# THE INSTITUTE OF MATHEMATICAL SCIENCES

**C. I. T. Campus, Taramani,**

**Chennai - 600 113.**

# ANNUAL REPORT

**Aug 2002 - Jul 2003**

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# Foreword

I am pleased to present the progress made by the Institute during 2002-2003 in its many sub-disciplines and note the distinctive achievements of the members of the Institute.

As usual, 2002-2003 was an academically productive year in terms of scientific publications and scientific meetings.

In memory of the late Prof. Subhashish Nag, who was on the faculty of this Institute, a Prof. S. Nag Endowment Memorial Lecture Series has been established. The first lecture in this series was delivered by Prof. D. Sullivan, from the Department of Mathematics, State University of New York at Stony Brook, USA, in December 2002.

The Institute was honoured to host a visit by Prof. Gerard 't Hooft, Nobel Laureate, Universiteit Utrecht, during January 2003. In addition to interacting with the scientific community, Prof. 't Hooft gave a public lecture titled "The Universe Inside the Atom".

I congratulate Dr. Surya Ramana (Mathematics) and Dr. Subashis Sinha (Physics), who received the best thesis award of this Institute.

The Institute conducted a workshop on "Mathematica and the software packages Hyp and Hyp-q"; an international conference on "Special functions and their applications"; a discussion meeting on "Harmonic analysis"; a meeting on "Robustness, emergent behaviour and pattern formation in biological systems"; a school and workshop on "Automata, concurrency and logic"; and a discussion meeting on "Statistical mechanics of threshold activated systems".

The Institute co-sponsored and took active part in the discussion meeting on "Field-theoretic aspects of gravity-III" held at Kochi, and a seminar on "Current trends in Mathematics" at the Madras Christian College.

The following activities have become an annual feature of the Institute: (i) The Institute Seminar Week, (ii) NBHM Nurture Programme, (iii) Refresher course in Physics.

The Institute has also participated in several national and international collaborative projects: the IFCPAR projects on "Analytical and combinatorial number theory" and "Automata and concurrency: Syntactic methods for verification", the CD-ROMS project on "The life and works of Srinivasa Ramanujan", the "India-based neutrino observatory" project, the Indo-UK project on "Highly efficient data structures", the DRDO project on "Novel materials for applications in molecular electronics and energy storage devices" the DFG-INSA project on "The spectral theory of Schrödinger operators", and the Indo-US project on "Studies in quantum statistics".

This report has been compiled through the efforts of a committee consisting of Drs. Vijay Kodiyalam, Meena Mahajan, R. Parthasarathy, and Mr. Paul Pandian (Librarian). I owe my gratitude to all of them.

I look forward to another year full of distinctive achievements for the Institute.

August, 2003 **R. Balasubramanian**

# Contents

# Chapter 1

# The Institute

## 1.1 Board

Hon'ble Shri **M. Thambidurai**, Minister for Education, Government of Tamil Nadu, Fort St. George, Chennai 600 009 (Upto June 2003)
(**Chairman**)

Hon'ble Shri **S. Semmalai**, Minister for Education, Government of Tamil Nadu, Fort St. George, Chennai 600 009 (From June 2003)
(**Chairman**)

Dr. **Anil Kakodkar**, Chairman, AEC & Secretary to Government of India, Department of Atomic Energy, CSM Marg, Mumbai 400 001 (From December 2000)
(**Vice-Chairman**)

Prof. **S. K. Joshi**, Honorary Scientist Emeritus CSIR, Vikram Sarabhai Professor, National Physical Laboratory, Dr. K. S. Krishnan Road, New Delhi 110 012
(**Member**)

Prof. **E. Balagurusamy**, Vice Chancellor, Anna University, Chennai 600 025.
(**Member**)

Prof. **C. S. Seshadri**, Director, Chennai Mathematical Institute, Chennai 600 017
(**Member**)

Prof. **Mustansir Barma**, Department of Physics, Tata Institute of Fundamental Research, Mumbai 400 005 (From March 2001)
(**Member**)

Prof. **Ravi Kulkarni**, Director, Harish Chandra Research Institute, Chhatnag Road, Jhusi, Allahabad 211 019.
(**Member**)

Prof. **S. S. Jha**, Director, Tata Institute of Fundamental Research, Mumbai 400 005
(**Member**)

Smt. **Sudha Bhave**, I.A.S., Joint Secretary to Government of India, Department of Atomic Energy, CSM Marg, Mumbai 400 001
(**Member**)

Shri **R. Sriram**, I.A.S., Secretary to Government, Higher Education Department, Government of Tamil Nadu, Fort St. George, Chennai 600 009 (Upto June 2003)
(**Member**)

Shri **V.K. Subburaj**, I.A.S., Secretary to Government, Higher Education Department, Government of Tamil Nadu, Fort St. George, Chennai 600 009 (From June 2003)
(**Member**)

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

## 1.2 Executive Council

Prof. **S. K. Joshi**, Honorary Scientist Emeritus CSIR, Vikram Sarabhai Professor, National Physical Laboratory, Dr. K. S. Krishnan Road, New Delhi 110 012
(**Chairman**)

Prof. **C. S. Seshadri**, Director, Chennai Mathematical Institute, Chennai 600 017
(**Member**)

Prof. **Mustansir Barma**, Department of Physics, Tata Institute of Fundamental Research, Mumbai 400 005 (From March 2001)
(**Member**)

Prof.**Ravi Kulkarni,** Director, Harish Chandra Research Institute, Chhatnag Road, Jhusi, Allahabad 211 019 (From October 2001)
(**Member**)

Smt. **Sudha Bhave,** I.A.S., Joint Secretary to Government of India, Department of Atomic Energy, CSM Marg, Mumbai 400 001
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Shri **R. Sriram**, I.A.S., Secretary to Government, Higher Education Department, Government of Tamil Nadu, Fort St. George, Chennai 600 009 (Upto June 2003)
(**Member**)

Shri **V.K. Subburaj**, I.A.S., Secretary to Government, Higher Education Department, Government of Tamil Nadu, Fort St. George, Chennai 600 009 (From June 2003)
(**Member**)

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

## 1.3 Faculty

| *Name* | *Userid* | *Tel. Ext.* | *Res. Phone No.* |
|---|---|---|---|
| **Mathematics** | | | |
| **Balasubramanian, R.** | balu | 201 | 2245 3926 |
| **Kesavan, S** | kesh | 273 | 2641 2839, 2665 0535 |
| **Kodiyalam, Vijay** | vijay | 228 | 2490 2041 |
| **Krishna, M.** | krishna | 285 | 2449 1499 |
| **Nagaraj, D. S.** | dsn | 291 | 2448 1260 |
| **Paranjape, Kapil H.** | kapil | 218 | 2492 7243 |
| **Raghavan, K. N.** | knr | 255 | 2844 6319 |
| **Sankaran, P.** | sankaran | 221 | 2446 0909 |
| **Srinivas, K.** | srini | 244 | 2448 1256 |
| **Sunder, V. S.** | sunder | 206 | 2442 0082 |
| **Physics** | | | |
| **Anishetty, R.** | ramesha | 229 | 2496 0586 |
| **Balakrishnan, Radha** | radha | 203 | 2257 9653 |
| **Baskaran, G.** | baskaran | 233 | 2492 7304 |
| **Basu, Rahul** | rahul | 284 | 2245 4794, 2245 3297 |
| **Chakraborty, T.** | tapash | 215 | 2492 5271 |
| **Date, G.** | shyam | 280 | 2245 6148 |
| **Govindarajan, Thupil R.** | trg | 281 | 2492 7309 |
| **Hari Dass, N. D.** | dass | 275 | 2442 2767 |
| **Indumathi, D.** | indu | 225 | 2492 8138 |
| **Jagannathan, R.** | jagan | 219 | 2263 1638 |
| **Jayaraman, T.** | jayaram | 248 | 2492 9527 |
| **Kar, Guruprasad**[1] | gkar | | |
| **Kaul, R.** | kaul | 279 | 2441 3264 |
| **Majumdar, Parthasarathi** | partha | 282 | 2448 0793 |
| **Menon, Gautam I.** | menon | 292 | 2619 4134, 2621 3024 |
| **Mishra, Ashok K.** | mishra | 283 | 2448 2684 |
| **Murthy, M. V. N.** | murthy | 227 | 2257 9342, 2257 0652 |
| **Parthasarathy, R.** | sarathy | 214 | 2223 2021 |
| **Rama, S. Kalyana** | krama | 293 | - |
| **Ray, Purusattam** | ray | 231 | 2492 8251 |
| **Sathiapalan, Balachandran** | bala | 278 | 2492 7832 |
| **Shankar, R.** | shankar | 235 | - |

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[1] From 26.05.2003

| *Name* | *Userid* | *Tel. Ext.* | *Res. Phone No.* |
|---|---|---|---|
| **Sharatchandra, H. S.** | sharat | 276 | 2252 1388 |
| **Simon, R.** | simon | 232 | 2451 0280 |
| **Sinha, Rahul** | sinha | 290 | 2448 2190 |
| **Sinha, Sudeshna** | sudeshna | 216 | 2492 7243 |
| **Sinha, Sitabhra** [1] | sitabhra | 342 | |
| **Sridhar, R.** [2] | sridhar | 213 | 2441 9145 |
| **Srinivasa Rao, K.** [3] | rao | 220 | 2441 1347 |

**Theoretical Computer Science**

| | | | |
|---|---|---|---|
| **Arvind, V.** | arvind | 277 | 2235 2556 |
| **Lodaya, Kamal** | kamal | 286 | 2445 3312 |
| **Mahajan, Meena B.** | meena | 247 | 2440 4396, 2440 4395 |
| **Raman, Venkatesh** | vraman | 243 | 2244 5374 |
| **Ramanujam, R.** | jam | 288 | 2492 8138 |
| **Subramanian, C.R.**[4] | crs | 282 | |

## 1.4 Scientific Officers

| | | | |
|---|---|---|---|
| **Subramoniam, G.** | gsmoni | 217 | 2246 0520 |
| **Ravindra, Reddy** | ravi | 343 | 2492 7845 |

## 1.5 Project Staff

| | | | |
|---|---|---|---|
| **Gautam Dutta** [5] | - | - | - |
| **Abdul Salam** [6] | salam | - | - |
| **Srinivas, Shyam** [7] | sshyam | 326 | - |
| **Venkatesh, T.** | venky | 323 | - |

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[1] From 23.09.2002
[2] Until 31.05.2003
[3] Until 30.11.2002
[4] From 29.11.2002
[5] From 14.02.2003 until 30.06.03
[6] From 05.02.2003
[7] From 11.07.2003

## 1.6 Visiting Scientists

| *Name* | *Userid* | *Tel. Ext.* | *Res. Phone No.* |
|---|---|---|---|
| **Mani, H. S.** [1] | hsmani | 363 | - |
| **Parthasarathy, K. R.** [2] | krp | 295 | - |
| **Rai, Balram** [3] | balram | 328 | - |
| **Rajasekaran, G.** | graj | 230 | 2441 3395 |
| **Setlur, Girish** | gsetlur | 226 | - |
| **Sinha, Nita** | nita | 246 | 2448 2190 |
| **Srinivasa Rao, K.** [4] | rao | 220 | 2441 1347 |
| **Subramanian, C. R.** [5] | crs | 226 | 2448 0169 |

## 1.7 Post-Doctoral Fellows

**Mathematics**

| | | | |
|---|---|---|---|
| **Narasimhan, Anuradha**[6] | anuradha | - | - |
| **Gautam, Vishvajit V.** | vishvajit | 296 | 2254 2372 |

**Physics**

| | | | |
|---|---|---|---|
| **Bhattacharya, Sandip**[7] | sandip | - | - |
| **Ganguly, Avijit K.** | avijit | 324 | 2254 2588 |
| **Ghosh, Sibashish**[8] | sibashish | - | - |
| **Gupta, Nayantara**[9] | nayan | - | - |
| **Gurrappa, N.** | guru | - | - |
| **Harikumar, E.** | hari | 258 | - |
| **Mitra, Indrajit** | indrajit | 328 | - |
| **Roy, Anirban**[10] | anirb | - | - |

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[1] From 02.06.2003
[2] Until 31.01.2003
[3] Until 15.11.2002
[4] From 01.12.2002
[5] Until 27.11.2002
[6] From 15.03.2003
[7] From 02.01.2003
[8] From 31.01.2003
[9] From 26.06.2003
[10] From 04.02.2003

| | | | |
|---|---|---|---|
| **Ratnadeep, Roy**[1] | ratnadeep | - | - |
| **Sanjay** [2] | sanjay | 295 | - |

**Theoretical Computer Science**

| | | | |
|---|---|---|---|
| **Mishra, Sounaka**[3] | soun | 319 | - |
| **Narayanan, Vasumathi**[4] | vasumathi | 319 | - |

## 1.8 Ph.D. Students

| *Name* | *Userid* | *Tel. Ext.* | *Res. Phone No.* |
|---|---|---|---|
| **Mathematics** | | | |
| **Das, Paramita** | pdas | 224 | 2254 2050 |
| **Dey, Arijit** | arijit | 209 | 2254 2050 |
| **Ghosh, Shamindra Kumar** | shami | 224 | - |
| **Gyan, Prakash** | gyan | 211 | - |
| **Kanhere, Aaloka** | aaloka | 289 | - |
| **Muthukumar, T.** | tmk | 287 | - |
| **Sengupta, Ritabrata** | ritabrata | 272 | 2254 2050 |
| **Uma, V.** | uma | 224 | 2235 2556 |
| **Physics** | | | |
| **Bagchi, Arjun** | arjun | 211 | - |
| **Banerjee, Kinjal** | kinjal | 209 | - |
| **Basak, Soumen** | soumen | 344 | 2254 2050 |
| **Biswas, Turbasu** | turbasu | 211 | - |
| **Ezhuthachan, Bobby V. K.** | bobby | 334 | 2254 2050 |
| **Hossain, Golam Mortuza** | golam | 334 | 2254 2050 |
| **Karthik, G. V. S.** | karthik | 287 | - |
| **Kumar, Alok** | alok | - | - |
| **Lukose, Vinu** | vinu | 344 | - |
| **Mandal, Saptarishi** | saptarshi | - | - |
| **Mitra, Mithun Kumar** | mithun | 211 | - |
| **Rajesh, V.** | chinta | 289 | - |
| **Sankararaman, Sumithra** | sumithra | 259 | - |

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[1] From 29.10.2002
[2] From 22.05.2003
[3] Until 31.04.2003
[4] From 10.01.2003

| | | | |
|---|---|---|---|
| **Santosh, Kumar K.** | sant | 272 | 2254 2050 |
| **Sarkar, Swarnendu** | swarnen | 209 | 2254 2050 |
| **Sharma, Chandradev** | sharma | 344 | - |
| **Solomon, Ivan J.** | solomon | - | - |
| **Surendran, Naveen** | naveen | 211 | - |

**Theoretical Computer Science**

| | | | |
|---|---|---|---|
| **Kurur, Piyush P.** | ppk | 287 | - |
| **Meenakshi, B.** | bmeena | 259 | - |
| **Muthu, Rahul** | rahulm | 272 | 2233 5558 |
| **Suresh, S. P.** | spsuresh | 344 | - |
| **Vijayaraghavan, T. C** | tcvijay | 259 | 2466 0586 |
| **Sarma, Jayalal** | jayalal | 224 | - |
| **Chakraborty, Arindam**[1] | - | - | - |

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[1] Until 31.10.2002

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| *Name* | *Userid* | *Tel. Ext.* | *Res. Phone No.* |
|---|---|---|---|
| **Ramakrishna Manja**<br>*Registrar* | manja | 208 | 2492 5297 |
| **Jayaraman, R.**<br>*Admn. Officer* | rjao | 242 | 2371 9889 |
| **Vishnu Prasad, S.**[1]<br>*Admn. Officer* | svishnu | 242 | 2492 7832 |
| **Krishnan, S.**<br>*Accounts Officer* | skao | 241 | - |
| **Paul Pandian, M.**<br>*Librarian* | pandian | 237 | - |

**Amulraj, D.**
**Arangarajan, R.**
**Ashfack Ahmed**
**Babu, B.**
**Balakrishnan A. R.**[2]
**Balakrishnan, J.**
**Elumalai, G.**
**Ganapathi, R.**
**Gayatri, E.**
**Geetha, M.**
**Indra, R.**
**Janakiraman, J.**
**Jayanthi, S.**[3]
**Mohan, S.**
**Moorthy, E.**
**Munuswami, M.**
**Munuswami, N.**
**Muthukrishnan, M.**
**Muthusigamani, S.**
**Nityanandam, G.**
**Padmanabhan, T.**[4]
**Parijatham, S. M.**
**Parthiban, V.**
**Prema, P.**
**Radhakrishnan, M. G.**
**Rajasekaran, N.**
**Rajendran, C.**
**Ramesh, M.**
**Ravichandran, N.**
**Ravindran, A.**
**Rizwan Shariff, H.**
**Sankaran, K. P.**
**Selvaraj, M.**
**Tamil Mani, M.**
**Usha Devi, P.**
**Usha, Otheeswaran**
**Varadraj, M.**
**Vasudevan, T. V.**
**Venkatesan, G.**
**Venugopal, T.**

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[1] From 08.05.2003
[2] Until 31.07.2003
[3] From 27.06.2003
[4] From 30.05.2003

# Chapter 2

# Research and Teaching

## 2.1 Mathematics

### 2.1.1 Research Summary

#### Algebra

It is shown that if certain identities hold in an associative ring with identity in which a certain natural number is not a zero divisor, then the ring must be commutative. Moreover, it is shown that the assumption about the natural number is necessary [**N6**].

Some applications of closure operators in the category of groups are presented and linked with the join problem of subnormal subgroups in [**G1**] . An application of closure operators in the category of modules is given in [**G2**]. The main result shows that every subcategory $\mathcal{A}$ of injective modules of **R-mod** (under a mild condition) induces a torsion theory of R-mod. Some progress is made towards a categorical construction of 2-dimensional Extended Topological Quantum Field Theory.

Consider Schubert varieties in the variety of maximal isotropic subspaces. The Hilbert functions of points on these varieties are calculated. This is in the spirit of the work of Kreiman-Lakshmibai for Schubert varieties in the Grassmannian. As a special case, results of Conca on Hilbert functions of symmetric determinantal varieties are recovered.

A complete set of 'picture invariants' for complex semisimple Lie algebras is determined. This is in the spirit of the work of Datt-Kodiyalam-Sunder on complex semisimple (finite-dimensional) Hopf algebras.

#### Algebraic Geometry

Various problems on principal $G$ bundles and parabolic $G$ bundles are considered where $G$ is a connected reductive algebraic group in [**N2**] and [**N3**]. In recent work it is shown that the universal $G$ bundle on the moduli space of principal $G$ bundles over a compact Riemann surface exists if and only if $G$ is a group of adjoint type.

Explicit geometric constructions of certain Elliptic and Hilbert modular varieties are given. Along the way generalisations of certain classical constructions like Kummer's $16_6$ construction of a birational model of the moduli space of principally polarised abelian surfaces are obtained. A purely geometric description of the addition law on the general section of the Horrocks-Mumford bundle is also studied. Analytic descriptions are available but do not lend themselves to the computation of cohomology classes of algebraic cycles. The existence of interesting algebraic cycles is a consequence of the Tate conjectures as interpreted in this context by C. Schoen, S. Bloch, V. Kumar Murthy and others.

As a consequence of the study of modular forms with integral coefficients one obtains certain "motives" that have Hodge-type similar to that of the middle cohomology of a Calabi-Yau variety. The possibility is being explored of extending earlier work of D. Morrison for surfaces to show that there are actual Calabi-Yau varieties that exhibit the same Hodge structure as this middle cohomology.

To every algebraic codimension-$p$ subvariety of a smooth variety $X$ one can associate an element in the Deligne-Beilinson cohomology $H^{2p}_{D-B}(X, \mathbf{Q}(p))$. This can be extended by linearity to the free vector space on the collection of all such subvarieties; this homomorphism is called the *cycle class* homomorphism. It is well-known that the map is zero on the $\mathbf{Q}$-subspace of cycles rationally equivalent to zero. Examples constructed by D. Mumford in the early 1970's show that there are many cycles defined over a field of sufficiently large transcendence degree which are in the kernel of the cycle class homomorphism. In contrast, a conjecture of Bloch and Beilinson asserts that when the variety $X$ is defined over a number field $F$ and we consider only those subvarieties which are defined over some field extension of $F$, the subspace of cycles rationally equivalent to zero is precisely the kernel of the cycle class homomorphism. As a way of checking that this conjecture is "tight", C. Schoen and M. V. Nori produced some examples of cycles defined over a field of transcendence degree one which are in the kernel of the above cycle class homomorphism. It is shown in [**P**] that in each case when D. Mumford can construct a cycle in the kernel, there is a cycle which is defined over a field of transcendence degree one which *should* be in the kernel. The reason for the caveat is that the proof uses an analogous cycle class map which is defined using Galois cohomology; it is so far not known that the kernels of these two cycle class maps is identical.

In order to make certain definitions related with multiplier ideals more explicit, R. Lazarsfeld asked whether the resolution of Bogomolov and Pantev can be extended to include the exceptional locus. Specifically, if $X$ is a variety and $Z$ a closed subscheme, it was asked whether one can use the techniques to construct a projective birational morphism $f : Y \to X$ such that (a) $Y$ is smooth, (b) the inverse image $f^{-1}(Z)$ is a divisor, (c) the exceptional locus of $f$ is a divisor and (d) there is a divisor with simple normal crossings which contains the union of the above two divisors. This question is answered in the affirmative in a modified version of [**Pa2**] an earlier version of which has already been published.

In the "semi-classical" school of Chow, Weil and Zariski, an algebraic variety was understood in terms of the solutions of equations in a sufficiently large field called a *universal domain*. However, this left out an important aspect—nilpotent elements. Hence schemes were characterised by describing the associated sheaf of rings; a scheme was defined as a locally ringed space which had some additional properties. However Grothendieck pointed out that schemes can be characterised by their "functor of points". In fact we can restrict to ring-valued points. This definition is still not finitistic since the category of "all rings"

has certain obvious Russellian set-theoretic problems. It is shown that a finite-type scheme over **Z** is characterised by its functor of points for *finite* rings. Similarly, finite-type schemes over a field $k$ are characterised by their functors of points for $k$-algebras which are finite dimensional as vector spaces over $k$. Moreover, other geometric notions such as morphisms, vector bundles and even an analogue of sheaves can be given purely geometric definitions in this fashion.

From the explicit zeta functions obtained for the projective non-singular curves $aY^e = bX^e + cZ^e$ ($e = l, 2l$, $l$ an odd prime) defined over certain class of finite fields, the class numbers for the function fields of these curves are explicitly determined, in [**A**]. When the field of definition of the curve(s) is fixed, these results provide concrete information on the growth of class numbers for constant field extensions of the function field of the curve(s).

**Algebraic Number Theory**

The connection between Diophantine triples and units in the real quadratic fields is studied and a characterization of Diophantine triples $(a, b, c)$ is obtained for all $(a, b)$ satisfying certain conditions. In particular, all Diophantine triples $(1, r^2 - 1, c)$ are determined, when $r^2 - 1$ is odd, square free, and $r^2 - 2 = 2p$ where $p$ is an odd prime.

**Analytic Number Theory**

The gaps between zeros of Epstein's zeta function,$\zeta_Q(s)$ associated to certain positive definite quadratic forms $Q(x, y) = ax^2 + bxy + cy^2$on the critical line is studied. It was proved by H.A.S Potter and E.C. Titchmarsh (1935) that there is a zero $1/2 + i\gamma$ of $\zeta_Q(s)$ with $\gamma \in [T, T + T^{1/2+\epsilon}]$, for any fixed $\epsilon > 0$ and $T > T(\epsilon)$. It is shown that for any $\epsilon > 0$ and $T > T(\epsilon, Q)$, we have $\mid \gamma - T \mid < T^{5/11+\epsilon}$. Consequently, this also improves the result of Bruce Bernt (1971) on the gap between zeros of zeta function associated to an ideal class in an imaginary quadratic field. Further work is in progress.

For subsets of natural numbers satisfying certain combinatorial condition, a lower bound of asymptotic density is obtained in [**B**]

**Differential Equations**

The asymptotic behaviour of a Bingham fluid in a thin layer in three dimensional space is studied. Existence and uniqueness results for the limit problem are obtained. A lower dimensional 'Bingham-like' constitutive law is obtained in the limit. A similar law was obtained earlier in the two-dimensional case and it justified models used in the engineering literature in a mathematically rigorous fashion. In the course of this study, a class of function spaces of Sobolev type, with information on partial derivatives in only the vertical direction, was studied. A density theorem and a theorem of de Rham type characterising the annihilator of a certain subspace are proved for such spaces.

**Mathematical Physics**

Some new criteria are developed in [**Kr2**] using the Wavelet and its associated transforms to

identify the components of a probability measure. Such a procedure has use in identifying spectral types of self adjoint operators.

**Operator Algebras**

Investigation into completeness of what may be termed 'picture invariants' is continued and brought to a successful conclusion. It is first shown - in [**Ko1**] - that such an analysis leads to a complete family of numerical invariants for complex semisimple Hopf algebras. Further refinement of these methods has also led - in [**Ko5**] - to a complete family of numerical invariants for the so-called 'subfactor planar algebras'.

An attempt is being made to find the irreducible Hilbert modules over the Group Planar Algebras. Till now it has been figured out what the irreducible modules could be, but whether all of them have Hilbert module structure is still not known.

A very simple 'planar algebra' proof is given in [**D**] for the part of the Ocneanu-Szymanski theorem which asserts that for a finite index, depth two, irreducible $II_1$-subfactor $N \subset M$, the relative commutants $N' \cap M_1$ and $M' \cap M_2$ admit mutually dual Kac algebra structures. In the hyperfinite case, the same techniques also prove the other part which asserts that $N' \cap M_1$ acts on $M$ with invariants $N$.

**Topology**

Given a finitely generated group with a finite generating set one has a natural metric on the group namely the word metric. Changing the generating set to another finite generating set results in another metric but not the quasi-isometry class of the group. Thus the group of quasi-isometries of a finitely generated group is intrinsic to the given group itself. It is shown that the natural homomorphism from the group of automorphisms to the group of quasi-isometries of a finitely generated group is a monomorphism when the given group is torsion free and its virtual centre equals its centre. Given a non-elementary hyperbolic group it is shown that its virtual centre is finite and that the quotient by this finite (normal) group results in a group for which the above natural homomorphism is always a monomorphism.

The fundamental group and the universal cover of a real toric variety are determined and necessary and sufficient conditions are given under which (i) the fundamental group is abelian , (ii) the real toric variety is aspherical and (iii) the complement of a real subspace arrangement associated to the toric variety is a $K(\pi, 1)$ space. This work is [**U**]

### 2.1.2 List of Publications

The list of publications follows the following conventions: firstly, names of (co)authors who are not IMSc members are marked with a superscript *; secondly, the citation labels used for cross-referencing with the research summary are constructed from the last name of the first IMSc author and finally the list is ordered alphabetically according to the labels.

[**A**]
**N. Anuradha**.
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# 2.2 Physics

## 2.2.1 Research Summary

### Astro-particle Physics

Neutrino photon interaction has very important consequence in astrophysical situations. In presence of an external magnetic field it becomes more important. To one loop order the effective neutrino photon interaction takes place through the vector-vector type and the axialvector-vector type amplitudes. In view of this, an investigation was performed in [**Ga1**] to write down the form of the axialvector-vector amplitude to all orders in the external magnetic field in a medium. Its zero external momentum limit that contributes to the effective charge of the neutrinos inside a magnetized medium is obtained. Further its gauge invariance properties are shown.

Axions are one of those elusive particles, that evaded experimental detection so far. The coupling of axion to photon is a loop induced phenomena. Axions don't have direct coupling to photons at the tree level. More over this is also some what model dependent. An investigation was performed in [**Ga2**] to explore the modification of the effective axion photon coupling in a magnetized plasma. Astrophysical importance of this modification was also pointed out.

Till date, the dynamics of supernova explosion is not well understood. Though there had been attempts in that direction invoking various mechanisms none had been successful in explaining the physics behind the phenomena. The idea of streaming instability (of photons) has been put forward to account for the same. In this scenario, neutrino stream driven instability for photon's propagating modes (below pair production threshold) could be playing a major role during supernova explosion. Using charge conjugation symmetry of the background medium, it is argued that the photon polarization tensor, in the background of streaming neutrinos, would get a contribution of the order of $G_F$, i.e., the Fermi coupling constant. Depending on the physical situation, this contribution can have an opposite sign to that of usual photon polarization tensor ( that is without the neutrino stream). The dispersion relation for the photons, when estimated taking into account the contribution from the neutrino stream induced piece, it showed the possiblity of having an unstable mode. Based on the structure of the polarization tensor, it is argued in [**Ga4**] that the instability growth rate would be proportional to $\sqrt{G_F}$. And this process might turn out to be more successful in explaining the mechanism of supernova explosion.

Optical activity, that is rotation of plane of polarization of propagating light in a medium can be attributed to different sources. Notably the most commonly experienced phenomena is Faraday effect. The same can be caused by other *parity violating* interactions too, e.g due to neutrinos, axions etc. The effect of optical activity due to Kaluza Klein scalar field $\phi$, in the presence of an external field has been studied in [**Ga3**].

### Beam Physics

Traditional treatment of charged-particle beam optics, with wide ranging applications, from electron microscopy to particle storage rings, is based mainly on classical mechanics and classical electrodynamics. As part of an ongoing program to develop the quantum theory of charged-particle beam optics, a treatment of spin-$\frac{1}{2}$ particle beam transport through optical elements with straight and curved axes has been developed based on the proper equation, namely, the Dirac equation [**J**].

### Biological Physics

Molecular motors are protein molecules which move on the filaments which constitute the cytoskeleton of the cell. In collaboration with Prof. P.B. Sunil Kumar of IIT Madras, a detailed study of pattern formation in mixtures of molecular motors and microtubules has been undertaken. This study, which proceeds via the numerical solution of coarse-grained hydrodynamical equations of motion for fields governing the local microtubule orientation, as well as density fields for bound and free motors, is capable of generating *all* the disordered and relatively ordered states (lattice of vortices, lattices of asters and aster vortex mixtures) seen in experiments *in vitro*. A study of mitotic spindle formation using these equations supplemented by appropriate boundary conditions, reproducing some of the features of the mitotic spindle, is also attempted [**S1**]. A detailed phase diagram containing these phases is presented and how such a phase diagram can be used to rationalize the difference in the patterns formed by more processive (e.g. Kinesin) molecular motors and less processive ones (such as NCD) is illustrated.

Ventricular fibrillation (VF), the major reason behind sudden cardiac death, is turbulent

electrical activity in the ventricles (the two lower chambers of the heart). During VF, rapid irregular disturbances in the spatiotemporal electrical activation of heart makes it incapable of any concerted pumping action. A detailed study of the initiaton of VF and its termination by small amplitude electrical pulses has been undertaken. This study involves numerical solution of partial differential equations describing the time course of activation of ventricular cells coupled to each other by gap junctions. Both simplified excitable media models, as well as more biologically realistic models containing detailed ion channel kinetics are used. Using these models, the effects of a conduction inhomogeneity (corresponding to ischemic regions in the heart) on the initiation of spiral turbulence in cardiac tissue are investigated. The size of the inhomogeneity is found to be a key determinant in the transition from a spatiotemporally chaotic state (corresponding to VF) to a rigidly rotating wave anchored to the inhomogeneity (which is clinically manifested as ventricular tachycardia, abnormal rapid heartbeat) [**Sin1**]. As an ageing heart contains inhomogeneities of various sizes, this implies a possible crucial role of large ischemic regions in the initiation of VF.

Computational and probabilistic DNA sequence analysis (at the Rockefeller University, New York), focussing on gene regulation and detection of regulatory sites and motifs in cis-regulatory regions of genes, are studied.

### Classical and Quantum Gravity, Black Holes, Cosmology

Recent works on loop quantum cosmology shows how loop quantum gravity avoids the classically indicated Big Bang singularity. One of the crucial ingredients in this analysis is a *discrete evolution*. Whether this is something very special to loop quantum gravity or whether it could also be seen in more familiar systems is a question addressed. It is well known that the usual non-relativistic quantum mechanics can be viewed as a constrained system leading to a 'frozen time' formulation. By choosing a Fock-like representation for the extra 'time' degree of freedom, one can obtain a discrete Schrödinger equation. The issue of 'evolving observables' in this formulation is discussed. This mimics all the features seen in loop quantum cosmology. The relation to usual continuous time presentation as well as possibilities for pushing discrete evolution at the level of expectation values is also discussed [**Da1**].

In general, in loop quantum gravity, one expects the dynamical equation to be a difference equation. This however is *not* a discretization of a differential equation as done in numerical analysis. Rather, the difference equation is fundamentally specified by the quantization procedure. Such an equation has to admit a good *continuum approximation*. The analysis of this requirement also leads to a notion of *local stability*. These conditions are formulated and shown to be quite restrictive. This provides a means for resolving ambiguities inherent in quantization. The quantization of general homogeneous as well as isotropic cosmological models is shown to satisfy these conditions [**Dat**].

### Computational Physics

A group of physicists, Arvind, P.S. Chandi, and R.C. Singh, at the Guru Nanak Dev University constructed a simple circuit that would sample the instantaneous voltage of an AC source. The corresponding theory was developed so that the probability distribution resulting from the sampling could be used to extract information about the AC source. The results

were then compared with a simulated data sample. The project teaches students to learn about probability theory as well as learn to write simulations programs and understand the basics of data-fitting and analysis [**I1**].

### Condensed Matter Physics

The problem of an electron on a cylinder with a uniform radial magnetic field is analysed taking two different approaches. The first one takes quantum realization of symmetries as the primary concern and uses the theory of projective representations of the symmetry group of the cylinder. The second approach takes the Hamiltonian as the primary object and looks for possible admissible symmetries at the quantum level. Both approaches give the same result, namely, contrary to the naive expectation, the (classically indicated) symmetry group of the cylinder is *not* realised at the quantum level. In particular, only a discrete subgroup of the translations along the axial direction is realised. The size of the discrete translation step is controlled by the magnetic flux per slice of the cylinder [**Da2**].

A review article on the classical and quantum mechanics of *anyons* was prepared. This summarises works of the authors done over the past several years. In addition, the concept of *pseudo-integrability* is elaborated on in the context of anyons. Semiclassical approach to obtain the spectrum of many anyons is also discussed [**Da3**].

Using a detailed analysis of experimental data obtained from muon-spin rotation, neutron scattering and magnetization experiments, it is shown that the high-field state of underdoped LSCO is best described in terms of a vortex glass of line vortices, lacking long-range order but posessing pronounced short-ranged order. This is the first direct observation of the vortex glass phase in a microscopic measurement[**M2**]. The observation of negative third moments of the field distribution function deep into the vortex glass phase is indicative of strong three-body correlations favouring triangular lattice order locally, in the absence of long-ranged translational order. This work provides crucial support in favour of the idea of a "multi-domain glass" introduced in [G.I. Menon, Phys. Rev. B, **65**, 104527 (2002)]. Earlier data on BSCCO are currently being reexamined in the light of the predictions of this work, in particular the suggestion that negative third moments of the field distribution function should be observed in experiments on BSCCO at fields somewhat larger than have been accessed before. Questions of flux-line structure in the presence of columnar defects are also being studied.

In collaboration with Prof. Surajit Sengupta of the SNBNCBS, Kolkata, direct simulations of the depinning transition in the presence of an underlying structural phase transition are being attempted. Such studies will help to understand the relationship between the peak effect seen across phase boundaries between two structurally different phases in the disordered mixed phase.

The exact and semiclassical description of the particle number and kinetic energy densities for harmonically trapped fermion gases in arbitrary dimensions was investigated. The differential equations for these densities have been derived. These differential equations were known only in one and two dimensions but have now been derived in arbitrary dimentions. Through this it is now possible to identify the correct asymptotic limit when the Thomas-Fermi approximation becomes valid and thereby identify the Fermi energy uniquely in Thomas-Fermi densities.[**Mu**]

The properties of a layer of metal atoms adsorbed on a metal electrode are investigated as a function of coverage, focusing on metal - insulator transition [**Mi3**]. Metallization requires both a finite density of states near the Fermi level and a mean free path of electrons exceeding the lattice spacing. Application of the formalism to a copper layer adsorbed on a gold electrode in electrochemical environment shows that with increasing coverage, the adsorbarte passes from an insulating to a conductive state, then back to an insulating phase before becoming conductive again near full coverage. The multiple self-consistent values of the adsorbate average charge and the desolvation of the adspecies on metallization are the two important reasons behind this behaviour. These works lead to a new model for metal - insulator transition in electrosorbed layer.

An infinite U Hubbard model, which leads to exclusion of double occupancy of sites, has been described by a free orthofermion Hamiltonian which is exactly soluble. It is found that the orthofermion destribution function is similar to the mean number of trapped electrons in an impurity in a semiconductor where the double occupancy of the impurity is forbidden. In one dimension, the thermodynamics of free orthofermions gives the exact results of infinite U Hubbard model. This shows that at least in one-dimension, the fermions with exclusion of double occupancy of sites behave as free orthofermions [**Mi2**].

Studies on higher dimensional bosonization, solving the Luttinger model using the sea-boson method and the 2D weakly coupled model with short range interaction, have been done. A nonperturbative path integral formulation of gauge theories with no gauge fixing or ghosts has been developed. Application of these methods to disordred systems is underway.

### CP-Violation, Neutrinos and B-Physics

A detailed study of the penguin mode $b \to s\tau^+\tau^-$ is made, including the spin polarizations of both tau's. This decay mode can provide sensitive tests to New Physics (NP). In addition to the polarization asymmetries involving a single $\tau$, asymmetries for the case where both $\tau$ polarizations are simultaneously measured were constructed. Forward-backward asymmetries with polarized tau's were also studied. A large number of asymmetries are predicted to be significant ($\gtrsim 10\%$). This permits the measurement of all Wilson coefficients and the b-quark mass, thus allowing the standard model (SM) to be exhaustively tested. Furthermore, there are many unique signals for the presence of NP. For example, asymmetries involving triple-product correlations are predicted to be tiny within the SM, $O(10^{-2})$. Their observation would be a clear signal of NP [**Si3**].

In the SM, the cleanest extraction of the CP angles comes from neutral $B$ decays that are dominated by a single decay amplitude. If there happens to be a NP contribution to the decay amplitude, with a different weak phase, this could seriously affect the cleanliness of the measurement. There is already a hint of such NP, as indicated by the discrepancy between the value of $\beta$ extracted from $B^0_d(t) \to J/\psi K_s$ and that obtained from $B^0_d(t) \to \phi K_s$. However, it is important to confirm this through independent direct tests, and to make an attempt to obtain information about the NP amplitude, if possible. It was found that this type of NP can be uniquely probed by performing an angular analysis of the related $B \to V_1 V_2$ decay modes. There are numerous independent relations that are violated in the presence of NP, and several of these signals remain nonzero even if the strong phase difference between the SM and NP amplitudes vanishes. The most incisive test is a measurement of

the interference betwen CP-even and CP-odd contributions to the amplitude. For such observables (e.g. $\Lambda_{\perp i}$), neither tagging nor time-dependent measurements are required – one can also combine all neutral and charged $B$ decays, making it easier to discover NP. Furthermore, should a signal for NP be found, one can not only place a lower bound on the size of the NP amplitudes, but also a bound on the difference between the measured and true phase of $B^0 - \bar{B}^0$ mixing. By applying this analysis to the decays $B_d^0(t) \to J/\psi K^*$ and $B_d^0(t) \to \phi K^*$, one can confirm the presence of the NP. It can even be applied within the SM to analyze decays such as $B_d^0(t) \to D^{*+}D^{*-}$, which receive both tree and penguin contributions. A significant achievement is that the size of NP as well as the the deviation from $B^0 - \bar{B}^0$ mixing phase are expressed purely in terms of experimental observables, unlike other tests of NP [**Si1**, **Si5**].

Starting with the hypothesis that quark and lepton mixings are identical at the GUT scale, it is shown that the large solar and atmospheric mixing angles together with the small reactor angle can be understood purely as a result of renormalization group evolution.The only requirements are that the three neutrinos must have the same CP parity and must be quasi-degenerate in mass. A high point of this approach is the recognition that the smallness of the reactor angle is correlated with the smallness of the third CKM angle which is known to be small, being of the order of the cube of the Cabibbo angle.This analysis predicts the common Majorana mass for the neutrinos to be larger than 0.1 eV which falls right in the range that will be probed in the on-going or future experiments searching for neutrinoless double beta decay [**R3**].

A complete model of leptons is constructed, based on a novel symmetry. Invariance under a specific 3x3 unitary matrix $U$ in the lepton flavour space is chosen, such that the square of $U$ implements a simple discrete symmetry among the three neutrino flavours and the 4th power of $U$ is the unit matrix. Thus $U$ generates the cyclic group $Z_4$. The charged lepton mass matrix is nearly diagonal while the neutrino mass matrix is of the form suitable for explaining the maximal and large mixings in the atmospheric and solar neutrino oscillations, with nearly degenerate neutrino masses. Observable lepton flavour violation is predicted. Quarks can be incorporated into this $Z_4$ invariant model [**R2**].

The SNO neutral current (NC) data turns out to severely constrain the possibility of neutrino decay (with mixing). However it threw up the puzzle that the day-night aysmmetry was significantly less than zero in the NC sector. A formal analysis [**I2**] shows that such a non-zero asymmetry cannot be generated either by neutrino mixing or decay or a combination of the two.

**Foundations of Quantum Mechanics**

The basic difference between classical and quantum Physics is that in the later (i) nonorthogonal states exists and (ii) Correlations that cannot be explained by any classical hypothetical theory (called entanglement) exits. Developing a theory of entanglement is essential in the field of quantum information. Hence identification and study of measures of entanglement is considered a priority in the recent research. Two measures of entanglement, namely entanglemnt cost and distillabe entanglement are important due to their physical meaning. There indeed exists examples of states (called mixed states) where entanglement cost is strictly greater than distillable entanglement. This feature is called irreversibility. But it is

still not known whether all mixed states are irreversible or not. In this aspect, it is shown that for a set of density matrices this irreversibility holds, thus strengthening the belief that irreversibility is the generic property.

New classes of bipartite bound entangled states have been generated, each having positive partial transposition (PPT), starting from the PPT bound entangled states, generated by unextendable product bases of the respective bipartite systems. These later kind of bound entangled states are shown to be robust (against separability) upto certain level of perturbation. Any bipartite separable state necessarily satisfies the 'Range Criterion' (RC)., namely, if there is a set of product states spanning the range of a bipartite state, then the corresponding set of product states, each of which is obtained by taking complex conjugation of the second party's states, in the respective product state of the former set, also spans the range of the partially transposed state (taken with respect to the second party). Every bipartite density matrix of full rank satisfies RC. If a density matrix violates RC, it is not only true that the density matrix is entangled, but it is also true that it is not of full rank. But there was no example of bipartite bound entangled state, which is of non-full rank, but which satisfies RC. The above-mentioned new class of PPT bound entangled states are examples of this kind.

The amount of entangled resource (in terms of interaction) used to prepare any bipartite pure entangled state can be fully extracted, via distillation process (using local operations and classical communication (LOCC)), which uses infinitely many copies of the pure state. Thus bipartite pure states are 'reversible'. But pure states are adhere to decoherence, due to interaction with the environment, and transformed to mixed entangled states. So the basic question is: can one reversibly distill pure entangled states (used at the asymptotic formation procedures of the mixed entangled states) from mixed entangled states? People working in quantum information theory do believe that it is impossible, in general, but there is no general proof of it. Earlier it was shown that some PPT bound entangled states and distillable states in 3 X 3 are irreversible. Then, realizing unitarily (in some suspace S, say) the completely positive maps of entanglement breaking (of bipartite systems), it has been shown recently that entanglement of formation of of all density matrices having support in S is additive, and this gave rise to asymptotic entanglement of formation (called as entanglement cost) of these density matrices. Using this fact, irreversibility of some bipartite mixed entangled states were shown there. In the case when one subsystem of the bipartite system is of dimension two, the earlier result (dealing with the problem of 'disentanglement') shows that one can get some entanglement breaking maps (in $2 \times n$, where $n$ is greater than or equal to 2) by teleporting one subsystem (which is of dimension two) of the entangled state via a separable channel state. These maps are now used to calculate entanglement costs of different entangled states, having support on the respective subspace $S$ of $2 \times n$, and it is then shown that these states are irreversible. This approach can easiliy be generalized to same kind of density matrices in $d \times n$, where $n$ is greater than or equal to $d$.

### Mathematical Physics

The 24 Kummer solutions of the Gauss differential equation have been shown [**Sri4**] to be related to the 24 symmetries of the cube. Hypergeometric identites (or transformations) for ${}_{p+1}F_p$-series and for Kampé de Fériet series of unit arguments are derived systematically from known transformations of hypergeometric series and products of hypergeometric series,

respectively, using the beta integral method, Mathematica and the software package HYP created by Krattenthaler. These result in some known identites and also yield some new identities [**Sri3**].

Example 7, after Entry 43, in Chapter XII of the first Notebook of Srinivasa Ramanujan has been proved and, more generally, a summation theorem for ${}_3F_2(a, a, x; 1 + a, 1 + a + N; 1)$, where $N$ is a non-negative integer derived. This is a new summation theorem [**Sri10**] and its $q$-generalization has also been obtained. A proof of an elementary result of Ramanujan on nested roots, also called continued or infinite radicals, for a given integer $N$, expressed by him as a simple sum of three parts ($N = x + n + a$) is given and it is shown [**Sri7**] to give rise to two distinguishably different expansion formulas. It is shown that the second of these has better convergence properties than the one recorded by Ramanujan.

The Entries of Ramanujan in Chapter XII of his first Notbeook and the 'corresponding' Entries in Chapter X of his second Notebook were examined in the wake of the earlier studies of the Chapters on hypergeometric series by G.H. Hardy (1923) and B.C. Berndt (1989, 1994). New insights have been gained by this comparative study [**Sri8**].

A $q$-generalization of 'product densities' in stochastic point processes, by considering the statistical properties of a $q$-stochastic variable is made. This leads to a $q$-generalization of Stirling formula of the second kind. Although this generalization has been made in mathematics literature, the above-mentioned derivation is using probabilistic methods. A formula for the $q$-Bell number is derived which agrees with the semiclassical derivation using $q$-coherent states. Further work is in progress.

Katriel, Rasetti and Solomon (1996) have introduced a $q$-analogue of the Zassenhaus formula for disentangling exponential operators. It is shown that their $q$-Zassenhaus formula is not unique. A new $q$-Zassenhaus formula is proposed [**Sr**].

### Nonlinear Dynamics, Solitons and Chaos

A unified formalism recently presented had demonstrated that three distinct classes of space curve evolutions get associated with a given integrable equation, and not just one class, as had been hitherto envisaged. This formalism is applied to the nonlinear Schrödinger equation (NLS), which is an example of an "S-integrable" equation. The three surfaces swept out by the curves that correspond to a static envelope soliton are found explicitly[**B7**].

Each of the three moving curves associated with the NLS, is shown to be endowed with a corresponding infinite set of distinct geometric constraints. For the first curve,the velocity at each point is a local expression in the curve variables, while those of the other two curves are shown to be nonlocal. The curves associated with a moving envelope soliton are plotted and interpreted in the light of shape-preserving vortex filament motion observed in some fluids [**B5**].

This unified approach is applied to explicitly find the three geometrical characterizations of the Lamb equation, which is an example of a "C-integrable" equation. By showing its connection to the exactly solvable Belavin-Polyakov equation for a unit vector field, exact envelope soliton and novel envelope instanton solutions of the Lamb equation are obtained. The swept-out surfaces associated with the above solutions are also plotted, and some ap-

plications suggested [**B8**].

Nonlinear dynamics of the classical antiferromagnetic Heisenberg chain is studied. Two distinct low-energy sectors, the nonlinear sigma model sector and a "kink" sector are shown to emerge in a natural fashion, in the continuum limit. For the staggered magnetization, the former sector leads to precessing pulse solutions, while the latter supports moving kinks [**B1**].

The geometrical and topological aspects of a dynamical system are characterized by associating a geometric phase with a phase space trajectory. Using the example of a nonlinear driven damped oscillator, it is shown that this phase is resilient to fluctuations, responds to all bifurcations in the system, and also finds new geometric transitions. Enriching the phase space description is a novel phenomenon of "geometrical localization" which manifests itself as a significant deviation from planar dynamics over a short time interval [**B6**].

An exact analysis of the intrinsic dynamics of two types of biopolymers, described by the wormlike chain (WLC) and the wormlike rod chain (WLRC) models, respectively, is presented. Each model is mapped to a classical field theory for an appropriate unit vector field defined on the space curve formed by the axis of the biopolymer. Conformation dynamics is shown to be described by the soliton-bearing Landau-Lifshitz equation. The "conformon" hypothesized in biopolymers thus gets identified with a soliton [**B2**].

The geometric phase associated with the time evolution of the wave function of a Bose-Einstein condensate system in a double-well trap is calculated by using a model for tunneling between the wells. For a cyclic evolution, this phase is shown to be half the solid angle subtended by the evolution of a unit vector whose $z$ component and azimuthal angle are given, respectively, by the population difference and phase difference between the two condensates. For a non-cyclic evolution, an additional phase term arises. This geometric phase is also be obtained by mapping the tunneling equations on to the equations of a space curve. The importance of a geometric phase in the context of some recent experiments is pointed out [**B4**].

By mapping the classical evolution equation of the form $\frac{d\mathbf{a}}{dt} = \mathbf{B}(t) \times \mathbf{a}$ (which appears in various physical contexts) to a space curve, classical analogs of the Schrödinger and Heisenberg pictures used in quantum mechanics are obtained. The analogy is further clarified by using the relationship between this equation and the evolution of a quantum two-level system [**B3**].

Evidence for directed percolation (DP) universality at the onset of spatiotemporal intermittency (STI) was found in coupled circle maps, which is a model arising naturally in descriptions of solid state phenomena such as Josephson junction arrays. It was found that the onset of STI in this system was analogous to DP, with the transition being to an unique absorbing state for low nonlinearities, and to weakly chaotic absorbing states for high nonlinearities. The complete set of static exponents and spreading exponents at all critical points was found to match those of DP very convincingly. Further, hyperscaling relations were fulfilled, leading to independent controls and consistency checks of the values of all the critical exponents. These results lend strong support to the conjecture that the onset of STI in deterministic models belongs to the DP universality class [**Ja**].

The concept of a simple threshold controller which clips chaos to periods of widely ranging orders, in a chaotic circuit was experimentally verified. This was then used to implement

the fundamental NOR gate, thus obtaining a proof of principle experiment demonstrating the universal computing capability of chaotic systems [**Sinh5**].

The first experimental realisation of all the fundamental logic gates, flexibly, using a chaotic circuit, was obtained. In this scheme a simple threshold mechanism allowed the chaotic unit to controllably switch with ease between behaviours emulating the different gates. The combination of gates through a half-adder implementation was also demonstrated [**Sinh3**, **Sinh1**].

The first experimental verification of thresholding as a versatile tool for efficient and flexible chaos control was obtained. The strategy here simply involved monitoring a single state variable and resetting it when it exceeds a threshold. The success of the technique was demonstrated in rapidly controlling different chaotic electrical circuits, including a hyper-chaotic circuit, onto stable fixed points and limit cycles of different periods, by thresholding just one variable. The simplicity of this controller entailing no run-time computation, and the ease and rapidity of switching between different targets it offers, suggests a potent tool for chaos based applications [**Sinh4**].

### Statistical Mechanics

The phenomenon of persistence at the onset of spatio-temporal intermittency in coupled map lattices has been studied, pointing out that directed percolation universality appears to extend to persistence exponents as well. Such universality is indicated in studies on discrete, stochastic models in 1 and 2 dimensions. However, this study shows that at the onset of spatio-temporal intermittency in coupled map lattices, where the degrees of freedom are (a) continuous and (b) evolve deterministically rather than stochastically, directed percolation universality appears to hold too. The concept of persistence is also extended to coupled map lattice systems, and new experimental candidates for the observation of persistence exponents characterizing directed percolation are suggested.

The 'plate tectonics' and the earthquake dynamics are studied from the point of view of the possible contact area between two surfaces with fractal characteristics [**Ray1**].

It has been suggested in the literature that parastatistics field could not be represented using path integrals. This argument follows from the fact that the parastaistics can not be based on the topology of three dimensional space. This problem has been closely examined [**Mi1**] with a view that any field theory that can be constructed using the canonical formalism can also be constructed using path integrals. It may be noted that parastatistics requires hidden degrees of freedom whose origin is not connected to the topology of the space. This feature allows for the construction of a path inegral formalism for the parastatistics.

Wealth distribution across different societies and economies have been found to show power law characteristics (Pareto law). Recently there have been several attempts to find the origin of this power law distribution using asset exchange models inspired by kinetic theory of gases. A study of how asset exchange models can be mapped to random iterated function systems (IFS) giving new insights into the dynamics of wealth accumulation in such models is made, particularly focussing on the "yard-sale" (winner gets a random fraction of the poorer players wealth) and the "theft-and-fraud" (winner gets a random fraction of the

loser's wealth) asset exchange models. Several special cases including 2-player and 3-player versions of these 'games' allow the results to be connected with observed features in real economies, e.g. lock-in (positive feedback), etc. The realistic notion that a richer agent is less likely to be aggressive when bargaining over a small amount with a poorer player is then implemented. When this simple feature is added to the yard-sale model, in addition to the accumulation of the total wealth by a single agent ("condensation"), exponential and power-law distributions of wealth can be seen. Simulation results show that the power-law distribution occurs at the cross-over of the system from exponential phase to the condensate phase [**Sin2**].

The magnetic field induced spin flipping dynamics in disordered systems is studied, with the motive of finding the effect of disorder on first order transitions that is exhibited by pure magnetic systems[**Ro**].

**String Theory**

The asymptotic density of open $p$-brane states with zero-modes included is obtained. The resulting logarithmic correction to the $p$-brane entropy has a coefficient $-(p+2)/(2p)$, and is independent of the dimension of the embedding spacetime. Such logarithmic corrections to the entropy, with precisely this coefficient, appear in two other contexts also: a gas of massless particles in $p$-dimensional space, and a Schwarzschild black hole in $(p+2)$-dimensional anti de Sitter spacetime[**Ra2**].

Recent suggestion, that the emission of a quantum of energy corresponding to the asymptotic value of quasinormal modes of a Schwarzschild black hole should be associated with the loss of spin one punctures from the black hole horizon, fixes the Immirzi parameter to a definite value. It is shown that saturating the horizon with spin one punctures reproduces the earlier formula for the black hole entropy, including the $ln(area)$ correction with definite coefficient $(-3/2)$ for large area[**K**].

The commutators of the kappa-deformed Poincare Algebra (kappaPA) are studied in an arbitrary basis. It is known that the two recently studied doubly special relativity theories correspond to different choices of kappaPA bases. Another such example is presented. The classical limit of kappaPA is considered and particle velocity in an arbitrary basis is calculated. It has standard properties and its expression takes a simple form in terms of the variables in the Snyder basis. The particle trajectory is then studied explicitly for the case of a constant force. Assuming that the spacetime continuum, velocity, acceleration, etc. can be defined only at length scales greater than $x_{min} \neq 0$, the acceleration is shown to have a finite maximum [**Ra1**].

Previous results on lopp variables, that were obtained for the open bosonic string, are being extended to include Chan-Paton factors. This is expected to be the first step in understanding the closed bosonic string.

Condensation of tachyons that occur in closed superstring theory on orbifolds such as $C/Z_N$ is being studied.

NSR strings in the extended Nappi-Witten background which is the Penrose limit of a

certain NS5-brane supergravity solution are studied. The theory in the light-cone gauge is solved, obtaining the spectrum, which is world-sheet supersymmetric. In the light of the Little String Theory/NS5-brane duality, this spectrum should be in correspondence with the states of little string theory in the appropriate limit. A semiclassical analysis verifies that the relationship between energy and momentum, after a field redefinition, matches that found for a flat background. [**P1**]

Gauge theory/string theory duality and pp-wave string theory are studied. AdS/CFT correspondence or gauge/string duality has been an active area of research in last few years. The precise dictionary of the correspondence relates weakly coupled IIB string theory in Anti-de-Sitter (AdS) spacetime to a conformal field theory (CFT) on the boundary of the AdS spacetime (AdS/CFT correspondence). The correspondence is holographic in the sense that a d+1 dimensional theory of gravity in the bulk of AdS spacetime is dual to a d dimensional conformal theory on the boundary. The AdS/CFT duality has been successful in unfolding several mysteries of strongly coupled domain of gauge theories.

Recently, this duality has been generalized to string theory in plane-wave (pp-wave) background. Some of these backgrounds are obtained from the AdS type geometry in the Penrose scaling limit and in this respect the pp-wave/CFT duality is inherited from AdS/CFT correspondence.

The open string sector of these backgrounds is studied. Classical solutions of Dp-branes in most general pp-wave background have been successfully constructed.

The dynamics of rolling tachyon off an unstable D-brane is being studied.

### 2.2.2 List of Publications

The list of publications follows the following conventions: firstly, names of (co)authors who are not IMSc members are marked with a superscript *; secondly, the citation labels used for cross-referencing with the research summary are constructed from the last name of the first IMSc author and finally the list is ordered alphabetically according to the labels.

[**B1**]
**Radha Balakrishnan and Rossen Dandoloff***.
Nonlinear dynamics of the classical isotropic Heisenberg antiferromagnetic chain: The sigma model sector and the kink sector.
*Phys. Lett. A*, **303**, 273, 2002.

[**B2**]
**Radha Balakrishnan and Rossen Dandoloff***.
Nonlinear elastodynamics and energy transport in biopolymers.
2003.
IMSc/2003/06/14; nlin.PS/0304060 (Submitted).

[**B3**]
**Radha Balakrishnan and Rossen Dandoloff***.
Classical analogs of the Schrodinger and Heisenberg pictures in quantum mechanics using

the Frenet frame of a space curve.
*J.Phys.A: Math. Gen.*, 2003.
IMSc/2003/06/13 (To be published).

[**B4**]
**Radha Balakrishnan and Mitaxi Mehta***.
Geometric phase in a Bose-Einstein Josephson junctions.
2003.
IMSc/2003/06/15 (Submitted).

[**B5**]
**Radha Balakrishnan and S. Murugesh***.
Kinematics of three moving space curves associated with the nonlinear Schrodinger equation.
*Theor. Math. Phys.*, **133**, 1607, 2002.

[**B6**]
**Radha Balakrishnan and Indubala I. Satija***.
Anholonomy and geometrical localization in dynamical systems.
2003.
IMSc/2003/06/12; nlin.CD/0303071 (Submitted).

[**B7**]
**S. Murugesh* and Radha Balakrishnan**.
New geometries associated with the nonlinear Schrodinger equation.
*Euro. Phys. Jour. B*, **29**, 193, 2002.

[**B8**]
**S. Murugesh* and Radha Balakrishnan**.
Geometric characterizations of the Lamb equation.
*Journ. Math. Phys.*, **44**, 1415, 2003.

[**Ba**]
**Rahul Basu and K. Sridhar***.
$\eta_c$ production and dimuon enhancement in heavy ion collisions.
*European Journal of Physics*, 2003.
hep-ph/0301091 (Submitted).

[**D**]
**G. Date, M. Murthy, and R. Vathsan***.
Classical and quantum mechanics of anyons.
Nova Science, 2003.
IMSc/2003/01/01, condmat/0302019 (Submitted).

[**Da1**]
**G. Date**.
A discrete time presentation of quantum dynamics.
*Class. Quant. Grav.*, **20**, 303, 2002.

[**Da2**]
**G. Date and P. P. Divakaran**.
The Landau electron on a cylinder.
*Annals of Physics*, 2003.
IMSc/2003/05/10 , math-ph/0305041 (To be published).

[**Da3**]
**G. Date, M. V. N. Murthy, and Radhika Vathsan***.
Classical and quantum mechanics of anyons.
Nova Science, 2003.
IMSc/2003/01/01, cond-mat/0302019 (Submitted).

[**Dat**]
**Martin Bojowald* and Ghanashyam Date**.
Consistency conditions for fundamentally discrete theories.
2003.
IMSc/2003/07/17, gr-qc/0307083 (Submitted).

[**G**]
**P. M. Gade and Sudeshna Sinha**.
How crucial is small world connectivity for dynamics?
*Europhysics Letters*, 2003.
(Submitted).

[**Ga1**]
**Kaushik Bhattacharya* and Avijit K. Ganguly**.
The axialvector- vector amplitude and neutrino effective charge in a magnetized medium.
Physical Review D., 2003.
IMSc/2003/07/25 (To be published).

[**Ga2**]
**Avijit K. Ganguly**.
Axion photon mixing in a medium.
2003.
IMSc/2003/07/24 (Submitted).

[**Ga3**]
**Avijit K. Ganguly and R. Parthasarathy**.
Optical activity from extra dimension.
2003.
(Preprint: hep-th/0307129, IMSc/2003/07/23).

[**Ga4**]
**Avijit K. Ganguly and G. Rajasekaran**.
Photons in the background of streaming neutrinos.
2003.
(Preprint: IMSc/2003/07/22).

[**Go**]
**T R Govindarajan and E Harikumar**.
O(3) sigma model with Hopf term on fuzzy sphere.
*Nucl.Phys. B*, **655(3)**, 300, 2003.

[**H1**]
**E Harikumar, Indrajit Mitra, and H S Sharatchandra**.
Half-monopoles and half-vortices in the Yang-Mills theory.
*Phys.Lett. B*, **557(3-4)**, 303, 2003.

[**H2**]
**E Harikumar, Indrajit Mitra, and H S Sharatchandra**.
Perturbation theory including topological degrees of freedom: Yang-Mills theory in three Euclidean dimensions.
2003.
(Preprint: IMSc/2003/04/04, hep-th/0304140).

[**H3**]
**E Harikumar, Indrajit Mitra, and H S Sharatchandra**.
Topological field patterns of the Yang-Mills theory.
*Phys.Lett. B*, **557(3-4)**, 297, 2003.
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[**Ha**]
**E. Harikumar, I. Mitra, and H. S. Sharatchandra**.
Half-monopoles in the Yang-Mills theory.
In *QCD2002*, Nov 2002.
(To be published).

[**I1**]
**Arvind*, P.S. Chandi*, R.C. Singh*, D. Indumathi, and R. Shankar**.
Random sampling of an AC source: A tool to teach probabilistic observations.
*American J. Phys.*, 2003.
physics/0301002 (To be published).

[**I2**]
**D. Indumathi**.
Implications on neutrino oscillation plus decay from recent solar neutrino data.
2002.
hep-ph/0212038 (Submitted).

[**J**]
**R. Jagannathan**.
Quantum mechanics of Dirac particle beam transport through optical elements with straight and curved axes.
In Pisin Chen, editor, *Proceedings of the Joint 28th ICFA Advanced Beam Dynamics and Advanced and Novel Accelerators Workshop on Quantum Aspects of Beam Physics and*

*other Critical Issues of Beams in Physics and Astrophysics, January 7-11, 2003, Hiroshima, Japan.* World Scientific, Singapore, 2003.
physics/0304099 (To be published).

[**Ja**]
**T. M. Janaki, Sudeshna Sinha, and N. Gupte***.
Evidence for directed percolation universality at the onset of spatiotemporal intermittency in coupled circle maps.
*Physical Review E*, **67**, 056218, 2003.

[**K**]
**Romesh K. Kaul and S. Kalyana Rama**.
Black hole entropy from spin one punctures.
*Physical Review D*, **68(2)**, 024001, 2003.

[**M1**]
**Debasis Dan***, **A. M. Jayannavar***, **and Gautam I. Menon**.
A biologically inspired model for two-headed brownian motors.
*Physica A*, **318**, 40, 2003.

[**M2**]
**U. K. Divakar***, **A. J. Drew***, **S. L. Lee***, **R. Gilardi***, **J. Mesot***, **F. Y. Ogrin***, **D. Charlambous***, **E. M. Forgan***, **Gautam I. Menon, N. Momono***, **M. Oda***, **and C. Dewhurst***.
Direct observation of the flux-line glass phase in a type-ii superconductor.
2003.
(Submitted).

[**M3**]
**Gautam I. Menon, Sudeshna Sinha, and Purusattam Ray**.
Persistence at the onset of spatio-temporal intermittency in coupled map lattices.
*Europhysics Letters*, **61**, 27, 2003.

[**Mi1**]
**Oscar W. Greenberg* and Ashok K. Mishra**.
Path integrals for parastatistics.
2003.
(To be published).

[**Mi2**]
**Ram Kishore* and Ashok K. Mishra**.
Thermodynamics of infinite U Hubbard model.
*To appear in Physica C*, 2003.
(Submitted).

[**Mi3**]
**Ashok K. Mishra, Ram Kishore*, and Wolfgang Schmickler***.
Metal - insulator transition in a layer adsorbed on a metal electrode.
2002.
(Preprint: IMSc/2002/12/40).

[**Mu**]
**M. Brack* and M. Murthy**.
Harmonically trapped fermion gases: exact and asymptotic results in arbitrary dimensions.
*J.of Phys. A: Math. Gen.*, **36(04)**, 1111, 2003.

[**P1**]
* **P. Matlock, K.S. Viswanathan*, Y. Yang*, and R. Parthasarathy**.
NS5 brane and little string duality in the pp-wave limit.
2003.
(Preprint: hep-th/0305028).

[**P2**]
**R. Parthasarathy and R. Sridhar**.
A diagonal representation of quantum density matrix using $q$-boson coherent states.
*Physics Letters.A*, **305**, 105, 2003.

[**R1**]
**G. Rajasekaran**.
Recent developments in neutrino physics.
In A K Jain and A Navin, editors, *DAE-BRNS Symposium on Nuclear Physics, (Manonmaniam Sundaranar University, Tirunelveli, December 2002). Invited Talks, Vol 45A (2002)*, page 185. BRNS,DAE,Mumbai., Dec 2002.

[**R2**]
**Ernest Ma* and G. Rajasekaran**.
New "square root" model of lepton family symmetry.
2003.
hep-ph/0306264 (Submitted).

[**R3**]
**R. N. Mohapatra*, M. K. Parida*, and G. Rajasekaran**.
High scale mixing unification and large neutrino mixing angles.
2003.
IMSc/2003/01/02, hep-ph/0301234 (Submitted).

[**Ra1**]
**S. Kalyana Rama**.
Classical velocity in kappa-deformed Poincare algebra and a maximum acceleration.
*Modern Physics Letters A*, **18**, 527, 2002.

[**Ra2**]
**S. Kalyana Rama**.
Asymptotic density of open $p$-brane states with zero-modes included.
*Physics Letters B*, **566**, 152, 2003.

[**Ray1**]
**Srutarshi Pradhan***, **Bikas K. Chakrabarti***, **Purusattam Ray, and Malay K. Dey***.
Magnitude distribution of earthquakes: Two fractal contact area distribution.
*Physica Scripta T*, 2003.
(To be published).

[**Ray2**]
**Purusattam Ray**.
Spatial scaling in persistence.
*Physics A*, **314**, 97, 2002.

[**Ro**]
**Ratnadeep Roy and Purusattam Ray**.
Response of random-field ising model driven by an external field.
In *Int. J. Mod. Phys. B*, Jun 2003.
(To be published).

[**S1**]
**Sumithra Sankararaman, Gautam I. Menon, and P.B. Sunil Kumar***.
Modelling pattern formation in motor-microtubule mixtures.
*Physica Scripta*, **T106**, 26, 2003.

[**S2**]
**Sumithra Sankararaman, Gautam I. Menon, and P.B. Sunil Kumar***.
Self-organized pattern formation in motor-microtubule mixtures.
2003.
0307720 (Submitted).

[**S3**]
**Sumithra Sankararaman and Shankar R**.
Quantum hall skyrmion lattices at $g \approx 0$.
*Physical Review B*, **67**, 245102, 2003.

[**Si1**]
**David London***, **Nita Sinha, and Rahul Sinha**.
Signals of new physics using angular analysis in $B \to V_1 V_2$ decays.
In *Proceedings of the Workshop on the CKM Unitarity Triangle, IPPP Durham, April 2003*. Stanford Linear Accelerator Center Electronic Conference Proceedings Archive (eConf C0304052), Jul 2003.
hep-ph/0307308 (Submitted).

[**Si2**]
**David London***, **Nita Sinha, and Rahul Sinha**.
Determining weak phases using $B \to D^* V$ decays.
In *Proceedings of the Workshop on the CKM Unitarity triangle, IPP Durham, April 2003.* Stanford Linear Accelerator Center Electronic Conference Proceedings Archive (eConf C0304052), Jul 2003.
hep-ph/0307309 (Submitted).

[**Si3**]
**Wafia Bensalam***, **David London***, **Nita Sinha, and Rahul Sinha**.
Lepton polarization and forward-backward asymmetries in $b \to s\tau^+\tau^-$.
*Physical Review D*, **67**, 034007, 2003.

[**Si4**]
**N. G. Deshpande***, **Nita Sinha, and Rahul Sinha**.
Weak phase $\gamma$ using isospin analysis and time dependent asymmetry in $B_d \to K_s\pi^+\pi^-$.
*Physical Review Letters*, **90**, 061802, 2003.

[**Si5**]
**David London***, **Nita Sinha, and Rahul Sinha**.
Searching for new physics via an angular analysis of $B \to V_1 V_2$ decays.
*Physical Review Letters*, 2003.
hep-ph/0304230 (Submitted).

[**Sin1**]
**T. K. Shajahan***, **Sitabhra Sinha, and Rahul Pandit***.
Ventricular fibrillation in a simple excitable medium model of cardiac tissue.
*Int. J. Mod. Phys. B*, 2003.
(To be published).

[**Sin2**]
**Sitabhra Sinha**.
Stochastic maps, wealth distribution in random asset exchange models and the marginal utility of relative wealth.
*Physica Scripta (Ser. T)*, 2003.
cond-mat/0304324 (To be published).

[**Sinh1**]
**T. Munakata*** **and Sudeshna Sinha**.
Implementation of fundamental logical gates by 1-d chaotic elements.
In *Proceedings of COOL Chips VI, Yokohama*, page 73, Apr 2003.

[**Sinh2**]
**Sudeshna Sinha**.
Chaotic networks under thresholding.
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[**Sinh3**]
**T. Munakata*, Sudeshna Sinha, and W. L. Ditto***.
Chaos computing: Implementation of fundamental logical and arithmetic operations and memory by chaotic elements.
*IEEE Trans. on Circuits and Systems*, **49(11)**, 1629, 2002.

[**Sinh4**]
**K. Murali* and Sudeshna Sinha**.
Experimental control of chaos by thresholding.
*Physical Review E*, **68**, 016210, 2003.

[**Sinh5**]
**K. Murali*, Sudeshna Sinha, and W. L. Ditto***.
Realisation of the fundamental NOR gate using a chaotic circuit.
*Physical Review E*, **68**, 016205, 2003.

[**Sinh6**]
**K. Murali*, Sudeshna Sinha, and W. L. Ditto***.
Implementation of NOR gate by a chaotic Chua's circuit.
*Int. J. Bifurcation and Chaos*, 2003.
(To be published).

[**Sr**]
**R. Sridhar and R. Jagannathan**.
On the $q$-analogues of the Zassenhaus formula for disentangling exponential operators.
*J. Comp. Appl. Math.*, 2003.
math-ph/0212068 (To be published).

[**Sri1**]
**K. Srinivasa Rao**.
Numerical aspects of special functions.
In *Proceedings of Third Annual Conference of SSFA*. Tara Press, Varanasi, 2002.
(To be published).

[**Sri2**]
**K. Srinivasa Rao and C. Krattenthaler***.
Group theoretical aspects of hypergeometric functions and symmetries of angular momenutm coefficients.
In *Symmetries in Science XIII*, Jul 2003.
(To be published).

[**Sri3**]
**C. Krattenthaler* and K. Srinivasa Rao**.
Automatic generation of hypergeometric identities by the beta integral method.
*Journal of Computational and Applied Mathematics*, 2002.
(To be published).

[**Sri4**]
**S. Lievens*, K. Srinivasa Rao, and J. Van der Jeugt***.
The finite group of Kummer solutions.
*Integral Transforms and Special Functions*, 2002.
(To be published).

[**Sri5**]
**K. Srinivasa Rao**.
The $3n-j$ coefficients of angular momentum viewed from different sides.
In V.K.B. Kota, editor, *Nuclear Models*, page 92. Allied Publishers Pvt. Ltd., 2002.

[**Sri6**]
**K. Srinivasa Rao**.
Carl Friedrich Gauss: versatile virtuoso.
*Archives Internationales D'Histoire des Sciences*, 2003.
(Submitted).

[**Sri7**]
**K. Srinivasa Rao and G. Vanden Berghe***.
On Ramanujan's nested roots expansion.
*Applied Mathematics Letters*, 2003.
(Submitted).

[**Sri8**]
**K. Srinivasa Rao and G. Vanden Berghe***.
Revisiting a chapter from the Notebooks of Ramanujan on hypergeometric series.
*Archive for History of Exact Sciences*, 2003.
(Submitted).

[**Sri9**]
**K. Srinivasa Rao and G. Vanden Berghe***.
Gauss, Ramanujan and Hypergeometric Series Revisited.
*Historia Scientiarum*, 2003.
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[**Sri10**]
**K. Srinivasa Rao, G. Vanden Berghe*, and C. Krattenthaler***.
An entry of Ramanujan on hypergeometric series in his notebooks.
*Journal of Computational and Applied Mathematics*, 2003.
arXiv:math.CA/0304317v1 (Submitted).

### Books/Monographs Authored/Edited

The list below follows the same conventions as those followed for the list of publications.

[**B**]
Radha Balakrishnan, R. Dandoloff*, V. Gerdjikov*, D. Pushkarov*, and A. Saxena*, editors.
*Geometry, Integrability and Nonlinearity in Condensed Matter Physics.*, volume 29 of *Topical issue.*
The European Physical Journal B, 2002.

[**R**]
Purusattam Ray and Sitabhra Sinha, editors.
*Proceedings of the Discussion Meeting on Statistical Mechanics of Threshold Activated Systems.*
International Journal of Modern Physics B. 2003.
(To be published).

## 2.3 Theoretical Computer Science

### 2.3.1 Research Summary

#### Algorithms and Data Structures

A transposition acting on a string exchanges two adjacent substrings in the string. Computing the minimum number of transpositions required to sort a permutation is a well-studied problem in the literature, owing to its connection with genome rearrangement problems. The problem is neither known to be in P nor known to be NP-hard. Restricting the length of the substrings involved in the transposition to logarithmic in the string length does not make the problem easier. Consequently, bounded transpositions have also become the object of study. 3-bounded transpositions are of two types – a skip, exchanging two adjacent elements, and a hop, moving an element two positions away. It is known that *correcting hops* and *correcting skips*, those that do not create new pairs of out-of-order elements, suffice. In [**M1**], algorithmic and combinatorial aspects of correcting skips/hops are explored, with the aim of understanding 3-bounded transpositions better. The set of correcting-hop-free permutations is completely characterized, and an efficient algorithm to sort such permutations is obtained. The class of permutations which can be sorted using correcting hops alone is studied. The notion of correcting skips/hops is extended to *correcting moves* and it is shown that one can efficiently sort a permutation with a minimum number of correcting moves.

The problem of succinctly representing an arbitrary permutation, $\pi$, on $\{0, \ldots, n-1\}$ so that $\pi^k(i)$ can be computed quickly for any $i$ and any (positive or negative integer) power $k$, is investigated. It is shown that a representation taking $(1+\epsilon)n \lg n + O(1)$ bits suffices to compute arbitrary powers in constant time and a representation taking the optimal $\lceil \lg n! \rceil + o(n)$ bits can be used to compute arbitrary powers in $O(\lg n / \lg \lg n)$ time, or indeed in a minimal $O(\lg n)$ bit probes[**Ra2**].

Given a directed graph on $n$ vertices and an integer parameter $k$, the feedback vertex (arc) set problem asks whether the given graph has a set of $k$ vertices (arcs) whose removal results in an acyclic directed graph. The parameterized complexity of these problems, in the framework introduced by Downey and Fellows, is a long standing open problem in the area. These problems are addressed in the well studied class of directed graphs called tournaments.

While the feedback vertex set problem is easily seen to be fixed parameter tractable in tournaments, it is shown that the feedback arc set problem is also fixed parameter tractable and that the parametric dual problems (where the $k$ is replaced by 'all but $k$' in the questions) are fixed parameter tractable in oriented directed graphs (where there is at most one directed arc between a pair of vertices). More specifically, the dual problems shown fixed parameter tractable are: Given an oriented directed graph, is there a subset of $k$ vertices (arcs) that forms an acyclic directed subgraph of the graph?[**Ra3**].

In [**Mi1**], the inapproximability for two graph optimisation problems called monopoly and partial monopoly is considered. It is shown that these problems cannot be approximated within a factor of $(\frac{1}{3}-\epsilon)\ln n$ and $(\frac{1}{2}-\epsilon)\ln n$, respectively, unless $NP \subseteq DTIME(n^{O(\log\log n)})$. It is also shown that, if $\Delta$ is the maximum degree in a graph $G$, then both problems cannot be approximated within a factor of $(1-\epsilon)\ln\Delta$, unless $NP \subseteq DTIME(n^{O(\log\log n)})$, though the monopoly problem and the partial monopoly problem can be approximated within a factor of $1+\ln(\Delta+1)$ and $1+\ln(2\Delta+1)$, respectively. Finally, for cubic graphs, a 1.6154 approximation algorithm for the monopoly problem and a $\frac{5}{3}$ approximation algorithm for partial monopoly problem is given, and it is shown that they are APX-complete.

In [**Mi2**] a graph optimization problem called minimum monopoly problem is considered, in which it is required to find a minimum cardinality set $S \subseteq V$, such that, for each $u \in V$, $|N[u] \cap S| \geq \frac{|N[u]|}{2}$ in a given graph $G = (V, E)$. It is shown that this optimization problem does not have a polynomial time approximation scheme for $k$-regular graphs ($k \geq 5$), unless $PP = NP$. This is shown by establishing two $L$-reductions (an approximation preserving reduction) from minimum dominating set problem for $k$-regular graphs to minimum monopoly problem for $2k$-regular graphs and to minimum monopoly problem for $(2k-1)$-regular graphs, where $k \geq 3$. It is also shown that, for tree graphs, a minimum monopoly set can be computed in linear time.

### Automata, Logic and Concurrency

The series-parallel poset approach has been extended to infinite posets by D. Kuske. In joint work with D. Ranganayakulu [**L**], the earlier characterizations of sp-languages (by expressions, algebra and logic) accepted by 1-safe Petri nets has been extended to match Kuske's characterizations.

In order to extend this approach to a larger ranger of posets, the fusion operator for posets has been introduced. After getting feedback from a presentation, a written version is in preparation.

A notion of layering computations of message passing systems has been proposed, whereby systems may be studied as compositions of message patterns. Decidability of temporal logics over such structures has been studied, showing negative results for many subclasses, and appropriate bounds placed to obtain decidability using automata theoretic methods ([**Me**]).

The problem of verifying whether a security protocol preserves secrecy is generally undecidable, and it has been shown that decidability obtains when either messages are of bounded length but nonces are unbounded ([**R1**]), or when the set of nonces is fixed and bounded, but messages may be arbitrarily long ([**R2**]).

While doing the state reachability analysis of a specified set of communicating finite state machines (CFSMs), the traditional approach is to generate a single product state-graph from the set of component state graphs corresponding to the given FSMs. This approach gives rise to a state-space explosion problem that has to be addressed. A proposed solution for this problem is to transform the given CFSMs into what is defined as a corresponding set of *communicating minimal prefix machines* (CMPMs) that have embedded in them, only a minimal synchronization information about each other, but which is sufficient to do the global state analysis without actually generating the product graph as in the traditional method. Mathematically, a set of $n$ rooted trees representing the $n$ unfolded CMPMs corresponding to the set of $n$ graphs representing the given folded CFSMs is generated. Though disjoint, the nodes of these $n$ CMPM trees are related by a global accessibility relation using which one can not only decipher the global states using the local states but also distinguish conflict and concurrency, a significant lacunae of the traditional product-graph approach. In the current research, an attempt is being made to axiomatize the system of CMPMs using modal-logic and prove its *soundness* and *completeness*. It will be a *branching-time logic* as opposed to *linear-time logic* in order to express both *conflict* (choice) and *concurrency* relations along with global *causality* relation.

**Computational Complexity**

The following problems are studied in [**Ar3**]: Given a polynomial $f(x) \in \mathbb{Q}[x]$, (a) find the order of the Galois group of $f(x)$, and (b) determine the Galois group of $f(x)$ by finding a small generator set.

Assuming the the generalised Riemann hypothesis the following complexity bounds have been shown:

1. The order of the Galois group of an arbitrary polynomial $f(x) \in \mathbb{Q}[x]$ can be computed by a polynomial time deterministic algorithm making one query to a #P oracle. Furthermore, the order can be approximated by a randomized polynomial time algorithm with an NP oracle.

2. If $f$ is solvable by radicals then the order can be computed by a randomized polynomial time algorithm with an NP oracle.

3. For polynomials $f$ with abelian Galois group a generator set can be obtained by a randomized polynomial time algorithm

These results also hold for polynomials $f(x) \in K[x]$ where the number field $K = \mathbb{Q}(\theta)$ is specified by giving the minimal polynomial of $\theta$.

Motivated by the computer-generated nonadditive ((5,6,2)) code described in an article by Rains, Hardin, Shor and Sloane, a theory of non-stabilizer codes is developed of which the nonadditive code of Rains et al is an example. Furthermore, a general strategy of constructing

good nonstabilizer codes from good stabilizer codes and some explicit constructions and asymptotically good nonstabilizer codes are given. The explicit construction of a family of distance 2 non-stabilizer codes over all finite fields is described, of which the ((5,6,2)) code is a special example. Furthermore, using the theory developed, explicit constructions of examples of non-stablizer quantum codes of distance 3 are obtained. As in the case of stabilizer codes, fairly efficient encoding and decoding procedures can be designed. This work is reported in [**Ar5**].

The quantum complexity of the 0-1 Knapsack problem and 0-1 Integer Linear Programs is investigated. These problems admit $O(2^{n/2})$ time classical algorithms (for instances with $n$ variables) unlike general satisfiability. First an $O(2^{n/3})$ quantum algorithm for the 0-1 Knapsack problem with $n$ variables is obtained. More generally, for 0-1 Integer Linear Programs with $n$ variables and $d$ inequalities an $O(2^{n/3}n^d)$ quantum algorithm is obtained. For $d = o(n/\log n)$ this running time is bounded by $O(2^{n(1/3+\epsilon)})$ for every $\epsilon > 0$. Then a symmetric claw problem corresponding to 0-1 Knapsack is formulated and its quantum query complexity studied. For the symmetric claw problem a lower bound of $O(2^{n/4})$ is shown for its quantum query complexity and an $O(2^{n/3})$ upper bound is given by a quantum algorithm similar to the one for 0-1 Knapsack. Additionally, CNF satisfiability of CNF formulas $F$ is considered with no restrictions on clause size, but with the number of clauses in $F$ bounded by $cn$ for a constant $c$, where $n$ is the number of variables. A $2^{(1-\alpha)n/2}$ quantum algorithm for satisfiability is obtained in this case, where $\alpha$ is a constant depending on $c$. This work is reported in [**Ar7**].

### Graph Theory and Combinatorics

The work on relating the treewidth of an undirected graph with other structural parameters was further continued and strengthened. [**S3**] presents a lower bound on treewidth in terms of the second smallest eigenvalue of the associated Laplacian matrix. Using this, a lower bound of $\Omega(2^d/d)$ on the treewidth of the $d$-dimensional hypercube was also obtained. The known upper bound is $O(2^d/\sqrt{d})$. Similar lower bounds on the treewidth of Hamming graphs (a generalization of hypercubes) and strongly regular graphs are also presented.

Using recently established relationships between vertex expansion properties and treewidth, a lower bound of $\Omega((d-1)^{\lfloor (g-1)/2 \rfloor}/g)$ on the treewidth, in terms of girth $g$ (length of a shortest cycle) and average degree $d$, was also obtained. The proof of this bound uses the lower bound (recently established by Alon et al) on the number of vertices in a graph of specified girth and average degree. Also, in view of a widely believed conjecture on the existence of graphs with girth $g$ and minimum degree $\delta$ on at most $O((\delta-1)^{\lfloor (g-1)/2 \rfloor})$ vertices, the lower bound on treewidth seems tight upto a factor of $g$. These results are presented in full detail in [**S4**] and a brief sketch of them appears in [**S1**].

For an integer $b \geq 1$, the *b-choice number* (also referred to as *list b-chromatic number*) of a graph $G$ is the minimum integer $k$ such that for every assignment of a set $S(v)$ of at least $k$ colors to each vertex $v$ of $G$, there is a $b$-set coloring of $G$ that assigns to each vertex $v$ a $b$-set $B(v) \subseteq S(v)$ ($|B(v)| = b$) so that adjacent vertices receive disjoint $b$-sets. This is a generalization of the notions of choice number and chromatic number of a graph. Using probabilistic arguments, it is shown in [**S2**] that, for some positive constant $c > 0$ (independent of $b$), the $b$-choice number of any graph $G$ on $n$ vertices is at most $c(b\chi)(\ln(n/\chi)+1)$ where $\chi = \chi(G)$ denotes the chromatic number of $G$. For any fixed $b$, this

bound is tight up to a constant factor for each $n, \chi$. This generalizes and extends a result (and its proof) of Noga Alon wherein a similar bound was obtained for 1-choice numbers of complete $\chi$-partite graphs with each part having size $n/\chi$. It is also shown that the proof arguments can be made constructive leading to polynomial time approximation algorithms for the list $b$-set coloring problem on perfect graphs and circular-arc graphs.

### 2.3.2 List of Publications

The list of publications follows the following conventions: firstly, names of (co)authors who are not IMSc members are marked with a superscript *; secondly, the citation labels used for cross-referencing with the research summary are constructed from the last name of the first IMSc author and finally the list is ordered alphabetically according to the labels.

[**A**]
**Eric Allender***, **V. Arvind, and Meena Mahajan**.
Arithmetic complexity, Kleene closure, and formal power series.
*Theory of Computing Systems*, **36(4)**, 303–328, 2003.

[**Ar1**]
**V. Arvind and Piyush P. Kurur**.
Graph Isomorphism is in SPP.
In *Proceedings of the* $43^{rd}$ *Annual Symposium on Foundations of Computer Science FOCS*, page 743. IEEE, Nov 2002.

[**Ar2**]
**V. Arvind and Venkatesh Raman**.
Approximation algorithms for some parameterized counting problems.
In Bose and Morin, editors, *Proceedings of the 13th International Symposium on Algorithms and Computation, ISAAC 2002 Vancouver, BC, Canada*, page 453. Springer LNCS 2518, Nov 2002.

[**Ar3**]
**V. Arvind and Piyush P. Kurur**.
Upper Bounds on the Complexity of some Galois Theory problems.
In $14^{th}$ *International Symposium on Algorithms and Computation*. Springer, Jul 2003.
(To be published).

[**Ar4**]
**V. Arvind and Johannes Köbler***.
New lowness results for ZPP(NP) and other complexity classes.
*Journal of Computer and System Sciences*, **65(2)**, 257, 2002.

[**Ar5**]
**V. Arvind, Piyush P. Kurur, and K. R. Parthasarathy***.
Nonstabilizer quantum codes from abelian subgroups of the error group.
In *e-Print archive*. 2002.
(Preprint: quant-ph/0210097).

[**Ar6**]
**V. Arvind and K.R. Parthasarathy***.
A family of quantum stabilizer codes based on the Weyl commutation relations over a finite field.
In V. Lakshmibai et al, editor, *A tribute to C.S. Seshadri: Perspectives in Geometry and Representation Theory*, pages 133–154. Hindustan Book Agency, 2003.

[**Ar7**]
**V. Arvind and R. Schuler***.
The quantum query complexity of 0-1 knapsack and associated claw problems.
In *e-print Archive*. 2002.
(Preprint: quant-ph/0212048).

[**Ar8**]
**V. Arvind, K.V. Subrahmanyam*, and N.V. Vinodchandran***.
Query complexity of program checking with constant depth circuits.
*Chicago Journal of Theoretical Computer Science*, **2**, 1, 2002.

[**L**]
**D. Ranganayakulu* and Kamal Lodaya**.
Infinite series-parallel posets of 1-safe nets.
In P. Thangavel, editor, *Algorithms and Artificial Systems*, pages 107–124. Allied, 2003.

[**M1**]
**Meena Mahajan, R. Rama*, and S. Vijayakumar***.
On sorting by 3-bounded transpositions.
In *Proceedings, The R. C. Bose Centenary Symposium on Discrete Mathematics and Applications. 20–23 December 2002, ISI Kolkata*, Dec 2002.

[**M2**]
**Meena Mahajan and Priti Shankar***.
Madhu Sudan receives the Nevanlinna prize.
*Resonance*, **7(12)**, 84–90, 2002.

[**Me**]
**B. Meenakshi and R. Ramanujam**.
Reasoning about layered message passing systems.
In Lenore D. Zuck, Paul C. Attie, A. Cortesi, and S. Mukhopadhyay, editors, *Proceedings of Fourth Conference on Verification, Model Checking and Abstract Interpretation VMCAI 2003, Lecture Notes in Computer Science 2575*, page 268. Springer Verlag, Jan 2003.

[**Mi1**]
**Jaikumar Radhakrishnan*** **Sounaka Mishra and S. Sivasubramanian ***.
On the hardness of approximating minimum monopoly problems.
In *Proceedings of Foundations of Software Technology and Theoretical Computer Science Conference FST&TCS*, page 277. Springer LNCS 2556, Dec 2002.

[**Mi2**]
**Sounaka Mishra and S. Rao***.
Minimum monopoly in regular and tree graphs.
In *Proceedings, The R. C. Bose Centenary Symposium on Discrete Mathematics and Applications. 20–23 December 2002, ISI Kolkata*, Dec 2002.

[**R1**]
**R. Ramanujam and S. P. Suresh**.
A decidable subclass of unbounded security protocols.
In R. Gorrieri, editor, *Workshop on information theory and security*, page 11. ETAPS, Apr 2003.

[**R2**]
**R. Ramanujam and S. P. Suresh**.
An equivalence on terms for security protocols.
In R. Bharadwaj, editor, *Workshop on automatic verification of infinite state systems*, page 45. ETAPS, Apr 2003.

[**Ra1**]
**Venkatesh Raman, Saket Saurabh***, **and C. R. Subramanian**.
Faster fixed parameter tractable algorithms for undirected feedback vertex set.
In Bose and Morin, editors, *Proceedings of the 13th International Sympoisum on Algorithms and Computation, ISAAC 2002, Vancouver, BC, Canada*, page 241. Springer LNCS 2518, Nov 2002.

[**Ra2**]
**Ian Munro***, **Rajeev Raman***, **Venkatesh Raman, and S. S. Rao***.
Succinct representation of permuatations.
In J. C. M. Baeten, J. K. Lenstra, J. Parrow, and G. J. Woeginger, editors, *Proceedings of International Conference on Automata, Languages and Programmings (ICALP) 2003, Eindhover, The Netherlands*, page 345. Springer LNCS 2719, Jun 2003.

[**Ra3**]
**Venkatesh Raman and Saket Saurabh***.
Parameterized complexity of directed feedback set problems in tournaments.
In Frank Dehne, Jorg-Rudiger Sack, and Michiel Smid, editors, *Proceedings of the Workshop on Algorithms and Data Structures WADS 2003*, page 484. Springer LNCS 2748, Jul 2003.

[**Ra4**]
**Subash Khot*** **and Venkatesh Raman**.
Parameterized complexity of finding subgraphs with hereditary properties.
*Theoretical Computer Science*, **289(2)**, 997, 2002.

[**S1**]
**L. Sunil Chandran***, **T. Kavitha***, **and C.R. Subramanian**.
Isoperimetric inequalities and the width parameters of graphs.
In T. Warnow and B. Zhu, editors, *Ninth International Computing and Combinatorics Conference COCOON*. Springer-Verlag, LNCS series., Jul 2003.

[**S2**]
**C.R. Subramanian**.
List set coloring : bounds and algorithms.
Jun 2003.
(Submitted).

[**S3**]
**L. Sunil Chandran*** **and C.R. Subramanian**.
A spectral lower bound for the treewidth of a graph and its consequences.
*Information Processing Letters*, 2003.
(To be published).

[**S4**]
**L. Sunil Chandran*** **and C.R. Subramanian**.
Girth and treewidth.
2003.
(Submitted).

## 2.4 Student Programmes

### 2.4.1 Degrees Awarded

#### Doctoral Degrees Awarded during 2002 – 2003

#### Mathematics

Name: **Ravindra, G. V.**
Thesis Title: Cohomological detection of algebraic cycles
Thesis Advisor: Paranjape, Kapil H.
University: University of Madras

Name: **Murugesh, S.**
Thesis Title: Geometry of moving space curves associated with integrable equations: Connections and applications
Thesis Advisor: Balakrishnan, Radha
University: University of Madras

#### Theoretical Computer Science

Name: **Madhusudan, P.**
Thesis Title: Control and synthesis of open reactive systems
Thesis Advisor: Ramanujam, R.
University: University of Madras

Name: **Rao, S. S.**
Thesis Title: Succinct data structures
Thesis Advisor: Raman, Venkatesh
University: Madras University

#### Masters Theses during 2002 – 2003

#### Mathematics

Name: **Madonna, K. S.**
Thesis Title: Edge detection using wavelets
Thesis Advisor: Krishna, M.
University: Anna University

Name: **Sengupta, Ritabrata**
Thesis Title: Cyclic subgroups of the class group of quadratic fields
Thesis Advisor: Paranjape, Kapil H.
University: Anna University

**Physics**

Name: **Roy, Arya**
Thesis Title: Orientifolds and orbifolds
Thesis Advisor: Jayaraman, T.
University: Anna University

**Theoretical Computer Science**

Name: **Muthu, Rahul**
Thesis Title: A study of graph colouring notions
Thesis Advisor: Subramanian, C. R.
University: Anna University

### 2.4.2 Lecture Courses During 2002 - 2003.

The following **lecture courses** were offered during 2002 - 2003.

| Course Title | Period | Lecturer |
|---|---|---|
| **Mathematics** | | |
| Number Theory (reading course) | Aug-Oct 2002 | Srinivas, K. |
| Representation Theory | Jan-Apr 2003 | Raghavan, K. N. |
| **Physics** | | |
| Advanced Quantum Field Theory | Aug-Oct 2002 | Rajasekaran, G. |
| Advanced Topics in Condensed Matter Physics | Aug-Dec 2002 | Menon, Gautam I. |
| Classical Dynamics | Aug-Dec 2002 | Murthy, M.V.N. |
| Classical Electromagnetism | Aug-Dec 2002 | Indumathi, D. |
| Quantum Mechanics | Aug-Dec 2002 | Sathiapalan, Balachandran |
| Condensed Matter Physics | Jan-May 2003 | Sinha, Sitabhra |
| Particle Physics | Jan-May 2003 | Indumathi, D. |
| Quantum Field Theory I | Jan-Apr 2003 | Basu, Rahul |
| Statistical Mechanics | Jan-Apr 2003 | Ray, Purusattam |
| Introduction to General Relativity | Jun-Jul 2003 | Date, G. |
| **Theoretical Computer Science** | | |
| Algebraic Computation | Aug-Nov 2002 | Arvind, V. |
| Complexity Theory II | Aug-Nov 2002 | Arvind, V. |
| Design and Analysis of Algorithms | Aug-Dec 2002 | Raman, Venkatesh |
| Discrete Mathematics | Aug-Dec 2002 | Mahajan, Meena B. |
| Distributed Computing | Aug-Dec 2002 | Ramanujam, R. |
| Programming Languages | Aug-Dec 2002 | Lodaya, Kamal |

| | | |
|---|---|---|
| Randomness and Computation | Aug-Dec 2002 | Subramanian, C. R. |
| A First Course in Logic | Jan-May 2003 | Ramanujam, R. |
| Algorithms II | Jan-Apr 2003 | Raman, Venkatesh |
| Introduction to Computational Complexity | Jan-May 2003 | Mahajan, Meena B. |
| Theory of Computation II | Jan-Apr 2003 | Lodaya, Kamal |

In addition, the following **lecture courses** were offered during 2002 - 2003 by IMSc faculty in the National Undergraduate programme of the Chennai Mathematical Institute.

| Course Title | Period | Lecturer |
|---|---|---|
| **Mathematics** | | |
| Algebra I | Aug-Dec 2002 | Kodiyalam, Vijay |
| Calculus-I | Aug-Dec 2002 | Sankaran, P. |
| Analysis II | Jan-Apr 2003 | Krishna, M. |

### 2.4.3 Summer Students

Every summer, a small number of students from various institutes/universities come to our instituteand work on some learning/research projects with some faculty member for a period of four to six weeks.The following students visited the institute during Aug, 2002 - Jul, 2003.

| Student | Faculty |
|---|---|
| **Mathematics** | |
| Vidyaranya, K., First Grade College, Tirthahalli, Karnataka | Kesavan, S. |
| Dwivedi, Shivanand, IIT, Mumbai | Kesavan, S. |
| Dravid, Bharat, IIT, Kharagpur | Raghavan, K. N. |
| Sebastian, Ronnie, IIT, Kanpur | Raghavan, K. N. |
| **Physics** | |
| Joshi, Nikhil J., IIT, Kanpur | Date, G. |
| Chandra, Amar V., IIT,Kanpur | Date, G. |
| Chandrasekharan, R, R., IIT.Madras | Parthasarathy R. |
| Bijilash, B. S., IIT,Madras | Sinha, Sitabhra |
| Nirmal Thyagu, N., IIT,Madras | Sinha, Sitabhra |
| Sridhar, S., Indian Institute of Technology, Madras | Sinha, Sitabhra |

**Theoretical Computer Science**

| | |
|---|---|
| Polychroniadis, Olivier, ENS de Cachan | Lodaya, Kamal |
| Sohier, Julien, ENS de Cachan | Lodaya, Kamal |
| Kulkarni, Raghav, Chennai Mathematical Institute | Mahajan, Meena B. |
| Verma, Shobhit K., Chennai Mathematical Institute | Raman, Venkatesh |
| Roy, Debadyuti, Chennai Mathematical Institute | Ramanujam, R. |
| Chattopadhyay, Amit, Indian Statistical Institute, Kolkata | Ramanujam, R. |
| Gupta, Sushmita, Chennai Mathematical Institute | Subramanian, C. R. |

The following talks were organised as part of the programme for summer students:

- Introduction to library and e-journals (Paul Pandian)
- Introduction to IMSc computing facility (G. Subramoniam);
- Birth and death of a star (N.D. Hari Dass);
- Harmonic oscillators - I (R. Parthasarathy)
- Harmonic oscillator - II (R. Parthasarathy)
- Pancharathnam, Berry and geometric phases (R. Simon)

### 2.4.4 Other Students

Students also do their projects under the supervision of our faculty during the academic year.The following students visited the institute during Aug, 2002 - Jul, 2003.

| Student | Faculty |
|---|---|
| **Physics** | |
| Divya,A., SRC, Tiruchi | Indumathi, D. |
| Suganthi,M., SRC, Tiruchi | Indumathi, D. |
| **Theoretical Computer Science** | |
| Ramani, R., REC Tiruchi | Raman, Venkatesh |
| Poorna,V., REC Tiruchi | Ramanujam, R. |

### 2.4.5 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 paid 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 students of B.Sc (third year) 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 followed by an interview. The successful students are encouraged to attend seminars in the Institute and to work under the supervision of a faculty member at IMSc, during the summer vacation. They are expected to show their progress in their regular M.Sc course and if satisfied, the scholarship is extended to the second year of their M.Sc course.

During this academic year, the fellowship was awarded to Mr. R. M. Sarguna of Pachayappa's College and Mr. R. Chandrashaker of New College in Physics and to Ms. R. Srividya of Stella Maris College and Mr. R. Sivaguru of Madras Christian College in Mathematics.

## 2.5 Honours and Awards

**Balasubramanian, R.** was awarded Knight of the Order of Merite by the President of the French Republic, Jacques Chirac.

# Chapter 3

# Other Professional Activities

This chapter lists the activities carried out by the individual members of the institute in their professional capacity.

**Anuradha, N.**

Reviewer of Mathematical Reviews.

**Arvind, V.**

Member of Programme Committee, INDOCRYPT-2002, Third International Conference on Cryptology in India during Jan – Dec, 2002.

**Balasubramanian, R.**

Convener of Sectional Committee-I, Indian National Science Academy, Delhi during Jan 2001 – Jul 2003.

Member of Governing Council, Chennai Mathematical Institute during Mar 2001 – Jul 2003.

Member of Executive Committee, School of Mathematics, Anna University during May 2001 – Jul 2003.

Member of Fellowship Scrutiny Committee, The National Academy of Sciences, Allahabad during Aug 2001 – Jul 2003.

President of Cryptology Research Society of India, Kolkata during Oct 2001 – Jul 2003.

**Basu, Rahul**

Member of National Organising Committee for XV DAE Symposium in High Energy Physics held at Jammu University during Nov 11 – Nov 15, 2002.

Member of National Organising Committee for QCD 2002 held at IIT, Kanpur during Nov 18 – Nov 22, 2002.

**Date, G.**

Member of The Council of the Indian Association for General Relativity and Gravitation.

Member of National Organising Committee for Field Theoretic Aspects of Gravity - III held at Shanthigiri Ashram, Kunjattukara, Kerala during Jan 23 – Jan 29, 2003.

Member of Scientific Organising Committee for the International Conference on Gravitation and Cosmology, ICGC-2004. during Mar – Jul, 2003.

**Kesavan, S.**

Member of National Board for Higher Mathematics.

Member of Editorial Board, Journal of Analysis and Applications.

Member of Apex Committe, National Undergraduate Programme, Chennai Mathematical Institute.

Member of Programme Implementation Committee, National Undergraduate Programme, Chennai Mathematical Institute.

Member of Editorial Board, Mathematics Newsletter, Ramanujan Mathematical Society.

Reviewer of Mathematical Reviews.

Fellow of Forum d' Analystes.

Convener of Local Organising Committee for N. B. H. M. Nurture Programme held at IMSc during Jul 7 – Jul 25, 2003.

**Kodiyalam, Vijay**

Reviewer of Mathematical Reviews.

**Lodaya, Kamal**

Convener of International Organising Committee for 2nd Preparatory School and Workshop on Automata, Concurrency and Logic held at IMSc during Jan 24 – Jan 29, 2003.

**Mahajan, Meena B.**

Member of Programme Committee, International Conference on Foundations of Software Technology and Theoretical Computer Science (FST&TCS) 2002 during Jan – Dec, 2002.

Council member of Indian Association for Research in Computer Science IARCS during Aug – Dec, 2002.

**Menon, Gautam I.**

Convener of Local Organising Committee for Robustness, Emergent Behaviour and Pattern Formation in Biological Systems held at IMSc during Dec 1 – Dec 3, 2002.

Member of Local Organising Committee for Institute Seminar Week held at IMSc during Feb 18 – Feb 22, 2003.

Convener of Local Organising Committee for Fifth SERC School on the Physics of Disordered Systems held at IMSc during Apr 1 – Apr 21, 2003.

**Paranjape, Kapil H.**

Associate Editor of Editorial Board, Proceedings of Indian Academy of Sciences (Mathematical Sciences) during Dec 1995 – Jul 2003.

Member of Editorial Board, Journal of the Ramanujan Mathematical Sciences during Jan 1996 – Jul 2003.

Member of Editorial Board, "Resonance", A journal of Science Education during Jan 1997 – Dec 2002.

Member of Editorial Board, Texts and Readings in Mathematics (TRIM) during Jul 1998 – Jul 2003.

Member of Advisory Board of arXiv.org during Mar 2002 – Jul 2003.

**Raman, Venkatesh**

Member of Programme Committee of the 22nd FST & TCS conference during Jan – Dec, 2002.

Member of Council of Indian Association for Research in Computing Science during Dec 2002 – Jul 2003.

**Ramanujam, R.**

Member of Programme committee of FST&TCS 2002 during Jan – Dec, 2002.

**Ray, Purusattam**

Convener of Local Organising Committee for Statistical Mechanics of Threshold Activated Systems held at IMSc during Mar 24 – Mar 26, 2003.

Convener of Local Organising Committee for Fifth SERC School on the 'Physics of Disordered Systems' held at IMSc during Apr 1 – Apr 21, 2003.

**Sinha, Sitabhra**

Convener of Local Organising Committee for Statistical Mechanics of Threshold Activated Systems held at IMSc during Mar 24 – Mar 26, 2003.

**Sinha, Sudeshna**

Advisory Editor of AIP Journal "Chaos".

Convener of Local Organising Committee for Robustness, Emergent Behaviour and Pattern Formation in Biological Systems held at IMSc during Dec 1 – Dec 3, 2002.

**Srinivasa Rao, K.**

Convener of Local Organising Committee for Workshop on Mathematica and the software packages Hyp and Hyp-q held at IMSc during Sep 16 – Sep 20, 2002.

Convener of International Organising Committee for International Conference on Special Functions and their Applications held at IMSc during Sep 23 – Sep 27, 2002.

**Sunder, V. S.**

Member of Editorial Board of the Journal of the Ramanujan Mathematics Society during Aug 2001 – Jul 2003.

Member of Editorial Board of the Proceedings of the Indian Academy of Sciences (Math. Sci.). during Aug 2001 – Jul 2003.

Member of Editorial Board of the 'Texts and Readings in Mathematics' (or the TRIM) series published by the Hindustan Book Agency. during Aug 2001 – Jul 2003.

Member of 'Technical Advisory Committee' of the Indian Statistical Institute. during Aug 2001 – Jul 2003.

Member of Mathematical Sciences Research Committee constituted by the CSIR (to assess various proposals, etc.) during Aug 2001 – Jul 2003.

Convener of Local Organising Committee for Discussion Meeting on Harmonic Analysis held at IMSc during Dec 31, 2002 – Jan 1, 2003.

Convener of Local Organising Committee for Current Trends in Mathematics held at Madras Christian College during Feb 21 – Feb 22, 2003.

# Chapter 4

# Colloquia

## 4.1 Conferences/Workshops Held at IMSc

### 4.1.1 Workshop on Mathematica and the software packages Hyp and Hyp-q

This was the second time this workshop was conducted by the Institute for a group of selected active research workers in the area of special functions. The workshop was conducted by Prof. C. Krattenthaler of the University of Vienna, Austria, the creator of the software packages Hyp and Hyp-q. Lectures in the mornings were followed by practicals on the computer terminals in the afternoons. Prof. K. Srinivasa Rao and Dr. S. Lievens (University of Gent, Belgium) were assisting Prof. Krattenthaler in the practical classes in the afternoons.

### 4.1.2 International Conference on Special Functions and their Applications

This ICSF2002 was co-sponsored by the International Mathematical Union; Orthogonal Polynomials and Special Functions (OPSF) Activity Group of SIAM and the Society for Special Functions and Applications (SSFA) of India; as well as the National Board for Higher Mathematics, the Department of Science and Technology, and the Council of Scientific and Industrial Research of the Government of India, and was convened and conducted by Dr. K. Srinivasa Rao.

The Proceedings of the Conference edited by Professors R. Jagannathan, S. Kanemitsu, W. Van Assche and G. Vanden Berghe have been submitted to the Journal of Computational and Applied Mathematics in May 2003. This special issue is dedicated to the 60th Birthday of Dr. K. Srinivasa Rao and contains an article entitled: **K. Srinivasa Rao and his work** by W. Van Assche, G. Vanden Berghe and J. Van der Jeugt.

### 4.1.3 Discussion Meeting on Harmonic Analysis

This meeting was attended by a blend of mathematicians ranging from Ph.D. students to older and well-established research mathematicians. (As a pleasant bonus, we had the pleasure of having, in the audience, Professor Dennis Sullivan who was visiting the institute at that time, as well as some others who had come to Chennai to attend Professor Sullivan's lectures.)

The following people (from outside IMSc) participated in the meeting:

S.C. Bagchi, Biswaranjan Behera, Tirthankar Bhattacharyya, Debashis Bose, Anjan Kumar Chakraborty, Praveen Chaurasis, S.G. Dani, Santhanu Dey, Joydip Jana, N.R. Ladhawala, Shobha Madan, Rekha Mehta, M.G. Nadkarni, A.K. Nandakumaran, E.K. Narayanan, K. Parthasarathy, Sanjay Parui, S. Parvathi, R. Radha, C.R.E. Raja, P.K. Ratnakumar, Rama Rawat, Swagato Ray, Jyoti Sengupta, Dinesh Singh, Alladi Sitaram, V.V.K. Srinivas Kumar, R. Srinivasan, U.B. Tewari, S. Thangavelu and M.K. Viswanath.

In addition to thirty minute lectures by most of the participants, there was a course of four sixty-minute lectures on the theme *Spherical Functions on* $SU(1,1)$ - three by Swagato Ray of IIT, Kanpur and an introductory lecture by Alladi Sitaram of ISI, Bangalore.

This programme was made possible by generous support from the National Board for Higher Mathematics and the Council for Scientific Research.

### 4.1.4 Robustness, Emergent Behaviour and Pattern Formation in Biological Systems

This meeting was held at IMSc in December of 2002. It focused on current issues in the understanding of complex biological systems, in particular the study of pattern formation, emergence and robustness, and was addressed to theoretical physicists, biologists, applied mathematicians, biophysicists and engineers with an interest in these problems. This meeting was convened jointly by Gautam I. Menon and Sudeshna Sinha of IMSc. About 15 invited speakers both from India and abroad gave invited talks at this meeting which was also well attended by IMSc members. A list of speakers at this meeting follows:

- **Upinder Bhalla** NCBS, Bangalore
- **I. Bose** Bose Institute, Kolkata
- **Debashish Chowdhury** IIT, Kanpur
- **Julio Collado-Vides** CIFN-UNAM, Mexico
- **P. Hogeweg** Utrecht University, Netherlands
- **B.M. Jaffar Ali** AU-KBC Centre, Chennai
- **Sanjay Jain** Delhi University, Delhi
- **K. Kaneko** University of Tokyo, Japan

- **Gautam I. Menon** IMSc, Chennai
- **R. Ramaswamy** JNU, Delhi
- **Madan Rao** RRI and NCBS, Bangalore
- **G.V. Shivashankar** NCBS and RRI, Bangalore
- **Sitabhra Sinha** IMSc, Chennai
- **Somdatta Sinha** CCMB, Hyderabad
- **K. VijayRaghavan** NCBS, Bangalore

### 4.1.5 2nd Preparatory School and Workshop on Automata, Concurrency and Logic

This meeting was held on 24–29 Jan at the Institute of Mathematical Sciences, Chennai.

The three-day preparatory school (24–26 Jan) was aimed at college and university computer science teachers, and featured three 5-hour mini-courses: "Automata and Logic" by K. Lodaya and R. Ramanujam (IMSc), "Concurrency" by M. Mukund and K. Narayan Kumar (Chennai Mathematical Institute), and "Timed Systems" by P. K. Pandya (Tata Institute of Fundamental Research, Mumbai) and D. D'Souza (Indian Institute of Science, Bangalore).

The three-day workshop (27–29 Jan) followed, and had invited talks by 15 researchers from India, the Indian Ocean and Europe. The workshop had about 50 participants in all.

The talks covered message-passing and timed systems, temporal logics and their expressiveness over traces, monadic second-order logics over classes of graphs, bisimulation, Petri nets ... a reasonable sampling of ongoing work in the ACL area. The list of talks appears below.

Some French scientists coincided their visit to Chennai under the Indo-French project on "Automata and concurrency: syntactic methods for verification" (principal investigators: K. Lodaya from IMSc and P. Weil from LaBRI, Bordeaux) with the workshop.

- **S. Arun-Kumar** (IIT Delhi):
  *The fusion calculus*
- **Patricia Bouyer** (LSV, ENS Cachan):
  *Timed automata – from theory to implementation*
- **Jean-Michel Couvreur** (LSV, ENS Cachan; LaBRI, Bordeaux):
  *An automata approach to probabilistic verification*
- **Deepak D'Souza** (IISc, Bangalore; CMI, Chennai):
  *Controller synthesis with partial observation in a timed setting*
- **Zoltán Ésik** (University of Szeged):
  *Temporal logic and regular languages*

- **Paul Gastin** (Universität Stuttgart; LIAFA, Paris):
  *Global and local temporal logics for traces*
- **Astrid Kiehn** (IIT Delhi; TU München):
  *Complementing discrete-time timed automata*
- **Teodor Knapik** (Universit/'e de la R/'eunion):
  *Hyperalgebraic structures*
- **Kamal Lodaya** (IMSc, Chennai):
  *Poset languages of 1-safe Petri nets*
- **B. Meenakshi** (IMSc, Chennai):
  *Message-passing systems*
- **Madhavan Mukund** (CMI, Chennai):
  *Hereditary history preserving bisimulation*
- **K. Narayan Kumar** (CMI, Chennai):
  *Trace logics with agent-based modalities*
- **Paritosh Pandya** (TIFR, Mumbai):
  *Verification of dense-time properties by digitization and discrete-time analysis*
- **Antoine Petit** (LSV, ENS Cachan):
  *Data languages*
- **Pascal Weil** (LaBRI, Bordeaux):
  *On the notion of recognizability for sets of finite graphs*

### 4.1.6 Institute Seminar Week

The **Institute Seminar Week** was organized during February 19-26, 2003. The coordinators were Gautam I. Menon (Physics), Venkatesh Raman (TCS) and Kapil Paranjape (Mathematics). Seminars were held from 10 a.m. to 1 p.m. daily, with a break in between. The talks were well attended by students, faculty and visitors. The list of talks was as follows:

- **G. Baskaran**
  *A little bit about a qubit*
- **V. Uma**
  *Fundamental group of real toric varieties*
- **Sumithra Sankararaman**
  *Pattern formation in mixtures of motors and micro-tubules*
- **R. Ramanujam**
  *Program logics* vs. *Game logics*

- **E. Harikumar**
  *O(3) Sigma model on fuzzy sphere*
- **V.S. Sunder**
  *A complete set of numerical invariants for a subfactor*
- **G. Date**
  *Quantum cosmology*
- **Sounaka Mishra**
  *On the hardness of approximating monopoly and other related problems*
- **Radha Balakrishnan**
  *Anti-ferromagnetic dynamics: non-linear sigma model sector and Kink sector*
- **Gautam I. Menon**
  *Seeing vortex glasses*
- **Sibasish Ghosh**
  *Local distinguishability of bipartite maximally entangled states*
- **Kapil Paranjape**
  *The Hodge conjecture for Prym varieties*
- **Rahul Sinha**
  *Beautiful ways to search for new physics*
- **Piyush P. Kurur**
  *Graph Isomorphism is in SPP*
- **Sudeshna Sinha**
  *Surprising consequences of randomly coupling chaotic maps*
- **R. Jagannathan**
  *$(p, q)$-Hypergeometric series*
- **Rahul Basu**
  *Neutrino telescopes and perturbative QCD*
- **G. Rajasekaran**
  *Neutrinos have mass. So what?*
- **K.N. Raghavan**
  *Invariants for complex semisimple Lie algebras*
- **S.P. Suresh**
  *A decidable subclass of unbounded security protocols*
- **Naveen Surendran**
  *Real-space RG for $s = 1/2$ dimerised spin-chain*
- **Avijit Ganguly**
  *Photons in astrophysical objects*

- **B. Meenakshi**
  *Layering of message passing systems*
- **M.V.N. Murthy**
  *Harmonically trapped fermion gases: exact and asymptotic results in arbitrary dimensions*
- **Gyan Prakash**
  *On an additive representation function*
- **C.R. Subramanian**
  *Probabilistic arguments in graph theory*
- **Nita Sinha**
  *CP violating angles through time dependent asymmetries in B decays*
- **Kamal Lodaya**
  *Metric temporal logics*
- **Ratnadeep Roy**
  *Random field Ising model under an applied field*
- **N.D. Hari Dass**
  *Understanding black holes through quantum optics*
- **Purusattam Ray**
  *Persistence in coupled map lattices*
- **Indrajit Mitra**
  *Topological field patterns of the Yang-Mills theory*
- **Sitabhra Sinha**
  *Only the prudent gambler survives in the ecological Las Vegas*
- **R. Parthasarathy**
  *Strings in pp-wave curved background—exactly solvable*
- **D. Indumathi**
  *Physics issues with future possible ICAL detector at INO*

### 4.1.7 Statistical mechanics of threshold activated systems

This meeting was held in IMSc between March 24-26, 2003. It focussed on understanding the general principles underlying threshold activated dynamics observed in many physical processes, e.g., in sandpile models, granular flow, excitable media, fracture or breakdown, neural networks, Barkhausen noise, market models, etc. The meeting brought together active researchers working on these different systems. This meeting was convened jointly by Purusattam Ray and Sitabhra Sinha of IMSc. About 14 invited speakers from India and abroad gave talks at this meeting. In addition there was a poster session. A list of speakers at this meeting follows:

- **Garani Ananthakrishna** IISc, Bangalore
- **Mustansir Barma** TIFR, Mumbai
- **Bikas K. Chakrabarti** SINP, Kolkata
- **Deepak Dhar** TIFR, Mumbai
- **Alex Hansen** Norwegian University of Science & Technology, Norway
- **Jun-ichi Inoue** Hokkaido University, Japan
- **Kimmo Kaski** Helsinki University of Technology, Finland
- **Janos Kertesz** Technical University of Budapest, Hungary
- **S. S. Manna** SNBNCBS, Kolkata
- **K. P. N. Murthy** IGCAR, Kalpakkam
- **Rahul Pandit** IISc, Bangalore
- **Prabodh Shukla** NEHU, Shillong
- **Sudeshna Sinha** IMSc, Chennai
- **Dietrich Stauffer** University of Cologne, Germany

### 4.1.8 Fifth SERC School on the Physics of Disordered Systems

An SERC School on the "Physics of Disordered Systems" was held at IMSc during April 1-21, 2003. This school was jointly organized by Gautam I. Menon and Purusattam Ray of IMSc. About 34 participants from 22 Universities/Institutes from all over India, including both experimentalists and theorists, participated in this school. The speakers and topics covered were:

- **M. Barma** Overview and introduction to spin glasses
- **S. Bhattacharya** Vortex glass phases and depinning phenomena: experiments
- **S.M. Bhattacharjee** Directed polymers in random media
- **D. Dhar** Percolation
- **B.K. Chakrabarti** Disordered quantum spin models
- **S. P. Das** Mode coupling and the structural glass transition
- **S.N. Kaul** Experiments on spin glasses and other disordered spin systems
- **Deepak Kumar** Dilute magnets
- **T.V. Ramakrishnan** Introduction to disordered quantum systems

- **S.S.N. Murthy** Experiments on glasses
- **S. Sastry** Structural glasses: phenomenology, theory and simulations
- **Prabodh Shukla** Random field systems

Special lectures on related topics were also given by Sitabhra Sinha, Purusattam Ray and Gautam Menon of IMSc. In addition, a program of talks by speakers from IMSc was also scheduled as part of the school. Speakers in this program included Profs. N.D. Hari Dass, R. Simon, V. Arvind, M.V.N. Murthy, R. Balasubramanian and R. Shankar.

### 4.1.9 N. B. H. M. Nurture Programme

The Nurture Programme for the INMO awardees of 1999 - 2000 continued at the Institute of Mathematical Sciences Chennai and the participants were under the charge of the faculty comprising of Drs. V. Balaji, S. Kesavan (Convener), K. H. Paranjape, K. N. Raghavan and V. S. Sunder. The syllabus for self-study during the second year of the programme, *i.e.* 2002 - 2003, was Functional Analysis (based on the second part of the book by G. F. Simmons, Introduction to Topology and Modern Analysis), Algebra (Chapters 8, 9, 11, 12 and 14 of the book by M. Artin), Topology (based on Part II, Chapters 9 - 13 of the book by J. R. Munkres) and Analysis of Several Variables (based on Chapters 8 - 10 of W. Rudin's Principles of Mathematical Analysis).

The Contact Programme was held at the Institute of Mathematical Sciences, Chennai, from Monday, July 7 to Friday, July 25, 2003. Out of the 6 registered participants remaining at the end of the second year, 3 attended the programme.

During the first two days of this summer camp, the above subjects were revised by the members of the faculty. This was followed by lecture courses which built upon these subjects. Dr. D. S. Nagaraj gave two revision lectures in Topology followed by two lectures on the Topology of Manifolds. This was continued by Dr. V. Balaji (4 lectures) and Dr. K. H. Paranjape (2 lectures). Dr. V. S. Sunder gave 6 lectures on Functional Analysis leading to an introduction to $C^*$- Algebras. Dr. K. N. Raghavan gave 7 lectures on Representation Theory. Dr. S. Kesavan gave 6 lectures on Distribution Theory. Dr. R. Balasubramanian gave 6 lectures on Galois Theory. Dr. M. Krishna gave 5 lectures on Wavelets. In addition, Dr. K. H. Paranjape gave a special lecture on 'The Definition and Representation of Algebraic Numbers Geometrically' and Dr. V. Arvind gave a special lecture on 'The Graph Isomorphism Problem'. The programme concluded with the screening of a musical film (produced by the Clay Mathematical Institute) entitled 'Fermat's Last Tango' based on the experiences of A. Wiles in proving Fermat's Last Theorem.

During the last week, the participants were interviewed by the faculty to assess their progress.

## 4.2 Other Conferences/Workshops Organized by IMSc

### 4.2.1 Field Theoretic Aspects of Gravity - III

This was the third of a series of discussions meetings on field theoretic aspects of gravity and was organized by Dept. of Physics, Cochin University of Science and Technology, Kochi with partial funding from IMSc and IUCAA. The first meeting of this series was organized by IUCAA, Pune and the second was organized by IMSc, Chennai. This series is intended to bring together a small number of researchers in the areas of classical and quantum gravity from research institutes, the IITs and colleges/universities, and it has been proposed that this be made a regular annual feature.

FTAG-III was held at Shanthigiri Ashram, Kunjattukara, near Alwaye, Kerala during Jan 23-29, 2003. About 25 participants, including several from IMSc, attended. Topics ranging from entropy of black holes, naked singularities in gravitational collapse, and aspects of quantum cosmology to more general perspectives on gravity were covered in talks and informal but intense discussions. The list of speakers and topics is given below.

- **N. K. Dadhich**, IUCAA, Pune
  *Is Planck length fundamental for quantum gravity?*
- **G. Date**, IMSc, Chennai
  *A discrete time presentation of quantum dynamics.*
- **Harvinder Kaur Jassal**, IUCAA, Pune
  *Tachyon fields in cosmology: dark energy or dark matter?*
- **T. R. Govindarajan**, IMSc, Chennai
  *Non-commutative geometry and quantum gravity.*
- **Parampreet Singh**, IUCAA, Pune
  *Dynamics of extended objects in GR - from action to phases.*
- **Minu Joy**, CUSAT, Kochi
  *Physics of early universe - a field theoretic approach.*
- **N. D. Hari Dass**, IMSc, Chennai
  *Conserved quantities in gauge and diffeomorphism invariant theories and their relation to black hole entropy.*
- **Sukratu Barve**, PRL, Ahmedabad
  *Quantum stress tensor in cylindrical collapse: an example.*
- **Bala Sathiapalan**, IMSc, Chennai
  *ADS/CFT correspondence and black holes.*
- **T. Padmanabhan**, IUCAA, Pune
  *Action functional and dynamics of gravity: a new perspective.*
- **L. Sriramkumar**, HCRI, Allahabad
  *Modified dispersion relations and the Bekenstein's bound on specific entropy.*

- **S. Mukherjee**, North Bengal University, Darjeeling
  *Create your own universe: hot or cold, open or closed.*
- **Soumen Basak**, IMSc, Chennai
  *'Super Resonance' from a rotating black hole.*
- **K. Babu Joseph**, CUSAT, Kochi
  *Some remarks on pre-big-bang cosmology.*
- **L. P. Singh**, Utkal University, Bhubaneswar
  *Space time dependent Lagrangian and the Barriola-Vilenkin monopole.*
- **Moncy V. John**, St Thomas College, Kozencherry
  *Modified de Broglie-Bohm approach to quantum mechanics.*

### 4.2.2 Current Trends in Mathematics

The purpose of this seminar was to get various mathematicians and theoretical computer scientists who all have some link with Madras Christian College (MCC) to try and get across the message through their lectures that there is good research which can be done and is being done in these areas by people with this background. This seminar was aimed primarily at the post-graduate students at MCC as well as others from neighbouring colleges who might be interested. It was made possible by financial support from the Indian Academy of Sciences.

## 4.3 Seminars

| Date | Speaker<br>Affiliation | Title |
|---|---|---|
| 2-8-2002 | A. Punnoose<br>Weizmann Inst., Israel | Dilute electron gas near the metal-insulator transition: role of valleys in silicon inversion layers |
| 5-8-2002 | K.T.Arasu<br>Wright State Univ. | Perfect sequence theorems |
| 6-8-2002 | N.Sabu<br>IMSc | Mathematical elasticity |
| 7-8-2002 | L. Sriramkumar<br>HRI, Allahabad | Cavity with a moving wall and the Bekenstein's bound on specific entropy |
| 8-8-2002 | V.S.Sunder<br>IMSc | Generators for tangles |
| 8-8-2002 | V. Arvind<br>IMSc | PRIMES is in P |
| 13-8-2002 | Roy Joshua<br>Ohio State Univ. | Intersection theory on algebraic stacks - an introduction |
| 13-8-2002 | Diptiman Sen<br>CTS, IISc, Bangalore | Junction of several quantum wires: a renormalization group study |
| 16-8-2002 | Sriram Ramaswamy<br>Dept. of Physics, IISc, Bangalore | Melting-freezing cycles in sheared crystalline layers |
| 16-8-2002 | S. Srinivasa Rao<br>IMSc | Succinct data structures |
| 16-8-2002 | Rama Govindarajan<br>JNCASR, Bangalore | Universal behaviour of entrainment due to coherent structures in a chaotic vortical Flow |
| 21-8-2002 | K. R. Parthasarathy<br>IMSc | Classical and quantum information theory |

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|---|---|---|
| 22-8-2002 | R. Balasubramanian<br>IMSc | Primality testing |
| 22-8-2002 | Manas Sardar<br>MSD, IGCAR, Kalpakkam | Spin polarized transport in superconductors |
| 29-8-2002 | Suresh Nayak<br>CMI | Grothendieck duality Pseudo-functor |
| 3-9-2002 | S. Ramanan<br>TIFR | Derived categories |
| 5-9-2002 | P. Madhusudan<br>IMSc | Control and synthesis of open reactive systems (thesis viva) |
| 5-9-2002 | M. Mahajan, D. S. Nagaraj, K. Paranjape<br>IMSc | Fields medals and Nevanlinna prize |
| 6-9-2002 | Christopher L. Henley<br>Cornell Univ., U.S.A | Overcoming degeneracy in a frustrated antiferromagnet |
| 9-9-2002 | R. Samuel<br>ESD, ISRO Satellite Centre, Bangalore | Laser based interferometric techniques in structural Component Testing |
| 9-9-2002 | R. Parthasarathy<br>TIFR | Ordered Bratteli diagrams, dimension groups and topological dynamics |
| 12-9-2002 | R. Parthasarathy<br>TIFR | Ordered Bratteli diagrams, dimension groups and topological dynamics |
| 16-9-2002 | Gautham Dayal<br>CMI | Finite Heisenberg group |
| 17-9-2002 | V. Srinivas<br>TIFR | Modules of finite length and projective dimension, and algebraic cycles |
| 19-9-2002 | Prof. C. Krattenthaler<br>Univ. of Vienna | Planar partitions |
| 20-9-2002 | S. Kalyana Rama<br>IMSc | Classical velocity in $\kappa-$deformed poincare algebra and a maximum acceleration |

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|---|---|---|
| 20-9-2002 | Reuben Rabi | Polylogarithms and the Hodge conjecture |
| 20-9-2002 | Lis Brack-Bernsen<br>Univ. of Regensburg | Teaching of Babylonian mathematics |
| 26-9-2002 | Paramita Das<br>IMSc | Hopf algebras - a pictorial approach |
| 1-10-2002 | M. Brack<br>Univ. of Regensburg | Basics and new developments in periodic orbit theory (I) |
| 4-10-2002 | M. Brack<br>Univ. of Regensburg | Basics and new developments in periodic orbit theory (II) |
| 4-10-2002 | V. S. Sunder<br>IMSc | Meeting with students from Maharaja college |
| 7-10-2002 | M. Brack<br>Univ. of Regensburg | Basics and new developments in periodic orbit theory: (III) |
| 7-10-2002 | Kapil Paranjape<br>IMSc | Kummer's $16_6$ |
| 9-10-2002 | M. Brack<br>Univ. of Regensburg | Basics and recent developments in periodic orbit Theory: (IV) |
| 9-10-2002 | J. Samuel<br>RRI | Stretching it a bit: DNA elasticity and the worm-like chain |
| 10-10-2002 | R. Balasubramanian<br>IMSc | Catalan's conjecture |
| 10-10-2002 | Supurna Sinha<br>RRI | Semi-flexible polymers: structure and elasticity |
| 11-10-2002 | J. Samuel<br>RRI | Stretching it a bit: DNA elasticity and the worm-like chain |
| 17-10-2002 | D.-N. Verma<br>TIFR | Representation theory of the general linear groups |

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|---|---|---|
| 23-10-2002 | Sitabhra Sinha<br>IMSc | "How green was my network!" - Complexity and dynamical stability in evolving ecological networks |
| 25-10-2002 | Prabal Maiti<br>Caltech, U.S.A | Multiscale modelling of DNA and dendrimer systems: their application in nanotechnology and drug delivery |
| 28-10-2002 | Vijay Kodiyalam<br>IMSc | Complete invariants for complex semisimple Hopf algebras |
| 29-10-2002 | C. Ravi<br>Anna Univ. | Phase stability of $Ti_2ZrAl$ by first principles calculation |
| 30-10-2002 | Girish S. Setlur<br>IMSc | Density phase transformation of Bose fields : applications to gauge theory |
| 5-11-2002 | S. Anantharamakrishna<br>Imperial College, London | Sojourn times for quantum mechanical scattering |
| 6-11-2002 | G. Baskaran<br>IMSc | Carbon nanotubules |
| 11-11-2002 | Vijay Kodiyalam<br>IMSc | Complete invariants for complex semisimple Hopf algebras |
| 14-11-2002 | Rupert Yu<br>Universite de Poitiers, France | Some commuting Varieties |
| 18-11-2002 | Wolfgang Schmickler<br>Univ. of Ulm, Germany | Models and simulations for electrochemical nanotechnology |
| 19-11-2002 | Sonjoy Majumder<br>HRI, Allahabad | Accurate theoretical calculations of astrophysical atomic emission lines using quantum many body theory |
| 21-11-2002 | Gyan Prakash<br>IMSc | Cubic moment of Dirichlet L-function at s=1/2 |
| 22-11-2002 | Sumati Surya<br>Univ. of Alberta, Canada | Positive mass from holographic causality |
| 25-11-2002 | Martin Bojowald<br>Penn State Univ., U.S.A | Loop quantum cosmology |

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|---|---|---|
| 28-11-2002 | Vishvajit V. S. Gautam<br>IMSc | Turaev theorem for modular category revisited |
| 3-12-2002 | T. Chakraborty<br>IMSc | How to remove a Laughlin quasi-hole |
| 4-12-2002 | Rowena Ball<br>ANU, Canberra, Australia | Bifurcations and degenerate singularities in reduced models for fusion plasma dynamics |
| 11-12-2002 | V. S. Varadarajan<br>UCLA | Super-symmetry for mathematicians |
| 11-12-2002 | V. S. Varadarajan<br>UCLA | Super-symmetry for mathematicians |
| 12-12-2002 | Ivan Kausz<br>Universität Regensburg | On the factorisation rule for generalised theta functions |
| 12-12-2002 | Deepak Kumar<br>SPS, Jawaharlal Nehru Univ., Delhi | Peculiar metal-insulator transitions in semiconductors |
| 13-12-2002 | Deepak Kumar<br>SPS, Jawaharlal Nehru Univ., Delhi | Self-consistent theory of localization in films |
| 13-12-2002 | M. S. Raghunathan<br>TIFR | Atiyah-Singer index theorem |
| 16-12-2002 | Prashant Jaikumar<br>McGill Univ. | Superconducting quarks at high density and neutron stars |
| 17-12-2002 | Bruce Normand<br>Univ. of Fribourg, Switzerland | How to destroy a spin liquid: novel Effects from non-magnetic impurities |
| 18-12-2002 | A. Chainani<br>IPR, Ahmedabad | Electronic structure of $MgB_2$ and $ZrB_2$ |
| 19-12-2002 | Bruce Normand<br>Univ. of Fribourg, Switzerland | Field-induced magnetic quantum phase transitions: thermodynamic and dynamic properties of $TlCuCl_3$ |
| 19-12-2002 | Micheal Cowling<br>Univ. of New South Wales | Geometry of nilpotent groups |

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|---|---|---|
| 20-12-2002 | A. Bansil<br>Northwestern Univ., U.S.A | Some recent results concerning correlation effects in 3D quantum dots and photoemission from cuprates |
| 23-12-2002 | Manu Mathur<br>SNBNCBS, Kolkata | SU(N) coherent states |
| 23-12-2002 | Dennis Sullivan<br>CUNY, New York | String topology |
| 24-12-2002 | Ivo Sachs<br>Trinity College, Dublin | Quasinormal modes and linear response theory |
| 24-12-2002 | Dennis Sullivan<br>City Univ. NY, USA | String operators in topology |
| 26-12-2002 | N.G. Deshpande<br>Univ. of Oregon, U.S.A | Probing new physics with beauty mesons |
| 26-12-2002 | Dennis Sullivan<br>City Univ. NY, USA | String operators in topology |
| 26-12-2002 | V.P. Srinivasan<br>Univ. of California, Berkeley | Teraflop emulation platform |
| 27-12-2002 | G. Manoj<br>Virginia Polytechnic Inst., U.S.A | Diffusion-limited reactions on the cell surface |
| 27-12-2002 | Dennis Sullivan<br>City Univ. NY, USA | String operators in topology |
| 27-12-2002 | Debabrata Goswami<br>TIFR | Ultrafast pulse shaping for quantum information processing |
| 30-12-2002 | Prabodh Shukla<br>NEHU, Shillong | Surprising effect of small quenched disorder on magnetization reversal in a driven Ising model |
| 31-12-2002 | Debanand Sa<br>Max Plank Inst. for Complex Systems, Dresden, | Fermi surface topology and ferromagnetic superconductivity in UGe2 |
| 1-1-2003 | S. Krishnan<br>TIFR Mumbai | Eigen values and average distance in graphs |

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| 2-1-2003 | Dennis Sullivan<br>City Univ. NY | String operators in topology |
| 3-1-2003 | Dennis Sullivan<br>City Univ. of NY | String operators in topology |
| 6-1-2003 | Dennis Sullivan<br>City Univ. of NY | String operators in topology |
| 7-1-2003 | John Madore<br>Universite de Paris - Sud | Noncommutative geometry and physics |
| 8-1-2003 | Rama Bansil<br>Boston Univ., U.S.A | Why the stomach doesn't digest itself–a physicists answer |
| 9-1-2003 | Hotishi Yamamoto<br>Tohoku Univ., Japan | Future heavy flavor facilities |
| 9-1-2003 | Nilamani Mathur<br>Supercomputing center, Univ. of Kentucky | Strangeness content in the nucleon |
| 10-1-2003 | A. Baumgaertner<br>FORUM Modellierung (MOD), Forschungszentrum Juelich | Function of ion channels |
| 13-1-2003 | Magesh Nandagopal<br>Univ. of Connecticut, U.S.A | Relaxation in atomic glasses |
| 16-1-2003 | V.M. Dehant<br>Royal Observatory of Belgium | NEtlander Ionosphere and Geodesy Experiment : NEIGE |
| 17-1-2003 | Gerard 't Hooft<br>Spinoza Inst., Univ. of Utrecht | Determinism in quantum mechanics |
| 20-1-2003 | Pushan Majumdar<br>Max Planck Inst., Munich | Low lying spectrum of the hadronic string |
| 22-1-2003 | S.V.M. Satyanarayana<br>IGCAR, Kalpakkam | Mechanism of cell motility in crawling cells |
| 27-1-2003 | M.K. Parida<br>NEHU, Shillong | Bi-large neutrino mixings from renormalization group evolution |

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| 28-1-2003 | K. R. Parthasarathy<br>IMSc | Choosing balls from urns and commutation rules in quantum mechanics |
| 29-1-2003 | Sanjay<br>IoP, Bhubaneshwar | Aspects of gauge/string duality |
| 31-1-2003 | R. Sasaki<br>Yukawa Inst., Kyoto | CP(N) and complex Grassmannian sigma models |
| 31-1-2003 | Kavitha Ramanan<br>Lucent | Reflected diffusions and their applications |
| 3-2-2003 | R. Sasaki<br>Yukawa Inst., Kyoto | Integrable nonlinear dynamics: from classical to quantum many body field theory |
| 4-2-2003 | Mukund Balasubramanian<br>Boston Univ. | Functional architecture of primate visual cortex - how physics can influence the study of brain & behaviour |
| 4-2-2003 | Manindra Agrawal<br>IIT Kanpur | Primes is in P |
| 7-2-2003 | John Willinsky<br>UBC, Canada | Open journal systems |
| 10-2-2003 | M. S. Raghunathan<br>TIFR | Some personalities in the Indian mathematical scene of the 20th century |
| 11-2-2003 | Catalin Dima<br>ENSEIRB, Univ. of Bordeaux | Timed regular languages : A quest |
| 12-2-2003 | E Subramanian<br>Dept of Biophysics, Univ of Madras | Bioinformatics: Retrospect and prospects |
| 12-2-2003 | Carlos Castro<br>Clark Atlanta Univ., U.S.A | On the variable fine structure constant, strings and maximal acceleration phase space relativity |
| 14-2-2003 | Carlos Castro<br>Clark Atlanta Univ., U.S.A | Final steps towards a proof of the Riemann hypothesis |

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| 17-2-2003 | Nayantara Gupta<br>IACS, Kolkata | High energy neutrinos from gamma ray bursts |
| 18-2-2003 | T. Padmanabhan<br>IUCAA | Action principle for Gravity - a new thermodynamic perspective |
| 18-2-2003 | S. Sarala<br>IIT, Kanpur | Large scale alignment of optical polarization from quasars and pseudoscalar-photon mixing |
| 24-2-2003 | Dipankar Chakrabarti<br>SINP, Kolkata | (2+1)d QCD in similarity renormalisation approach |
| 24-2-2003 | B. Sury<br>ISI, Bangalore | Arithmetic groups |
| 27-2-2003 | V. Lakshmibai<br>Northeastern Univ., USA | Ubiquity of schubert varieties |
| 27-2-2003 | S. Ganesh<br>Univ. of Texas, Austin | Wave-packet dynamics in slowly perturbed crystals: Gradient corrections and Berry-phase effects |
| 28-2-2003 | B. Sury<br>ISI, Bangalore | Arithmetic groups |
| 3-3-2003 | Naresh Dadhich<br>IUCAA, Pune | Field of a gravitational dyon: The most general solution |
| 4-3-2003 | B. Sury<br>ISI, Bangalore | Arithmetic groups |
| 4-3-2003 | Sandip Bhattacharyya<br>IMSc | Duality and non-commutativity: String theoretic application |
| 7-3-2003 | B. Sury<br>ISI, Bangalore | Arithmetic groups |
| 10-3-2003 | E. Subramanian<br>Dept. of Biophysics, Madras Univ. | Bioinformatics: Retrospect and prospects (II) |
| 11-3-2003 | B. Sury<br>ISI, Bangalore | Arithmetic groups |

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| 13-3-2003 | B. Sury<br>ISI, Bangalore | Congruence subgroup problem |
| 14-3-2003 | B. Sury<br>ISI, Bangalore | Arithmetic groups |
| 14-3-2003 | Vishvajit V. S. Gautam<br>IMSc | Modular categories in TQFT |
| 17-3-2003 | Helmut Seidl<br>Univ. of Trier | Numerical document queries |
| 19-3-2003 | Pravabati Chingangbam<br>Jamia Millia Islamia, Delhi | Action in quantum mechanics |
| 20-3-2003 | M. G. Nadkarni<br>Univ. of Mumbai | Good subsets of n-fold cartesian product |
| 27-3-2003 | B.K. Chakrabarti<br>SINP, Kolkata | Gas models of traders' market : wealth distributions |
| 27-3-2003 | Kavita Jain<br>TIFR, Mumbai | Infinite cluster formation in non-equilibrium disordered systems |
| 28-3-2003 | Bornali Purkayastha<br>NEHU, Shillong | Intermediate breakings in SUSY SO(10) |
| 31-3-2003 | V. V. S. Gautam<br>IMSc | Modular categories and TQFT |
| 3-4-2003 | Thomas Schroeder<br>NORDITA, Denmark | A tunable, coarse-grained off-lattice protein model |
| 10-4-2003 | Parvati Shastri<br>Mumbai Univ. | Integral points on the unit circle |
| 11-4-2003 | P. Hislop<br>Univ. of Kentucky | Edge currents in quantum hall geometries |
| 16-4-2003 | T. C. Vijayaraghavan<br>IMSc | Derandomizing polynomial identity tests |
| 16-4-2003 | Somendra M. Bhattacharjee<br>IOP, Bhubaneswar | Unzipping DNA |

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| 17-4-2003 | Dutta Sreedhar<br>TIFR, Mumbai | Asymptotic distributions of<br>periodically driven stochastic systems |
| 24-4-2003 | A. Jensen<br>Univ. of Aalborg, Denmark | Nelson model with less than 2 photons |
| 29-4-2003 | Tribikram Gupta<br>HRI, Allahabad | Ultrasonic attentuation in d-wave<br>superconductors |
| 30-4-2003 | J. Maharana<br>IOP, Bhubaneswar | Symmetries of dilaton-axion string<br>cosmology |
| 6-5-2003 | Rahul Muthu<br>IMSc | Algorithmic aspects of lovasz local<br>lemma |
| 7-5-2003 | A. Mukherjee<br>ISI, Calcutta | Recent developments on the poincare<br>conjecture |
| 8-5-2003 | A. Narasimhan<br>IMSc | Jacobsthal sums over finite fields and<br>some applications |
| 8-5-2003 | K Narayan Kumar<br>CMI | Local LTL with past constants is<br>expressively complete for<br>Mazurkiewicz traces. |
| 16-5-2003 | Sharadha Ramanan<br>TCS, Chennai | Random graphs and Networks in<br>Bioinformatics |
| 20-5-2003 | Pijush Bhattacharjee<br>Indian Inst. of Astrophysics,<br>Bangalore | Ultrahigh energy cosmic rays: new<br>physics or extreme astrophysics? |
| 21-5-2003 | Madhav V. Ranganathan<br>Stanford Univ., U.S.A | Kinetic theory for density fluctuations<br>in one-component monoatomic fluids<br>at equilibrium |
| 21-5-2003 | R. Balasubramanian<br>IMSc | Number theoretic aspects of<br>cryptology |
| 22-5-2003 | S. Anbarasu<br>Anna Univ. | DNA computing |
| 27-5-2003 | Gautam I. Menon<br>IMSc | Seeing vortex glasses |

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| 28-5-2003 | Tomy Scaria<br>SNBNCBS, Kolkata | Abelian gauge transformations and Wigner's little group |
| 30-5-2003 | Gautam I. Menon<br>IMSc | Pattern formation in mixtures of molecular motors and microtubules |
| 3-6-2003 | N. Ganeshwar<br>IIT, Powai | Spectral approximation of integral operators |
| 4-6-2003 | Mohua Banerjee<br>IIT Kanpur | Algebras from rough sets |
| 4-6-2003 | P.M. Gade<br>IMSc | Physicists in finance |
| 1-7-2003 | N. Gurappa<br>IMSc | New technique to solve linear differential equations with an application to Calogero-Sutherland models |
| 8-7-2003 | Rahul Siddharthan<br>Rockefeller/IMSc | DNA, gene regulation, development and evolution: A beginner's introduction (Talk 1) |
| 10-7-2003 | Rahul Siddharthan<br>Rockefeller/IMSc | DNA, gene regulation, development and evolution: A beginner's introduction (Talk 2) |
| 11-7-2003 | Rahul Siddharthan<br>Rockefeller/IMSc | DNA, gene regulation, development and evolution: A beginner's introduction (Talk 3) |
| 11-7-2003 | L. Sunil Chandran<br>MPI for Informatik, Germany | Girth and treewidth |
| 17-7-2003 | Jaikumar Radhakrishnan<br>TIFR Mumbai | Bounded round quantum communication complexity of set disjointness |
| 23-7-2003 | Santosh Vempala<br>MIT, USA | How to compute the volume? |
| 23-7-2003 | Tabish Qureshi<br>Jamia Milia Univ., Delhi | Popper's experiment and nonlocality in quantum mechanics |

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| 25-7-2003 | Girish Setlur<br>IMSc | Unified theory of landau fermi liquids, luttinger liquids and wigner crystals |
| 28-7-2003 | M. Muthukumar<br>Univ. of Massachusetts, Amherst | Soups of coulomb strings: DNA solutions |
| 29-7-2003 | Prasannaa Thati<br>Univ. of Illinois,<br>Urbana-Champaign | Verification of asynchronous systems with unbounded and unordered message buffers |
| 30-7-2003 | M. Muthukumar<br>Univ. of Massachusetts, Amherst | Charge regularization and DNA condensation |
| 31-7-2003 | Ashvin Vishwanath<br>MIT, U.S.A | Luttinger theorem from momentum counting: analogues for superfluids and fractionalized phases |
| 31-7-2003 | Madhavan Mukund<br>CMI | Netcharts: bridging the gap between HMSCs and executable specifications |

# Chapter 5

# External Interactions

## 5.1 Collaborative Projects with Other Institutions

### 5.1.1 Analytic and Combinatorial Number Theory

The principal Collaborators for this project are Prof. R. Balasubramanian of IMSc and Prof. Goutami Bhowmik, Laboratoire d' Arithmetique, Universite des Sciences et Technologies de Lille (France). This project is funded by the Indo-French Centre for the Promotion of Advanced Research (IFCPAR), Delhi.

It is proposed to study some problems in combinatorial and analytic number theory. The study will be in two parts. The first part shall consist of the study of error terms of classical and more recent arithmetical functions in particular classes of divisor functions. The second part shall be devoted to Ramsey type questions in combinatorial number theory.

### 5.1.2 Automata and concurrency: Syntactic methods for verification

K. Lodaya visited LaBRI, Université Bordeaux-1, during Sep-Oct 2002. M. Mukund and K. Narayan Kumar visited Ecole Normale Supèrieure (Cachan), LaBRI (Bordeaux) and LIAFA (Paris) during May-Jun 2003.

From the French side, P. Gastin (LIAFA, Paris), A. Petit (ENS Cachan) and P. Weil (LaBRI, Bordeaux) visited IMSc during Jan-Feb 2003. They participated in the 2nd Workshop on Automata, Concurrency and Logic held by IMSc, 27–29 Jan 2003.

### 5.1.3 CD-ROMs Project on the Life and Work of Srinivasa Ramanujan

This is a joint project between the IMSc and the National Multimedia Resource Center of C-DAC, Pune, funded by the Department of Science and Technology, Governemnt of India. The object is to bring out two (or more) CD-ROMs on the life and works of Srinivasa

Ramanujan. Prof. K. Srinivasa Rao is the domain expert / content provider for this project. A web site is also to be created on Srinivasa Ramanujan as a part of this project.

### 5.1.4 India-based Neutrino Observatory (INO)

The feasibility study for India-based Neutrino Observatory (INO) is in full swing after a Memorandum of Understanding (MOU) was signed in September, 2002 leading to the formation of a National Neutrino Collaboration Group. The members from IMSc in INO are involved in (a) simulation studies for the large Iron-Calorimeter (ICAL) detector, (b) site survey for locating INO and (c) awareness campaign in order to generate human resources necessary for such a large project.

(a) In the area of simulations the group has installed a Neutrino Event Generator program–NUANCE. This is a general purpose program developed at UC-Irvine and has now been successfully adapted with suitable modifications for the ICAL detector to generate events from atmospheric neutrinos (the main programme of ICAL). The group is now engaged in extending the event generator program to cover other interesting neutrino sources from neutrino factories (long-baseline) and Ultra-High Energy Neutrino sources (UHE). Work is also in progress in the area of detector simulation using the CERN-based GEANT code as also in the area of track recognition and fitting.

(b) The site survey for locating INO at PUSHEP in Nilgiri mountains has now been completed. The full feasibility report including geotechnical report from the Geological Survey of India, Chennai is now available. It has been concluded that the PUSHEP site in Singara offers one of the best sites for locating INO, considering various critical factors such as (1) physics requirements, (2) geotechnical assessment and recommendation, (3) ease of access, (4) local scientific and industrial infrastructure, etc. Work is in progress to study the stress conditions at the cavern location and the access tunnel in order to facilitate laboratory cavern design.

(c) In the area of human resource development for INO, members of IMSc group continue to be engaged in giving series of lectures at various institutions to attract and train large number of scientists and also engineers. Being a large project, INO would require a huge number of scientists and engineers to conduct experiments.

More details may be found at the website http://www.imsc.res.in/~ino

The INO Group at IMSc includes: G. Dutta (from Feb–July 2003), D. Indumathi, H.S. Mani (from Jun 2003), M.V.N. Murthy, G. Rajasekaran and Abdul Salam (from Feb 2003).

### 5.1.5 Indo-UK project on Highly Efficient Data Structures

In this year, under this project, Venkatesh Raman visited University of Leicester from September 25th to October 7th, 2002. Rajeev Raman from Leicester University visited IMSc for three weeks in February 2003. The project ended in March 2003.

### 5.1.6 Metal-Insulator Transition in an Adsorbed Layer at an Electrochemical Interface

This DST-DAAD joint research project was completed in July 2003. A. K. Mishra (IMSc) and Prof. W. Schmickler (Univ. of Ulm, Germany) were the project members.

### 5.1.7 Novel Materials for applications in Molecular Electronics and Energy Storage Devices

In January 2002, the DRDO has sanctioned a project on Novel Materials for Applications in Molecular Electronics and Energy Storage Devices. The project team consists of A.K. Mishra (IMSc), Sheela Berchmans (CECRI), and V. Yeganaraman (CECRI). The project duration is for three years.

### 5.1.8 Spectral Theory of Schrödinger Operators

This is a project to do research on spectral theory of some random and deterministic Schrödinger operators. The project is funded by Deutsche Forschungsgemeinschaft (DFG), Germany and the Indian National Science Academy (INSA), India. The principal investigators from the German side are M Demuth, Technical University of Clausthal and W. Kirsch, Ruhr University, Bochum. The principal investigator from the Indian side is M. Krishna, IMSc. The project period is three years starting July, 2003.

### 5.1.9 Studies in Quantum Statistics

An Indo-US Collaboration project on Studies in Quantum Statistics, involving IMSc and University of Maryland (USA), has been approved. The project team consists of A.K. Mishra (IMSc) and Prof. O.W. Greenberg (Maryland Univ.). The project duration is for three years and it commences from May 2002.

## 5.2 Institute Associateships

The Institute has established short-term associateships in **Mathematics, Theoretical Physics and Theoretical Computer Science** to enable teachers from colleges and universities to work at the Institute. The programme is envisaged to develop interaction between the members of the faculty of the Institute and scientists in the university system. Under this programme, 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 (s)he is expected to visit the Institute at least twice during this period.

The Institute will bear the expenses of round-trip travel (by rail) from the Associate's normal place of work to Chennai and will also pay a daily allowance to cover local expenses at Chennai. During their stay at Chennai, Associates will be accommodated in the Institute Guest House.

Associates who visited the Institute during the period 01.08.02 to 31.07.03 are :

**Ranbir Chakraborti**
Dept. of Theoretical Physics, Univ. of Madras, Chennai
07.10.2002 to 22.10.2002; 16.12.2002 to 31.12.2002 and 17.04.2003 to 30.06.2003

**P. S. Joag**
Dept. of Physics, Univ. of Pune, Pune
08.06.2003 to 05.07.2003

**D.K. Choudhury**
Dept. of Physics, Guwahati Univ., Guwahati
22.06.2003 to 05.07.2003

**Mohua Banerjee**
Dept. of Mathematics, IIT, Kanpur
06.05.2003 to 07.06.2003

**C.S. Narayanamurthy**
M.S. Univ., Gujarat
15.05.2003 to 10.06.2003

**Neyaz Ahmad Sheik**
Dept. of Mathematics, R.E.C., Kashmir
05.01.2003 to 05.02.2003

**M.S. Datt**
Dept. of Mathematics, Univ. of Hyderabad, Hyderabad
05.05.2003 to 05.06.2003

**Santhosh George**
Govt. College of Arts, Science and Commerce, Sanquelim, Goa
03.05.2003 to 23.05.2003

**P. Paulraja**
Dept. of Mathematics, Annamalai Univ., Annamalainagar
02.05.2003 to 23.05.2003

**Parvati Shastri**
Dept. of Mathematics, Univ. of Mumbai, Mumbai
16.03.2003 to 14.04.2003

**M.K. Parida**
Dept. of Physics, North Easter Hill Univ., Shillong
15.01.2003 to 29.01.2003

**Devendra Kumar**
Dept. of Mathematics, D.S.M. Degree College, U.P.
14.12.2002 to 14.01.2003

**S.M. Hegde**
Dept. of Mathematics, NITK, Karnataka
16.12.2003 to 16.01.2003

**Prabodh Shukla**
Dept. of Physics, North Eastern Hill Univ. Shillong
14.12.2002 to 09.01.2003

**Swapan Mandal**
Dept. of Physics, Viswa-Bharati, Santiniketan
14.12.2002 to 13.01.2003

**S.K. Basu**
Banaras Hindu Univ., Varanasi
30.09.2002 to 15.10.2002

## 5.3 Conference Participation and Visits to Other Institutions

**Arvind, V.**

Visited University of Ulm during Oct 6 – Nov 14, 2002. Mainly did some collaborative research and gave two lectures.

Participated in *Dagstuhl Seminar on Algebraic Methods in Classical and Quantum Computation* held at Schloss Dagstuhl, Saarbruecken, Germany. during Oct 13 – Oct 18, 2002. Gave a talk there.

**Balakrishnan, Radha**

Participated in *National Conference on Recent Developments in Nonlinear Science* held at Indian Institute of Science, Bangalore during Aug 1 – Aug 2, 2002. Gave an invited talk titled "Differential geometry of evolving space curves and integrable equations: New links".

Visited Institute of Physics, Bhubaneswar during Aug 11 – Aug 14, 2002. Gave an invited colloquium titled "Geometry, integrability, and nonlinearity: Some applications in physics", and a special seminar titled "The Schrodinger equation as a moving curve".

Visited George Mason University, USA during Nov 1 – Nov 30, 2002 and Jul 7 – Jul 31, 2003 for research collaboration.

**Balasubramanian, R.**

Visited ACCESS, Coimbatore on Aug 6, 2002. Delivered Keynote address.

Attended the Cryptology Conference at ISI, Delhi during Sep 3 – Sep 5, 2002.

Attended the Cryptology Meeting at the Indian Statistical Institute, Delhi during Oct 3 – Oct 5, 2002.

Delivered a lecture on Cryptology at the Tamil Nadu Mathematical Society, Salem on Oct 19, 2002.

Visited Indian Institute of Technology, Kanpur during Dec 14 – Dec 16, 2002. Lectured on Sieve Methods.

Visited Kerala Mathematical Association, Kozhancherry, Kerala on Jan 9, 2003. Gave a lecture on Cryptology.

Visited Anjali Ammal Engineering College, Thiruvarur on Mar 17, 2003. Gave a lecture on Cryptology.

Visited Indian Institute of Science, Bangalore on Mar 28, 2003. Lectured on Cryptology.

Visited Amrita Institute of Technology & Science, Kollam Dist. on Apr 11, 2003. Gave a lecture on Cryptology at National Workshop on Information Security and Cryptography.

Visited Kishore Vaigyanik Protsahan Yojana, Bangalore on May 6, 2003. Gave a lecture on Prime Numbers.

Visited Indian Institute of Technology, Kanpur on Jun 3, 2003. Lectured on Cryptology.

Visited Bhabha Atomic Research Centre, Mumbai on Jun 14, 2003. Gave a lecture on Prime Numbers.

**Basu, Rahul**

Participated in the XV DAE Symposium during Nov 11 – Nov 15, 2002 and delivered a plenary talk.

Participated in QCD 2002 during Nov 18 – Nov 22, 2002 and gave a summary talk.

Visited HRI Allahabad during Nov 25 – Dec 1, 2002. Research Collaboration

Participated in *Linear Collider Workshop* held at TIFR, Mumbai during Jan 1 – Jan 2, 2003.

Participated in *PASCOS '03* held at TIFR. Mumbai during Jan 3 – Jan 11, 2003.

Participated in *Quark Gluon Plasma* held at VECC Kolkata during May 5 – May 7, 2003.

Participated in *Linear Collider Workshop* held at TIFR Mumbai during May 8 – May 10, 2003.

Visited LAPTH, Annecy, France during Jun 23 – Jul 25, 2003. Research Collaboration

**Das, Paramita**

Participated in *Lectures on Free Probability* held at Indian Statistical Institute, Bangalore during Feb 3 – Feb 15, 2003. Gave a talk titled "Pictorial proof of the Ocneanu-Szymanski theorem"

**Date, G.**

Participated in *National Workshop on Astronomy and Astrophysics* held at St Marthoma College, Tiruvalla, Kerala during Oct 7 – Oct 9, 2002. Gave three lectures on General Relativity

Participated in *Workshop on Quantum Gravity* held at Raman Research Institute, Bangalore during Nov 28 – Dec 9, 2002. Presented a seminar on "Discrete time presentation of quantum dynamics".

Participated in *The XXII Conference of the IAGRG* held at IUCAA, Pune during Dec 11 – Dec 14, 2002. Presented an invited talk on "Discrete time presentation of quantum dynamics".

Participated in *SERC 2002 Preparatory School* held at IIT, Mumbai during Dec 16 – Dec 21, 2002. Gave a course of six lectures on "Introduction to general relativity and gravitation".

Participated in *Field Theoretic Aspects of Gravity-III* held at Cochin Univ. of Science and Technology, Cochin during Jan 23 – Jan 29, 2003. Gave a talk on "Discrete time presentation of quantum dynamics"

**Ezhuthachan, Bobby V. K.**

Participated in *workshop on string theory* held at Harish Chandra Research Institute,Allahabad ,India during Dec 11 – Dec 21, 2002.

**Ghosh, Shamindra K.**

Participated in *ICM 2002 Satellite Conference on Operator Algebras and Applications* held at Chengde, Hebei Province, China during Aug 14 – Aug 18, 2002.

Participated in *ICM 2002* held at Beijing, China during Aug 20 – Aug 28, 2002.

Participated in *Lectures on Free Probability* held at Indian Statistical Institute, Bangalore during Feb 3 – Feb 15, 2003.

**Harikumar., E.**

Participated in *QCD 2002* held at Indian Institute of Technology, Kanpur. during Nov 18 – Nov 22, 2002.

Participated in *Non Commutative Geometry and Quantum Field Theory* held at IMSc, Taramani during Jan 10 – Jan 15, 2003.

Visited School of Physics, University of Hyderbad, Hyderbad. during Feb 1 – Feb 9, 2003. TPSC Visit

Visited Centre for Theoretical Studies,Indian Institute of Science, Bangalore. during Mar 24 – Mar 26, 2003. Seminar

**Hossain, Golam Mortuza**

Participated in *Loop Quantum Gravity Workshop* held at Raman Research Institute, Bangalore, India during Nov 28 – Dec 9, 2002.

**Indumathi, D.**

Visited U. Cal., Irvine and Riverside, U.S.A. during Dec 10 – Dec 19, 2002. Interaction with D. Casper on INO/Nuance related work; interaction with E. Ma on neutrino decay; gave a talk.

Participated in *NUINT'02* held at U. California, Irvine during Dec 10 – Dec 14, 2002.

Participated in *INO Update meeting* held at SINP, Kolkata during Apr 1 – Apr 3, 2003.

**Jagannathan, R.**

Participated in *Joint 28th ICFA Advanced Beam Dynamics and Advanced and Novel Accelerators Workshop on Quantum Aspects of Beam Physics and other Critical Issues of Beams in Physics and Astrophysics* held at Hiroshima University, Japan during Jan 7 – Jan 11, 2003. Gave an invited talk on "Quantum mechanics of electron beam transport through optical elements with Curved Axes"

Visited High Energy Accelerator Research Organization (KEK), Tsukuba, Japan during Jan 12 – Jan 16, 2003. Gave a seminar on "Quantum mechanics of accelerator optics"

Visited Chennai Mathematical Institute, Chennai during Jan 21 – Apr 30, 2003. Taught a course on "Physics" to the II Semester B.Sc.(Maths.) students

**Kesavan, S.**

Participated in *International Conference on Nonlinear Partial Differential Equations - Theory and Approximation* held at City University of Hong Kong, Hong Kong. during Aug 29 – Sep 2, 2002. Delivered an invited talk.

Visited Département de Mathematiques, Université de Metz, Metz, France. during Oct 1, 2002 – Jan 31, 2003. Visiting Professor. Gave two lecture courses - Numerical analysis and Nonlinear Functional Analysis. Gave a seminar talk.

Visited Université Paul Sabatier, Toulouse, France. during Nov 4 – Nov 8, 2002. Delivered three lectures which were video recorded for inclusion in the module "Control and homogenization" of the Indo-French Cyber University Project (FICUS).

Visited Centre de Mathématiques Elie Cartan, Université de Nancy I, Nancy, France. on Jan 15, 2003. Delivered a seminar talk.

Visited University of Westminster, London, UK. during Feb 1 – Feb 28, 2003. Visit under the INSA - Royal Society Exchange Programme.

Participated in *Tenth ramanujan Symposium on Wavelet Analysis* held at Ramanujan Institute for Advanced Study in Mathematics, University of Madras, Chennai. during Mar 19 – Mar 21, 2003. Delivered an invited talk.

**Kodiyalam, Vijay**

Participated in *International Congress of Mathematicians* held at Beijing, China during Aug 20 – Aug 28, 2002.

Participated in *Discussion meeting in harmonic analysis* held at I.M.Sc. during Dec 30, 2002 – Jan 1, 2003. Delivered a talk on "Representation models for symmetric groups"

Visited Indian Statistical Institute, Bangalore during Feb 3 – Feb 14, 2003. Attended a series of lectures on "Free probablity" given by Prof. Phillipe Biane and delivered a talk on "The generalised Procesi-Razmyslov theorem"

Visited University of Hyderabad during Feb 28 – Mar 1, 2003. Delivered a talk on "An application of classical invariant theory to distinguishing algebraic objects"

**Krishna, M.**

Participated in *Harmonic Analysis* held at Institute of Mathematical Sciences during Dec 30, 2002 – Jan 1, 2003.

Visited Ruhr University Bochum, Germany during Jul 1 – Jul 5, 2003.

Visited Technicla University of Clausthal during Jul 6 – Jul 15, 2003. Gave a talk on "New criteria to identify spectrum"

**Kurur, Piyush P.**

Participated in *FSTTCS 2003* held at Indian Institute of Technology, Kanpur during Dec 10 – Dec 16, 2002.

**Lodaya, Kamal**

Participated in *Workshop on Theoretical Computer Science* held at University of Colombo during Jul 29 – Aug 5, 2002. Gave 6 lectures on Computability.

Visited LaBRI, Université Bordeaux-1 during Sep 16 – Oct 8, 2002.

Participated in *Workshop on Logic, Graph Transformations and Discrete Structures* held at Universitat Politècnica de Catalunya, Barcelona during Oct 11 – Oct 12, 2002. Gave an invited talk on "A definition of fusion for posets".

Participated in *Workshop on Modal logic and applications* held at Calcutta Logic Circle, University of Calcutta during Oct 28 – Oct 31, 2002. Gave 4 lectures on modal logic.

Participated in *22nd FSTTCS Conference* held at IIT Kanpur during Dec 11 – Dec 13, 2002.

Visited School of Computer Science, University of Birmingham during May 26 – Jun 27, 2003. Gave a seminar and a course of lectures on "Models and logics for concurrency."

Visited School of Computing Science, University of Newcastle on Jun 18, 2003. Gave a seminar on "A syntax for Petri nets."

**Mahajan, Meena B.**

Participated in *Workshop on automata theory* held at SSN College of Engineering, Chennai during Apr 21 – Apr 30, 2003. Gave a lecture on "Algorithms for automata"

Visited Rajalakshmi Engineering College, Chennai on Jul 18, 2003. Gave a talk titled "Algorithmic issues in sorting"

**Meenakshi, B.**

Participated in *International Summer School on "Models, algebras and logic of engineering software"* held at Marktoberdorf, Germany during Jul 30 – Aug 11, 2002.

Visited University of Reunion, Reunion islands, France during Oct 16 – Nov 11, 2002 for research work. Gave a talk titled "Reasoning about message-passing systems" on 25th October 2002.

Visited Department of Computer and Information Sciences, University of Pennsylvania, USA during Jan 6 – Jan 8, 2003. Gave a talk titled "Reasoning about layered message-passing systems".

Participated in *4th International Conference on Verification, Model Checking and Abstract Interpretation* held at New York, USA during Jan 9 – Jan 11, 2003. Presented a paper titled "Reasoning about layered message passing systems".

Visited SRI International, USA. on Jan 16, 2003. Gave a talk titled "Reasoning about layered message-passing systems".

Participated in *2nd Workshop and School on Automata, Concurrency and Logic* held at The Institute of Mathematical Sciences, Chennai during Jan 24 – Jan 29, 2003. Gave a talk titled "Reasoning about layered message-passing systems" at the workshop.

**Menon, Gautam I.**

Participated in *Robustness, Emergent Behaviour and Pattern Formation in Biological Systems* held at IMSc, Chennai during Dec 3 – Dec 5, 2002. Talk on "Physical robustness as an organizing principle". Was also joint organizer of this meeting (with Sudeshna Sinha)

Participated in *India and Abroad: A Conference on Condensed Matter Physics* held at S.N. Bose National Centre for Basic Sciences, Kolkata during Jan 3 – Jan 5, 2003. Member, Advisory Committee

Visited S.N. Bose National Centre for Basic Sciences, Kolkata during Jan 5 – Jan 8, 2003. Delivered a seminar on "Persistence with parallel dynamics"

Participated in *Protein Association and Aggregation* held at Tata Institute of Fundamental Research, Mumbai during Feb 22 – Feb 23, 2003. Invited talk on "Self-organization in motor-microtubule mixtures"

Participated in *Refresher Course in Computer Applications in Physics Research and Education* held at Madras University, Chennai during Feb 24 – Mar 12, 2003. Gave a series of lectures on "Monte Carlo simulations"

Visited Tata Institute of Fundamental Research, Mumbai during Mar 3 – Mar 9, 2003. Delivered a seminar on "Physical robustness as an organizing principle for biological systems"

Participated in *Unconventional Applications of Statistical Physics* held at Saha Institute of Nuclear Physics, Kolkata during Mar 20 – Mar 22, 2003. Invited talk on "Pattern formation in motor-microtubule mixtures"

Participated in *Statistical Mechanics of Threshold Activated Systems* held at IMSC. Chennai during Mar 24 – Mar 26, 2003. Chaired a session

Participated in *Interdisciplinary Aspects of Biological Systems* held at Indian Institute of Technology Madras, Chennai on Apr 25, 2003. Invited talk on "Pattern formation in motor-microtubule mixtures"

Visited Tata Institute of Fundamental Research. Mumbai during May 2 – May 6, 2003. Delivered a seminar on "Local structure in vortex glass phases"

Visited University of Fribourg, Fribourg, Switzerland during Jun 11 – Jun 15, 2003. Delivered a seminar on "Asters, spirals and vortices in a model for pattern formation in motor-microtubule mixtures"

Participated in *Systemes Fortement Correles: A Workshop on Strongly Correlated Systems* held at University of Geneva, Geneva, Switzerland on Jun 13, 2003. Invited talk on "Strong correlations in unusual (classical) contexts"

Visited University of Lausanne, Lausanne, Switzerland on Jun 16, 2003. Delivered a seminar on "Asters, spirals and vortices in a model for pattern formation in motor-microtubule mixtures"

Visited Paul Scherrer Institute, Villigen, Switzerland on Jun 17, 2003. Delivered a seminar on "Local structure in vortex glass phases"

Visited ETH, Zurich, Switzerland during Jun 18 – Jun 20, 2003. Delivered a seminar on "Local structure in vortex glass phases". Participated in collaborative research on the structure of pancake vortices near free surfaces.

Participated in *Ninth International Workshop on Vortex Matter and European Science Foundation Workshop on Vortex Dynamics* held at CNRS Centre, Oleron Island, France during Jun 23 – Jun 27, 2003. Invited presentation (talk + poster) on "Local Structure in vortex glass phases"

Visited University of Toulouse, Toulouse, France during Jun 28 – Jul 2, 2003. Delivered a seminar on "Pattern formation in motor-microtubule mixtures"

Visited University of St. Andrews, St. Andrews, Scotland during Jul 6 – Jul 9, 2003. Engaged in collaborative research with the St. Andrews group on the interpretation of muon-spin-rotation spectra in high-$T_c$ superconductors. Gave a seminar on "Local Structure in vortex glass phases"

**Mishra, Ashok K.**

Visited Chemistry Department, IIT Mumbai on Sep 14, 2002.

Participated in *Electrochemistry in Molecular and Microscopic Dimensions* held at Heinrich-Heine-Universtat, Dusseldorf, Germany during Sep 15 – Sep 20, 2002. Delivered an invited talk on "Metallization in an adsorbed layer and its effect on adsorbate mediated electron transfer process"

Visited Department of Electrochemistry, University of Ulm, Germany during Sep 21 – Oct 11, 2002. Visited Prof W. Schmickeler under a DST-DAAD joint project on "Metal-insulator transition in an adsorbate layer at an electrochemical interface".

Visited Hahn-Meitner Institute, Berlin, Germany on Oct 14, 2002. Held discussions on Femtosecond Spectroscopy

Visited Central Electrochemical Research Institute, Karaikudi during Nov 7 – Nov 11, 2002. This visit was under CSIR-CECRI Visiting Associateship Programme

Visited Department of Physics, University of Maryland, USA during Dec 20, 2002 – Jan 19, 2003, under a DST - NSF joint research project on 'Studies in Quantum Statistics'.

Visited Central Electrochemical Research Institute, Karaikudi during Mar 5 – Mar 8, 2003.

Visited Central Electrochemical Researh Institute, Karaikudi during Jul 20 – Jul 25, 2003. This visit is in connection with DRDO Research Project on 'Novel Materials for applications in Molecular Electronics and Energy Storage Devices'

**Mishra, Sounaka**

Participated in *22nd Foundations of Software Technology and Theoretical Computer Sc ience Conference* held at IIT Kanpur during Dec 12 – Dec 14, 2002. Presented the paper "On the Hardness of Approximating Minimum Monopoly Problems".

Participated in *R. C. Bose Centenary Symposium on Discrete Mathematics and its Applications* held at ISI Kolkata during Dec 20 – Dec 23, 2002. Presented the paper "Minimum Monopoly in Regular and Tree Graphs".

**Mitra, Indrajit**

Participated in *QCD2002* held at IIT, Kanpur during Nov 18 – Nov 22, 2002. Delivered a talk on "Half-monopoles in the Yang-Mills theory."

**Murthy, M.V.N.**

Visited Materials Science Laboratory, IGCAR, Kalpakkam on Oct 21, 2002. Colloquium: Neutrinos-Why detect them?

Visited TIFR on Jan 9, 2003. INO - Program Management Committee and Working group coordinators' discussion meeting.

Visited VECC-SINP during Mar 31 – Apr 2, 2003. INO-Collaboration meeting : Reported on the Site Survey results for INO.

Visited Department of Physics and Astronomy, Mcmaster University, Hamilton, Canada during May 2 – Jun 24, 2003. Research Collaboration: Many particle density of states of trapped bosons.

**Muthu, Rahul**

Participated in *Pre-Conference Workshop on Complexity and Parameters: Logic and Structure - FSTTCS 2002* held at IIT, Kanpur during Dec 10 – Dec 11, 2002. Participated.

Participated in *FSTTCS 2002* held at IIT,Kanpur during Dec 12 – Dec 14, 2002. Participated.

Participated in *Preparatory School and Workshop on Automata, Concurrency and Logic* held at IMSc, Chennai during Jan 24 – Jan 29, 2003. Participated.

**Nagaraj, D. S.**

Participated in *Computational Aspects of Algebraic Geometry* held at Harish-Chandra Research Institute, Allahabd during Jan 2 – Jan 11, 2003. Gave four invited lectures titled "sheaf cohomology in algebraic geometry"

Visited Harish-Chandra Research Institute, Allahabd during Jan 13 – Jan 24, 2003.

Visited Universite D'Artois. at Lens, France. during May 7 – Jun 6, 2003. Gave four lectures on "Characteristic classes". Visited University of Lille, at Lille, France and gave one seminar on Krull-Schmidt reduction theorem for Principal bundles"

Participated in *Mini-Workshop on Curves over finite fields.* held at University of Mumbai, Mumbai during Jul 21 – Jul 25, 2003. Gave two lectures titled "Curves and their function fields" and "Riemann-Roch theorem"

**Narayanan, Vasumathi K.**

Participated in *Automata, Logic and Concurrency workshop* held at IMSc, Chennai during Jan 24 – Jan 31, 2003.

Visited Prathyusha Engineering College, near Poonamalle, Chennai during Feb 15 – Feb 28, 2003. Visited this Institute affiliated to Anna University and gave a couple of guest lectures on "Computer architecure" to B.E students during week-ends.

**Paranjape, Kapil H.**

Participated in *Cryptology Conference* held at ISI, Delhi, New Delhi during Sep 3 – Sep 5, 2002. Gave an invited address on "How group schemes can be used in Cryptology".

Participated in *One Day Colloquium sponsored by Prof. Vaidyanathaswamy Mathematics Trust* held at The Ramanujan Institute for Advanced Study in Mathematics on Mar 27, 2003. Gave an invited address on "Categorical approach to the Foundations of Mathematics"

Participated in *Fifth National Meeting in Commutative Algebra and Algebraic Geometry (CAAG V)* held at Department of Mathematics, Indian Institute of Technology, Bombay during Apr 1 – Apr 5, 2003. Gave an invited address on "A finitistic definition for arithmetical schemes".

Visited CIMAT, Guanajuato, Mexico during Jun 12 – Jun 15, 2003. Discussions with colleagues.

Participated in *The Arithmetic, Geometry and Topology of Algebraic Cycles* held at UNAM, Morelia, Mexico during Jun 15 – Jul 4, 2003. Gave a course on "Explicit computations of and in Chow groups" in the Workshop component. Gave an invited talk on based on [**P**].

**Parthasarathy R.**

Visited Department of Physics, Simon Fraser University, Vancouver, Canada. during Sep 1 – Dec 30, 2002. Interacted with the high energy physics group on string theory.

Participated in *Fifth International Conference on Symmetry in Nonlinear Mathematical Physics.* held at National Academy of Sciences of Ukraine, Kiev. during Jun 23 – Jun 29, 2003. Invited talk on "Diagonal representation of density matrix using q-coherent states". Chaired a session in the conference.

**Raghavan, K. N.**

Participated in *Geometric Group Theory* held at IIT Guwahati during Dec 2 – Dec 21, 2002.

**Rajasekaran, G.**

Participated in *Neutrino Collaboration Meeting* held at Variable Energy Cyclotron Centre,Calcutta during Sep 9 – Sep 10, 2002.

Visited Indian Institute of Science,Bangalore on Sep 16, 2002. Presented a talk titled "SNO solves the solar neutrino problem".

Visited Raman Research Institute,Bangalore on Nov 14, 2002. Presented a talk on "Nobel Prize (2002) and Neutrino Physics"

Participated in *DAE-BRNS Symposium on Nuclear Physics* held at Manonmaniam Sundaranar University,Tirunelveli during Dec 26 – Dec 30, 2002. Gave a talk on "Recent developments in neutrino physics".

Participated in *International Conference on Particles,Strings and Cosmology (PASCOS)* held at TIFR,Bombay during Jan 3 – Jan 8, 2003.

Participated in *Workshop on Noncommutative Geometry and Quantum Field Theory* held at IMSc, Madras during Jan 9 – Jan 15, 2003. Gave a talk on "A new differential calculus on the noncommutative Manin space"

Participated in *SERC School on Plasma-based Particle Accelerators* held at Saha Institute of Nuclear Physics,Calcutta during Feb 3 – Feb 21, 2003. Gave a talk on "The future of high energy physics".

Participated in *22nd Meeting of the Astronomical Society of India* held at Thiruvananthapuram during Feb 13 – Feb 15, 2003. Presented a talk titled "Recent discoveries in neutrino physics".

Participated in *Neutrino Collaboration Meeting* held at Saha Institute of Nuclear Physics, Calcutta during Mar 31 – Apr 3, 2003. Gave a talk titled "Introduction to INO".

Participated in *Workshop on Neutrinos* held at Kavli Institute of Theoretical Physics, University of California,Santa Barbara,USA. during Apr 7 – May 9, 2003. Presented two papers titled "Dynamical breaking of electroweak symmetry" and "Unification of quark and neutrino mixings".

Visited University of California,Riverside,USA during May 12 – Jul 4, 2003. Pursued collaborative research with faculty at UCR and gave a talk on "Neutrino mixing and its unification with quark mixing".

Participated in *5th International Workshop on Neutrino Factories and Superbeams* held at Columbia University,New York during Jun 5 – Jun 11, 2003. Presented a talk titled "India-based Neutrino observatory and its role in long-base-line experiments"

**Rama, S. Kalyana**

Participated in *String Theory Workshop* held at Harish Chandra Research Institute, Allahabad during Dec 10 – Dec 30, 2002.

Participated in *Conference on Non commutative Geometry* held at Institute of Mathematical Sciences, Chennai during Jan 15 – Jan 22, 2003.

**Raman, Venkatesh**

Visited University of Leicester, U.K. during Sep 25 – Oct 7, 2002. Collobarated with Rajeev Raman and gave a talk on "Efficient fixed parameter tractable algorithms for undirected feedback vertex set".

Participated in *Workshop on Parameterized Complexity* held at IIT Kanpur, India during Dec 10 – Dec 11, 2002. Gave a talk on "Parameterized counting".

Participated in *22nd Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS)* held at IIT Kanpur, India during Dec 12 – Dec 14, 2002.

Visited St. Joseph's College, Tiruchi on Feb 28, 2003. Gave a three hour lecture on algorithms in the refresher course in Computer Science organized by Bharathidasan University.

Gave a talk on "Recent trends in data structures and algorithms" in the conference on recent trends in Computer Science.

Participated in *Dagstuhl Seminar on Fixed Parameter Algorithms* held at Schloss Dagstuhl, Germany during Jul 27 – Jul 31, 2003. Gave a talk on "Parameterized complexity of feedback set problems"

**Ramanujam, R.**

Participated in *Workshop on Theoretical Computer Science* for college and university teachers held at University of Colombo, Sri Lanka during Jul 31 – Aug 2, 2002. Gave a minicourse of 6 lectures on automata theory.

Visited Tata institute of fundamental research during Jan 2 – Jan 15, 2003. Lecture on "Knowledge based semantics of messages".

Participated in *International conference on game theory* held at Taj Hotel, Mumbai during Jan 5 – Jan 9, 2003.

Participated in *Workshop and preparatory school on automata, logic and concurrency* held at IMSc during Jan 24 – Jan 31, 2003. Lectures on linear time temporal logic.

Participated in *National Seminar on algorithms and artificial Systems* held at University of Madras, Chennai during Jan 30 – Feb 1, 2003. Automata for verification of control properties of systems.

Participated in *Workshop on automata theory* held at SSN College of Engineering, Chennnai during Apr 21 – Apr 30, 2003. Lecture on 'Automata theory for verification'.

Participated in *Workshop on network security* held at Madras Institute of Technology, Chennai during May 28 – May 30, 2003. Lecture on 'Analysis of security protocols'.

Participated in *Summer School on Networking to E-seva* held at SSN College of Engineering, Chennai during Jun 10 – Jun 30, 2003. Lecture on 'Foundations of network security'.

**Ray, Purusattam**

Visited The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy during Aug 1 – Sep 30, 2002. Gave a talk 'Persistence Under Synchronous Dynamics' on 19.9.2002.

Participated in *School on 'Statistical Physics, Probability Theory and Computattional Complexity'* held at The Abdus Salam International Center for Theoretical Physics, Trieste, Italy. during Aug 26 – Sep 7, 2002.

Participated in *Refresher Course on Computer Applications in Physics Education and Research* held at University of Madras, Chennai during Mar 3 – Mar 5, 2003. Gave lectures on 'Molecular Dynamics Simulation'

Participated in *International Conference on Unconventional Applications of Statistical Physics* held at Saha Institute of Nuclear Physics, Kolkata during Mar 20 – Mar 22, 2003. Invited talk on 'Persistence in Non-equilibrium Systems'

**Roy, Ratnadeep**

Participated in *Discussion meeting on threshold activated systems* held at IMSc during Mar 24 – Mar 26, 2003.

Participated in *Fifth SERC School on The Physics of Disordered systems* held at IMSc during Apr 1 – Apr 21, 2003.

**Sankaran, P.**

Visited Pondicherry University, Pondicherry, during Nov 11 – Nov 13, 2002. Gave six lectures on "Complete metric spaces" in the Refresher course on Topology and Analysis.

Participated in *International Conference on geometric group theory* held at IIT, Guwahati during Dec 16 – Dec 21, 2002. Gave an invited talk on "Automorphisms and quasi-isomorphisms of finitely generated groups."

Participated in *Institutional and Instructional Programme on Discrete Mathematics* held at Ramanujan Institute for Advanced Studies in Mathematics, University of Madras, Chennai during Feb 3 – Feb 15, 2003. Gave two lectures on Expanding graphs and Kazhdan groups.

Visited Department of Mathematics and Statistics, University of Calgary, Calgary, Canada. during May 2 – Jul 31, 2003. Gave a talk on "Topology of toric varieties" in the Non-commutative Geometry Seminar, on 10th June, 2003.

Participated in *Canadian Mathematical Society- Summer Meet* held at University of Alberta, Edmonton, Canada, during Jun 14 – Jun 16, 2003. Gave a talk on "A coincidence theorem for holomorphic maps G/P."

Visited University of British Columbia, Vancouver, Canada during Jul 7 – Jul 9, 2003. Gave a seminar talk on "Cohomology of toric bundles."

Visited University of Toronto, Mississauga, Ontario, Canada during Jul 28 – Jul 31, 2003. Gave a talk on "A coincidence theorem for holomorphic maps to G/P" on 29th July 2003. Gave a talk on "Cohomology of toric bundles" at the University of Toronto, Toronto, on 31st July, 2003.

**Sankararaman, Sumithra**

Participated in *Workshop on Robustness, Emergent Behaviour and Pattern Formation in Biological Syatems* held at The Institute of Mathematical Sciences, Chennai during Dec 1 – Dec 3, 2002.

Visited Department of Physics, University of Illinois, Chicago during Feb 22 – Feb 28, 2003. Gave a talk on Self-organization in Mixtures of Motors and Microtubules.

**Sarma, Jayalal**

Participated in *Pre-Conference Workshop on Complexity and Parameters: Logic and Structure - FSTTCS 2002* held at Indian Institute of Technology Kanpur, INDIA during Dec 10 – Dec 11, 2002.

Participated in *22nd Conference on Foundations Of Software Technology and Theoretical Computer Science (FSTTCS 2002)* held at Indian Institute of Technology, Kanpur, India during Dec 12 – Dec 14, 2002.

Participated in *Post-Conference Workshop on Coding and Number Theory FSTTCS 2002* held at Indian Institute of Technology Kanpur, INDIA during Dec 15 – Dec 16, 2002.

Participated in *2nd Preparatory School and Workshop on Automata, Concurrency and Logic* held at The Institute of Mathematical Sciences, Chennai, India during Jan 24 – Jan 29, 2003.

**Sathiapalan, Balachandran**

Participated in *FTAG* held at Santhigiri Ashram, Kunchaattukara, Alwaye. during Jan 23 – Jan 29, 2003.

Visited ICTP,Trieste,Italy during Jun 13 – Jul 29, 2003. Research. Seminar on Loop Variables (22nd July)

**Sinha, Nita**

Participated in *Indian Linear Collider Working Group* held at TIFR, Mumbai during Jan 1 – Jan 2, 2003.

Participated in *IXth International Symposium on Particles, Strings and Cosmology (PASCOS'03)* held at TIFR, Mumbai during Jan 3 – Jan 8, 2003.

Participated in *Workshop on the CKM Unitarity Triangle* held at Institute for Particle Physics Phenomenology (IPPP), Durham, UK during Apr 5 – Apr 9, 2003. Gave an invited talk on "Determining weak phases using $B \to D^* V$ Decays".

Visited Theory Group, Stanford Linear Accelerator Center, Stanford University, USA during May 6 – May 13, 2003.

Participated in *Workshop on the Discovery Potential of an Asymmetric B Factory at* $10^{36}$ *Luminosity* held at Stanford Linear Accelerator Center, Stanford University, USA during May 8 – May 10, 2003. Invited talk on "Weak phase $\gamma$ using $B \to K\pi\pi$ modes".

Visited Institute of Theoretical Sciences, University of Oregon, USA during May 14 – May 21, 2003. Delivered the High Energy Physics Seminar, "Clean techniques to measure $\gamma$".

Visited Laboratoire Renẽ J.-A. Lẽvesque, Université de Montréal, Montréal, Canada during May 22 – Jun 3, 2003.

**Sinha, Rahul**

Participated in *Indian Linear Collider Working Group* held at TIFR, Mumbai during Jan 1 – Jan 2, 2003.

Participated in *IXth International Symposium on Particles, Strings and Cosmology (PASCOS'03)* held at TIFR, Mumbai during Jan 3 – Jan 8, 2003.

Participated in *Workshop on the CKM Unitarity Triangle* held at Institute for Particle Physics Phenomenology (IPPP), Durham, UK during Apr 5 – Apr 9, 2003. Delivered an invited talk , "Signals of new physics using angular analysis in $B \to V_1 V_2$ decays".

Visited Department of Theoretical Physics, University of Oxford, Oxford, U.K. during Apr 9 – Apr 10, 2003. Delivered a talk entitled "Extracting CP violating weak phases without hadronic uncertainity"

Visited Theory Group, Stanford Linear Accelerator Center, Stanford University, USA during May 4 – May 13, 2003. Visitor of Theory Group

Participated in *Workshop on the Discovery Potential of an Asymmetric B Factory at* $10^{36}$ *Luminosity* held at Stanford Linear Accelerator Center, Stanford University, USA during May 8 – May 10, 2003. Delivered an invited talk , "Signals of new physics using angular analysis in $B \to V_1 V_2$ decays".

Visited Institute of Theoretical Sciences, University of Oregon, USA during May 14 – May 21, 2003. Collaboration

Visited Laboratoire Renẽ J.-A. Lẽvesque,Université de Montréal, Montréal, Canada during May 22 – Jun 3, 2003. Collaboration

**Sinha, Sitabhra**

Visited Indian Institute of Science, Bangalore during Oct 30 – Nov 1, 2002.

Participated in *Robustness, Emergent Behaviour and Pattern Formation in Biological Systems* held at IMSc, Chennai during Dec 1 – Dec 3, 2002. Invited talk on "Assembling robust communities: Complexity and stability in growing networks"

Visited University of Madras, Department of Theoretical Physics, Chennai during Mar 10 – Mar 11, 2003. Two lectures on "Computer simulations in the physics of biological systems" as part of a UGC Refresher Course.

Participated in *International Conference on Unconventional Applications of Statistical Physics* held at Saha Institute of Nuclear Physics, Kolkata, India during Mar 20 – Mar 22, 2003. Invited talk on "Random iterated function systems and power law distribution of wealth in random asset exchange models"

**Sinha, Sudeshna**

Visited Biomedical Engineering Department, University of Florida, Gainesville during Sep 2 – Sep 17, 2002.

Participated in *Discussion Meeting on Statistical Mechanics of Threshold Activated Systems* held at IMSc, Chennai during Mar 24 – Mar 26, 2003. Invited Speaker

Visited Biomedical Engineering Department, University of Florida, Gainesville during May 21 – Jun 6, 2003. Delivered a talk in the Electrical and Computer Engineering Department.

Participated in *Workshop on Nonlinear Dynamics and Control* held at University of Florida during May 29 – May 30, 2003. Invited Speaker

**Srinivas, K.**

Participated in *International conference on special functions and their applications* held at IMSc during Sep 23 – Sep 27, 2002. Gave a talk with the title Selberg Class- a survey.

Participated in *National workshop on Cryptology* held at ISI, Delhi during Oct 3 – Oct 5, 2002.

Participated in *Indocrypt 2002* held at IDRBT, Hyderabad during Dec 14 – Dec 18, 2002.

Visited HRI, Allahabad during Feb 10 – Feb 19, 2003. Delivered a talk with the title "Recent developments in Selberg class".

Visited Institut de Mathematiques de Luminy, France during Apr 3 – Jun 30, 2003. visited as a CNRS research associate, initiated a project with Gilles Lachaud and Tsfasman.

Participated in *European school on Algebraic Geometry and Information Theory* held at CIRM, Luminy, France during May 12 – May 16, 2003.

Participated in *Conference on Arithmetic, Algebraic Geometry and Coding Theory* held at CIRM, Luminy, France during May 19 – May 23, 2003. Gave a talk with the title Distinct zeros in the Selberg Class.

Visited Department of Mathematics, University of Turku, Finland during May 24 – Jun 4, 2003. Gave a talk on "Distinct zeros of functions in the Selberg class" on 27th May, 2003, worked with Matti Jutila on some problems related to the zeros of the Epstein's zeta function.

Visited Department of Mathematics, University of Lille, Lille, France during Jun 19 – Jun 20, 2003. Delivered a talk on Selberg Class.

Visited University of Paris VI, Paris during Jun 21 – Jun 24, 2003. Delivered a talk on "Recent results in Selberg class"

Visited Department of Mathematics, University of Nancy, France during Jun 25 – Jun 26, 2003. Delivered a talk on Selberg Class.

Visited Department of Mathematics, University of Genova,Italy during Jul 4 – Jul 15, 2003. Delivered a talk on "Recent developments in Selberg class", discussed with Alberto Perelli on the zeros of functions of degree up to 2 in the Selberg class on the critical line.

Visited Department of Mathematics, University of Roma tre, Rome during Jul 16 – Jul 19, 2003. Discussed mathematics with Francesco Pappalardi.

**Srinivasa Rao, K.**

Visited George Sudarshan Center for Theoretical Physics and Computer Science, C.M.S. College, Kottayam, Kerala during Jul 31 – Aug 2, 2002. Gave three lectures on "Quantum computing: an introduction", "Hypergeometric functions" and "Life and work of Ramanujan".

Visited Velammal College of Engineering, Chennai on Aug 6, 2002. Lecture on the Life and Work of Srinivasa Ramanujan.

Visited National Multimedia Resource Centre, C-DAC, Pune during Aug 9 – Aug 11, 2002. Gave a two part lecture on the Life and work of Ramanujan and a lecture demonstration of MikTeX.

Visited Andhra University, Waltair during Aug 24 – Aug 25, 2002. "National Symposium on Nuclear Models", a two-day meeting in honour of Prof. D. Ratna Raju on the occasion of his 60th birthday. Gave an invited talk on "The 3n-j coefficients of angular momentum viewed from different sides".

Participated in *Workshop on Mathematica and the software packages Hyp and Hyp-q* held at The Institute of Mathematical Sciences, Chennai. during Sep 16 – Sep 20, 2002. Be-

sides convening and conducting this Workshop, was also a resource person for the afternoon practical sessions.

Participated in *International Conference on Special Functions and their Applications* held at The Institute of Mathematical Sciences, Chennai during Sep 23 – Sep 27, 2002. Besides convening and conducting the conference, chaired a session and gave an invited talk

Visited Flemish Royal Academy of Belgium for Science and the Arts, Brussels, Belgium during Sep 30 – Nov 15, 2002. Project on Creativity in Science, through the works of Ramanujan, S.N. Bose, S. Chandrasekhar and C.V. Raman. Research work was on the Notebooks of Ramanujan and in particular, a study of the work of Ramanujan on Hypergoemteric series.

Visited University of Antwerp, Belgium on Oct 29, 2002. Lecture on "Life and glimpses into the work of Srinivasa Ramanujan (1887 - 1920)."

Visited Gawahati University. during Nov 21 – Nov 24, 2002. To conduct the Ph.D. Viva-Voce examination (Nov. 22) of P. Rajkhowa on "Partition identities (Rogers-Ramanujan: new identites)". Delivered a lecture (Nov. 23) on the Life and Work of Ramanujan at at the Arya Vidya Peeth College, Guwahati.

Visited Karpagam Arts and Science College, Coimbatore. on Dec 18, 2002. Two part, three hours, lecture on the Life and work of Srinivasa Ramanujan.

Visited Sukritindra Oriental Research Institute, Kuthapady, Thammanam, Cochin, Kerala. during Dec 19 – Dec 22, 2002. Invited participant in the International Conference on the Heritage and history of Mathematical Sciences (ICHHMS 2002) and delivered a lecture on "Ramanujan's Notebooks: a national heritage".

Visited Vel-Tech Engineering College, Avadi, Chennai on Jan 9, 2003. Delivered the Key-note address in the National Conference on Industrial Mathematics.

Visited Karpagam College of Engineering, Coimbatore. on Jan 11, 2003. Lecture on the Life and Work of Srinivasa Ramanujan.

Visited Quaid-E-Millath Government College for Women, Chennai. on Jan 21, 2003. To deliver a lecture in their one-day Intercollegiate seminar on "Aesthetics and applications of mathematics".

Visited National Multimedia Resource Center of C-DAC, Pune. during Feb 5 – Feb 11, 2003. For the CD ROMs Project work on the Life and Work of Srinivasa Ramanujan, as the Principal Investigator and sole content provider. Also to present the work done so far in the project at a Project Programme Management Group (PPMG) meeting of the DST

Visited Flemish Royal Academy of Belgium for Science and the Arts, Brussels, Belgium. during Feb 15 – Jun 30, 2003. The second part of the Project on Creativity in Science.

Visited University of Brussels, Belgium. on May 8, 2003. To deliver a lecture on "Gauss, Ramanujan and hypergeometric series".

Visited Department of Mathematics, Cornell University, Ithaca, USA. during May 17 – May 20, 2003. Delivered a lecture on the Life and Work of Ramanujan on May 19.

Visited Department of Mathematics, State University of Delaware, Delaware, USA. on May 21, 2003. Delivered a lecture on the web site created for Srinivasa Ramanujan.

Visited Department of Mathematics, University of Delaware, Delaware, USA. on May 22, 2003. A power point presentation of the life and work of Srinivasa Ramanujan.

Visited University of Gent, Belgium. during Jun 27 – Jul 4, 2003. As Examiner for the Ph.D. Viva-Voce exam of Stijn Lievens and for discussions on problems of mutual interest.

Visited University of Brussels, Brussels. during Jul 7 – Jul 11, 2003. For discussions with Prof. C. Quesne on problems of mutual interest in q-series.

Participated in *Symmetries in Science - XIII* held at Kloster Mehrerau, Collegium Bernardi, Bregenz, Austria during Jul 20 – Jul 24, 2003. This conference was in honour of Professors Francesco Iachello, Akito Arima and Marcos Moshinsky. Gave an invited talk on *Group theoretical aspects of hypergeometric functions and Symmetries of Angular Momentum Coefficients* and chaired a session.

**Subramanian, C. R.**

Participated in *School on Statistical Physics, Probability Theory and Computational Complexity* held at The abdus salam International Centre for Theoretical Physics (ICTP) during Aug 26 – Sep 4, 2002.

Participated in *Conference on Typical-Case Complexity, Randomness and Analysis of Search Algorithms* held at The abdus salam International Centre for Theoretical Physics (ICTP). during Sep 5 – Sep 7, 2002.

Participated in *Workshop on Parameterized Complexity* held at Indian Institute of Technology, Kanpur during Dec 10 – Dec 11, 2002. Gave a talk on Faster FPT Algorithms for Undirected Feedback Vertex Set.

Participated in *22nd International Conference on Foundations of Software Technology and Theoretical Computer Science (FST&TCS-2001)* held at Indian Institute of Technology, Kanpur during Dec 12 – Dec 14, 2002.

Visited Tata Institute of Fundamental Research, Mumbai during Jul 21 – Jul 23, 2003. Gave two talks, one on "Tight upper bounds on list chromatic numbers", the other "On sampling colorings of bipartite graphs".

Visited Department of Mathematics, Cochin University of Science and Technology, Cochin. during Jul 30 – Jul 31, 2003. Gave a talk on "Probabilistic arguments in Combinatorics".

Participated in *Workshop on Graph Theory* held at Rajagiri School of Engineering and Technology, Cochin during Jul 30 – Jul 31, 2003. Gave three lectures on randomized algorithms for network reliability.

**Sunder, V. S.**

Participated in *Satellite Conference (to ICM) on Operator Algebras and Its Applications* held at Chengde, China during " Aug 13 – Aug 19, 2002. Gave a talk titled "On Jones' planar algebras".

Participated in *International Congress of Matheaticians* held at Beijing, China during Aug 20 – Aug 28, 2002.

Visited Cochin University of Science and Technology during Sep 27 – Sep 28, 2002. Delivered the Third Professor Wazir Hasan Abdi Memorial Lecture on *From von Neumann algebras to knot theory: the work of Vaughan Jones.*

Visited Indian Institute of Science, Bangalore on Oct 9, 2002. Lectured at the mathematics Colloquium, on "The Riesz representation theorem revisited".

Visited Indian Statistical Institute, Bangalore on Oct 11, 2002. Lectured at the Mathematics Colloquium on "The Riesz representation theorem revisited".

Visited Indian Statistical Institute, Bangalore during Feb 3 – Feb 14, 2003. To attend a series of lectures on "Free probability" given by Professor Philippe Biane.

Visited Madras Christian College during Feb 21 – Feb 22, 2003. To organise a seminar, and to give a lecture on "Operator algebras - the non-commutative world".

Participated in *Platinum Jubilee Workshop* held at Ramanujan Institute for Advanced Study in Mathematics, during Mar 17 – Mar 18, 2003. Gave a lecture titled "The Riesz theorem revisited".

Participated in *One Day Colloquium sponsored by the Prof. Vaidyanathaswamy Mathematics Trust* held at The Ramanujan Institute for Advanced Study in Mathematics on Mar 27, 2003. Gave a lecture titled "Complete family of numerical invariants for a subfactor".

Visited Indian Statistical Institute, Kolkata during Apr 29 – Apr 30, 2003. To attend a meeting of the Technical Advisory Committee and give a lecture (on "A complete family of numerical invariants for a subfactor").

**Suresh, S.P.**

Participated in *FOSAD'02 - 3rd International School on Foundations of Security Analysis and Design* held at University of Bologna Residential Center, Bertinoro, Italy during Sep 23 – Sep 27, 2002.

Visited Information Security Group, Instituto di Informatica e Telematica - IIT, Pisa, Italy during Sep 30 – Oct 4, 2002. Gave a talk titled "Decidability issues in security protocols".

Participated in *Workshop on Automata, Logic and Concurrency* held at Institute of Mathematical Sciences, Chennai during Jan 24 – Jan 31, 2003.

Participated in *WITS'03-Workshop on Issues in the Theory of Security,part of ETAPS'03* held at Warsaw, Poland during Apr 5 – Apr 6, 2003. Presented a paper titled "A decidable subclass of unbounded security protocols".

Visited IPI PAN - The Institute of Computer Science of the Polish Academy of Sciences on Apr 9, 2003. Gave a talk titled "Decidable subclasses of security protocols".

Participated in *AVIS'03-Workshop on Automated Verification of Infinite-State Systems, part of ETAPS'03* held at Warsaw, Poland on Apr 12, 2003. Presented a paper titled "An equivalence on terms for security protocols".

**Uma, V.**

Participated in *The Fifth National Meeting in Commutative Algebra and Algebraic Geometry. (CAAG V)* held at IIT Mumbai and the University of Mumbai. during Apr 1 – Apr 5, 2003. Gave a talk titled "Cohomology of toric bundles".

## 5.4 Visitors from Other Institutions

| Name | Affiliation | Period of Visit |
|---|---|---|
| Tucsnak Mauris | Univ. of Nancy, France | 01.08.02 – 04.08.02 |
| L. Sriramkumar | HRI, Allahabad | 05.08.02 – 09.08.02 |
| A.P. Balachandran | Syracuse Univ. | 03.08.02 – 09.08.02 |
| K.T. Arasu | Wright State Univ., U.S.A | 03.08.02 – 11.08.02 |
| Ramesh Hariharan | IISc, Bangalore | 16.08.02 |
| S. Srinivasa Rao | BRICS, Denmark | 09.08.02 – 18.08.02 |
| Subrata Bal | Kyoto Univ. | 08.08.02 – 20.08.02 |
| Ramesh Krishnamurti | Simon Fraser Univ., Canada | 29.05.02 – 26.08.02 |
| Manas Sardar | IGCAR, Kalpakkam | 22.08.02 – 23.08.02 |
| Sibasish Ghosh | ISI, Kolkata | 01.08.02 – 31.08.02 |
| Priti Shankar | IISc, Bangalore | 05.09.02 |
| Christopher Henley | Cornell Univ. | 05.09.02 – 08.09.02 |
| R. Parthasarathy | TIFR, Mumbai | 16.08.02 – 15.09.02 |
| Amitava Bhattacharya | TIFR, Mumbai | 26.04.02 – 26.05.02 |

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|---|---|---|
| S. Arunagiri | NTHU, Taiwan | 08.07.02 – 08.09.02 |
| C.V. Sukumar | Univ. of Oxford, England | 30.09.02 – 02.10.02 |
| Matthias Brack | Univ. of Regensburg, Germany | 15.09.02 – 11.10.02 |
| A.C. Naolekar | ISI, Kolkata | 02.09.02 – 13.09.02 |
| Mitaxi Mehta | H.R.I., Allahabad | 11.09.02 – 16.09.02 |
| C.M. Chandrashekar | Raman Research Inst., Bangalore | 20.09.02 – 24.09.02 |
| S.K. Karthick Kumar | American College, Madurai | 12.08.02 – 24.09.02 |
| Tarkeshwar Singh | Delhi College of Engg., Delhi | 04.04.02 – 02.10.02 |
| K. Ramachandra | NIAS, Bangalore | 27.09.02 |
| Nicholas Sabu | Univ. of Westminster, London | 15.07.02 – 15.10.02 |
| Supurna Sinha | Raman Research Inst., Bangalore | 08.10.02 – 11.10.02 |
| Prabal Maiti | Caltech, U.S.A. | 24.10.02 – 28.10.02 |
| S.D. Adhikari | HRI, Allahabad | 30.10.02 – 05.11.02 |
| Abbas Ali | Aligarh Muslim Univ., Aligarh | 01.11.02 – 06.11.02 |
| D.N. Verma | TIFR, Mumbai | 17.09.02 – 18.11.02 |
| Sumati Surya | Univ. of Alberta, Canada | 22.11.02 – 26.11.02 |

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|---|---|---|
| Martin Bojowald | The Pennsylvania State Univ., U.S.A. | 23.11.02 – 27.11.02 |
| Niraj Prasad | IIT, Kanpur | 30.07.02 – 02.12.02 |
| Bosco Emmanuel | Central Electrochemical Research Inst., Karaikudi | 25.11.02 – 29.11.02 |
| G.V. Ravindra | TIFR, Mumbai | 01.11.02 – 02.12.02 |
| Rowena Ball | Australian National Univ., Australia | 03.11.02 – 08.11.02 |
| Anirban Roy | ISI, Kolkata | 10.11.02 – 11.12.02 |
| Ivan Kausz | TIFR, Mumbai | 04.11.02 – 15.12.02 |
| Bruce Normand | Univ. de Fribourg, Switzerland | 09.12.02 – 26.12.02 |
| Ashish Chainani | Inst. for Plasma Research | 18.12.02 – 19.12.02 |
| Deepak Kumar | JNU, New Delhi | 12.12.02 – 15.12.02 |
| V. Muruganandam | Pondicherry Univ. | 18.12.02 – 20.12.02 |
| Michael Cowling | Univ. of New South Wales, Australia | 17.12.02 – 20.12.02 |
| A.M.M. Pruisken | Univ. of Amsterdam | 20.12.02 – 24.12.02 |
| S. Chaturvedi | Univ. of Hyderabad | 22.12.02 – 24.12.02 |
| N. Mukunda | IISc, Bangalore | 20.12.02 – 24.12.02 |

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| G.V. Ravindra | TIFR, Mumbai | 22.12.02 – 25.12.02 |
| Ivo Sachs | Univ. of Dublin, Ireland | 22.12.02 – 27.12.02 |
| N.G. Deshpande | Univ. of Oregon, Oregon | 26.12.02 – 31.12.02 |
| K.T. Arasu | Wright State Univ., U.S.A. | 24.12.02 – 26.12.02 |
| Michael Fellows | Univ. of New Castle, Australia | 15.12.02 – 02.01.03 |
| Indranil Biswas | TIFR, Mumbai | 23.12.02 – 31.12.02 |
| Manu Mathur | SNBNCBS, Calcutta | 03.12.02 – 27.12.02 |
| Debabrata Goswami | TIFR, Mumbai | 26.12.02 – 30.12.02 |
| Debanand Sa | Max Planck Inst. for Complex Systems, Germany | 31.12.02 – 04.01.03 |
| Kulkarni Ravi S. | HRI, Allahabad | 22.12.02 – 04.01.03 |
| Hitoshi Yamanoto | Tohoku Univ., Japan | 08.01.03 – 10.01.03 |
| Nilmani Mathur | Kansas Univ. Supercomputer Centre | 06.01.03 – 10.01.03 |
| Artur Baumgartner | Forum Modellierung, Germany | 08.01.03 – 13.01.03 |
| Patrick Aurenche | LAPP Annecy, France | 11.01.03 – 21.01.03 |
| Michel Fontannaz | LPTHE, Paris, France | 10.01.03 – 28.01.03 |
| Kamales Kar | Saha Inst. of Nuclear Physics, Kolkata | 13.01.03 – 24.01.03 |

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| Debasis Sarkar | Univ. of Calcutta, Kolkata | 05.01.03 – 25.01.03 |
| Pushan Majumdar | Max Planck Inst., Germany | 16.01.03 – 23.01.03 |
| G. 'T Hooft | Spinoza Inst., Netherlands | 16.01.03 – 18.01.03 |
| Guruprasad Kar | ISI, Kolkata | 05.01.03 – 29.01.03 |
| Sanjay | IoP, Bhubaneshwar | 28.01.03 – 31.01.03 |
| Teodor Knapik | Université de la Réunion | 04.01.03 – 04.02.03 |
| Pascal Weil | LaBRI, Université de Bordeaux-1 | 18.01.03 – 01.02.03 |
| Antoine Petit | LSV, ENS de Cachan | 18.01.03 – 01.02.03 |
| Jean-Michel Couvreur | LSV, ENS de Cachan | 19.01.03 – 02.02.03 |
| Patricia Bouyer | LSV, ENS de Cachan | 18.01.03 – 01.02.03 |
| Paul Gastin | LIAFA, Paris | 22.01.03 – 09.02.03 |
| Catalin Dima | LaBRI, Université de Bordeaux-1 | 05.02.03 – 15.02.03 |
| Deshouillers Jean-Marc | Université Victor Segalen Bordeaux, France | 05.02.03 – 13.02.03 |
| C.V.K. Baba | TIFR, Mumbai | 11.02.03 – 14.02.03 |
| M. Demuth | Univ. of Clausthal, Germany | 13.02.03 – 23.02.03 |
| S. Sarala | IIT, Kanpur | 17.02.03 – 19.02.03 |

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| T. Padmanabhan | IUCAA, Pune | 09.02.03 – 12.02.03 |
| Nayantara Gupta | Indian Association for the Cultivation of Science, Kolkata | 16.02.03 – 18.02.03 |
| Carlos Castro | Center for Theoretical Studies of Physical Systems | 10.02.03 – 25.02.03 |
| Ram Kishore | Aerospace Inst., Brazil | 17.02.03 – 02.03.03 |
| Bhagwandas | Indore Univ. | 08.02.03 – 08.03.03 |
| B. Sury | ISI, Bangalore | 17.02.03 – 14.03.03 |
| Tarun Kanti Ghosh | ICTP, Italy | 07.03.03 – 11.03.03 |
| Rossen Dandoloff | Universite de Cergy-Pontoise, France | 22.02.03 – 04.04.03 |
| Kavitha Jain | TIFR, Mumbai | 27.03.03 – 29.03.03 |
| S.D. Adhikari | HRI, Allahabad | 30.03.03 – 06.04.03 |
| Geetu Narang | Guru Nanak Dev Univ., Amritsar | 06.01.03 – 06.04.03 |
| Diptiman Sen | IISc, Bangalore | 04.04.03 |
| P.D. Hislop | Univ. of Kentucky, U.S.A | 04.04.03 – 14.04.03 |
| Maya P.N. | CUSAT, Cochin | 10.03.03 – 10.04.03 |
| P.M. Gade | BITS, Pilani | 16.01.03 – 10.04.03 |

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| Sreedhar Dutta | TIFR, Mumbai | 29.03.03 – 19.04.03 |
| S.M. Srivastava | ISI, Kolkata | 21.04.03 – 23.04.03 |
| Jensen | Univ. of Alborg, Denmark | 16.04.03 – 27.04.03 |
| Jnanadeva Maharana | IoP, Bhubaneshwar | 27.04.03 – 04.05.03 |
| Harvinder Kaur Jassal | IUCAA, Pune | 27.04.03 – 03.05.03 |
| Swapan Majhi | HRI, Allahabad | 24.04.03 – 05.05.03 |
| K. Gowri Navada | FMKMC College, Madikeri | 09.04.03 – 07.05.03 |
| Amiya Mukherjee | ISI, Kolkata | 14.03.03 – 11.05.03 |
| Ajay Patwardhan | St. Xavier's College, Mumbai | 11.05.03 – 25.05.03 |
| Suresh Vettoor | St. Dominics College, Kerala | 26.05.03 – 31.05.03 |
| S. Thangavelu | ISI, Kolkata | 25.05.03 – 27.05.03 |
| V. Ravindran | HRI, Allahabad | 26.05.03 – 30.05.03 |
| K.V. Vidyaranya | Tunga Mahavidyalaya, Karnataka | 15.05.03 – 13.06.03 |
| Shajahan T.K. | IISc, Bangalore | 15.05.03 – 30.06.03 |
| Stephen Baier | HRI, Allahabad | 20.06.03 – 05.07.03 |
| N. Narayanan | TIFR, Mumbai | 17.04.03 – 11.07.03 |

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|---|---|---|
| N. Mukunda | IISc, Bangalore | 04.07.03 – 05.07.03 |
| Sunil Chandran L. | Max-Planck Inst. for Informatik, Germany | 09.07.03 – 12.07.03 |
| Santhosh Vempala | M.I.T., U.S.A | 22.07.03 – 23.07.03 |

# Chapter 6

# Infrastructure

## 6.1 Computer Facilities

This year, two 16-node Xeon-based Linux Cluster systems were built. One is meant for heavy-duty number-crunching applications, while the other is a pilot cluster for the ILGTI project, built using the Wulfkit network interface. The necessary compilers have been installed on the clusters, and necessary benchmark studies have been carried out to fine-tune the performances for both the clusters.

The file server disk storage capacity has been enhanced further to provide more work space to users.

A few peripherals were added to the IMSc computing facility: a color laser printer capable of maximum printing size A3 was installed, and a new color scanner with provision for scanning slides and negatives was added.

## 6.2 The Library

The Institute Library holds a total collection of 49408 books and bound periodicals as on March 31, 2003. This includes an addition of 1639 volumes during the current year. The library subscribes to about 300 national and international journals in the subject areas of Theoretical Physics, Mathematics and Theoretical Computer Science including journals on exchange. The library has a well balanced collection on these subject areas and is a resource for research workers of the entire southern region.

The NBHM has recognized this Institute library as the Regional Library for Mathematics. There are about 4000 outside users from colleges, universities and research institutions from different parts of the country who made use of the library facilities for their academic and research information needs.

The library has access to over 1500+ online journals from major publishers such as Elsevier, American Mathematical Society, American Physical Society, Springer Verlag, World Scientific, Institute of Physics, etc.

Access to online journals is restricted to members of the Institute.

## Services

Apart from developing the collection, the library offers reprographic and inter library loan services. Using Libsys software, the library catalogue has been computerized and made available online to the readers both within and outside the Institute Campus. Online request for acquisition of books and status of borrowings have also been enabled using Libsys.

A new website has been launched to host all the electronic information resources and to provide information about the library and its services.

Library is a member of DAE Libraries Consortium that subscribes to SCIENCE DIRECT SERVICE of Elsevier.

Library is also coordinating the MathSciNet consortium which provides online access to MathSciNet for 8 participating institutions in the southern region.

Library is an institutional member of AMS, MALIBNET and IAPT.

## Acknowledgment

The Library gratefully acknowledges the donation of valuable books journals, and other reading materials received during the current year from the persons and organizations mentioned below:

NBHM
DOOR Programme

Mathematical Society of Japan

V. Arvind, IMSc
G. Baskaran, IMSc
R. Ramanujam, IMSc
T.C. Vijayaraghavan, IMSc

R. Balasubramanian, IMSc
Kamal Lodaya, IMSc
K. Srinivasa Rao

Anil Seth
K.R. Parthasarathy
N.R. Ranganathan

V. Kamakoti
R. Ramachandran

Samik Gupta
Stephen Lobo

Soundararajan

V. Krishnamurthy