physics	Aug-Dec, 1998	R. Shankar and Ramesh Anishetty
String Theory	Aug-Dec, 1998	Bala Sathyapalan
Statistical Physics	Jan-May, 1999	M. V. N. Murthy
Quantum Field Theory	Jan-May, 1999	G. Rajasekaran
Introductory Condensed Matter Physics	Jan-May, 1999	Purusattam Ray
Introductory Particle Physics	Jan-May, 1999	Rahul Sinha
Introduction to Cell Biology	Jan-May, 1999	G. Baskaran
Theoretical Computer Science		
Complexity Theory	Aug-Nov, 1998	M Mahajan
Algorithmic Methods in Verification	Aug-Nov, 1998	R Ramanujam
Randomized Algorithms	Aug-Nov, 1998	V Raman
Finite Model Theory	Aug-Nov, 1998	K. Lodaya and A Seth

K. Lodaya, taught a *Programming in C* course for Anna University students in their M.Sc. programme, with students from Computer Science, Mathematics and Applied Chemistry disciplines.

S. Kesavan gave a course of lectures on *Calculus II* under the National Undergraduate Programme in Mathematics, Chennai Mathematical Institute, from January to April, 1999.

2.7.2 Summer Students

Every summer, a small number of students from various Institutes/Universities come to our Institute and work on some learning/research projects with some faculty member for a period of four to six weeks. During the last summer (May 15 - July 15), the following students visited our institute under this scheme.

Student	Faculty
Mathematics	
Aleemuddin Siddiqui, ISI Calcutta	Kapil Paranjape
Swaminathan, IIT Chennai	D. S. Nagaraj
Lakshmi Ramachandran, IIT Chennai	D. S. Nagaraj
L. Shanta Singh, Manipur University	R. Balasubramanian
Physics	
J. Daniel, Loyola College, Chennai	K. Srinivasa Rao
R. Gnanaguru, Loyola College, Chennai	K. Srinivasa Rao
R. Chandramouli, A.M. Jain College, Chennai	Gautam I. Menon
S. Monica, Univ. Madras, Chennai	G. Baskaran
J.D.C.G. Deborah, Univ. Madras, Chennai	G. Baskaran
L. Arun, IIT Kharagpur	N. D. Hari Dass
P. Ghosh, IIT Kanpur	N. D. Hari Dass
P. Sreeja, BITS Pilani	Sudeshna Sinha
N. Ganesh, IIT Chennai	Sudeshna Sinha
B. Vaishnav, IIT Kharagpur	Parthasarathi Majumdar/ S. Kalyana Rama
A. Maharana, IIT Kanpur	Romesh Kaul
B. Anusha, American College, Madurai	R. Jagannathan
Theoretical Computer Science	
Sanjukta Bhowmick, Haldia Institute of Technology	R. Ramanujam
K. Jambunathan, ISI Calcutta	R. Ramanujam
K.V.M. Naidu, IIT Guwahati	Kamal Lodaya

2.7.3 NBHM Nurture Programme 1998 - 99

The Contact Programme at the end of the fourth, and final, year of the NBHM Nurture Programme 1995-96 was held at the Institute of Mathematical Sciences, Chennai, from Monday, June 28 to Friday, July 16, 1999. Of the 11 students who attended the Programme last year, 7 were re-invited this year and 5 of them attended the Programme.

These students continued to be under the charge of the Faculty comprising of V. Balaji (Chennai Mathematical Institute-CMI), R. Balasubramanian (IMSc.), S. Kesavan (IMSc., Convener), P. Sankaran (CMI), V. S. Sunder (IMSc.) and K. N. Raghavan (CMI). In addition, D. S. Nagaraj (IMSc) gave some lectures.

For the course work assigned for the fourth year, *i.e.* 1998-99, the students were asked to select two of the following five topics for self study: Commutative Algebra, Knot Theory, Lie Groups, Number Theory and Partial Differential Equations.

During the Contact Programme, lecture courses were given on the following topics: Number Theory, Primality Testing, Cryptography and Coding Theory (8 lectures by R. Balasub-

ramanian), Elliptic Curves (3 lectures by D. S. Nagaraj) and Topological Quantum Field Theories (4 lectures by V. S. Sunder).

In addition, the participants were asked to give two seminar talks each, the topics of these talks being taken from the subjects chosen by them for self study. The talks given were:

- p-adic Integers and p-adic Equations.
  Manifolds I.
  M. Chandrasekhar

- Dirichlet's Theorem on Arithmetic Progressions.
  Dedekind Domains.
  S. A. Khot

- The Heat Equation.
  Structure of p-adic Units.
  G. Muralikrishnan

- Some Knot Invariants.
  An heuristic Approach to Knot Invariants using Chern- Simons Theory.
  Sameer Murthy

- Primary Decomposition of Ideals.
  Manifolds II.
  Devavrat Shah

2.7.4 Apalat Fellowship

In order to encourage bright B.Sc. students to take up Physics or Mathematics for their higher studies, the Institute is offering two fellowships, one in Mathematics and another in Physics for students studying in and around Chennai. This goes under the name of APALAT-IMSc scholarship. The scholarship amount is Rs.1000 per month for 10 months of the academic year and is given during their M.Sc. programme. Each student is expected to work under the guidance of a faculty member in the respective discipline of the Institute.

Heads of the Departments in Physics and Mathematics of various colleges in the city are contacted to suggest five bright third year B.Sc students who are likely to join M.Sc programme in an institution in Chennai. Out of them, one student in each subject is selected through a written test and an interview. The successful students are encouraged to attend seminars in the Institute and to spend the summer vacation at IMSc under the supervision of a faculty member. They are expected to show their progress in their regular M.Sc course and if satisfied, the scholarship will be extended to the second year of their M.Sc course.

During this academic year, the fellowship was awarded to Ms. P. Vasundhra of SDNB Vaishnav College for Women, for Mathematics and Ms. K. M. Frenyjoy of Madras Christian College, for Physics. Ms. Vasundhra is working under the guidance of K. Srinivas, and Ms Frenyjoy under the guidance of R. Parthasarathy.

2.8 Institute Associateships

The Institute has established short term associateships in **Theoretical Physics, Mathematics** and **Theoretical Computer Science** for teachers from colleges and universities to visit and work at the Institute. The program is envisaged to develop interaction between the members of the faculty of the Institute and scientists in the university system. Under this program, an Associate can visit the Institute once or twice a year, up to a total of 90 days per year, each visit lasting a minimum of three weeks. The tenure of an Associate will be for a period of three years and he/she is expected to visit the Institute at least twice during this period.

The Institute will bear the expenses of the travel from the place of work to Chennai and back and will also pay a daily allowance to cover local expenses at Chennai. During their stay at the Institute, the Associates will be accommodated in the Institute Guest House.

For the year 1998 - 99, the following seven scientists working in various Indian universities were offered Associateships.

- **Dr. Subhash J. Bhatt**, Department of Mathematics Sardar Patel University, Vallabh Vidyanagar.
- **Dr. T. K. Das**, Department of Mathematics, Faculty of Science The M.S. University of Baroda, Vadodara.
- **Dr. Sukanto Dutta**, Department of Physics, S.G.T.B. Khalsa College, University of Delhi, Delhi.
- **Dr. Prabodh Shukla**, Department of Physics, North Eastern Hill University, Shillong.
- **Dr. M. K. Chakraborty**, Department of Pure Mathematics, University of Calcutta, Calcutta.
- **Dr. Sanjeev Kant Soni**, Senior Lecturer, S.G.T.B. Khalsa College, University of Delhi, Delhi.
- **Dr. M. K. Parida**, Department of Physics, North Eastern Hill University, Shillong.

2.9 Visits to Other Institutions

(**including participation in conferences and workshops**)

Adhikari, R.

Delivered a seminar in the *Neutrino Physics Conference* held at the Department of Physics, University of Hyderabad, in November, 1998.

Visited the Mehta Research Institute, Allahabad, for a month in April, 1999 and delivered a seminar on *Constraints on mixing angles of Majorana neutrinos.*

Delivered a seminar on *Constraints on mixing angles of Majorana neutrinos* in the Department of Physics, Visva-Bharati University, Santiniketan on May 9, 1999 under the TPSC programme.

Anishetty, R.

Attended the *QCD* meeting hosted by the Institute in NCRA, Ooty from September 26 to October 4, 1998; also organized the meeting.

Arun Kumar, S.

Attended the *Indo-French Workshop on Probing Fundamental Problems with Lasers and Cold Atoms*, held at the Indian Institute of Astrophysics from January 4 to 8, 1999.

Attended the *Discussion Meeting on Quantum Computation*, held at the Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore from July 19 to 23, 1999.

Arvind, V.

Visited the Tata Institute of Fundamental Research, Mumbai from February 25 to March 1, 1999 to attend the workshop on *De-randomization.*

Visiting Ulm University, Germany, currently from April 1, 1999.

Balakrishnan, R.

Visited the Université de Cergy Pontoise, Paris, France as a Visiting Professor from August 15 to September 15, 1998. Delivered a colloquium on *Nonlinearity and geometry.*

Visited the Center for Nonlinear Studies, Los Alamos National Laboratory, U.S.A., as a Consultant from September 17 to September 30, 1998.

Presented a seminar on *Motion of space curves and physical applications* at Brandeis University, Waltham, U.S.A, on October 2, 1998 and at Boston College, Boston, U.S.A., on October 6, 1998.

Presented a seminar on *Field-induced spatial chaos in the XY spin chain* at the IMSc Discussion Meeting on *Spatio-temporal Physics and Chaos* held at Ooty from February 25 to 27, 1999.

Presented an invited talk on *Two-branch energy structure of spins on curved surfaces and anholonomy* at the *International Symposium on Quantum Many-Body Physics* held at Jawaharlal Nehru University, New Delhi, from March 5 to 7, 1999.

Visited the Limburgs Universitair Centrum, Belgium from May 20 to 30, 1999.

Visited the Université de Cergy Pontoise, Paris, France from June 1 to 30, 1999.

Delivered an invited lecture titled *Nonlinear sigma model on curved manifolds and energy-geometric phase connection* at the International Conference *Nonlinearity, Integrability and All That: Twenty Years after NEEDS 79*, held from July 1 to 10, 1999 at Gallipoli, Lecce, Italy. Chaired a session and served as one of a 6-member panel of experts during the discussion session on *Future Directions in Nonlinearity and its Applications.*

Balasubramanian, R.

Gave an invited talk entitled *An asymptotic formula for a sequence* at the *International Conference on p-adic Analysis, Summability Theory, Fuzzy Analysis and Applications*, Chennai, December 21 to 24, 1998.

Gave a talk on *Graham's conjecture* at the meeting of the *Ramanujan Mathematical Society*, Bangalore, June, 1999.

Gave a talk on *The analytic class number formula and Ramachandra units*, at the *Workshop on Cyclotomic Fields*, Pune, June, 1999.

Gave a talk on *Some problems in number theory and combinatorics*, at the *Training Programme for Olympiad Students*, Mumbai, June, 1999.

Gave a talk on *Number theory and cryptology*, at the *Workshop on Cryptology*, CAIR, Bangalore, July, 1999.

Baskaran, G.

Visited the Joint Institute for Nuclear Research, Dubna, Russia, for a week in August 98 and delivered two talks:
i. *Sharpened version of RVB theory of superconductivity* on August 4, 1998.
ii. *SO(5) issue in cuprates* on August 6, 1998.

Visited the Institute for Theoretical Physics at the University of Gottingen, Germany for a week in August 1998 and delivered two talks:
i. *Issues with SO(5)* on August 10, 1998.
ii. *Anomalous properties of composite fermi liquid* on August 12, 1998.

Delivered one talk at the Nuclear Physics Department of the University of Madras on *Rich physics in magnetic oxides* on September 23, 1998.

Delivered one talk at the Ooty meeting on *Gauge Theory* on *Gauge fields and confinement in strongly correlated electron systems* on October 1, 1998.

Visited the Academic Staff College at Bharathiar University, Coimbatore during October 8 - 9, 1998 and Delivered four talks :
i. *Power of Physics.*
ii. *Physics of friction.*
iii. *Superconductivity.*
iv. *High temperature superconductivity.*

Delivered a talk at the Institute of Physics, Bhubaneswar on *P-wave superconductivity in* Sr_2RuO_4 on October 13, 1998.

Delivered four lectures on *Fractional quantized Hall effect* at the workshop on *Strongly Correlated Electron Systems* organized at the Physics Department of IIT, Kharagpur from October 14 to 17, 1998.

Delivered an IIT-Kharagpur General Colloquim on *The 1998 Nobel Prize in Physics* on October 14, 1998.

Delivered a talk at the Physics Department of IISc, Bangalore on *P-wave superconductivity in* Sr_2RuO_4 on October 28, 1998.

Delivered a Colloquim at RRI, Bangalore on *The 1998 Nobel Prize in Physics* on October 28, 1998.

Delivered a talk at CLRI, Madras *The 1998 Nobel Prize in Physics* in November 1998.

Delivered a talk at CLRI, Madras on *K S Krishnan and his works* on December 3, 1998.

Delivered a talk at the *K S Krishnan Birth Centenary Meeting* at the Physics Department of the University of Allahabad, Allahabad on December 5, 1998 on *Where are we in the theory of superconductivity?*

Delivered two talks at the Asia Pacific Center for Theoretical Physics, Seoul, Korea:
i.*Failure of Fermi liquid theory in 2 and 3 dimensions* on December 9, 1998.
ii.*P-wave superconductivity in* Sr_2RuO_4 on December 9, 1998.

Delivered three lectures at the *Workshop on Strongly Corrleated Electron Systems* at the Physics Department of the Pohong Institute of Science and Technology (POSTECH), Pohong, South Korea:
i. *Failure of Fermi liquid theory* on December 11, 1998.
ii. *P-wave superconductivity in* Sr_2RuO_4 on December 11, 1998.
iii. *Physics at half filled Landau level* on December 12, 1998.

Delivered a talk at the *Annual Meeting of the Indian National Science Academy* held at IIT,

Madras in the session on *Physics at the Turn of the Century* on *Condensed matter physics at the turn of the century* on December 30, 1998.

Visited the Academy of Sciences, Hanoi, Vietnam and gave a talk at the workshop (from January 4 to 10, 1999) on *Strongly Correlated Electron Systems* on *General issues in strongly correlated electron systems.*

Panelist at the *Indo-Israel Meeting in Modern Condensed Matter Physics* from January 22 to 25, 1999 organized by INSA at Delhi and gave a talk on *Issues in strongly correlated electron systems.*

Delivered a talk at the Department of Nuclear Physics in a meeting organized for College Physics Teachers on *Superconductivity* on February 1, 1999.

Delivered a talk at the Department of Theoretical Physics, University of Madras on *Fractional quantized Hall effect* on February 24, 1999.

Delivered a talk at the 'Science Day' on February 26, 1999, organized by the Center for Bio-Technology, Anna Universityon *Physics and Biology.*

Delivered a talk at the Indian Physics Association, IGCAR, Kalpakkam chapteron *K S Krishnan and his works* in February 1999.

Delivered a talk at the meeting on 'Quantum Many Body Theory' (organized in honour of R Rajaraman's 60th Birth Day) on *Status of the theory of high temperature superconductivity* in March, 1999.

Deliverd a talk at the Golden Jubilee Celebration of the Thiagarajar College, Madurai on *Power of Physics* on March 30, 1999.

Delivered a Colloquim, a talk and a Public Lecture at the Physical Research Laboratory, Ahmedabad, on the following topics respectively:
Fractional quantized Hall effect on April 7, 1999.
New concepts in high temperature superconductivity on April 8, 1999.
Physics and Biology on April 9, 1999.

Delivered a special lecture entitled *Physics and Biology* in the *Programme for the Gifted Youth*, organized by IIT, Madras and Bharatiya Vidya Bhavan at IIT, Madras on April 27, 1999.

Visited the Physics Department of Princeton University, Princeton, NJ, USA from June 12 to July 10, 1999.

Visited Brookhaven National Laboratory, Long Island, NY, USA from July 7 to 9, 1999 and deliverd a talk on *Competition between charged stripes and superconductivity.*

Visited the International Center for Theoretical Physics, Trieste, Italy during July 99 as a Director of the workshop on *Open Problems in Strongly Correlated Electrons* from July 12

to 30,1999. Presented a paper on *Charge stripes and high temperature superconductivity.*

Biswas, J. G.

Visited the Université de Paris VII, Paris, France during March and April, 1999, sponsored by an Indo-French NBHM-CNRS programme.

Attended a conference on *Hodge Theory, Motives and K-Theory* at Genova, Italy, from March 26 to 28,1999.

Gave a talk on *Roitman's theorem for singular varieties* in the Algebraic Geometry Seminar at the Université de Paris VII.

Chakraborty, T.

Completed two years of sabbatical leave at the Max-Planck-Institute for Physics of Complex Systems, Dresden, Germany, from May 1997 to June 1999.

Presented an invited talk at the *Condensed Matter and Materials Physics Conference*, UMIST, Manchester, UK, from December 20 to 23, 1998.

Presented a colloquium talk at the Department of Physics, University of Augsburg, Germany, on January 25, 1999.

Attended the *Centennial Meeting of the American Physical Society*, Atlanta, USA, from March 19 to 26, 1999.

Presented a seminar talk at the Department of Physics and Astronomy, University of Missouri, Columbia, USA. on March 29, 1999.

Presented a seminar talk at the Institute of Theoretical Physics, Technical University, Dresden, Germany, on April 29, 1999.

Presented a seminar talk at the Department of Physics, University of Antwerp, Belgium, on May 11, 1999.

Das, J.

Participated in the conference *Statphys Calcutta -III on Fracture, Breakdown and Earthquake* at the S.N. Bose National Centre for Basic Sciences, Calcutta, from January 9 to 12, 1999. Presented a poster titled *Dynamics of ordering of isotropic magnets.*

Dasgupta, A.

Visited IAS, Princeton, USA from September 28 to October 9, 1998 and delivered a talk on *Near horizon geometry and fermion emission from black holes.*

Visited the California Institute of Technlogy, Stanford University, University of Pennsylvania, Syracuse University, USA and AEI, Germany, during September-October, 1998 and

delivered talks on *Near horizon geometry and fermion emission from black holes.*

Attended the 3rd Puri Workshop on *Quantum Field Theory, Quantum Gravity and Strings*, Puri, India and delivered a talk in December, 1998.

Delivered a review talk on *Black hole thermodynamics*, at the *YATI Meeting*, Calcutta, March, 1999.

Date, G.

Attended the *International Conference on Mathematical Physics*, Nagpur University, Nagpur, January 1999 and presented a talk in the contributed papers session.

Ghosh, P. K.

Visited Centre for Theoretical Studies, IISc., Bangalore, November 1998. Presented a seminar on *Novel classical ground state of a many-body system in arbitrary dimensions.*

Visited Saha Institute of Nuclear Physics, Calcutta, December 1998. Presented a seminar on *Novel classical ground state of a many-body system in arbitrary dimensions.*

Visited S. N. Bose Centre, Calcutta, December 1998. Presented a seminar on *Novel classical ground state of a many-body system in arbitrary dimensions.*

Visited Visva-Bharati, Santiniketan, December 1998. Presented a seminar on *Novel classical ground state of a many-body system in arbitrary dimensions.*

Govindarajan, T. R.

Visited IOP, Bhubaneswar, during August 4-5, 1998.

Visited Dubna, Russia as part of the delegation for the conference under Integrated Long Term Project, from August 10 to 21, 1998.

Visited Syracuse University, USA, from August 27 to December 2, 1998.

Attended conference on *Quantum Gravity, Strings and Field Theory*, Puri, Orissa, from December 9 to 21, 1998.

Visited Syracuse University, USA, from January 16 to June 11, 1999.

Attended the APS centennial conference at Atlanta, USA, from March 20 to 23, 1999.

Hari Dass, N. D.

Visited the National Laboratory for High Energy Physics(KEK), Tsukuba, Japan, from August 18 to December 21, 1998. Delivered a seminar on *Protective measurements in quantum mechanics.*

Visited the Max Planck Institute for Physics, Munich, Germany from July 5 to September 4, 1998. Delivered a seminar on *Asymptotically free extensions of QCD.*

Visited the Tanashi Campus of KEK, Tokyo, Japan, during October 12-13, 1998. Delivered a seminar on *Protective measurements in quantum mechanics.*

Visited the Yukawa Institute, Kyoto and the Physics Department, Kyoto University, Kyoto, from October 18 to 25, 1998. Delivered the following seminars:
Interaction of F & D -strings in matrix models,(YITP)
Cold atom tests for quantum mechanics and quantum gravity,(Phys. Dept)

Visited the Physics Department, Hokkaido University, Japan from November 3 to 9, 1998. Delivered a seminar on *Protective measurements in quantum mechanics.*

Attended the Nishinomiya-Yukawa Memorial Meeting on *Dynamics of Strings and Fields* at Nishinomiya, Japan, December 1998.

Attended the Yukawa Institute Workshop on *Dynamics of Strings and Fields*, Kyoto, Japan, December 1998 and delivered a talk *Interaction of F & D-strings in matrix models.*

Visited Waseda University, Tokyo, Japan, in December 1998 and delivered a seminar on *Protective measurements in quantum mechanics.*

Visited Graduate University, Kanagawa, Japan during December 1998 and delivered a colloquium on *Quantum theory of brain: fantasy or reality?*

Visited Chulalongkorn University, Bangkok, Thailand, from December 21 to 28, 1998 and delivered the talks:
1. *Birth and death of stars.*
2. *Duality in physics.*
3. *M-theory.*

Attended the Indo-French Workshop on *Probing Fundamental Interactions Through Lasers and Cold Atoms* at the Indian Institute of Astrophysics, Bangalore, from January 6 to 8, 1999 and delivered an invited talk on *Testing quantum mechanics and quantum gravity using cold atoms.*

Attended the Meera Memorial Meeting at Mysore, from January 25 to 31, 1999 and delivered the following talks:
1. *Entangled states and quantum measurement problem*(2 talks).
2. *Quantum theory of brain- fantasy or reality?*

Attended the Workshop on *Many-body Theories and Field Theories*, Jawaharlal Nehru University, New Delhi, from March 5 to 9, 1999, and delivered an invited talk on *Chirality - The Holy Grail in particle physics.*

Visited Guru Nanak Dev University, Amritsar, from March 12 to 17, 1999 and delivered the following talks:
1. *Quantum theory of brain* (Colloquium).

2. *Foundations of quantum mechanics.*
3. *Current trends in particle physics.*

Attended the XVII International Symposium on *Lattice Field Theory* (Lattice'99), at Pisa, Italy, from June 28 to July 3, 1999 and delivered a talk on *Numerical simulation of d=3 SU(2) lattice gauge theory in the dual formulation.*

Attended the *Strings'99* meeting at Potsdam, Germany, from July 19 to 25, 1999

Indumathi, D.

Attended the *Neutrino Physics Workshop* at Central University, Hyderabad during November 6, 7 1998 and gave an invited talk on *Neutrinos and supernovae.* Attended the QCD '98 Workshop, Chennai, from November 30 to Dec 8, 1998 and presented an overview of *Structure functions.*

Attended the DAE Symposium, Chandigarh, December 1998 and gave an invited talk on *Structure functions and deep inelastic scattering.*

Jagannathan, R.

Visited the Bogoliubov Laboratory for Theoretical Physics (BLTP), Joint Institute of Nuclear Research (JINR), Dubna, from August 8 to 17, 1998 and the Institute for Theoretical and Experimental Physics (ITEP), Moscow, on August 17, 1998.

Participated in the Russian-Indian International Workshop on *Topological and Integrable Field Theories*, held at BLTP, JINR, Dubna, from August 11 to 14, 1998, and delivered a talk on *Some physically interesting realizations of quantum groups and algebras.*

Delivered a course of lectures on *Introduction to statistical mechanics* in the UGC Refresher Course for College Teachers conducted by the Department of Theoretical Physics, University of Madras, during February-March, 1999.

Jayaraman, T.

Attended the Puri Workshop on *Strings, Quantum Field Theory and Gravity* in December 1998 and delivered a talk on *D-branes on curved spaces.*

Attended the *Extended Workshop on String Theory* from June 1 to July 16, 1999 at the International Centre for Theoretical Physics, Trieste, Italy.

Kesavan, S.

Visited the University of Rome, La Sapienza, Rome, Italy, from October 20 to December 20, 1998. Delivered a course of lectures on *Introduction to symmetrization and applications.* Gave a colloquium talk on *Two dimensional approximation of three dimensional eigenvalue problems in thin shell theory.*

Gave colloquium talks on *Homogenization of an optimal control problem* at the University of Florence (November, 1998), the University of Rome II, Tor Vergata (November 1998) and the University of Naples, Federico II (December 1998).

Kodiyalam, V.

Attended the Conference in honour of David Rees at Exter, England, from August 13 to 16, 1998 and gave a talk.

Attended the *International Congress of Mathematicians*, Berlin, Germany, from August 17 to 25, 1998 and gave a talk.

Visited the University of Nebraska, Lincoln, USA, from August 26 to December 24, 1998.

Delivered a Colloquium Talk at the University of Kansas, USA, on October 22, 1998.

Delivered a Colloquium Talk at Purdue University, USA, on October 27, 1998.

Krishna, M.

Attended the instructional workshop on *Internet and the Website Development* held on September 24, 1998 at IGCAR, Kalpakkam, and gave a talk on *World Wide Web.*

Delivered a series of lectures in the refresher course in mathematics for college teachers held at the Academic Staff College, Goa University, Goa, on *Spectral theory of self adjoint operators* from November 29 to December 3, 1998.

Attended the Workshop on *Operator Theory* conducted at the Indian Statistical Institute, Bangalore, from December 27, 1998 to January 1, 1999 and gave a series of lectures on *Inverse spectral theory.*

Visited the University of Clausthal, Germany, from April 12 to May 19, 1999 and gave a series of lectures on *Techniques in spectral theory.* Also gave a colloquium talk on *Inverse spectral theory and the Riemann zeta function* on May 23, 1999.

Visited the University of Erlangen, Germany, during May 20 - 21, 1999 and gave a Colloquium talk on *Mobility edge in some random models* and an informal talk on *Inverse spectral theory and the Riemann zeta function.*

Visited the University of Bochum, Germany, from May 22 to July 2, 1999 and gave a series of lectures on *Techniques in Spectral theory.*

Lodaya, K.

Presented the paper *A Kleene iteration for parallelism* at the *18th FST & TCS Conference*, Chennai, December 1998.

Delivered a course of three lectures on *Logic and automata on words and terms* at the *Summer School on Complexity, Logic and Applications*, Calcutta University, from June 24 to 30, 1999.

Delivered two lectures on *Principles of programming languages* at the UGC course for computer science teachers at Madras University, during July 9 - 10, 1999.

Madhusudan, P.

Attended the *19th International Summer School on Calculational System Design*, Marktoberdorf, Germany, from July 28 to August 9, 1998.

Visited BRICS, University of Aarhus, Denmark, from August 10 to 14, 1998, and gave a talk entitled *Controllers for discrete event systems.*

Visited RWTH, Aachen, Lehrstuhl Informatik VII, Aachen, Germany, from August 17 to 20, 1998, and gave a talk entitled *Controllers via morphisms.*

Attended the *18th FST & TCS Conference*, from December 17 to 19, 1998, Chennai.

Attended the BRNS Workshop on *Verification of Digital and Hybrid Systems*, from January 7 to 11, 1999 at TIFR, Mumbai.

Mahajan, M.

Attended the *Eighteenth Foundations of Software Technology and Theoretical Computer Science (FST&TCS) Conference*, Chennai from December 17 to 19, 1998.

Attended the *Workshop on De-randomization*, Tata Institute of Fundamental Research, Mumbai, from February 25 to March 6, 1999. Delivered talks on *De-randomization for space bounded computation.*

Delivered the *Prof. P. S. Manisundaram Endowment Lecture* at the Department of Mathematics, Bharathidasan University, Tiruchirappalli, on *A combinatorial algorithm for the determinant* on March 19, 1999.

Delivered a lecture in the *UGC Refresher Course in Computer Science* at the Department of Mathematics, Bharathidasan University, Tiruchirappalli, on *Data structures and algorithms* on March 19, 1999.

Visited Rutgers University, U.S.A., from May 24 to July 30, 1999. Gave a talk titled *A combinatorial algorithm for Pfaffians* on July 14, 1999.

Attended the *DIMACS-DIMATIA Workshop on Algebraic Methods and Arithmetic Circuits* at Rutgers University, USA, from June 2 to 4, 1999.

Majumdar, P.

Presented an invited lecture entitled *Aspects of canonical quantum gravity* at the *Third International Workshop on Quantum Field Theory, Quantum Gravity and String Theory*, Puri, December, 1998.

Visited the Centre for Relativity and Cosmology, Physics Department, Jadavpur University, Calcutta, in March (1 week) and May-June, 1999 (10 days). Delivered a talk entitled *Aspects of supersymmetry breaking* in March, 1999.

Presented an invited lecture entitled *Black holes* for students of Bharatiya Vidya Bhavan in the Programme for Gifted Youth organized at the Indian Institute of Technology, Chennai.

Meenakshi. B.

Attended the *FST&TCS Conference*, IMSc, from December 17 to 19, 1998 and the pre-conference workshop on *Finite Model Theory* during December 15 - 16, 1998.

Attended the *BRNS Workshop on Verification of Digital and Hybrid Systems*, TIFR, Mumbai from January 7 to 11, 1999.

Mehta, M. P.

Visited ICTP, Trieste, Italy, from August 4 to October 10, 1998. Attended the *Workshop on Dynamical Systems*, from August 31 to September 18, 1998.

Attended the *Indo-French Workshop on Probing Fundamental Problems with Lasers and Cold Atoms*, IIA, Bangalore, from January 4 to 8, 1999.

Attended the *Discussion Meeting on Spatio-Temporal Physics*, Udagamandalam, from February 25 to 28, 1999 and delivered a talk entitled *Phase-space survivors in some area-preserving maps and their physical implications.*

Visited the ICTP/SISSA Group under the Federation Arrangement from July 2 to August 12, 1999 and attended the *International Conference on Macroscopic Quantum Coherence Phenomena* from July 5 to 9, 1999.

Menon, G. I.

Attended the *Discussion Meeting on Soft Materials*, Raman Research Institute, Bangalore, India, January, 1999.

Talk on "Superconductivity" at Stella Maris College, February, 1999.

Visited the Centre for Condensed Matter Theory, Indian Institute of Science, Bangalore and Raman Research Institute, Bangalore, from March 17 to 26, 1999 and delivered a seminar on *Why are the numbers so small? Understanding muon-spin rotation experiments in BSCCO*, Centre for Condensed Matter Theory, IISc., Bangalore.

Delivered a seminar on *Interacting molecular Brownian motors*, Raman Research Institute, Bangalore, India, March 1999.

Attended *SIMLEP : A Simulation Model for Leprosy Transmission Control*, ICMR, Chennai, on April 5, 1999.

Delivered a lecture on *Interacting molecular Brownian motors* at the *Mid-Year Meeting of the Indian Academy of Sciences*, Bangalore on July 17, 1999.

Murthy, M. V. N.

Delivered lectures on *Fractional exclusion statistics- a generalised Pauli principle* in the *Refresher Course on Statistical Mechanics*, University of Madras, February 1999.

Nagaraj, D. S.

Was a Resource Person for the *Refresher Course in Mathematics*, Calicut University, Calicut from November 9 to 11, 1998 and delivered 6 lectures on *The fundamentals of algebraic geometry.*

Was a Resource person for the *Refresher Course in Mathematics for College Teachers*, Victoria College, Palakkad, during January 13 - 14, 1999 and delivered 4 lectures on *Algebraic geometry.*

Attended the conference on *Commutative Algebra and Algebraic Geometry*, MRI, Allahabad, from February 2 to 6, 1999.

Nagaraj, S. V.

Attended the *FST-TCS International Conference* held in Chennai from December 17 to 19, 1998.

Paranjape, K. H.

Visited the Université de Paris VII, Paris, France during July - August 1998. Delivered the following talks:
1. *The resolution of singularities.*
2. *Homological algebra.*

Delivered a talk on *Spectral sequences* at the ICM satellite conference on *Algebraic Geometry* at the University of Essen, Germany.

Attended the *Second National Conference on Algebraic Geometry*, MRI, Allahabad and delivered a talk on *Resolution of singularities* in February 1998.

Parthasarathy, R.

Gave an invited talk on *Towards touching the two ends in QCD*, at the QCD meeting held at Ooty, organized by IMSc.

Gave an invited talk on *QCD and string theory* at the QCD workshop held at Chennai, organized by IMSc.

Rajasekaran, G.

Gave the INSA S.N.Bose Award talk on *Can we go beyond Bose-Einstein and Fermi-Dirac statistics ?*, at TIFR, Mumbai on September 21, 1998.

Attended the mini Workshop on QCD at Udhagamandalam from October 1 to 3, 1998 and gave a talk on *QCD strings.*

Attended the Workshop on QCD at IMSc, Madras in November 1998.

Participated in the *Workshop on Neutrino Physics*, University of Hyderabad, from November 6 to 8, 1998 and gave two talks.

Attended the Workshop on *Quantum Field Theory, Quantum Gravity and Strings* at Puri, from December 9 to 19, 1998.

Participated in the *Meeting of the Astronomical Society of India* at Bangalore from February 1 to 3, 1999 and gave a talk on *Oscillations of solar and atmospheric neutrinos.*

Gave a talk on *Bose-Einstein and Fermi-Dirac statistics* in the School for College and University Teachers organized by Department of Theoretical Physics, University of Madras, on February 27,1999.

Gave an invited special talk on *Neutrino Physics* in the *Workshop on Nuclear Structure* held at the Department of Nuclear Physics, University of Madras on March 11, 1999.

Visiting the University of California, Riverside, USA, from June 1 to August 7 1999.

Rajesh M.

Attended the *Third School on Nonlinear Functional Analysis and its Applications* at ICTP, Trieste, Italy from October 12 to 23, 1998.

Attended the Conference in Honour of Prof. Louis Nirenberg of Courant Institute held from October 26 to 30, 1998 at ICTP, Trieste, Italy.

Visited the Indian Statistical Institute, Bangalore during June 28 - 29, 1999.

Rama, S. Kalyana

Attended the conference on *String theory, Quantum Field Theory* held in Puri, in December 1998.

Tutored the course on Black Hole physics in the SERC school, held in Mysore in Jan-Feb 1999.

Ramachandran, R.

Attended and inaugurated the *Third Puri Workshop on Quantum Field Theory, Strings and Quantum Gravity*, from December 9 to 18, 1998 at Puri.

Led a delegation of 7 Indian Scientists to the *Indo-Russian Workshop on Integrable Systems, Topological Field theory and Strings* at Dubna, Russsia from August 11 to 15 and visited ITEP, Moscow on August 17, 1999. Delivered a Lecture on *Pomeranchuk to M Theory - A personal perspective* at the workshop.

Attended the *Symposium on Quantum Many Body Physics* at Jawaharlal Nehru University, New Delhi, from March 5 to 7, 1999. Presented a talk on *Story of Spin in Nucleon.*

Attended mid-year meeting of Indian Academy of Science, Bangalore, during July 17-18, 1999.

Raman, V.

Attended the *18th Conference on Foundations of Software Technology and Theoretical Computer Science (FST & TCS)* in Chennai from December 17 to 19, 1998 and chaired a session.

Gave four lectures on *Graph Algorithms* in the *UGC Refresher Course in Mathematics* held in Cochin during February 15 - 16, 1999.

Participated in the *Workshop on De-randomization* held at Tata Institute of Fundamental Research, Mumbai, from February 21 to March 7, 1999 and gave a talk on *Small sized perfect Hash family and de-randomizing color coding algorithms.*

Gave a course of seven lectures on *Data structures and graph algorithms* in the *Orientation Course on Foundational Aspects of Computer Science for Teachers* held from May 24 to June 14, 1999 at IMSc., Chennai.

Ramanujam, R.

Gave a talk at Naval Physical and Oceanographic Laboratory, Cochin, on January 22, 1999, on *Formal verification of concurrent systems.*

Gave a set of 6 lectures in a UGC refresher course conducted by Bharatidasan University, Tiruchirappalli, from March 10 to 13, 1999, on *Logic and automata.*

Ray, P.

Visited the University of Mainz, Mainz, Germany from July to September, 1998. Delivered a seminar on *Melting in two-dimensional polydisperse systems.*

Attended 20th IUPAP International Conference on Statistical Physics in Paris, from July 20 to 24, 1998 and presented two papers.

Visited HLRZ, Juelich, Germany, during September 15 - 16, 1998. Delivered a seminar on *Topological defects due to size dispersity and its effect on melting.*

Visited the University of Duisburg, Duisburg, Germany, from September 22 to 24, 1998. Delivered a seminar on *Crystallisation in size-dispersed systems.*

Attended Statphys-Calcutta III, International Conference on Statistical Physics; Major Theme: Statistical Physics of Fracture, Breakdown and Earthquake, from January 1 to 10, 1999 and gave an invited talk.

Sabu, N.

Attended the *Third School on Non-linear Functional Analysis and Applications to Differential Equations* held at ICTP Trieste, Italy, from October 12 to 31, 1998.

Sathiapalan, B.

Visited TIFR Bombay and IIT, Kanpur to give talks under the TPSC programme, from November 8 to 18, 1998.

Attended *Workshop on Frontiers in Field Theory, Quantum Gravity and String Theory*, Puri, from December 9 to 19, 1998 and gave a talk entitled *Hagedorn transition revisited.*

Seth, A.

Attended *FST & TCS Conference*, from December 17 to 19, 1998, Chennai.

Visited Computer Laboratory at Cambridge University, UK, from June 8 to 28, 1999.

Delivered a talk at Nottingham University, UK, on June 14, 1999 entitled *On the expressive power of finitely many generalized quantifiers.*

Delivered a talk at Oxford University, UK, on June 22, 1999 entitled *A survey of feasibility in higher types.*

Delivered a talk at Leicester University, UK, on June 25, 1999 entitled *On the expressive power of finitely many generalized quantifiers.*

Delivered an invited talk in the *Workshop on Implicit Computational Complexity*, held during June 30-July 1, 1999 at Trento, Italy, entitled *A survey of feasibility in higher types.*

Attended the conference on *Logic in Computer Science* from July 2 to 5, 1999 at Trento, Italy.

Sharatchandra, H. S.

Delivered an invited talk entitled *A systematic computational scheme for the infrared properties of 2+1- and 3+1- dimensional Yang-Mills theory,* in the Parallel Session on *Field Theory* at *ICHEP'98, International Conference on High Energy Physics*, 1998, Vancouver.

Attended Workshop on QCD at Ooty , from September 28 to October 2, 1998 and delivered a talk on *Topological centers and computation of confinement effects.*

Attended the *Workshop on Quantum Field Theory, Quantum Gravity and Strings*, Puri, from December 9 to 19, 1998 and presented a talk on the *Topological centers of gauge fields.*

Attended QCD 98, at IMSc, from November 30 to December 8, 1998 and gave a talk on *Topological centers.*

Attended *Quantum Many Body Physics*, international symposium organised by the School of Physical Sciences, Jawaharlal Nehru University, New Delhi, from March 5 to 7, 1999 and gave an invited talk on *Computation of confinement effects.*

Presented a seminar on *Coherent states for the hydrogen atom*, at the School of Physics, JNU, Delhi, on December 5, 1998.

Delivered three lectures on *Phase Transitions* in the *Refresher Course in Statistical Physics for College Teachers* conducted by Department of theoretical Physics, University of Madras, February, 1999.

Simon, R.

Gave a course of four lectures on *Quantum Mechanics* during October 16 - 17, 1998 in the *Refresher Course for College Teachers*, Academic Staff College, Bharathiar University, Coimbatore.

Participated in the *K.S. Krishnan Birth Centenary Conference*, held at the University of Allahabad, from December 4 to 7, 1998 and gave an invited talk on *Krishnan and the sampling theorem.*

Participated in the *International Conference on Optics and Optoelectronics* held at Dehradun, from December 9 to 12, 1998 and gave an invited talk on *Quality factors of a light beam.*

Participated in the Indo-French Workshop on *Probing Fundamental Problems with Lasers and Cold Atoms*, Indian Institute of Astrophysics, Bangalore from January 4 to 8, 1999.

Visited the Department of Electrical Engineering, Indian Institute of Science, Bangalore from April 9 to 11, 1999 and gave a talk on *Sampling theorem and the K.S. Krishnan identities.*

Attended the *International Conference on Squeezed States and Uncertainty Relations* (ICSSUR–VI) held at Naples from May 24 to 29, 1999 and gave an invited talk on *Peres criterion and Gaussian states: the connection between entanglement and nonclassicality.*

Visited the Università di Roma Tre, Rome from May 30 to June 6, 1999 and gave a talk on *Invariant quality parameters of a light beam.*

Visited Centro Internacional de Ciencias, Cuernavaca, Mexico from June 24 to July 11, 1999 to participate in the *Work Period on Optical Phase Space*, and gave a talk on *Optical phase*

space and the symplectic group, and one on *Geometric phases in optics.*

Participated in the *Discussion Meeting on Quantum Computers*, held at the Jawaharlal Nehru Centre for advanced Scientific Research, Bangalore, from July 19 to 23, 1999 and gave two talks on *Quantum entanglement.*

Sinha, R.

Visited the Nagoya University and KEK, Tsukuba, Japan during July, 1998.

Visited TRIUMF, University of British Columbia, Vancouver, Canada, during July - August, 1998.

Attended the XXIX *International Conference on High Energy Physics*, Vancouver, Canada, frpm July 23 to 29, 1998.

Visited the Université de Montréal, Montréal, the McGill University, Montréal, and the Carleton University, Ottawa, Canada, during August 1998 and delivered seminar talks.

Visited the Chandigarh University, Chandigarh during December, 1998.

Attended the XIII *DAE Symposium in High Energy Physics*, Chandigarh, from December 26 to 31, 1998 and delivered an invited plenary talk.

Visited the Mehta Research Institute, Allahabad, during January 1999.

Visited the Université de Montréal, Montréal, Canada, during May-June 1999.

Visited the Carleton University, Ottawa, Canada, during June 1999.

Sinha, Subhasis

Participated in the Indo-French Workshop at IIAP, Bangalore. Delivered a talk on *Collective excitations in Bose-Einstein condensate.*

Delivered a talk on *Thermodynamic properties of trapped bosons at finite temperature* at the S. N. Bose Centre, Calcutta.

Sinha, Sudeshna

Visited the School of Physics, Georgia Institute of Technology, Atlanta, USA from May 19 to June 3, 1999.

Participated in *Dynamic Days Asia Pacific*, held in Hong Kong, from July 13 to 16, 1999.

Sridhar, R.

Delivered a course of lectures on *Applications of Fermi Statistics* in the *UGC Refresher Course for College Teachers* conducted by the Department of Theoretical Physics, Univer-

sity of Madras, during February-March, 1999.

Srinivas, K.

Gave 10 talks on *Number theory* to graduate students in the *Mathematics Training Camp* held at Bhawanipatna, Orissa, from September 20 to October 10, 1998.

Inaguarated the Mathematics Association of Gurunanak College, Chennai, on January 11, 1999 and gave a talk on *The divisibility properties of numbers*.

Visited the National Institute for Advanced Studies, Bangalore from April 6 to 11, 1999.

Participated in the 14^{th} *Annual Conference of The Ramanujan Mathematical Society*, held at IISc, Bangalore from June 7 to 9, 1999, delivered an invited talk *On Ramanujan's lattice point problem*.

Attended the International Conference on *Analytic Number Theory and Diophantine Approximation* held at Pisa, Italy from June 28 to July 9, 1999, and delivered a talk on *Notes on Riemann zeta-function*.

Visited the Department of Mathematics, University of Genova, Genova, Italy, from July 10 to 16, 1999, and delivered a talk *On the poles of certain Dirichlet Series*.

Srinivasa Rao, K.

Delivered an invited talk at the *86th Indian Science Congress* in the Mathematics Division, held at the Anna University, from January 3 to 9, 1999, on *Life and work of Srinivasa Ramanujan*.

Was an invited participant in the Humboldt Foundation's two-day meeting for the Humboldt Fellows, held at Hyderabad, in November 1998.

Participated in the *International Conference on Quantum Theory and Symmetries* held at Goslar from July 18 to 22,1999, and gave an invited talk entitled *Symmetries of the 9-j coefficient and the transformation and summation formulas for the hypergeometric series.*

Srinivasa Rao, S.

Attended the *18th FST & TCS conference* held at Chennai from December 17 to 19, 1998.

Attended the *Workshop on De-randomization* held at TIFR, Mumbai from February 21 to March 7, 1999.

Sunder, V. S.

Attended the *International Congress of Mathematicians* at Berlin, Germany, from August 18 to 26, 1998.

Visited the Technical University at Clausthal, Germany from August 27 to 29, 1998, and lectured on *Algebras of G-relations*.

Attended the *François Jaeger Memorial Conference* at Grenoble, France, from August 31 to September 4, 1998 and lectured on *Algebras of relations*.

Was a Visiting Professor at California State University at Hayward during the Fall Quarter (September-December, 1998). During this time, in addition to the courses taught there, also gave a colloquium on *Knots*.

Gave two lectures at the University of California at Berkeley entitled *The subgroup subfactor* at the *Functional Analysis Colloquium* on October 20, 1998 and *From hypergroups, via commuting squares, to subfactors* at the *Subfactors Seminar* on November 24, 1998.

Visited the University of California at Santa Barbara from December 3 to 5, 1998, and lectured on *The subgroup subfactor*.

Was a Visiting Professor at the University of Iowa during during January-May 1999. Apart from the courses taught there, also gave a lecture on *Equivalence relations and towers of algebras* on February 9, 1999, at the *Operator Theory Seminar*.

Gave a lecture titled *From ergodic theory to subfactors* at the *Iowa-Nebraska Functional Analysis Seminar* on April 17, 1999, at Drake University.

Attended the *Great Plains Operator Theory Seminar* at Ames, Iowa, from May 26 to 30, 1999, and gave one of the Plenary Lectures on *Vertex models*.

Suneeta, V.

Attended the Puri Workshop from December 9 to 19, 1998.

Suresh, S. P.

Attended the *School on Finite Model Theory* held during December 15-16, 1998 at IMSc, Chennai.

Attended the *18th Conference on the Foundations of Software Technology and Theoretical Computer Science (FST-TCS 1998)* held from December 17 to 19, 1998 at IMSc, Chennai.

Vathsan, R.

Attended the *III Puri Workshop on Quantum Field Theory, Quantum Gravity and Strings*, from December 9 to 19, 1998.

Attended the *International Conference on Mathematical Physics*, Nagpur University, from January 11 to 16, 1999 and gave a talk on *Classical and quantum aspects of anyons.*

Visited the Centre for Theoretical Studies, IISc, Bangalore, from February 14 to 17, 1999 and gave a talk on *Many-particle clusters in two dimensions: classical ground state and*

semiclassical corrections.

Visted the Raman Research Institute, Bangalore, from February 18 to March 18, 1999 and gave a talk entitled *Many-particle clusters in two dimensions: classical ground state and semiclassical corrections* and a review talk entitled *Generalized black hole mechanics and isolated horizons.*

Visited the Institute of Physics, Bhubaneshwar, during June 17 - 18, 1999 and gave a talk entitled *Many-particle clusters in two-dimensions.*

Visited the Condensed Matter Theory Group of ICTP under the Federation Arrangement and attended the Workshop on *Strongly Correlated Electron Systems* and the *1st S. Lindquist Conference: Q.Phases in Electron Systems in Low Dimensions* from July 5 to 31, 1999.

2.10 Collaborative Projects with Other Institutes

2.10.1 Indo-Russian Integrated Long Term Programme of S & T

Under the Integrated Long-Term Programme of Cooperation in Science and Technology between India and Russia a three year proposal (1998-2000) was approved by DST.

As part of the project, in the first year a Russian-Indian International Workshop on *Topological and Integrable Field Theories* was organized at the Bogoliubov Laboratory for Theoretical Physics, Joint Institute for Nuclear Research (JINR), Dubna, Russia, during August 11-14, 1998. A seven member Indian delegation visited Russia to participate in the organization of this workshop. The members of the delegation were: *R. Ramachandran* (IMSc), *T. R. Govindarajan* (IMSc), *R. Jaganathan* (IMSc), *Anjan Kundu* (Saha Institute of Nuclear Physics), *Sunil Mukhi* (Tata Institute of Fundamental Research), *Jnanadev Maharana* (Institute of Physics) and *Dileep Jatkar* (Mehta Research Institute of Mathematics and Mathematical Physics).

Members of the Advisory Committee were: *R. Ramachandran, A. Belavin, A. Morozov, P. Kulish* and *V. Rubakov*. Members of the Organizing Committee were: *A. Fillippov* (Chairman), *A. Isaev, T. R. Govindarajan, D. Kazakov* and *S. Pakuliak* (Scientific Secretary).

The Lectures and Reports at the Workshop covered *Integrable Models, Quantum Symmetries, Topological Field Theories* and *New Developments in String Theory.*

Besides the seven members of the Indian delegation there were about twenty five Russian participants in the Workshop. The Workshop was inaugurated on 11th August by V.G. Kadyshevsky, Director, JINR and the scientific programme of the Workshop started with the one-hour lecture by R. Ramachandran reviewing the *developments in theoretical particle physics from the Pomeranchuk theorem to the current M-theory.* All the members of the Indian delegation gave one-hour lectures.

2.10.2 Federation Arrangement with the Abdus Salam ICTP

Federation arrangement with the Abdus Salam ICTP International Centre for Theoretical Physics, Trieste has been renewed for three years from 1999. The expenses of visits undertaken in relation to this arrangement shall be financed on a cost-sharing basis. The Centre shall pay to each scientist in the local currency of the Centre an amount intended to contribute towards daily subsistence expenses. This amount shall be determined by the Centre, and the total amount to be paid for this purpose shall be limited to 150 days for all such visits for the entire period of the duration of the arrangement. The Centre shall also contribute towards travel expenses of scientists from the Institute to the Centre in an amount not to exceed Italian Lire 1,200,000 per person and Italian Lire 4,800,000 for the total of all such visits and the Institute will bear the remaining travel cost. The timing and the duration of the visit (minimum duration 3 weeks) may be so arranged to take advantage of various activities at ICTP. The agreement stipulates that the privilege is made use of for the 'junior' members of the Institution, with an age limit of 40 years.

Mitaxi Mehta, a PDF of our Institute visited ICTP under this arrangement from July 2,

1990 to August 12, 1999. Also Radhika Vathsan, a JRF of our Institute visited from July 5 to 31, 1999.

2.10.3 DST-DAAD Project in Theoretical Computer Science

A DST-DAAD joint project was approved under the Personnel Exchange Programme-99 for the period April 1999 to March 2001.

The project title is *Complexity and Algorithmic Issues in Fixed Parameter (In)Tractability.* The institutions involved are Institute of Mathematical Sciences, Chennai and University of Ulm, Ulm, Germany. V. Arvind, Meena Mahajan, Venkatesh Raman, S. Srinivasa Rao from IMSc, K. V. Subramanyam of Chennai Mathematical Institute, and Johannes Köebler, Rainer Schüler and W. Lindner from University of Ulm are involved in the project.

The Indian side of the project grant from DST covers expenses for the Indian researchers to visit Ulm University, Germany and for the local hospitality expenses for the German visitors when they visit Institute of Mathematical Sciences, Chennai. Under this project, S. Srinivasa Rao, a JRF of our Institute is visiting Ulm University from July 25 to August 25, 1999.

2.11 Other Professional Activities

Adhikari, R.

Supervising a Ph.D. student G. Omanovic, Department of Theoretical Physics, University of Natural and Mathematical Sciences at Zagreb, Zagreb, Croatia.

Anishetty, R.

One of the organisers of Workshop on QCD, Ooty from September 28 to October 5, 1998.

Arvind, V.

Programme committee co-chair of the 18th FST & TCS Conference, December 1998. Programme committee member for the 19th FST & TCS Conference.

Balasubramanian, R.

Conducted a symposium on the works of the Fields Medallists ICM 98.
Member of the selection committee for the Young Scientist Fellowships scheme of Tamil Nadu State Council for Science and Technology.
Member, National Board for Higher Mathematics.
Member, Scrutinising Committee of National Academy of Sciences, Allahabad.
Member, Editorial Board, Indian Journal of Pure and Applied Mathematics.
Member, Editorial Board, National Academy of Science Newsletter.
Member, National committee (INSA) for IMU.
Member, Programme Advisory committee, S.N.Bose center for Basic Sciences. Member, Mac Committee of DST.
Member, Research Advisory Committee, Chennai Mathematical Institute

Basu, Rahul

Member, Organizing Committee of QCD 98

Convener, Sixth Workshop in High Energy Physics Phenomenology, to be held from January 3 to January 15, 2000 at IMSc.

Chakraborty, T.

Editor, International Journal Physica E (North-Holland).

Hari Dass, N. D.

Member, IAGRG Council.
Secretary for the Conference and member of Local Organising Committee, International Symposium on Lattice,2000.
Member, National Organising Committee, Winter School and Workshop on Foundations of Quantum Theory, S.N. Bose Centre, Calcutta January 2000.

Lectured on the works of Meghnad Saha and Chandrasekhar to high school students at the summer programme conducted by the Children's Club, Chennai.
Gave a talk on "How to carry out Physics Projects" to High School teachers at the Regional Meet of School Teachers at Kalpakkam.
Participated in the design of Summer projects for High School students

Govindarajan, T. R.

Vice President, Indian Physics Association, Madras Chapter.

Member, National Organizing Committee, III Puri Workshop on Quantum Field Theory, Quantum Gravity and Strings.

Kaul, Romesh

Convener, National Organizing Committee, III Puri Workshop on Quantum Field Theory, Quantum Gravity and Strings.

Kesavan, S.

Organized the fourth contact programme of the Nurture Programme (NBHM), June 28 - July 16, 1999.
Member, Programme Advisory Committee, National Undergraduate Programme in Mathematics, Chennai Mathematical Institute (CMI), Chennai.
Member, Programme Implementation Committee, National Undergraduate Programme in Mathematics, CMI, Chennai.

Kodiyalam, Vijay

Gave a course of 5 lectures on Combinatorics for the MTTS programme held at IIT Chennai during May 18 - June 12, 1999

Krishna, M.

As a member PAC-MS of SERC, DST attended a few project evaluation and review meetings during the academic year.

Mahajan, Meena

Co-Chair, Organizing Committee of the 18th International Conference on Foundations of Software Technology and Theoretical Computer Science FST&TCS, held in Chennai in December 1998.

Majumdar, Parthasarathi

Started work, as Principal Collaborator on a DAE-BRNS Project on 'Cosmology with Torsion' in collaboration with Dr Soumitra SenGupta, Senior Lecturer, Physics Department, Jadavpur University, Calcutta. One JRF has been employed to work on this project which is being carried out mainly in Jadavpur University. This project is funded by DAE under

the University-DAE Research Institute Collaboration Programme.

Mishra A. K.

Reviewed for Mathematical Review the book 'Supersymmetry in Disorder and Chaos' by K. Efatov, Cambridge University Press 1997, pp.441+xiii.

Paranjape, K. H.

Associate Editor for The Proceedings of the Indian Academy of Sciences, (Mathematical Sciences).
Member of the Editorial Board for the Journal of the Ramanujan Mathematics Society.
Member of the Editorial Board for 'Resonance' A Journal of Science Education.

Rajasekaran, G.

Chairman of Programme Committee for the 64th Anniversary Meeting of INSA, held at Chennai from December 29 to 31, 1999.
As a part of this meeting, organized a symposium "Physics at the turn of the century" highlighting the achievements and perspectives in Physics, Astrophysics and Biology.
Member, Governing Council of MRI, Allahabad.

Ramachandran, R.

Member, Sectional Committee for Physics, Indian Academy of Science, Bangalore (until December 1998).
Member, Board of Studies, Indira Gandhi National Open University, New Delhi.
Member, School of Physics Board, University of Hyderabad.
Member, Board of Research, University of Madras, Madras.
Member, Strategic Planning Committee at IIT Madras.
Member, Working Committee of Current Science Association.
Area Co-ordinator for Mathematics and Mathematical Sciences of the Indo Russian Integrated Long Term Program (ILTP) of Co-operation in Science and Technology.
Vice President, MALIBNET, Madras Library Network.

Raman, Venkatesh

Member, Organizing Committee of the 18th Conference on Foundations of Software Technology and Theoretical Computer Science between from December 17 to 19, 1998.

Ramanujam, R.

Co-chaired the Programme Committee of *FST&TCS*, held at Chennai from December 17 to 19, 1998.
Co-ordinated the orientation course on *Foundational Aspects of Computer Science* for College/University teachers held at IMSc from May 24 to June 12, 1999.

Ray, P.

Regular associate of the ASICTP, Trieste, Italy.

Sathiapalan, B.

Member, National Organizing Committee, III Puri Workshop on Quantum Field Theory, Quantum Gravity and Strings.

Seth, A.

Organized (with Anuj Dawar, University of Cambridge, UK) the school on Finite Model Theory held at IMSc during 15-16 December, 1998.

Sharatchandra H.S.

One of the organisers of Workshop on QCD, Ooty from September 28 to October 5, 1998. One of the organisers of QCD'98 at IMSc from November 30 to December 8, 1998. On the National Organising Committee of Lattice 2000, to be held at IISc, Bangalore in August 2000.

Simon, R.

Member, Programme Advisory Committee (PAC) on *Lasers, Optics, Atomic and Molecular Physics*, Department of Science and Technology, Government of India.

Member, Editorial Board, *Pramana – Journal of Physics*.

Member, National Organizing Committee, *National Laser Symposium*, to be held at the University of Hyderabad, December 15–17, 1999.

Member, National Organizing Committee, *Winter Institute on Foundations of Quantum Theory and Quantum Optics*, to be held at S.N. Bose National Centre for Basic Sciences, Calcutta, January 1–13, 2000.

Sinha, Sudeshna

Organized a Discussion Meeting on Spatiotemporal Physics, at the Radio Astronomy Centre of Ooty, February 25 to 28, 1999.
Invited to be a member of the Advisory Editorial Board of the AIP journal *Chaos*, for an initial term of 3 years beginning 1 January 1999.

Srinivas, K.

Member, Interview Board for the NCERT Scholarship awards for 1998-99.

Member, Programme Implementation Committee, National Undergraduate Programme in Mathematics, CMI, Chennai.

Sunder, V.S.

Member, Editorial Board of the Journal of the Ramanujan Mathematics Society.
Member, Sectional Committee for Mathematics of the Indian Academy of Sciences.
Member, Programme Implementation Committee, National Undergraduate Programme in Mathematics, Chennai Mathematical Institute.

2.12 Visitors

Name	Affiliation	Period of Visit
Y. Manoussakis	Université de Paris, Orsay	28.07.98 to 02.08.99
Tabish Qureshi	IGCAR, Kalpakkam	30.06.98 to 01.09.98
M. Sanjay Kumar	Raman Research Institute Bangalore	27.08.98 to 06.09.98
Kurt Bernardo Wolf	Instituto de Investigaciones en mathematicas Aplicadas y en Sistemas, Universidad Nacional Autonoma de Mexico, Mexico	17.08.98 to 12.09.98
Sasti Brata Kabiraj	M.G.S. Vidyalaya, Barjora, Bankura, West Bengal	06.10.98 to 19.10.98
Rajan Gupta	Los Alamos, USA	07.12.98 to 11.12.98
H.E. Stanley	Centre for Polymer Physics Boston University, USA	25.12.98 to 03.01.99
L. V. Satyanarayana	Loyala College, Chicago, USA	21.12.98 to 24.12.98
Indranil Biswas	School of Mathematics TIFR Mumbai	22.12.98 to 07.01.99
Filomena Pacella	Dipartimento di Matematica Università di Roma Italy	04.01.99 to 10.01.99

Manisha Kulkarni	Indian Institute of Science Bangalore	18.12.98 to 15.01.99
Bindu A. Bambah	Centre for Advanced Study in Mathematics Punjab University Chandigarh	07.01.99 to 16.01.99
J. Batt	University of Munich Germany	13.01.99 to 17.01.99
Ashvin Vishwanath	Princeton University, USA	20.01.99 to 21.01.99
G. Suryan	IISc Bangalore	21.01.99 to 24.01.99
J. Oesterle	Université Pierre et Marie Curie and Institut Henri Poincaré Paris, France	02.12.98 to 31.01.99
Bruno Khan	Institut de Mathématiques de Jussieu, Université de Paris VI, France	24.01.99 to 30.01.99
Layla Pharamond Dit D'Costa	Institut Mathematiques de Jussiene Universite Paris, France	09.02.98 to 31.01.99
Fernando J.S. Moraes	Departamento De Fisica Utpe, Brazil	24.01.99 to 06.02.99
Plakida Nikolai	Joint Institute of Nuclear Research Dubna, Moscow, Russia	06.02.99 to 11.02.99
Bruce Berndt	Dept. of Mathematics University of Illinois USA	04.01.99 to 10.01.99

Von Gehlen, Gunter	Physikalisches Institut University of Bonn Germany	16.02.99 to 21.02.99
Maurizio Paoluzzi	Università di Roma II, Roma Italia	05.12.98 to 04.02.99
Elizabeth Gasparim	Depto. de Matematica Universidade Federal de Pernambuco Brasil	11.10.98 to 10.03.99
P. Bro Miltersen	BRICS, University of Aarhus Denmark	20.02.99 to 23.02.99
L. M. Sehgal	Inst. of Theoretical Physics RWTH Aachen Germany	21.02.99 to 28.02.99
Loic Merel	Université de Paris VI, France	28.02.99 to 02.03.99
Biswajit Chakraborty	S.N. Bose National Centre for Basic Sciences, Calcutta	11.02.99 to 05.03.99
Chandramowliswaran	Vellore Engineering College, Vellore	11.10.98 to 10.03.99
Tahlamann Fabrice	EEPES, CNRS France	11.10.98 to 10.03.99
Rossen Dandoloff	Laboratoire de Physique Théorique, Université de Cergy-Pontoise, France	20.02.99 to 28.03.99
Srinath Cheluvaraja	TIFR Mumbai	10.01.99 to 05.05.99
C.A. Safeeque	W.M.O. Arts and Science College Kerala	04.04.99 to 06.05.99

V.C. Kuriakose	Cochin University of Science and Technology, Kochi	03.05.99 to 07.05.99
R. Chandramouli	A.M. Jain College Chennai.	05.05.99 to 15.06.99
S. Arun Kumar	IIT Delhi	19.05.99 to 18.06.99
Birjoo D. Vaishnav	Haldia Institute of Technology Midnapur	08.05.99 to 20.06.99
J. Mossino	Ecole Normale Supèrieure de Cachan, France	22.06.99 to 25.06.99
V. Kumar Murty	University of Toronto, Canada	18.06.99 to 08.07.99
Subashree Desikan	MRI Allahabad	19.05.98 to 19.07.99
V. Kumar Murty	Dept. of Maths University of Toronto	18.06.99 to 08.07.99
R. Srinivasan	Mehta Research Institute Allahabad	20.05.99 to 20.07.99
Pablo Ares Gastesi	TIFR Mumbai	12.07.99 to 22.07.99
Asim Kumar Ray	Visva Bharati University Santiniketan	20.07.99 to 28.07.99
M. Muthukumar	University of Massachusetts Amherst	06.07.99 to 02.08.99

2.13 Honours and Awards

Hari Dass, N. D. was elected Fellow of the National Academy of Sciences, Allahabad, in 1998.

Nag, S. was awarded the Shanti Swarup Bhatnagar Award for Mathematical Sciences for the year 1998.

Simon, R. was elected Fellow of the Indian National Science Academy, New Delhi, in 1998.

Srinivasa Rao, K. was elected Fellow of the National Academy of Sciences, Allahabad, in 1998.

Chapter 3

Computer Facilities

During the past year, there has been further significant strengthening of the Institute computer system in terms of hardware, software, and internet services.

The LAN has been strengthened by moving to a **switched network** sitting on fibre backbone connecting the Nehru Centenary Library building, IMSc main building and guest house complex. The switches, routers, hubs, terminal server, modems are housed in air cooled racks in a central location.

A new Sun Enterprise-450 (2xUltraSPARC-II 248MHz) has been put in operation as a file server under Solaris-2.6 replacing the older SunSPARC-10 file server. Along with this the Network Information Service (NIS) and the Network File System (NFS) have also been revamped. Further re-organisational work in this connections is under way.

Two duplex laser printers have been installed on the LAN and located in the Main building and Library building. A color laser printer is also available for users.

During this period, a **Cluster Super Computer System** has been made available to users. This is built out of 16xPentium II 400MHz CPUs, each with 64MB SDRAM, 4GB HDD connected through an Intel switch housed in a suitably designed rack. The system runs Linux RedHat 5.0 O/S

A data projector has been acquired for use in computer based presentation. An additional video presenter attachment is also available for VCR/VCD/DVD display.

GNU software, especially Linux has been systematically introduced at IMSc for all the internet and intranet services. All the faculty offices are equipped with pentiums running Linux O/S. The Linux systems were implemented and extensively debugged by Kapil Paranjape, T. Jayaraman, Rahul Basu, Suresh Rao and G. Subramoniam.

The computer facility is managed by one full-time system administrator, Dr. G. Subramoniam. The ERNET has provided for a project assistant to help in the network related activities. These are being managed by Dr. Suresh Rao.

Chapter 4

The Library

The Institute library, with its collection of about 38,860 basic and advanced level text books, research monographs and research journals covering Mathematics, Theoretical Physics and Theoretical Computer Science, continues to be the hub of the research activity. It plays the role of a regional library catering to the needs of research scholars and scientists. As a result, the number of the users of the library from outside the Institute has been steadily increasing.

Under the 'library augmentation' budget head of the 9th Five Year Plan, about 375 back volumes and 136 books were added to the main collection. A new subscription to the "Math-SciNet" is also covered under this budget head. This on-line version of the Mathematical Reviews database contains reviews of research papers and books in mathematics and related areas since 1940. The easy access to this vast database is very useful for the research work of the members of the Institute.

Three personal computers were also added to the library under this project. LIBSYS 3.4, the latest version of library automation software, has been implemented and integrated with the main computer network of the Institute. Its OPAC (Online Public Access Catalogue) module enables users to retrieve full information about the books/journals by using a variety of searches based on author names(s), title, keywords or search strings with combination of boolean operators etc. Its web-based interface can presently be accessed from PC's within the library building and is expected to be accessible from other terminals on the main computer network in the near future. The library machines are on a Windows-NT 4.0 network.

Under the Non-Plan budget, 2,190 volumes (books and bound periodicals) were added to the collection. The library continues to subscribe to about 260 research journals of international repute, most of which arrive by air-mail. The library has "ONLINE" access to sizable number of journals which is available to the Institute members. The Institute also became a member under the "Institutional Membership" scheme of the American Mathematical Society.

The library maintains a pre-print library and good number of them were received from leading research Institutions on reciprocal basis. We continues to get books, journals and photocopies of research articles from various libraries in the country under Inter-library loan scheme and it provides similar services on a reciprocal basis.

During the past year, the photo-copying facility in the library has been utilised to the tune

of about two lakh copies by the Institute members and outside users.

K. Santhanagopalan, Librarian and G. Venkatesan, Deputy Librarian attended the one day workshop on *Networking of Libraries* on July 28, 1999, organized by the Science City, DOTE campus, Chennai.

The library gratefully acknowledges the donation of many valuable books/journals received during the year 98-99, from the following persons:

R. Balasubramanian, R. Ramachandran, K.Srinivasa Rao, Kamal Lodya, Krishna Maddaly, R. Sridhar, M. Rajesh, Saraji Ray Choudhuri, all from IMSc;

Morvan from Université Denis Diderot, Paris, France,
Ram Murthy from Queen's University, Canada,
A. Vijaya Kumar from Anna University.

The library acknowledges the following organizations/Programmes for their donation of books/proceedings:

- Door Programme in Computer Science for Conference Proceedings,
- ICTP, Italy
- NBHM, DAE
- Department of Mathematics, Pondicherry University.

Subhashis Nag (1955 - 1998)

Professor Subhashis Nag passed away on Tuesday, December 22, 1998 at the age of 43 years. He is survived by his wife, Mrs. Sutapa Nag.

Prof. Nag was a highly talented mathematician and had several achievements to his credit in his field of research. He won several laurels, both national and international. He was a Fellow of the Indian Academy of Sciences, Bangalore. He was selected to receive the prestigious Shanti Swarup Bhatnagar Award in Mathematical Sciences for the year 1998. It is unfortunate that his demise occurred before the actual award ceremony.

Born on August 14, 1955 in a family devoted to industry, Prof. Nag cut a different path for himself by choosing to study mathematics. A brilliant alumnus of Calcutta University, he won five memorial gold medals for his performance and also the National Science Talent Search Scholarship awarded by the NCERT to pursue a career in the basic sciences. He got his Ph. D. degree from Cornell University, Ithaca, USA and worked briefly as Assistant Professor at the University of Michigan, Ann Arbor, USA. He returned to India and thereafter he was associated with several schools of excellence such as the Tata Institute of Fundamental Research, Mumbai, the Indian Statistical Institute at Calcutta and at Bangalore and, finally, the Institute of Mathematical Sciences, Chennai (since 1991). He has been invited as Visiting Professor by several major universities all over the globe. He occupied, on three different occasions, the Einstein Visiting Chair of the Graduate Center of the City University of New York.

His research interests could be broadly described as Complex Analytic Geometry with special emphasis on Teichmüller Theory and its central connections to Mathematical Physics through String Theory. His research has received a lot of international acclaim. His book on the theory of Teichmüller spaces has been very well received.

He was a very energetic lecturer and passed on his infectious enthusiasm to young students.