HARISH-CHANDRA RESEARCH INSTITUTE

ACADEMIC REPORT

(2003 - 2004)

Chhatnag Road , Jhunsi , Allahabad - 211 019 ,
India

Contents

ABOUT THE INSTITUTE

The Early Years

Till 10th October 2000 the Institute was known as the Mehta Research Institute of Mathematics and Mathematical Physics (M.R.I). On 11.10.2000 it was renamed as Harish-Chandra Research Institute (H.R.I) after the mathematician, late Prof. Harish-Chandra.

The Institute started with the efforts of Dr. B. N. Prasad, a mathematician at the University of Allahabad, who obtained the initial support from the B. S. Mehta Trust, Calcutta. Dr. Prasad was succeeded in January 1966 by Dr. S. R. Sinha, also of Allahabad University. He was followed by Prof. P. L. Bhatnagar, who joined as the first formal Director. On Prof. Bhatnagar's demise in October 1976, the responsibilities were again taken up by Dr. Sinha. In January 1983, Prof. S. S. Shrikhande of Bombay University joined as the next Director of the Institute. During his tenure the dialogue with the Department of Atomic Energy (DAE) entered into the decisive stage and a review committee was constituted by the DAE for examining the future of the Institute. In 1985 the then Chief Minister of Uttar Pradesh, agreed to provide sufficient land for the Institute and the DAE promised financial support for meeting both the recurring and non-recurring expenditure. In January 1992, finally, about 66 acres of land was acquired in Jhusi, Allahabad.

Prof. Shrikhande was followed by Prof. H. S. Mani who took over as the Director in January 1992. With his joining and, the shift to the new campus at Jhusi in 1996, the activities of the Institute picked up quickly. This phase of rapid growth is still continuing.

The New Phase

After a distinguished tenure of about nine years Prof. Mani retired in August 2001 and the charge was taken over by Professor Ravi S. Kulkarni. The Institute continues to be devoted to fundamental research in various fields of Mathematics and Theoretical Physics and is a Fully Aided Institute, within the DAE family, Govt of India. Since the year 1992 it has achieved satisfactory progress, as is evident from the recognition received by many of its faculty members, both at the national and international levels. Amongst them, Prof. Ashoke Sen, Prof. D. Prasad and Dr. D. Choudhury merit special mention. Prof. Ashoke Sen was also honoured with the Padmashree Award in the year 2001.

The Institute has a residential campus in Jhusi, with a very well endowed research library, state of the art computational facilities and fast internet links to the outside world. There is an active Graduate Program and a large traffic of visiting scientists and students at the Institute. H.R.I is now considered a premier institute for research in fundamental physics and mathematics in the country.

DIRECTOR'S REPORT

Perhaps the best academic news since July 2003, is a number of faculty appointments in both Mathemacitcs and Physics. Dr.s C.S. Dalawat, Ratnakumar P.K., and N. Raghavendra joined in Mathematics. Dr.s Prasenjit Sen and T.P. pareekh joined in Physics. Moreover Dr.s Anindya Datta, S. Choubey, Asheshkrishna Datta, K. Sengupta and T.K. Das (Physics) have accepted our offers.

There are four Visiting Scientists: Dr.s Jayanthan, and Baier in Mathematics and Dr.s Supurna Sinha and Prof. J. Samuel in Physics. Moreover, Dr.s R. Sharma and M. Keshari will be coming as Post-doctoral Fellows (Mathematics) and Dr.s S.B. Datta has joined as PDF in Physics, Dr.s P. Mehta, Thampan, Thirupathi, and Kuzuyuki will be joining as PDFs in Physics.

In contrast to previous years, the Institute has made good progress in attracting research scholars. In Mathematics seven Research Scholars, and in Physics nine Research Scholars joined HRI this year. This has been partly possible because of the establishment of HRI-IGNOU Intergrated Doctoral Programme last year, which has allowed us to make offers to bright undergraduates, desirous of pursuing research careers in Mathematics and Physics.

Adjunct Distinguished Professorships were offered to Prof.s Indranil Biswas, A. Raichaudhury, S. Mukhi, D. Sen, T.V. Ramakrishnan and T. Padmanabhan.

The academic work of the Institute has continued in full swing. Among the honours received by our faculty a particular mention deserves to be made of the prestiguous S.S. Bhatnagar award to prof. Biswarup Mukhopadhyaya, D.Sc. (Hons) from Calcutta University to Prof. Ashoke Sen and a Life-time Service Award from INSA, New Delhi to Prof. I.B.S. Passi.

The Institute hosted the following major scientific meetings:

Setellite Conference on Commutative Algebra and Combinatorics:

A workshop on Computational Algebraic Geometry and the Conference on Commutative Algebra and Combinatorics was organised during 8th to 13th December 2003 in which about 60 scientists participated. The conference was organised in collaboration with the Bhaskaracharya Pratishthana, Pune.

Advanced Schoool on Physics on Galaxy Formation:

The Advanced School on Physics on Galaxy Formation attracted about 30 participants who attended the school during December 16-29, 2003.

Summer School on Gravitation and Cosmology:

The Institute organized a Summer School on Gravitation and Cosmology during May 10-21, 2004.

Visiting Students Summer Programme:

Institute conducted the VSS Promramme (Maths) during June 7-26, 2004.

The VSS Programme (Physics) was also conducted during the period and batches of students attended the same from time to time.

special School for High school and Intermediate students was organised by Dr. V.D. Singh during July 5-10, 2004.

Science Talent Search Examination:

HRI has always made special efforts to participate in the scientific life of Allahabad, and more generally in U.P. and India at all levels. "Talent Search Awards" in collaboration with the National Science Academy (Allahabad) is one of the major event. The Institute conducted the annual Science Talent Examination on 20th November 2003 for IX - XII standard students from schools and colleges in and around Allahabad in the subjects of Mathematics and Physics. About 450 students participated in the day long examination. The results have since been declared and the awardees have been given away the prizes.

NBHM Scholarship Test and Interviews:

The NBHM Scholarship Test and Interviews were held in November 2003 in which about 50 candidates appeared. The next NBHM test was conducted on June 26, 2004.

JEST: Physics - Test and interviews were held during May 24-25, 2004.
Mathematics - Test and interviews were held during 30-July 3, 2004.

HRI Colloquium Lectures:

a. Prof. Krishnaswamy Alladi, University of Florida, on 2nd January, 2004 spoke on A Theorem of Gollnitz and its place in the theory of partitions.

b. Prof. Norbert Schlomiuk, McGill University, Canada, on 14th January, 2004 spoke on Andre Weil remembered.

c. Prof. Victor Kac, MIT, USA, on 16th January, 2004 spoke on Freely Generated Vertex (=Chiral) Algebras. He also gave a lecture on 19th January, 2003 on Infinite Dimensional Lie Super Algebras and Standard Model.

d. Prof. Robert V. Moody, University of Alberta, Edmonton, Canada spoke on "Coherence and A periodic Order" on March 23rd, 2004.

e. Prof. S.M. Bhattacharjee, Institute of Physics, Bhubaneswar gave a lecture on "DNA Unzipping by Force" on April 16th, 2004.

Colloquium by Prof. K.W. Gruenberg:

Prof. K.W. Gruenberg from the Queen Marry West Field College, London visited the Institute in October, 2003 and gave a colloquium on the 23rd October 2003. The topic on which Prof. Gruenberg spoke was "Invariants of finite groups associated with free resolutions".

Visit by Prof. Shing-Tung Yau:

Prof. Shing-Tung Yau, (Fields Medal 1984), Harvard University, USA and Director, The Institute of Mathematical Sciences, The Chinese University of Hong Kong, Shatin, Hong Kong visited the Institute during 25th-28th January 2004. During his stay at the Institute he gave a popular lecture on Geometry, Its Charm and Applicatios on the 27th January. He also gave a scientific lecture on the 28th January on Positivity of Local Mass in General Relativity.

We discussed the possibilities of collaboration between DAE-Institute and the Chinese University of Hong Kong, China in the fields of Mathematics and Theoretical Physics.

Lectures by Prof.s J. Coats and Sujatha:

Prof.s J. Coates (University of Cambridge, UK) and R. Sujatha (TIFR, Mumbai) visited the Institute during March 22-April 2, 2004, and they delivered a series of lectures on "Iwasawa Algebras and Arithmetic".

Non-academic Activities:

Installation and Garlanding the Statue of Late Shri Giridharilal Mehta:

A major event was in the memory of a very special person to HRI, Shri Giridharilal Mehta- a function was organised on 26th Feb. 2004 for installatoin and garlanding the statue of Shri Mehta installed in the foyer of the Library building. The Institute owes its existence to the generous grant made by Shri Giridharilal Mehta in 1975. Shri Avnish Mehta was the Chief Guest of Honour. Shri Avnish Mehta, Prof. Ravi S. Kulkarni and Prof. Raghunathan paid tributes to Shri Giridharilal Mehta on this occasion.

The Director's address on the occasion is enclosed.

Painting Workshop on Tribal, Traditional and Flok Art styles:

A 10 days painting workshop was organised in collaboration with the North Central Zone Culture Center (NCZCC), Allahabad in September 2003 in which about 13 painters from different parts of the country participated. The paintings completed during the period of the workshop were shared between the Institute and the NCZCC.

Rajbhasha Programmes:

The Rajbhasha Day was celebrated on 18th 20 September 2003, in which about 35 children of the members of the Institute participated in the various evnents. A Kavi Goshthi was also organised in which some prominent poets from Allahabad took part.

A workshop on the constitutional provisions pertaining to the Rajbhasha was organised on 7th November 2003 in which Shri V.P. Tiwari, Junior Hindi Translator, gave a lecture.

The website of the Institute in Hindi was been developed and will soon be put on the net for the befefit of members and others alike. Under the auspices of the Rajbhasha Samiti a popular lecture was organised on 14th May 2004 in which Prof. Yoganand Sinha, Dept. of Psychology, University of Allahabad spoke on "Allahabad through a Rear View Mirror" covering certain interesting sites and events of Allahabad during the last century.

Popular talks:

Popular talks were delivered by Mr. Lalit Uniyal on 25th Nov. 2003 on Concepts Experiences in a National Building Endavour and Dr. Sarita Bajaj on 12th Feb. 2004 on Common Hormonal Problems.

Meeting of Registrars:

Meeting of the Registrars of DAE-Aided Institutions was held during April 15-16, 2004. Dr. T. Sahay, Registrar, TIFR gave a talk on Communication Skills on April 15th 2004.

HRI Welfare Trust:

A major development at HRI this year was the establishment of the HRI Welfare Trust. The idea was mooted as early as October 2001. Finally it has become a reality. The Trust registered in Allahabad, has a tax-exempt 80G status. Prof. Rajesh Gopakumar, Shri Sanjeev Kashalkar, and I signed the Trust Deed. Other people connected with this activity from its beginning include Prof.s Raj Gandhi, Sudhakar Panda, Ashoke Sen, and Shri Amit Roy. The idea is to create a corpus to help the lower level employees of the Institute in the educaiton of their children, or occasions of dire need, and to offer them annual gifts at festive occasions. The Trust may also be used to offer special prizes such as Best Thesis Awards, or Best Service Awards. In legal terms, the Trust has no link with HRI, but in social and psychological terms it has to do with all of us in the HRI family.

Help should be given to a needy person at the right time and place. It should be given without anticipation of return. Then it becomes a benign experience to the giver also (Geeta 17.20)

19.07.2004 **RAVI S. KULKARNI**
Encl.

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Governing Council

1.	Prof. M.S. Raghunathan (Chairman)	School of Mathematics Tata Institute of Fundamental Research Homi Bhabha Road Mumbai - 400 005
2.	Mr. S.L. Mehta (Vice Chairman)	4, Clive Row Kolkata - 700 001
3.	Mrs. Sudha Bhave (Member)	Joint Secretary (R& D) Govt. of India, DAE Chhatrapati Shivaji Maharaj Marg Mumbai - 400 001
4.	Mr. Rahul Asthana (Member)	Joint Secretary (F) Govt. of India, DAE Chhatrapati Shivaji Maharaj Marg Mumbai - 400 001
5.	Mr. Rama Kant Mishra (Member)	IAS (Retd.) 23/1E, P.C. Banerjee Road Allen Ganj Allahabad 211 002
6.	Mr. Avnish Mehta (Member)	4 Penn Road Kolkata - 700 027
7.	Prof. R. Balasubramanian (Member)	Director Institute of Mathematical Sciences CIT, Campus, Taramani Chennai - 600 113

8.	Dr. J.N. De (Member)	BH-135, Sector-III Salt Lake Kolkata - 700 091
9.	Prof. Narendra Kumar (Member)	Director Raman Research Institute C.V. Raman Avenue, Sadashivanagar Bangalore - 560 080
10.	Prof. H.S. Mani (Member)	Visiting Professor Institute of Mathematical Seiences CIT Campus, Taramani Chennai - 600113
11.	Mr. O.P. Srivastava (Member)	Director of Higher Education Uttar Pradesh Allahabad - 211 001
12.	Prof. Ravi S. Kulkarni (Ex-Officio Member)	Director Harish-Chandra Research Institute Allahabad - 211 019

ACADEMIC STAFF

Regular Members in Mathematics:

S. D. Adhikari
Punita Batra
Kalyan Chakraborty
Rukmini Dey
Ravi S. Kulkarni
D. Prasad (on lein)
B. Ramakrishnan
S. N. Rai
Maneesh Kr. L. Thakur
E. K. Narayanan
D. Surya Ramana
N. Raghvendra
R. Thangadurai

Visiting Professors in Mathematics:

Prof. I.B.S. Passi
Prof. S.D. Tripathi

Regular Members in Physics:

J.S. Bagla
D. Choudhury
D. Ghoshal
Raj Gandhi
Rajesh Gopakumar
Dileep Jatkar
B. Mukhopadhyaya
P. Majumdar
S. Naik
S. Panda
V. Ravindran
Ashoke Sen
Sumathi Rao
S. Goswami
L. Sriram Kumar
T.P. Pareek
Shiv K. Sethi

Visiting Professor in Physics:

Prof. R. Ramachandran

Visiting Fellow in Mathematics:

Dr. Manoj Kumar

Visiting Scientists in Mathematics:

C.S. Dalawat
Roman Mikhailov
Amora Nongkynrih

Visiting Fellows in Physics:

Alok Chandra Gupta
Agha Afsar Ali
H. Takata
Prasanta K. Das
Arta Sadarzadeh
Namit Mahahjan
Pravabati Chingangbam
K.P. Yogendran
S.G. Manickam
Somdatta Bhattacharya
Arnab Kr. Ray

Visiting Scientists in Physics:

Ashok Sethia (CSIR)
Girish Setlur

Ph.D. Students in Mathematics:

Shripad M. Garge
Sanoli Gun
Purusottam Rath
Anupam Kr. Singh
Siddhartha Sarkar
Krishnendu Gangopadhyaya
Brundaban Sahu
Girja Shankar Tripathi
Jitendra Kr. Bajpai
Mukund Madhav Mishra
Vikram Aithal
Supriya A. Pisolkar
Tanusree Pal
V.V. Awasthi

Ph.D. Students in Physics:

Sourin Das
Pomita Ghoshal
Sanjeev Kumar
P. Konar
S.K. Majhi

Chandrima Paul
Jayanti Prasad
S. Ray
S.K. Gupta
Suvankar Dutta
H.R. Srikanth
Kalpataru Pradhan
Arijit Saha
Nishikanta Khandai
Nabamita Banarjee
Anamitra Mukherjee
Rajeev Kr. Jain
Manoj Kr. Srivastava
Anurag Tripathi
Bindusar Sahoo
Ali Raza Tavanfar

ADMINISTRATIVE STAFF

Dr. S.N. Rai	Dean(Admin.)
Shri Sanjeev Kashalkar	Registrar
Shri Sanjaya Saran	Deputy Registrar
Shri Raaj Kumar Gulati	Accounts Officer
Shri V.R. Tiwari	Librarian
Shri Prabhat Kumar	Senior Private Secretary
Shri Amit Roy	Internal Audit cum Admn. Officer
Shri K.S. Shukla	Professional Assistant
Shri Jagannath Yadav	Accountant
Shri R.P. Sharma	Manager Guest House
Ms. Archana Tandon	Office Superintendent
Shri Deepak Srivastava	Store Purchase Officer
Shri V.P. Tiwari	Jr. Hindi Translator
Shri Uma Kant Dwivedi	Cashier
Shri D. Malhotra	UDC
Shri K.K. Srivastava	UDC
Shri Yashpal Singh	Steno
Mrs Sumitra	UDC
Shri Parmanand Mishra	Jr. Library Assistant
Shri Dharmpal Sharma	Jr. Library Assistant
Mrs Seema Agarwal	Receptionist
Shri Kashi Prasad	Driver
Shri Ram Dulare Maurya	Peon
Shri Dina Nath Dube	Peon
Shri Lalloo Ram	Night Watchman
Shri Kamlesh Thakur	Watchman
Shri Ramakant Dixit	Watchman/Peon
Shri Kamta Prasad	Watchman/Peon
Shri Rajesh Kumar	Sweeper
Shri Munna Lal	Gardener

Engineering/Technical Staff:

Shri K. Venkatraman	Sr. Consultant
Shri Manish Sharma	Scientific Officer 'C'
Shri R.N. Shukla	Scientific Officer 'D'
Shri Sanjai Verma	Systems Manager
Ms. Anju Verma	Scientific Asstt.
Shri Ajay Kumar Srivastava	Jr. Engineer (Electrical)
Shri V.K. Srivastava	Jr. Engineer (Civil)
Shri S.R. Joshi	Horticulturist
Shri Ajay Srivastava	Jr. Engineer (Electrical)

Medical Consultants:

Dr. G.S. Sinha	Authorised Medical Consultant
Dr. R.R. Saraswat	Emergency Medical Officer
Dr. Rakesh Verma	Emergency Medical Officer
Dr. S.D. Pandey	Emergency Medical Officer
Shri S.R. Gautam	Sr. Pharmacist
Shri S.P. Shrivastav	Compounder
Shri Alok Pandey	Compounder

ACADEMIC REPORT - MATHEMATICS

Sukumar Das Adhikari

Publications

Research Papers:

1. **Remarks on some zero-sum problems**
   (Jointly with Purusottam Rath)
   Expo. Math. 21, no. 2, 185 – 191 (2003).

2. **Monochromatic configurations for finite colourings of the plane**
   (Jointly with Purusottam Rath)
   Note di Matematica, to appear.

3. **Remarks on some zero-sum problems**
   (Jointly with Purusottam Rath)
   Expositiones Mathematicae, to appear.

Expository articles:

1. **Some questions regarding visibility of integer lattice points in** $\mathbb{R}^d$, Proceedings of the Session in analytic number theory and Diophantine equations (Bonn, January – June 2002) (Eds. D. R. Heath-Brown and B. Z. Moroz), Bonner Mathematische Schriften, **Nr. 360**.

Conferences/workshops/symposia attended:

1. Attended a Workshop on Commutative Algebra and Combinatorics held at University of Pune during 7–12 July, 2003.

2. Attended a conference in Number Theory held at the National Institute of Advanced Studies, IISc Campus, Bangalore, during the period December 13-15, 2003.

3. Attended the joint India-AMS Mathematics meeting at IISc Campus, Bangalore in December 2003.

Visits to other Institutes:

1. Visited Indian Statistical Institute, Bangalore Centre for the period June 16–20, 2003.

2. Visited Tata Institute of Fundamental Research for the period July 14 to August 11, 2003.

3. Visited University of Lille under IFCPAR project between HRI and University of Lille.

Lectures outside the Institute:

1. Gave a course on Algebra to the level II students at MTTS, Mysore during May 26 – June 14, 2003.

2. Gave a course of lectures in a Workshop on Commutative Algebra and Combinatorics held at University of Pune during 7–12 July, 2003.

3. Gave a course of lectures at the Interactive Training Camp for undergraduate and first year master's level students in Mathematics organised by Institute of Mathematics and Applications, Bhubaneswar in October 2003.

4. Gave Key-note address in the National Seminar on History, Heritage and Development of Mathematical Sciences held at Dr. Shyama Prasad Mukherjee Govn. Degree College, Allahabad during Oct 18-20, 2003.

5. Gave some talks in the 'International Workshop on Computational Algebraic Geometry' held at HRI during 8-13 Dec., 2003.

6. Gave a talk at the 'Conference in Number Theory' held at the National Institute of Advanced Studies, IISc Campus, Bangalore, during the period December 13-15, 2003.

7. Gave a talk at S.K. Malik Memorial Chandigarh Mathematics Colloquium held at Department of Mathematics, Panjab University, Chandigarh during March 12-13, 2004.

8. Gave a course of lectures in 'Groupe de travail d'analyse harmonique et théorie analytique de Lille' on certain aspects of Combinatorial Number Theory.

Other activities.

1. Was a member of the international and local organising committee of the 'International Conference on Commutative Algebra and Combinatorics and International Workshop on Computational Algebraic Geometry' held at HRI during 8-13 Dec., 2003, which was jointly organised by Bhaskaracharya Pratishthana, Pune and Harish-Chandra Research Institute, Allahabad.

2. Dr. Anirban Mukhopadhyay finished his Doctoral Dissertation under my supervision and received the provisional certificate for the same from Allahabad University. Currently he is a Post Doctoral Fellow at IMSc, Chennai.

3. Gave a one semester course on Topology to the first year Ph. D. students.

Research Projects.

Working on some questions in Combinatorics, Combinatorial Number Theory and Transcendental Number Theory.

Punita Batra

Research Summary:

In a joint work with Prof. Stephen Berman, I tried to find the generators and relations of Intersection matrix algebras of type $sl_3(R_{[2]})$, where $R_{[2]}$ is the $\mathbb{C}$-algebra of Laurent polynomials in the 2 non-commuting variables t_1, t_2. This work is still going on. For a definition of Intersection matrix algebras of type $sl_3(R_{[2]})$, one can see the paper "Lie Algebras graded by finite root systems and the intersection matrix algebras of Slodowy" by Berman and Moody, Inventiones Mathematicae, 108, 323-347(1992).

In another project with Prof. S. Eswara Rao, I tried to prove if g is a centerless Lie-n-tori of type B_n, then g is isogenous to twisted multi loop Lie algebra. I am trying to prove the similar results for centerless Lie-n-tori of type F_4 and G_2.

Publications

Representations of twisted multi-loop Lie algebras, Journal of Algebra, 272(404-416), 2004.

Preprints:

1) Integrable modules for the twisted affine Kac-moody Lie algebras, In Preparation.

2) (With S. Eswara Rao) Realization of Lie-n-tori of type B_n, F_4 and G_2, In Preparation.

Conference/Workshops Attended:

1) Workshop and Conference on Infinite Dimensional Lie Theory and its Applications, The Fields Institute, Toronto, July 17-25, 2003.

2) International Colloquium on "Algebraic Groups and Homogeneous Spaces, TIFR, Bombay, January 6-14, 2004.

Visits to other Institutes:

1) Visited University of Saskatoon, Canada from June 23 - July 13, 2003.

2) Visited The Fields Institute, Toronto, Canada from July 14 - July 24, 2004.

Invited Lectures/Seminars:

1) Representations of twisted multi loop Lie algebras in The Fields Institite, Toronto on July 21, 2003.

Other Activities:

1) Gave a series of five lectures on "Bilinear Forms and Lie Algebras" at HRI in VSSP programme in May 2003.

2) Gave two lectures on "Quadratic Inequalities" in Hindi in the Rajbhasha programme organised by Dr. V. Singh in May 2003.

3) Gave first year graduate course "Algebra" in Fall semester 2003.

4) Coordinator JEST(Mathematics) 2004 exam, at H. R. I.

Kalyan Chakraborty

Research Summary: I am interested in finding an upperbound on the number of quadratic nimber fields and function fields whose class group has an element of a given order. Recently in two joint works with A. Mukhopadhayay I have got results in this direction and the work is in progress to improve these bounds. I am interested in the L- functions associated to Hilbert modular forms and am studying their value at the point 1 when twisted by a character. I am also studying exponential sums over finite fields with Prof. S. Adhiakari.

Publications:
(1) Exponents of class groups of real quadratic function fields; to appear in Proc. of Amer. Math. Soc.

Preprints:
(1) Exponents of class groups of real quadratic function fields(II).
(2) On the divisibility of class numbers of real quadratic fields.

Conference/Workshops Attended:
Attended " Conference in Number theory", NIAS, B'lore, December 13–15, '03.

Visits to other Institutes:
(1) Visited University of Paris, VII, 27th April to 31st May, '04.
(2) Visited University Roma Tre, 1st June to 8th June, 04.

Invited Lectures/Seminars:
(1) Gave a 45 minutes talk at the "Number Theory Conference", NIAS, B'lore. (2) Gave a one hour talk at the Number Theory Seminar at University of Paris, VII.

Other Activities: Prepared a draft propopsal for the Golden Jubilee celebration of DAE and attended a meeting at BARC regarding this.

Shripad M. Garge

Research Summary:

I work on the arithmetic of linear algebraic groups. This involves understanding the structure of linear algebraic groups over certain special fields, like global fields, local fields and finite fields.

One of the questions that I studied in this year concerned with the structure of linear algebraic groups over finite fields. Let H be a semisimple linear algebraic group defined over a finite field $\mathbb{F}_q$. It is a theorem of Emil Artin and Tits et. al., that if H is a simple algebraic group, then it is determined (upto isomorphism) by the order of $H(\mathbb{F}_q)$, the $\mathbb{F}_q$ rational points of H, except in some cases which can be explicitly given. It is natural to study the situation for semisimple groups. The following theorems are proved in **[2]**.

Theorem 1 *Let H_1 and H_2 be two split semisimple simply connected algebraic groups defined over finite fields $\mathbb{F}_{q_1}$ and $\mathbb{F}_{q_2}$ respectively. Let X denote the set $\{8, 9, 2^r, p\}$, where $2^r + 1$ is a prime and p is a prime of the form $2^s \pm 1$. Suppose that, for $i = 1, 2$, A_1 is not one of the direct factors of H_i whenever $q_i \in X$ and B_2 is not a direct factor of H_i whenever $q_i = 3$. Then, if $|H_1(\mathbb{F}_{q_1})| = |H_2(\mathbb{F}_{q_2})|$, the characteristics of $\mathbb{F}_{q_1}$ and $\mathbb{F}_{q_2}$ are the same.*

Theorem 2 *Let H_1 and H_2 be two split semisimple simply connected algebraic groups defined over finite fields $\mathbb{F}_{q_1}$ and $\mathbb{F}_{q_2}$ of the same characteristic. Suppose that the order of the finite groups $H_1(\mathbb{F}_{q_1})$ and $H_2(\mathbb{F}_{q_2})$ are the same, then $q_1 = q_2$. Moreover the fundamental degrees (and the multiplicities) of the Weyl groups $W(H_1)$ and $W(H_2)$ are the same.*

Thus, the situation is reduced to understanding the groups H_1 and H_2 defined over a finite field $\mathbb{F}_q$ such that $|H_1(\mathbb{F}_q)| = |H_2(\mathbb{F}_q)|$. We put an equivalence structure on the set of pairs of groups of the same order defined over $\mathbb{F}_q$ given by $(H_1, H_2) \sim (H_1', H_2')$ if and only if there exist groups G, G' defined over the same field such that

$$H_1 \times G \xrightarrow{\sim} H_1' \times G' \quad \text{and} \quad H_2 \times G \xrightarrow{\sim} H_2' \times G'.$$

The set of equivalence classes then admits the structure of an abelian group in an obvious way. We give an explicit set of generators for this group. We also give a geometric reasoning for this coincidence of orders.

The other question that I studied in this year is about excellence of algebraic groups.

An algebraic group defined over a field k is said to be excellent if for any extension L/k, the anisotropic kernel of $G \otimes_k L$ is defined over k. This notion is a generalization of the notion of excellence in the theory of quadratic forms. The excellence properties of some groups of classical type have been studied so far. These properties are usually related with the arithmetic properties of the field k. However, the exceptional group of type G_2 is excellent over any field. We prove

that the group of type F_4 is also excellent over any field ([**3**]). The proof uses the theory of Albert algebras and the octonion algebras in detail.

Preprints:

1. Maximal tori determining the algebraic group (to appear in the Pacific Journal of Mathematics),
2. On the order of finite semisimple groups (submitted),
3. Excellence properties of F_4.

Conference/Workshops Attended:

1. International conference on Algebra and Number theory, Hyderabad (11–16 December, 2003).
2. A session for young researchers in commutative algebra and algebraic geometry, IISc, Bangalore (December 16, 2003).
3. Joint India-AMS mathematics meeting, IISc, Bangalore (17–20 December, 2003).
4. International colloquium on algebraic groups and homogeneous spaces, TIFR, Mumbai (6–14 January, 2004).
5. Conference and workshop on linear algebraic groups, quadratic forms and related topics, Eilat, Israel (1–5 February, 2004).

Visits to other Institutes:

1. Tata Institute of Fundamental Research (December 25, 2003 – January 25, 2004).
2. University of Tel Aviv, Israel (February 6–15, 2004).

Invited Lectures/Seminars:

1. *Maximal tori determining the algebraic group*, A session for young researchers in commutative algebra and algebraic geometry, IISc, Bangalore.
2. *Maximal tori determining the algebraic group*, Conference and workshop on linear algebraic groups, quadratic forms and related topics, Eilat, Israel.

Other Activities:

1. Two lectures on polyhedra and their symmetry groups in the VSSP 2003,
2. Two lectures in the basic notions seminar on 'the basic aspects of K-theory'.

Sanoli Gun

Research Summary:

(1) (with B. Ramakrishnan) : **Lacunarity of certain Dedekind η-Products.**
Short Summary: A formal power series $x^\nu \sum_{n=0}^{\infty} a(n)x^n$ is called *lacunary* if the arithmetic density of its non-zero coefficients is zero. Lacunarity of modular forms associated to Dedekind η-products is not just the pursuit of some exotic isolated theory. These have important connections with the theory of elliptic curves and modular forms. Just to cite an example, the lacunary form $\eta^2(4z)\eta^2(8z)$ is nothing but the inverse Mellin transform of the Hasse-Weil L-function of the elliptic curve $y^2 = x^3 - x$. This curve plays a pivotal role in Tunnell's work on the "Congruent Number Problem".

J. -P. Serre's result [*Glasgow Math. J.* **27**, 203–221] on all even powers of the Dedekind eta-function which are lacunary proves that the non-zero values of Ramanujan's Function $\tau(n)$ are of arithmetic density non-zero.

B. Gordon and S. Robins [*Glasgow Math. J.* **37**, 1–14] used Serre's method to classify all two eta products of the form $\eta^r(z)\eta^s(2z)$, where $r + s$ is even and $rs \neq 0$.

In this work, we classify all lacunary modular forms associated to the eta-products of the form $\eta^r(z)\eta^s(3z)$, where $r + s$ is even and $rs \neq 0$. As an application one gets identities for the coefficients of these lacunary modular forms.

(2) (with B. Ramakrishnan) : **On the representation of integers as sums of odd number of squares.**
Short Summary: A classical problem in number theory is to give an explicit formula for the number of ways one can represent a non-negative integer n as a sum of k squares, where k is a positive integer. The study of $r_k(n)$ has a long history. A general formula for $r_k(n)$, when k is even was stated by Ramanujan . It was proved by Mordell. It is also known that $r_k(n)$ can be expressed in terms of coefficients of Eisenstein series and cusp forms. For odd values of k a general formula is not known, though formulas for particular values of k are known. For example, the formulas for $r_k(n)$ or $r_k(n^2)$ are known for $k = 1, 3, 5, 7, 9, 11, 13$. These formulas were obtained either by an elementary method or by using the theory of modular forms. Using the Shimura Correspondence we obtain an explicit formula for $r_{2k+1}(n^2), n \geq 1$. As a consequence, we prove that the values at $1 - k$ of the Dirichlet L-functions twisted by the character χ_4 are rational and which can be written down explicitly using our formula. Here χ_4 is the trivial character or the non-trivial character modulo 4 depending on whether k is even or odd.

(3) (with Shaun Cooper, Michael D. Hirschhorn and B. Ramakrishnan) :
Multiplicative Relations for Certain Powers of Euler's Product.
Short Summary: Certain arithmetic relations for the coefficients in the expansions of $(q)_\infty^r$, $(q)_\infty^r(q^t)_\infty^s$, $t = 2, 3, 4$ were studied by M. Newman, S. Cooper, M. D. Hirschhorn, R. Lewis, S. Ahlgren and R.Chapman. In this work, we prove similar identities for certain multi-product expansions using an elementary method.

(4) (with B. Ramakrishnan, B. Sahu and R. Thangadurai) :
Distribution of Quadratic non-residues which are not primitive roots.
Short Summary: In this paper we study the distribution of quadratic non-residues which are not primitive roots modulo p^h or $2p^h$ where p is an odd prime and $h \geq 1$ is an integer using elementary and combinatorial methods.

Conferences attended :

1. Conference on "Number Theory" in the honour of Prof. K. Ramachandra on his 70th birthday held at NIAS, Bangalore from 13th Dec. – 15th Dec. 2003.
2. Joint India-AMS Mathematical Meeting, Bangalore, India from 17th Dec. –20th Dec. 2003.

Other activities:

Conducted tutorial session in the VSSP programme.

Ravi S. Kulkarni

Research Summary:

1) In the past few years I have been working on a general theory of dynamical types of transformations in classical geometries. This theory extends a part of Weyl's work on compact Lie groups to arbitrary actions. I reported the initial developments in earlier communications. Last year, I have worked out further details. A thesis by Rony Gouraige in City University of New York (who visited HRI in 2002-03) entitled "Conjugacy Classes of Centralizers in the Algebra of Endomorphisms of a finite-dimensional vector space over a central division algebra", is a good illustration of this theory. The whole work will appear in the form of some papers and a monograph.

2) Frenet's curvatures for curves with variable speed, and arithmetic aspects of curvatures functions in pseudo-Riemannian geometry (in preparation).

(Generalizing an old work of W. Blaschke, we study intrinsic and extrinsic curvature functions in pseudo-Riemannian geometry. A theme is : for pseudo-Riemannian manifolds admitting polynomial parametric equations with rational coefficients, the squares of curvature functions at rational points are rational numbers.)

3) (with Satya Deo) : Branched Coverings, Labelled Coverings, and Transitive permutation Groups. (in preparation).

Invited Lectures/Seminars:

1) University of Toronto, Toronto, Canada, November 2003.

2) Rutgers University, New Brunswick, NJ, November 2003.

3) Prof. C. S. Venkataraman Memorial Lecture, organized by the Ramanujan Mathematical Society, in Dr. B. R. Ambedkar University, Agra, July 2004.

4) Morningside Center of Mathematics, Chinese Academy of Sciences, August 2004.

Other Activities:

I participated in 1) the NBHM-sponsored Advanced Foundational School on Differential Topology, and Linear Algebra, at IIT Bombay, Powai, in May 2004 (4 lectures each), and 2) Visiting Students Summer Programme, HRI, in June 2004 (8 lectures).

E. K. Narayanan

Research Summary:

Some questions in Integral Geometry were considered on Euclidean spaces and Heisenberg groups. Functions whose spherical averages are zero over conical manifolds of spheres were studied in detail. Using tools from PDE we prove that the family of spheres in R^n which intersects a given subset A of R^n uniquely determines a continuous function provided that the set A is not contained in any $(n-2)$ dimensional affine plane. In particular given n points in general positions, ie: affinely independent, the spheres passing through these points uniquely determine any continuous function by its averages, while no $(n-2)$ points do the job.

On the Heisenberg group we prove a local version of the two radius theorem for the class of continuous functions. More precisely, if f is a continuous function on the Heisenberg group and the spherical means $f * \mu_{r_1} = f *_{\mu_{r_2}} = 0$, in a cylindrical region of the type $B_R \times R$ then f is the zero function provided $r_1 + r_2 < R$ and no radial eigenfunction of the Heisenberg sublaplacian vanishes simultaneously on the spheres of radius r_1 and r_2 in C^n.

Publications:

1. *Multipliers for the twisted Laplacian* Colloq. Math., 97 (2003), no.2, 189-205.

Preprints:

1. *An optimal theorem for the spherical maximal operator on the Heisenberg group (jointly with S. Thangavelu)* (jointly with S. Thangavelu)., to appear in Contemporary Mathematics series.

2. *A local two radius theorem for the twisted spherical means on* C^n (jointly with M. L. Agranovsky), to appear in Contemporary Mathematics series.

3. *Injectivity of the spherical mean operator on conical manifolds of spheres* (jointly with M. L. Agranovsky).

Conference/Workshops Attended:

Spectral Theory and Geometry, in memory of Robert Brooks. Technion, Israel, Jan 2004.

Visits to other Institutes:

1. Academic visit to Bar-Ilan university, Israel, from Nov 2003 to April 2004.

I. B. S. Passi

Research Summary:

The groups with the property that their integral group rings have hyperbolic unit groups were examined and some definitive results obtained (jointly with S. O. Juriaans and Dipendra Prasad).

The multiplicative Jordan decomposition property for units in integral group rings of finite groups was studied (jointly with A. W. Hales).

Augmentation powers, dimension subgroups, group homology, cyclic homology and higher traces on group rings were studied (jointly with R. Mikhailov).

Work on the book *Algebra* Vol. 4: Field Theory, in collaboration with I. S. Luthar, was continued and completed.

Publications:

1. *A contribution to Bass' conjecture* [jointly with Ioannis Emmanouil], *J. Group Theory* (to appear).
2. *Hyperbolic unit groups* [jointly with S. O. Juriaans and Dipendra Prasad], *Proc. Amer. Math. Soc.* (to appear).
3. *Augmentation powers and group homology* [jointly with Roman Mikhailov], *Journal of Pure and Applied Algebra* (to appear).
4. Book: *Algebra* Vol. 4: Field Theory [jointly with I. S. Luthar], Narosa Publishing House, New Delhi (to appear).
5. Book review: *Subgroup Growth* by Alexander Lubotzky and Dan Segal, Progress in Mathematics Vol. **212**, Birkhäuser Verlag, Basel, 2003. *Journal of the Indian Institute of Science* (to appear).

Preprints:

1. *A transfinite filtration of Schur multiplicator* (jointly with R. Mikhailov).
2. *Higher traces on group rings* (jointly with R. Mikhailov).
3. *Homology of Centralizers* (jointly with R. Mikhailov).

Conference/Workshops Attended:

1. International Conference on Commutative Algebra and Combinatorics, HRI, Allahabad, December 8-13, 2003.

2. The Joint India-AMS Mathematics Meeting held at Bangalore, December, 2003.

3. 91st Session of Indian Science Congress held at Chandigarh during January 2004.

Visits to other Institutes:

1. University of California, Los Angeles & San Diego (USA) (two weeks in May 2003).

2. Forschungsinstitut für Mathematik, Eidg. Tech. HocHschule, Zürich (Switzerland) (three weeks in June 2003).

3. Institut de Recherche Mathématique Avancëe, Université Louis Pasteur, Strasbourg (France) (two weeks during June/July, 2003).

Invited Lectures/Seminars:

1. *Algebraic elements in group rings* at University of California (Los Angeles), University of California (San Diego) and ETH (Zürich).

2. *Jordan decomposition* at Uiversité Louis Pasteur (Strasbourg) and India-AMS special session on "The many facets of linear algebra and matrix theory", Bangalore.

3. *Hyperbolic groups* at the Symposium on Recent Trends in Algebra and Number Theory held at Chandigarh during the 91st Session of ISCA in January, 2004.

Other Activities:

1. Taught a course on Algebra.

2. Gave the following series of advanced lectures at HRI:

   (a) *Group Rings;*

   (b) *Asymptotic Group Theory*.

3. Organized a weekly *Seminar in Group Theory* in which various visiting and local mathematicians participated.

4. Was Convener (with D. Jatkar) of the *HRI Colloquium* until October 2003; this is a joint programme of the Schools of Mathematics and Physics.

N. Raghavendra

Research Summary:

I have been working with Indranil Biswas, TIFR, Mumbai, on transversely complex manifolds. These are generalizations of transversely holomorphic foliations. Specifically, we have been developing the basic constructs of transversely complex manifolds, and of characteristic classes of bundles on them.

D. Surya Ramana

Research Summary:

Continued work certain problems involving the application of exponential sums begun last academic year.

Publications:

Adhikari, S. D. and Ramana, D. S. *Siegel's theorem : finiteness of integral points*, Elliptic curves, modular forms and cryptography (Allahabad, 2000), 139–149, Hindustan Book Agency, New Delhi, 2003.

Preprints:

Suresh Nayak and D.S. Ramana, *Tarski's Plank Problem for the Disc*.

Conference/Workshops Attended:

Presented a paper titled "Vinogradov's Method for Sums of Fractional Parts" at the Joint India-AMS conference at Bangalore in December, 2003.

Presented a paper titled "A Remark on Some Exponential Sums" in the Conference in honour of Professor K. Ramachandra at Banglaore in December, 2003.

Visits to other Institutes:

Visited the Department of Mathematics, Panjab University, Chandigarh in April - May, 2003 and delivered four lectures on Exponential Sums.

Academic recognition/Awards:

Received the best thesis award for the period Jan 2001- March 2002 from the Institute of Mathematical Sciences, Chennai.

Other Activities:

Gave a semester long course titled Analysis II for first year doctoral students at H.R.I..

Organised the mathematics part of the annual science talent test conducted by H.R.I. for high school students from Allahabad.

B. Ramakrishnan

Research Summary:

1. (with S. Gun) : **Lacunarity of certain Dedekind η-Products**.
Short Summary: A formal power series $x^\nu \sum_{n=0}^{\infty} a(n)x^n$ is called *lacunary* if the number of non-zero Fourier coefficients $a(n)$ with $n \leq t$ is $o(t)$. In other words, the arithmetic density of its non-zero coefficients is zero.

In 1985 J. -P. Serre [*Glasgow Math. J.* **27**, 203–221] classified all even powers of the Dedekind eta-function which are lacunary. More precisely, he proved that $\eta^r(z)$ is lacunary if and only if $r = 2, 4, 6, 8, 10, 14$ or 26.

B. Gordon and S. Robins [*Glasgow Math. J.* **37** (1995), 1–14] used Serre's method to classify all two eta products of the form $\eta^r(z)\eta^s(2z)$, where $r + s$ is even and $rs \neq 0$.

In this work, we classify all lacunary forms associated to the eta-products of the form $\eta^r(z)\eta^s(3z)$, where $r + s$ is even and $rs \neq 0$. In particular, we prove the following theorem;
Theorem: Suppose that $r + s$ is even and $rs \neq 0$. Then $\eta^r(z)\eta^s(3z)$ is lacunary if and only of (r, s) is one of the following 18 pairs:
$k = 1$; $(1, 1)$ $(-1, 3)$ $(3, -1)$
$k = 2$; $(-1, 5)$ $(5, -1)$ $(1, 3)$ $(3, 1)$ $(2, 2)$
$k = 3$; $(3, 3)$
$k = 4$; $(-1, 9)$ $(9, -1)$ $(-2, 10)$ $(10, -2)$
$(-3, 11)$ $(11, -3)$ $(5, 3)$ $(3, 5)$
$k = 7$; $(7, 7)$.

2. (with S. Gun) **On the representation of integers as sums of odd number of squares**.
Short Summary: A classical problem in number theory is to give an explicit formula for the number of ways one can represent a non-negative integer n as a sum of k squares, where k is a positive integer. The study of $r_k(n)$ has a long history. For $k = 2, 4, 6, 8$, elegant formulae for $r_k(n)$ were found by Jacobi. A general formula for $r_k(n)$, when k is even was stated by Ramanujan . It was proved by Mordell. It is also known that $r_k(n)$ can be expressed in terms of coefficients of Eisenstein series and cusp forms and Rankin showed that the cusp form part is non-trivial for $k > 8$. Recently, combining a variety of methods, S. Milne obtained formulas for $r_{4s^2}(n)$ and $r_{4s^2+4s}(n)$ for every positive integer s. Using Zagier's work on the Kac-Wakimoto conjecture, K. Ono [*J.Number Theory* **95** (2002), 253–258.] obtained formulas (simpler than Milne's) for $r_{4s^2}(n)$ and $r_{4s^2+4s}(n)$, which are sums of products of divisor functions. For odd values of k a general formula is not known, though formulas for particular values of k are known. For example, the formulas for $r_k(n)$ or $r_k(n^2)$ are known for $k = 1, 3, 5, 7, 9, 11, 13$. These formulas were obtained either by an elementary method or by using the theory of modular forms.

In a recent work, S. Cooper [*J. Number Theory* **103** (2003), 135–162] conjectured a formula for $r_{2k+1}(p^2)$. Using the Shimura Correspondence we obtain an explicit formula for $r_{2k+1}(n^2), n \geq 1$. As a consequence, we prove that the values at $1-k$ of the Dirichlet L-functions twisted by the character χ_4 are rational, which can be written down explicitly using our formula. Here χ_4 is the trivial character or the non-trivial character modulo 4 depending on whether k is even or odd.

3. (with Shaun Cooper, Michael D. Hirschhorn and S. Gun) **Multiplicative Relations for Certain Powers of Euler's Product**.
Short Summary: Certain arithmetic relations for the coefficients in the expansions of $(q)_\infty^r$, $(q)_\infty^r(q^t)_\infty^s$, $t = 2, 3, 4$ were studied by M. Newman, S. Cooper, M. D. Hirschhorn, R. Lewis, S. Ahlgren and R.Chapman. In this work, we prove similar identities for certain multi-product expansions using an elementary method. This result is equivalent to show that certain Dedekind eta-products are lacunary.

4. (with S. Gun, B. Sahu and R. Thangadurai) **Distribution of Quadratic non-residues which are not primitive roots**.
Short Summary: In this paper we study the distribution of quadratic non-residues which are not primitive roots modulo p^h or $2p^h$ where p is an odd prime and $h \geq 1$ is an integer using elementary and combinatorial methods.

5. (with M. Manickam) **An estimate for certain average of the special values of character twists of Hecke L-functions**.
Short Summary: We prove the Lindelöf hypothesis in weight aspect for the average of the special values of the twisted L-functions of newforms, which generalizes the work of W. Kohnen and J. Sengupta.

Publications:

1. An Introduction to Modular Forms and Hecke Operators, (with M. Manickam), in *Elliptic Curves, Modular Forms and Cryptography*, Hindustan Book Agency (2003), 223–245.

2. Elliptic Curves, Modular Forms and Cryptography, Edited by A. K. Bhandari, D. S. Nagaraj, B. Ramakrishnan, and T. N. Venkataramana, Hindustan Book Agency 2003.

Conference/Workshops Attended:

1. Attended and gave a 40 minutes talk in the 18th Annual Workshop on Automorphic Forms held at the Department of Mathematics, University of California, Santa Barbara, USA during March 21–24, 2004.

Visits to other Institutes:
1. Visited Department of Mathematics, Vivekananada College, Chennai during December 2003 – January 2004.

Purusottam Rath

Research Summary:

Zero-sum Ramsey theory is a rather recently developed and developing area in Combinatorics which has brought in algebraic tools and algebraic flavour to Ramsey theory. The paradigm of zero-sum problems can be formulated as understanding the following question: If elements of some combinatorial structure is mapped into a finite group, whether there exists a substructure sum of whose images in the group is the identity. The area is full of questions and conjectures and we have been endeavouring to answer and solve some of those.

The other question we are interested in constitutes one of the central questions in the area of Additive Number Theory, namely estimating the size of sum and product sets. Erdos and Szemeredi made the beautiful conjecture that a finite set of positive integers cannot have simultaneously few sums and few products. Freiman's path breaking work in multidimensional arithmetic progressions has made important inroads to this deep and difficult question and the conjecture has been proved in affirmative in some conditional cases. But the main conjecture remains unsolved.

Publications:

Remarks on some zero-sum problems
(Jointly with S.D.Adhikari)
Expo. Math. 21, no. 2, 185 – 191 (2003).
Monochromatic configurations for finite colourings of the plane
(Jointly with S.D.Adhikari)
Note di Matematica, to appear.

Preprints:

Method of approximation in Transcendental Number Theory

Conference/Workshops Attended:

1: Attended the Conference " Young Researchers - Modular Forms and Transcendental Number Theory " held at CIRM, Marseilles, France in May 2003.
2: Attended the "International Conference on Commutative Algebra and Combinatorics" held in H.R.I in December 2003.
3: Attended the satelite conference in Number Theory held in Bangalore in December 2003.
4: Attended the AMS-INDIA conference held in Bangalore in December.

Invited Lectures/Seminars:

Gave a talk in the "International Conference on Commutative Algebra and Combinatorics" held in H.R.I in December 2003.

Anupam Kumar Singh

Research Summary:

I have been working with Dr. Maneesh Thakur on problems related to the exceptional group of type G_2 over arbitrary fields. We completed our investigation of reality properties in G_2. An element is called real if and only if it is conjugate to its inverse. Given a group of type G_2 over a field k, one can realize it as the automorphism group of an octonion algebra over k. We were successful in determining the cases when reality holds and found counterexamples in other cases.

Motivated by some partial results in the direction of determining conjugacy classes and a question asked by Prof. R. S. Kulkarni to determine z-conjugacy classes, I (with Dr. M. Thakur) have been exploring anisotropic G_2 over arbitrary field k. Let G be an automorphism group of some octonion division algebra, which is an anisotropic group of type G_2. Two elements in G are called z-conjugate if and only if their centralizers are conjugate. We determine z-conjugacy classes of G and further, we have made computations of conjugacy classes in groups of type G_2.

I am investigating the "Reality" question in $spin$ groups and other exceptional groups as well.

Preprints:

1. Reality properties of conjugacy classes in G_2 (submitted).
2. Conjugacy classes in anisotropic G_2 (in preparation).

Conference/Workshops Attended:

1. International Conference on Algebra and Number Theory (11-16 December 2003) in University of Hyderabad.
2. Joint India-AMS mathematics meeting (17-20 December 2003) in IISc Bangalore.
3. Workshop on Linear Algebraic Groups, Quadratic Forms And Related Topics (1-5 February 2004) in Eilat organisd by European Research and Training Network "Algebraic K-theory, Linear Algebraic Groups and Related Structures" (HPRN–CT–2002–00287).

Other Activities:

1. I helped in the tutorial sessions in VSSP-2003.
2. I delivered two introductory lectures on Representation theory of finite groups in Basic Notions Seminar in January 2004.

Maneesh Thakur

Research Summary:

With Anupam Singh, I have completed our investigations of reality properties for conjugacy classes in groups of type G_2. We have used our results and techniques to compute centralisers of elements and their conjugacy classes in groups of type G_2 over arbitrary fields. We plan to carry out this for other exceptional groups as well. The project to describe rational subgroups of algebraic groups is in progress. There is a one to one correspondence between isomorphism classes of k-maximal tori in $SU(V,h)$ and isomorphism classes of certain etale algebras of dimension n containing L, a quadratic extension of k. Here (V,h) is a hermitian space over L of dimension n. This has been effectively used to describe maximal tori in anisotropic groups of type G_2. With Dr. R. P. Shukla, have completed two articles on Coxeter Groups and Pseudo Reflection groups. These are to be published in the proceedings of the Geometric Group Theory workshop (GGT 2002), held at Guwahati.

Publications:

1. The etale Tits' Process of Jordan algebras revisited (with H. P. Petersson), Journal of Algebra, 273 (2004) 88-107.

Preprints:
1. Reality Properties of Conjugacy Classes in G_2 (with Anupam Singh), submitted.
2. Coxeter Groups, Preprint (with R. P. Shukla)
3. Some topics in Pseudo Reflection Groups, Preprint (with R. P. Shukla).
4. A note on Hermitian forms, Preprint.
5. Conjugacy Classes in G_2 (in progress).
6. Rational subgroups of G_2 and F_4 (work in progress)

Conference/Workshops Attended:
1. Buildings and Polygons, University of Wurzburg, September 2003.
2. Joint AMS-India meeting, IISc. Bangalore (December 2003).
3. Algebraic Groups and Homogeneous Spaces, TIFR Bombay (January 2004).

Visits to other Institutes:
1. FernUniversitat, Hagen (Germany), July 2003.
2. ICTP, Trieste, August-October 2003.

Invited Lectures/Seminars:

1. Reality Prperties for Conjugacy Classes in G_2, 3 lectures at Hagen.
2. G_2 and Reality, in "Buildings and Polygons", at University of Wurzburg.
3. Some conjugacy results for G_2, ICTP.
4. Reality Properties for G_2, AMS-India meeting, IISc.
5. Algebras with Involutions and Classical Groups, 3 lectures at HRI.

R. Thangadurai

Research Summary:

During this year, I continued my exploration in "Zero-sum Problems" in the field of Combinatorial number theory and also in Bernoulli numbers.

Publications:

1. On the structure of sequences with forbidden zero-sum subsequences, (with W. D. Gao), *Colloquim Mathematicum*, **98** , No. 2, (2003), 213-222.

2. Adams Theorem on Bernoulli Numbers Revisited, Journal of Number Theory, **106**, (2004), 169-177.

3. On a variant of Kemnitz Conjecture, (with W. D. Gao), Journal of Combinatorial Theory, Series A, **107**, (2004), 69-86.

4. Olson's Constant for the group $\mathbb{Z}_p \oplus \mathbb{Z}_p$, (with W. D. Gao and I. Z. Ruzsa), Journal of Combinatorial Theory, Series A, **107**, (2004), 49-67.

Preprints:

1. On a structure of p-zero-sum free sequences, (with W. D. Gao and A. Panigrahi), *Preprint*, 2004.

2. Distribution of Quadratic non-residues which are not primitive roots, (with S. Gun, B. Ramakrishnan and B. Sahu), *Preprint*, 2004.

Conference/Workshops Attended:

1. Conference on "Number Theory" in the honor of Prof. K. Ramachandra on his 70th birthday held at NIAS, Bangalore from 13th Dec. – 15th Dec. 2003.

2. Invited speaker for the workshop on Discrete Mathematics to be held in Poona University from 21st March- 24th March, 2004.

Visits to other Institutes:

1. Visited University of Poona, Pune
2. Bhaskaracharya Prathisthana, Pune

Invited Lectures/Seminars:

1. Invited speaker at the Conference on "Number Theory" in the honor of Prof. K. Ramachandra on his 70th birthday held at NIAS, Bangalore from 13th Dec. – 15th Dec. 2003.

2. Invited speaker for the workshop on Discrete Mathematics to be held in Poona University from 21st March- 24th March, 2004.

Other Activities:

Guiding Student: Mr. Brundaban Sahu, a second year student has taken a year long project under me on "Combinatorial Number Theory" from August 2003.

Graduate Courses taught: Introduction to Number Theory during August, 2003 to December, 2003.

Participation in Committees:

1. Jest Committee (2003-04): Co-ordinator
2. Visiting Students including VSSP (2003-04): Co-ordinator
3. Graduate Committee (2003-04): Member
4. Computer Committee (2003-04): Member
5. Sports and Entertinement Committee (2003-04): Member

ACADEMIC REPORT - PHYSICS

Jasjeet Singh Bagla

Research Summary: My main research interest for the last few years has been Cosmology and the physics of the high redshift Universe. Most of these studies require use of N-Body simulations and developing algorithms for these is also one of my interests. Suryadeep Ray and I have developed a highly optimised parallel version of the TreePM code that can be used to run simulations with more than 10^7 particles. With this code, we can run such a large simulation through more than 10^3 time steps in less than two days. This allows us to model gravitational clustering and galaxy formation in a more realistic manner.

Studies of clustering of galaxies in the non-linear regime are plagued by the issue of bias. It has long been recognised that measurement of higher order correlations and moments allow determination of bias. However in absence of clean analytical formulation in the non-linear regime, there is no clear method of making use of higher order moments for this purpose. Numerical studies carried out with Suryadeep Ray suggest that it is nearly impossible to differentiate models using higher order moments if we are looking the distribution of over-dense regions.

With Jayanti Prasad and Suryadeep Ray, we studied the interplay of clumping at small scales with the collapse and relaxation of large perturbations. Substructure can play an important role in the relaxation process. It can induce mixing in the phase space, or change density profiles by introducing transverse motions, and, gravitational interactions between small clumps can make the relaxation effectively collisional even for a collisionless fluid. Thus it is important to understand the role played by substructure in gravitational collapse and relaxation in the context of an expanding background. In our preliminary studies we modelled the large scale collapse as that of a plane wave. We find that in absence of substructure, collapse of a plane wave perturbation leads to formation of a pancake with multi-stream regions. A comparison with the adhesion approximation suggests that the preferred value of effective viscosity depends primarily on the number of streams in a region. The presence of sub-structure speeds relaxation of plane wave and makes the collapsed region thinner. In turn, the collapse of plane wave leads to larger clumps. We are studying the role played by substructure in gravitational collapse by considering more generic situations.

Recent observations have shown that the universe is accelerating and it is also nearly flat, i.e., there is no spatial curvature. The accelerated expansion of the universe requires either a cosmological constant or some form of dark energy to drive the acceleration, with $w \equiv p/\rho < -1/3$. Although a cosmological constant is the simplest solution from a phenomenological point of view, requiring just one fine tuned parameter, there is no natural explanation of the small observed

value. This has led theorists to develop models in which a field, typically a scalar field, provides the source of dark energy. In the absence of significant spatial variation in the dark energy, the key difference between such models and the one with the cosmological constant is that, in general, w is a function of redshift in the former. With H.K.Jassal and T.Padmanabhan, we are carrying out a detailed study of available observations to see if the variation of w with redshift can be detected or ruled out.

Publications:

- Bagla J.S. and Ray S. : *Performance characteristics of the TreePM method*, New Astronomy 8, 665, 2003.
- Bagla J.S. : *A parallel TreePM code*, *Numerical Simulations in Astronomy*, ed. K.Tomisaka and T.Hanawa, 2003, p.32.
- Bagla J.S. : *Cluster Computing at HRI*, Proceedings of DAE meeting on Parallel computing and its applications in science and engineering, BARC, p.219, 2003.
- Bagla J.S. and White M. : *Prospects for Detecting Neutral Hydrogen Using 21-cm Radiation from Large Scale Structure at High Redshifts*, *the IAU 8th Asian-Pacific Regional Meeting, Proceedings volume I, Eds. Satoru Ikeuchi, John Hearnshaw, and Tomoyuki Hanawa; ASP conference series, vol.289, p.251*, 2003.

Conference/Workshops Attended:

- *The Provocative Universe*, a conference held in honour of Prof.J.V.Narlikar, IUCAA, Pune, June 30 – July 2, 2003.
- *Parallel computing and its applications in science and engineering*, BARC, Mumbai, Nov.27–28, 2003.
- International Conference on Gravitation and Cosmology, Cochin, Jan.5–10, 2003.

Visits to other Institutes:

- Inter-University Centre for Astronomy and Astrophysics, Pune, June 29 – July 28, 2003.
- Inter-University Centre for Astronomy and Astrophysics, Pune, Jan.12–25, 2004.
- Raman Research Institute, Bangalore, Jan.27 – Feb.12 and Feb.16–20, 2004.

- Insitute of Mathematical Sciences, Chennai, Feb.13–15, 2004.

Invited Lectures/Seminars:

- *The galaxy correlation function and bias*, an invited talk in *the Provocative Universe*, a conference held in honour of Prof.J.V.Narlikar, IUCAA, Pune, June 30 – July 2, 2003.
- *Cluster computing at HRI*, a talk in the meeting on *Parallel computing and its applications in science and engineering*, BARC Mumbai, Nov.27–28, 2003.
- *Cluster computing at HRI*, seminar at IUCAA, Pune, Jan.21, 2004.
- A series of lectures on *N-Body simulations of gravitating systems*, Raman Research Institute, Bangalore, Jan.29 – Feb.6, 2004.
- *Studying galaxy clustering on Linux clusters*, colloquium at the Dept. of Physics, Indian Institute of Science, Bangalore, Feb.10, 2004.
- *Cluster computing at HRI*, a presentation at Centre for Development of Advanced Computing (CDAC), Bangalore, Feb.11, 2004.
- *Cluster computing at HRI*, colloquium at IMSc, Chennai, Feb.13, 2004.
- *Gravitational Clustering*, colloquium at Indian Institute of Astrophysics (IIA), Bangalore, Feb.17, 2004.
- *Gravitational Lensing and the Cosmic Microwave Background Radiation*, an invited talk in a discussion meeting on Cosmic Microwave Background Radiation, Coorg, Feb.21–26, 2004.

Academic recognition/Awards:

- I have been nominated a member of the International Astronomical Union (IAU). Members from each country are nominated by a national coordination committee.

Other Activities:

- I managed the procurement and setting up of a Linux cluster at HRI. The 42 node cluster, called *Kabir*, was set up during the summer of 2003. Several other facilities, such as large data storage and data backup have also been set up for use with the cluster. *Kabir* is one of the fastest super-computing facilities in India. Its utilisation in the first four months after commissioning has been more than 50%. System management of this cluster is done by a group of users led by me. More information on this is available at http://cluster.mri.ernet.in/.

- I organised an advanced school on the physics of galaxy formation. A total of 20 participants attended courses offered by more than 10 experts, a large fraction of experts and many participants were from outside India. Presentations made by speakers in this school are available online.
- I gave a series of six lectures on basics of galaxy formation and on N-Body simulations in the school on physics of galaxy formation.
- I gave a lecture on astrophysics in the rajbhasha programme here at HRI.
- Two students did projects with me over the summer of 2003. These students were Nishikanta Khandai (IIT Mumbai) and Manu Awasthi (IT-BHU, Varanasi).
- I gave a one semester course on Astrophysics for second year graduate students.

Debajyoti Choudhury

Research Summary:

Most of my research activity during the last year was concentrated on *(a)* identifying signals of physics beyond the Standard Model (SM) at colliders and *(b)* studying cosmological implications of String Theory inspired higher dimensional models.

- **Signals for physics beyond the Standard Model**
  - **Higgs physics**
    At future experimental facilities (the LHC as well as linear colliders), it might be possible to not only discover Higgs particles but to measure their couplings as well. In Ref.[1], we argue that the ZZH coupling constitutes a simple probe of the nature of the scalar sector responsible for electroweak symmetry breaking. We demonstrate the efficacy of this measure through an analysis of four-dimensional models containing scalars in arbitrary representation of $SU(2) \times U(1)$, as well as extra-dimensional models with a non-factorizable geometry. A possible role for the $t\bar{t}H$ couplings is also discussed.
  - **Supersummetry**
    Although the scalar partners of the leptons are expected to be amongst the lisghtest of the supersymmetric particles, they can be notoriously difficult to detect at hadronic colliders (such as the LHC). In Ref.[2] we demonstrate that charged slepton pairs produced via vector-boson fusion along with two high-mass, high-p_T forward/backward jets (in two opposite hemispheres) can have a higher production cross-section for heavy slepton masses than that from conventional Drell-Yan production at a hadronic collider. We analyse the signal and leading backgrounds in detail in the minimal supersymmetric standard model with conserved baryon and lepton numbers. Our investigation reveals that the mass reach of the vector-boson fusion channel is certainly an improvement over the scope of the Drell-Yan mode.

– **Higher dimensional theories**

The models of large extra compact dimensions, as suggested by Arkani-Hamed, Dimopoulos and Dvali, predict exciting phenomenological consequences with gravitational interactions becoming strong at the TeV scale. Such theories can be tested at the existing and future colliders. In Ref.[1], we study the contribution of virtual Kaluza-Klein excitations in the process $e^+e^- \to t\bar{t}H$ at future linear collider (NLC). We find that the virtual exchange KK gravitons can modify the cross-section $\sigma(e^+e^- \to t\bar{t}H)$ significantly from its Standard Model value and will allow the effective string scale to be probed up to 7.9 TeV. Furthermore, such a measurement has great potential in identifying the source of the new physics thus observed.

- **String Theory inspired Cosmology**

  In a previous exercise, we had analysed the effective action of the tachyon field on a D-brane, of both bosonic as well as superstring theory. We had found that the non-standard kinetic term of the tachyon field requires a correction to the Born-Infeld type Lagrangian. The resulting dynamics had a very interesting cosmological significance, particularly in the context of inflation.

  Continuing in the above direction, we next studied a more realistic string theory inspired model for hybrid inflation [3]. The context is provided by a brane-antibrane system partially compactified on a compact submanifold of (a caricature of) a Calabi-Yau manifold. The interbrane distance acts as the inflaton, whereas the end of the inflationary epoch is brought about by the rapid rolling of the tachyon. The number of e-foldings is sufficiently large and is controlled by the initial conditions. The slow roll parameters, however, are essentially determined by the geometry and have little parametric dependence. Primordial density fluctuations can be made consistent with current data at the cost of reducing the string scale.

List of Research Papers written

1. ZZH Coupling: A Probe to the origin of EWSB?
   D. Choudhury, *A. Datta* and *K. Huitu*
   Nucl. Phys. **B673** 385 (2003).

2. Slepton production from gauge boson fusion
   D. Choudhury, *A. Datta, K. Huitu, P. Konar, S. Moretti* and *B. Mukhopadhyaya*
   Phys. Rev. **D68**:075007,2003

3. Hybrid Inflation and Brane-Antibrane System
   D. Choudhury, *D. Ghoshal, D.P. Jatkar* and *S. Panda*
   Jour. Cosmology and Astropart Phys. **07**, 009 (2003).

4. Higgs production in association with top quark pair at e^+e- colliders in theories of higher dimensional gravity
   D. Choudhury, *N.G. Deshpande* and *D.K. Ghosh*
   hep-ph/0311284

Conference/Workshops Attended:

- Meeting on Neutrino Physics, Argonne National Lab, Argonne, USA.

Visits to other Institutes:

- High Energy Physics Division, Argonne National Lab, Argonne, USA (May-Jun 2003).
- Theory Division, Fermi National Accelerator Lab, Batavia, USA (Jul 2003).

Students guided

Mr. Swapan K. Majhi is currently pursuing his Ph.D. under my supervision. Apart from this, I also interact on a regular basis with Mr. Partha Konar (student of Prof. B. Mukhopadhyaya).

Prasanta Kumar Das.

Research Summary:

Last one year I have completely devoted myself in looking several phenomenological aspects of radion both at the precission and the collider level. A list of my publication(s) and preprints is given below. Presently I am doing some related study for the non-leptonic decay mode of B-meson with the technique called QCD factorisation.

Publications:

- "Implications of a light radion on $\beta(\lambda)$ and $\beta(g_t)$ and a lower bound on radion vev" –**Prasanta Kr. Das** and Uma Mahanta (published in MPLA)/hep-ph/0110309.

Preprints:

- "Muon anomalous magnetic moment and a lower bound on the Higgs mass due to a stabilized radion in the Randall-Sundrum model "- **Prasanta Kr. Das** (submitted to PRD).
- "Higgs pair production due to radion resonance in Randall-Sundrum model: prospects at the Large Hadron Collider"– **Prasanta Kr. Das** and Biswarup Mukhopadhyaya (submitted to EPJC), hep-ph/0303135.

Conference/Workshops Attended:

- I have Attended the wrokshop ACFA at TIFR, Mumbai in Dec. 03.
- Also I have Attended the workshop WHEPP8 at IITK, Mumbai in Jan. 04.

Visits to other Institutes:

- I have Visited the University of Kansas, USA during the summer, 03 for some collaborative work.
- I have visited IMSc, Chennai and CTS, Bangalore as a TPSC speaker during March-April, 04.

Invited Lectures/Seminars:

- I have given a seminar at the Physics Dept. of University of Kansas, USA based on my work on Triviality bound of higgs mass due to a light stabilized radion.
- I have given seminars at Syracuse Univ. USA, Montreal Univ. Canada based on my works of radion phenomenology.

Raj Gandhi

Research Summary:

My research has mainly focussed on neutrino physics and the particle physics/ astro-physics interface.

Over the past year I have been actively involved along with several other physicists in writing and preparing a proposal for a planned Indian Neutrino Observatory (INO). With Anindya Datta, I have done detailed studies of the physics possibilities and potential of the INO detector.This work is ongoing, and currently Poonam Mehta, a student from Delhi University,Pomita Ghoshal and Srubabati Goswami are also actively contributing to the INO effort at HRI.

With A. Datta, Poonam Mehta and Uma Sankar, (hep-ph 0312027) we have shown that atmospheric neutrinos can provide a sensitive and robust probe of CPT violation (CPTV). We performed realistic event-rate calculations and studied the variations of the ratio of total muon to antimuon survival rates with L/E and L ($L \equiv$ baseline length, $E \equiv$ neutrino energy) in a detector capable of identifying the muon charge. We demonstrated that measurements of these ratios when coupled with the significant L and E range which characterizes the atmospheric neutrino spectrum provide a method of both detecting the presence of such violations and putting bounds on them which compare very favourably with those possible from a future neutrino factory.

With A. Datta, Pomita Ghoshal, Poonam Mehta, S Goswami and Uma Sankar, we are finishing a study of matter effects in the mu-tau oscillation probability.

With my student, Pomita Ghoshal, I am working on studies of the effects of muon polarization at neutino factories.

Publications:

A. Datta, R. Gandhi, P. Mehta and S. U. Sankar, "Atmospheric neutrinos as a probe of CPT and Lorentz violation," arXiv:hep-ph/0312027.(to appear in Physics Lett B)

R. Gandhi, K. Kar and S. Uma Sankar, "Working Group Report: Neutrino And Astroparticle Physics," Pramana **60**, 405 (2003).

Preprints:

- *Matter effects in* $P_{\nu_\mu \to \nu_\tau}$ with A. Datta,P. Ghoshal, S.Goswami, P. Mehta and S. Uma Sankar, in preparation.
- *Atmospheric Neutrino Physics Sensitivity studies for a Large Mass Iron Calorimeter*, with A. Datta,P. Ghoshal, S.Goswami, P. Mehta and S. Uma Sankar, in preparation.

Invited Talks and Seminars

May 12, 2003	Invited Plenary talk at the International Conference on TRENDS IN NEUTRINO PHYSICS, Argonne National Labs, Chicago.
May 6, 2003	Invited talk at PHENO 03 Symposium on High Energy Particle Phenomenology, Madison, Wisconsin.
May 24, 2003	High Energy Seminar, Brookhaven National Lab, New York.
April, 2004	Invited Plenary talk at the Conference on PERSPECTIVES IN PARTICLE PHYSICS AND COSMOLOGY, PRL, Ahmedabad

Other Activities:

Teaching and Mentoring Activity

I have taught the Quantum Mechanics course for first year students in Fall 2003. I am guiding Pomita Ghoshal towads her Ph.D. In addition, Poonam Mehta, a PhD student from Delhi University, has been closely working with me over the past 2 years and we have written several papers together.

INO RELATED WORK

I continue to be closely involved in INO work. I am on the Programme Management Committee for the project, and have regularly participated in meetings and decision making. In addition, I am Co-ordinator for the Physics subgroup of the Collaboration, which is responsible for the physics part of the project. At present we are writing the physics chapter for the Detailed Project Report which will shortly be submitted to the funding agencies and become a INO public document.

Finally, I have convened and/or served on institute committees.

Debashis Ghoshal

Research Summary:

A model of hybrid inflation, inspired by string theory in the context of a brane-antibrane system is studied in detail. The branes are taken to be partially compactified on a six-dimensional compact space. The interbrane distance acts as the inflaton, whereas the end of the inflationary epoch is brought about by the onset of the tachyon which rapidly rolls to the minimum of its potential. The number of e-foldings is controlled by the initial conditions and can be sufficiently large. The slow roll parameters turn out to be determined by the geometry and allow for little parametric dependence. We show that the primordial density fluctuations can be made consistent with current data, but this requires a low string scale. (Work in collaboration with D. Choudhury, D.P. Jatkar and S. Panda.)

The condensation of tachyon in the presence of a nonzero Neveu-Schwarz field-strength $H = dB$ is investigated. An operator valued gauge field configuration is proposed to describe an NS-5-brane as well as an intersecting system of a semi-infinite D6-brane with its boundary on a NS5-brane. It is shown that operator valued gauge fields are better thought of as mathematical objects known as gerbes. (Work in collaboration with D.P. Jatkar and M. Kreuzer.)

The nonlocal effective field theory of the tachyonic scalar of the p-adic string theory is deformed by a noncommutative parameter. A soliton with gaussian profile was obtained for all values of the noncommutative parameter. It is shown to interpolate smoothly between the p-adic solitons of the original (commutative) theory and the noncommutative soliton at infinite noncommutativity.

Publications:

Hybrid inflation and the brane-antibrane system
J. Cosmology & Astrophys. **0307**: 009 (2003)
(in collaboration with D. Choudhury, D.P. Jatkar and S. Panda)

Preprints:

Noncommutative p-tachyon
HRI-P/031101 (To be published in the proceedings of *p-Adic MathPhys 2003*)
NS fivebrane and tachyon condensation
HRI-P-0312001, hep-th/0312245
(in collaboration with D.P. Jatkar and M. Kreuzer)

Conference/Workshops Attended:

1. *p-Adic MathPhys 2003* at the Steklov Institute, Moscow, Russia (Oct 2003).
2. *National Workshop on String Theory* at the Indian Institute of Technology (Kanpur), Kanpur, India (Dec 2003).

3. *VIII Winter School of APCTP/KIAS on String Theory* at Korea Institute of Advanced Study, Seoul, South Korea (Feb 2004).

Visits to other Institutes:

1. Harvard University, Cambridge, USA (one month during Apr–May, 2003).
2. LPTHE, Université Pierre & Marie Curie Paris VI, Paris, France.
3. Institute of Mathematical Sciences, Chennai, India.
4. Tata Institute of Fundamental Research, Mumbai, India (on sabbatical leave from Jan–Mar, 2004).

Invited Lectures/Seminars:

1. *NS fivebrane and tachyon condensation*, a seminar at the Centre for Theoretical Physics, MIT, Cambridge, USA.
2. *Hybrid inflation and brane-antibrane system*, Paris area joint string theory seminar.
3. *Noncommutative p-tachyon*, invited seminar in *p-Adic MathPhys 2003* at the Steklov Institute, Moscow, Russia; also in the *National Workshop on String Theory* at the Indian Institute of Technology (Kanpur), Kanpur, India.
4. *Recent progress in p-adic string theory*, seminar at the Institute of Nuclear Research, Moscow, Russia.
5. *Noncommutative solitons in a nonlocal field theory*, a seminar at the Institute of Mathematical Sciences, Chennai, India.
6. *Supersymmetric gauge theories I*, a course of five invited lectures in the *VIII Winter School of APCTP/KIAS on String Theory* at Korea Institute of Advanced Study, Seoul, South Korea.

Academic recognition/Awards:

Awarded the *Invitation Fellowship* (long-term) of the *Japan Society for the Promotion of Science* for the year 2004–05.

Other Activities:

Taught part of the graduate course *Mathematical Physics I* during the semester Aug–Dec, 2003.

Pomita Ghoshal

Research Summary:

During the last one year, I started my research work with Prof. Raj Gandhi in the field of neutrino physics.

- Currently I am working on studies of neutrino oscillations, especially in long-baseline experiments (e.g. MINOS, CERN to Gran-Sasso, Fermilab to SLAC). This involves an understanding of matter effects on neutrino oscillations.

  The evolution equation for neutrinos in matter can be solved analytically in the constant density approximation. We have tried to obtain analytic expressions for oscillation probabilities in constant density matter using certain approximations, and compared them with the results of a full numerical integration of the evolution equation.

  The PREM profile is used to obtain density profiles along the baseline as the neutrino beam passes through the earth, as well as to compute the relevant average density for a given baseline.

  The oscillation probabilities are useful in determining the neutrino mixing parameters, after accounting for certain degeneracies in the measurements. Recently we have focussed on muon neutrino survival probabilities as a probe for the determination of oscillation parameters.

- I have also been involved in calculations involving decay rates of polarized muons yielding muon neutrinos in neutrino factories. The standard expressions for energy and angular distribution of the emitted leptons include the muon mass and polarization, but neglect electron and neutrino masses and average over their polarizations. We have been trying to determine the distribution as a function of electron and finally neutrino masses and helicities. The object is to get some idea of the probability of obtaining wrong helicity neutrinos in such decays. This study may be expected to provide some insight into the Dirac/Majorana nature of neutrinos.

Conference/Workshops Attended:

- 19th Main SERC School on Theoretical High Energy Physics, University of Rajasthan, Jaipur (9th-28th February, 2004)
- International Conference on Perspectives in Particle Physics, Gravitation and Cosmology, Physical Research Laboratory, Ahmedabad (30th March-3rd April, 2004)

Other Activities:

- Worked as a tutor for the course taken by Raj Gandhi in Quantum Mechanics for first year students in H.R.I (August - December, 2003).

Rajesh Gopakumar

Research Summary:

In the last year I have continued my study of the relation between gauge theories and string theories.

In particular, my goal has been to answer the question of how exactly a gauge theory (in the large N limit) can reorganise itself into a dual closed string theory. Moreover, we would like to see if there is a systematic procedure which enables one to contruct the string theory starting from the field theory.

I have made some progress towards this end in the last year. In a couple of papers I have studied how free field theories in the large N limit can be reorganised into closed string theories. The answer comes via implementing the geometric idea of open-closed string duality on the field theory diagrams. To do so, a proper time parametrisation of field theory amplitudes is useful.

I show that this parametrised representation can be organised in a way which manifests the sum over Feynman graphs of the field theory as actually a sum over the two dimensional worldsheets underlying the dual closed string theory. In fact, this procedure also enables us to access the correlators of the two dimensional worldsheet theory of the string. This contains, in principle, all the information to construct the dual closed string theory. I have shown how the expected AdS structure of the closed string theory emerges from a study of two and three point functions.

At present I am engaged in developing this program further so as to be able to extract useful information about the dual string theory which might otherwise be inaccessible.

Publications:

1. R. Gopakumar, "From Free Fields to AdS", hep-th/0308184, (To appear in Phys. Rev. **D** .)

2. R. Gopakumar, "From Free Fields to AdS -II", hep-th/0402063, (To appear in Phys. Rev. **D** .)

Conference/Workshops Attended:

1. Amsterdam workshop on Quantum Gravity and String Theory,
University of Amsterdam, Jun. 2003.

2. Second Crete Regional meeting on String Theory
Kolymbari, Greece, Jun. 2003.

3. Strings 2003, Kyoto, Japan, July 2003.

4. IPM String School and Workshop 2003,
Anzali, Iran, Sep. 2003.

5. Workshop on Geometry and Topology Inspired by Physics,
University of Kochi, Dec. 2003.

6. National Workshop on String Theory, I.I.T. Kanpur, Dec. 2003.

Visits to other Institutes:

1. Harvard University, Cambridge, USA (March, 2003).
2. Rutgers University, USA (April, 2003).
3. Institute for Advanced Study, Princeton, USA, (April-June, 2003).
4. University of Amsterdam, The Netherlands, (June 2003, Apr. 2004).
5. I.I.T. Kanpur, (July 2003, Jan-Feb. 2004).
6. Saha Instt. of Nuclear Physics (Oct. 2003).
7. University of Paris VI, France (Mar. 2004).
8. Trinity College, Dublin, Ireland (Mar. 2004).

Invited Lectures/Seminars:

1. Seminar, IAS, Princeton, (May 2003).
2. Seminar, Amsterdam Workshop on String Theory, (Jun. 2003).
3. Lecture series at Second Crete Regional meeting on String Theory Kolymbari, Greece, (Jun. 2003).
4. Lecture Series at IPM String School and Workshop 2003, Anzali, Iran, (Sep. 2003).
5. Colloquium and Seminar, Saha Instt. of Nuclear Physics (Oct. 2003).
6. Colloquium, HRI, (Nov. 2003).
7. Lecture at Workshop on Geometry and Topology Inspired by Physics, University of Kochi, (Dec. 2003).
8. Lectures at National Workshop on String Theory, I.I.T. Kanpur, (Dec. 2003).
9. Seminar, University of Paris VI, France (Mar. 2004).
10. Public lectures on "Gauge Theory and Gravity" at Hamilton Institute March Meeting, Trinity College, Dublin, (Mar. 2004).

Other Activities:

Was one of the organisers of the "Eighth APCTP Winter School on String theory", Seoul, Korea, (Feb. 2003).

Srubabati Goswami

Research Summary:

The physics implications of the second phase data from the SNO experiment have been examined. The effect of these data on the allowed ranges of the solar neutrino oscillation parameters, Δm^2_{21} and $\sin^2\theta_{12}$, are studied in the cases of two- and three- neutrino mixing. In the latter case we obtain an upper limit on the angle θ_{13}. Constraints on the solar ν_e transitions into a mixture of active and sterile neutrinos are also presented. Finally, we give predictions for the day-night asymmetry in the SNO experiment, for the event rate in the BOREXINO and LowNu experiments, and discuss briefly the constraints on the solar neutrino oscillation parameters which can be obtained with prospective KamLAND

A new reactor power plant Shika-2, with a power of approximately 4 GW and at a distance of about 88 km from the KamLAND detector is scheduled to start operating in March 2006. We have studied the impact of the $\bar{\nu}_e$ flux from this reactor on the sensitivity of the KamLAND experiment to the solar neutrino oscillation parameters. We present results on prospective determination of $\Delta m^2_{\odot}$ and $\sin^2\theta_{\odot}$ using the combined data from KamLAND and the solar neutrino experiments, including the effect of the Shika-2 contribution to the KamLAND signal and the latest data from the salt enriched phase of the SNO experiment. We found that contrary to the expectations, the addition of the Shika-2 reactor flux does not improve the $\sin^2\theta_{\odot}$ sensitivity of KamLAND, while the ambiguity in $\Delta m^2_{\odot}$ measurement may even increase, as a result of the averaging effect between Kashiwazaki and the Shika-2 reactor contributions to the KamLAND signal.

We have also studied the physics potential of the KamLAND detector in probing neutrino oscillation parameters through observation of supernova neutrinos. In particular, we discuss the possibilities of probing the mixing angle θ_{13} and determining the sign of Δm^2_{32} from the total charged current(CC) event rates on the proton and ^{12}C target, as well as from the CC spectra. We discuss the chances of probing the earth matter effect induced modulations from the observation of CC spectra in the different CC reactions in KamLAND and find the volume required to get a statistically significant signature of the earth matter effect in different energy bins. We also calculate the event rates expected in the neutral current (NC) reactions on Carbon and free proton and investigate if the charged current to neutral current ratios, which are free of the absolute luminosity uncertainty in the supernova neutrino fluxes, can be useful in probing the oscillation parameters.

Publications:

1. Constraints on neutrino oscillation parameters from the SNO salt phase data.
   A. Bandyopadhyay, S. Choubey, S. Goswami, S. T. Petcov and D. P. Roy, Phys. Lett. B **583**, 134.

2. On the measurement of solar neutrino oscillation parameters with KamLAND
   A. Bandyopadhyay, S. Choubey, S. Goswami and S. T. Petcov,
   arXiv:hep-ph/0309236,
   Phys. Lett. B 581, 62, (2003).

3. Exploring the sensitivity of current and future experiments to $\theta(\odot)$
   A. Bandyopadhyay, S. Choubey,S. Goswami, arXiv:hep-ph/0302243, to appear in Phys. Rev. D. Phys. Rev. D **67** 113011, (2003).

Preprints:

1. Prospects of probing theta(13) and neutrino mass hierarchy by supernova neutrinos in KamLAND, A. Bandyopadhyay, S. Choubey, S. Goswami and K. Kar, arXiv:hep-ph/0312315

2. Solar neutrino oscillation parameters after KamLAND S. Goswami, A. Bandyopadhyay and S. Choubey, arXiv:hep-ph/0312028.

3. Solar Neutrinos and 1-3 mixing S. Goswami and A. Y. Smirnov, (in preparation).

Conference/Workshops Attended:

1. NANP' 03, Institute of Nuclear Research, Dubna, Russia, June 2003.

2. Discussion Meeting on Neutrinos, PRL , Ahmedabad

3. Workshop on High energy Physics, IIT, Mumbai

Visits to other Institutes:

1. Saha Institute of Nuclear Physics, Calcutta
   1st - 3rd April, 1st -7th July, 2003.

2. SISSA, Trieste, 3rd - 20th June, 2003.

3. PRL, Ahmedabad, August 2003

4. ICTP, Trieste, 9th September - 3rd November, 2003.

5. Tata Institute of Fundamental Research, Mumbai 5th - 7th November, 2003

6. IIT, MUmbai 3rd - 14th January, 2004

Invited Lectures/Seminars:

1. Solar neutrino oscillation parameters after KamLAND ,NANP, DUbna, Russia, June 2003
2. Solar neutrino oscillation parameters after KamLAND , PRL, Ahmedabad, August 2003
3. Precision Measurement of solar neutrino oscillation parameters , ICTP, Trieste, October 2003
4. Precision Measurement of solar neutrino oscillation parameters TIFR, Mumbai, November 2003
5. Global Analysis of Neutrino Oscillation , PRL, Ahmedabad , March, 2004

Other Activities:

1. I have acted as the joint Co-ordinator, Astroparticle Physics group in WHEPP8, IIT, Mumbai January 2004.
2. I have taught the course on Mathematical Methods-II to first year graduate students.
3. Served in the computer committee and the medical committee as a member.

Alok Chandra Gupta

Research Summary:
Most of my research interest for the last few years have been *Multi-wavelengths variability of different classes of Active Galactic Nuclei* and *Photometric studies of Star Clusters in the Milky Way*.

Optical Photometric Observations of $\gamma-$Ray Loud Blazars
We reported results of our optical photometric observations of ten gamma-ray loud blazars namely: 0219+128 (3C66A), PKS 0420-014 (OA 129), S5 0716+714, 0754+100 (OI 090.4), 0827+243 (OJ 248), 1652+398 (Mrk 501), 2200+120 (BL Lacertae), 2230+114 (CTA 102), 2251+158 (3C 454.3) and 2344+514. The observations were carried out in September − October 2000 using the 70 cm optical telescope at Abstumani Observatory, Georgia. We found intra-day variations in PKS 0420-014, S5 0716+714, BL Lacertae and CTA 102. A variation of 0.3 magnitude over a time scale of about 3 hours was observed in the R passband in BL Lacertae on JD 2451827. We did not detect any variation in 3C66A, Mrk 501 and 3C454.3 during our observations. We did not detect any clear evidence of variation in 1ES 2344+514 during our two weeks observing run of the TeV gamma-ray source.

Near Infrared Intra-day Variability of Mrk 421
We reported results from our monitoring of the BL Lac object Mrk 421 in the near-IR J band. The observations, aimed at studying the intra-day variability (IDV) of the object, were carried out systematically over an extended (and near-continuous) period of eight nights from the 1.2 meter Mount Abu Infrared Telescope, India. There are limited studies for Mrk 421 in the J band for such an extended period. The observation epoch for this study (25 February - 5 March 2003) was chosen to significantly overlap other concurrent studies of Mrk 421 in the X-ray/γ-ray regions being conducted using the Rossi X-ray timing explorer (RXTE) and the solar tower atmospheric Cherenkov effect experiment (STACEE). Hence these results could be useful for a multi-wavelength analysis of the variability behavior of Mrk 421. We find that Mrk 421 was quite active during the observed period and showed significant IDV and short term variability. A maximum variation of 0.89 magnitudes is seen over the entirety of the observed period. Flaring activity, with typical brightness variations of ~ 0.4, are also seen on several occasions. The extent of the variability observed by us is compared with the results of other similar studies of Mrk 421 in the J band.

Intra-night Optical Variability of BL Lacs, Radio-Quiet Quasars and Radio-Loud Quasars
We reported monitoring observations of 20 high-luminosity active galaxies, 12 of which are radio-quiet quasars (RQQs). Intra-night optical variability (INOV) was detected for 13 of the 20 AGN, including 5 of the 12 RQQs. The variations are stronger and more frequent for blazars than for RQQs, which is in accord with our recently reported results for another sample. By combining these data with the INOV results obtained earlier in our programme, we have formed an enlarged sample consisting of 9 BL Lacs, 19 RQQs and 11 lobe-dominated radio-loud quasars (LDQs). The moderate level of INOV found for both RQQs and LDQs shows that INOV is not directly linked to the presence of radio emission. Further, we supplemented these new observations of 3 BL Lacs with additional data from the literature for 17 other BL Lacs. In this extended sample of 20 BL Lacs, stronger INOV is found for the *EGRET* detected subset.

Publications:
1. Optical Photometric Observations of $\gamma-$Ray Loud Blazars,
J. H. Fan, O. M. Kurtanidze, M. G. Nikolashvili, **A. C. Gupta**, J. S. Zhang & Y. H. Yuan
(2004), Chin. J. Astron. Astrophys., **4**, 133-142
2. Near Infrared Intraday Variability of Mrk 421,
A. C. Gupta, D. P. K. Banerjee, N. M. Ashok & U. C. Joshi
(2004), *Astronomy & Astrophysics*, (in press)
3. Intra-night Optical Variability of BL Lacs, Radio-Quiet Quasars and Radio-Loud Quasars,
C. S. Stalin, **Alok. C. Gupta**, Gopal-Krishna, Paul J. Wiita & Ram Sagar
(2004) (submitted to Monthly Notices Roy. Astron. Soc.)

Preprints:
1. CCD Photometric Observations of the Galactic Globular Clusters NGC 1904 and NGC 6341,
A. C. Gupta (astro-ph 0311443)
2. Near Infrared Intraday Variability of Mrk 421,
A. C. Gupta, D. P. K. Banerjee, N. M. Ashok & U. C. Joshi (astro-ph 0405186)

Conference/Workshops Attended:
1. Advanced School on the Physics of Galaxy Formation during December 16$-$30, 2003 at HRI, Allahabad.

Visits to other Institutes:
1. State Observatory, Nainital during September 02−07, 2003.
2. Physical Research Laboratory (PRL), Ahmedabad during February 01−14, 2004.
3. Tata Institute of Fundamental Research (TIFR), Mumbai during April 26−28, 2004.
4. Physical Research Laboratory (PRL), Ahmedabad during May 09 to June 05, 2004.

Invited Lectures/Seminars:
1. Variability in different classes of Active Galactic Nuclei, April 27, 2004 at Tata Institute of Fundamental Research (TIFR), Mumbai.

Academic recognition/Awards:
1. I am the principal investigator in the project *Optical and Near Infrared Observations of Blazars*. Telescope time during May 10-20, 2004 was alloted to our project for observations on 1.2 meter PRL Optical/IR telescope at Gurushikhar, Mount Abu.

3. Other Activities:
(i) Teaching:
A complete course on Multi-wavelength Observations and Data Analysis Techniques at HRI in the year 2003−2004.
(ii) Project Supervised:
Mr. Abhay Kumar Gupta from Department of Information Technology, Meerut Institute of Engineering and Technology, Meerut spent 2 months (July − August, 2003) at HRI and did Project on *Online Multi-wavelength Database for Blazars*.

Partha Konar

Research Summary:

During the period of last one year my research work have been focused mainly on two issues of looking for signals of physics beyond the standard model of particle physics. In the context of supersymmetry searches, we have continued further investigations, where the relevance of vector boson fusion (VBF) mechanism have been pointed out at hadronic collider. Secondly, I am also working on the ADD (Arkani-Hamed, Dimopoulos and Dvali) and RS (Randall-Sundrum) models with Extra spatial dimensions, which has been proposed as a solution to the hierarchy problem. Some new signals of such theories were investigated in the context of a proposed high energy e^+e^- linear collider. We are presently investigating some more possibilities to identify RS type graviton and their decay.

Recently, we showed [**Publications 1**] that charged slepton pairs produced via vector-boson fusion along with two high-mass, high-p_T forward/backward jets (in two opposite hemispheres) can have a higher production cross-section for heavy slepton masses than that from conventional Drell-Yan production at a hadronic collider. Thus, we concluded after a detailed simulation,it can improve the mass reach of slepton search at LHC.

From the feedback of our previous result, we investigated whether stau pairs produced via vector-boson fusion can be effective to discover Supersymmetric scenarios with inverted mass hierarchy [**preprint 1**], which is difficult to observe at a hadron collider. This turns out to be an interesting channel to study both in a model-independent way and with reference to some specific, well-motivated models. The mass reach at LHC are expected to be substantially hiked in this manner.

We studied [**Publications 2**] the process $e^+e^- \to e^+e^-$ + missing energy at a high-energy e^+e^- collider, where the missing energy arises from the radiation of Kaluza-Klein gravitons in a model with large extra dimensions. It is shown that at a high-energy linear collider, this process can not only confirm the signature of such theories but can also sometimes be comparable in effectiveness to the commonly discussed channel $e^+e^- \to \gamma$ + missing energy, especially for a large number of extra dimensions and with polarized beams. We also suggest some ways of distinguishing the signals of a graviton tower from other types of new physics signals by combining data on our suggested channel with those on the photon-graviton channel.

Preprints:

1. **Gauge boson fusion as a probe of inverted hierarchies in supersymmetry.**
   with *Biswarup Mukhopadhyaya.*
   e-Print Archive: hep-ph/0311347

Publications:

1. **Slepton production from gauge boson fusion.**
   with *Debajyoti Choudhury, Anindya Datta, Katri Huitu, Stefano Moretti, Biswarup Mukhopadhyaya.*
   e-Print Archive: hep-ph/0304192
   Published in *Phys.Rev.***D68**:075007, 2003

2. **Bhabha Scattering with Radiated Gravitons at Linear Colliders.**
   with *Sukanta Dutta, Biswarup Mukhopadhyaya, Sreerup Raychaudhuri.*
   e-Print Archive: hep-ph/0307117
   Published in *Phys.Rev.***D68**:095005, 2003

Conference/Workshops Attended:

1. Workshop on High Energy Physics Phenomenology, (WHEPP-8) during 5 -16 January, 2004 at Indian Institute of Technology, Mumbai.

2. 6th ACFA-LC workshop during 15-17 December, 2003 at TIFR, Mumbai.

3. 57th Scottish Universities Summer School in Physics on LHC Phenomenology during 17-29 August 2003 at St. Andrews, Scotland.

Visits to other Institutes

1. Visited Department of High Energy Physics, TIFR, Mumbai during 18th Dec. to 4th Jan. 2004.

2. Visited School of Physics and Astronomy, University of Southampton, England during 29th Aug. to 5th sept. 2003.

Invited Lectures/Seminars:

1. '*Search for Supersymmetry through Vector Boson Fusion*' a 'Free Meson seminar' on Feb. 2004 at TIFR, Mumbai.

2. '*Associated Graviton production in Bhabha Scattering at Linear Colliders*' Dec. 2003 at 6th ACFA-LC workshop at TIFR, Mumbai.

3. '*Signals of Supersymmetry in Vector Boson Fusion*' Sep. 2003 at the Department of Physics and Astronomy, University of Southampton, Southampton, England.

Other Activities:

1. Seminar *'Supersymmetric signals in Vector Boson Fusion'* March 23, 2004 at HRI.

Sanjeev Kumar

Research Summary:

Motivated by the experiments on the manganites, we are working on problems involving the lattice fermions strongly coupled to the classical spins and the adiabatic phonons. The manganite physics is extremely rich and a wide variety of phases and phenomena have been observed in the experiments. The theoretical understanding, however, is far from complete. The main difficulty seems to be the lack of reliable many body methods for handling such strong coupling problems.
Given all the complexities, the monte-carlo simulations seem to be the only unbiased method to study such problems. Unfortunately, the standard Exact-Diagonalisation based monte-carlo is extremely costly in terms of cpu time and restricts us to very small lattice sizes ($N \sim 100$). Although ED+MC on small sizes can give us insight into the thermodynamic properties, it is simply not good enough to make statements about the nature of transport properties of the system.
Over the last few years we have developed many-body methods for handling the strong coupling Classical-Quantum problems. These methods retain all the features of the ED+MC but try to access larger sizes. These have been successfully used by us for studying some outstanding problems relevant to the manganites and other strongly correlated systems. Here I briefly describe the two methods that we have recently developed and used.

(1) The Effective Hamiltonian Approach:
In the ED+MC approach a single update of the classical variable requires the full solution of the Schroedinger Equation. In a typical Monte-Carlo study one needs a large number of updates on classical variables before the system is in statistical equilibrium. This means that the time required by this approach $\tau_N \sim N_{MC}N^4$ leading to $N_{max} = 100$. In some models it is possible to write out the effective Hamiltonians (H_{eff})for the Classical Variables, with the parameters specified by the expectation values of the electronic operators in a state which in turn is determined by the H_{eff} itself. This leads to a coupled problem which needs to be solved self-consistently. The advantage is that the monte-carlo update now requires comparing classical energies which is $O(1)$ process in contrast to the $O(N^3)$ diagonalisation and one can easily study systems which are an order of magnitude larger than the N_{max} for ED+MC . The detailed form of the Effective Hamiltonian is model dependent. We have used this scheme to study :
(a) The Disordered Double Exchange Model.
(b) Double Exchange competing with Superexchange and the effect of weak disorder on the 1st order phase boundary.

(2) Travelling Cluster Approximation (TCA):
In this scheme we propose that in order to update a classical variable x_i, it is enough to look at a cluster Hamiltonian H_c on a lattice L_c^d around the site x_i.

Now the Monte-Carlo update requires diagonalising an Hamiltonian which has much smaller Hilbert space.Remember that a different Hamiltonian (H_c)has to be constructed in order to update a different site. This scheme is ofcourse exact in the limit $L_c \rightarrow L$ and $\tau_N \sim N_{MC} N N_c^3$ so one can again access $N \sim 1000$ with ease. We have studied models involving the interplay of lattice, spin and charge degrees of freedom in the presence of disorder, using the TCA approach.

Publications:

1.Inhomogeneous Ferromagnetism and Unconventional Charge Dynamics in Disordered Double Exchange Magnets: Sanjeev Kumar and Pinaki Majumdar
Phys. Rev. Lett. vol 91, 246602-1 (2003)

2.Nanoscale Phase Coexistence and Percolative Quantum Transport: Sanjeev Kumar and Pinaki Majumdar
Phys. Rev. Lett. vol 92, 126602 (2004)

3. Anti-Localisation to Strong Localisation: The Interplay of Magnetic Scattering and Structural Disorder: Sanjeev Kumar and Pinaki Majumdar
Europhys. Lett. vol 65, 75 (2004)

Preprints:

1. The Travelling Cluster Approximation for Strong Correlation Models of Lattice Fermions Coupled to Classical Fields: Sanjeev Kumar and Pinaki Majumdar
cond-mat/0406082

2. The Many Electron Ground State of the Adiabatic Holstein Model in Two and Three Dimensions: B. Poornachandra Sekhar, Sanjeev Kumar, Pinaki Majumdar
cond-mat/0406083

3. The Interplay of Disorder and Thermal Fluctuations in Strongly Coupled Electron-Phonon Systems: Sanjeev Kumar and Pinaki Majumdar
cond-mat/0406084

4. Metal-Insulator Transitions in the Disordered Holstein-Double Exchange Model in Three Dimension: Sanjeev Kumar and Pinaki Majumdar
cond-mat/0406085

Conference/Workshops Attended:
1. Summer College on Physics and Chemistry of Rare Earth Manganites , June-2003, ICTP, Trieste.
2. A Meeting on Parallel Computing.
Nov. 26-28, 2003 BARC, Mumbai.
3. A Conference on Spintronics.
Dec. 1-2, 2003 BARC, Mumbai.

Invited Lectures/Seminars:
1. Nanoscale Phase Coexistence and Percolative Quantum Transport. Poster at Manganites Conference in ICTP,Trieste.
2. Strong Correlation Models of Lattice Fermions Coupled to Classical Fields.
Thesis Seminar: HRI, Allahabad.

Namit Mahajan

Research Summary:
As we enter the precision era in particle physics, with more and more experiments yielding new and accurate results and improving upon the the older ones, the need to look more closely into the basic theory governing particle interactions can no longer be ignored or postponed. The main focus of my research work during the last one year has been to study two photon decay modes of B-mesons, an area that has become a very fertile and imprtant one to test and enhance our understanding of particle interactions. The two photon modes are expected to be observed in near future and therefore need to be precisely evaluated. Continuing with the previous work in this direction, along with my collaborators, two more decay modes were explored [3,4].
Non-commutative field theories have attracted a lot of interest and activity in the recent past. In [1], some phenomenological aspects were investigated while in [2], PCT theorem, one of the pillars of quantum field theory, was investigated in such a set up.
The unitarity violation in Littlest Higgs models was studied in preprint [1].

Publications:

1. $t \to bW$ IN NONCOMMUTATIVE STANDARD MODEL, **Namit Mahajan**, Phys. Rev. **D68**, 095001,2003 [arXiv: hep-ph/0304235].

2. PCT THEOREM IN FIELD THEORY ON NONCOMMUTATIVE SPACE , **Namit Mahajan**, Phys. Lett. **B569**, 85 ,2003 [arXiv: hep-th/0305105].

3. CP VIOLATION IN THE DECAY MODE $B \to \pi\gamma\gamma$. with S.R.Choudhury (Delhi U.), G.C. Joshi (Melbourne U.), **Namit Mahajan** and B.H.J.McKellar (Melbourne U.), Phys. Rev. **D69**, 054011,2004 [arXiv: hep-ph/0306293].

4. SHORT AND LONG DISTANCE CONTRIBUTIONS TO $B \to K^*\gamma\gamma$. with S.R.Choudhury (Delhi U.), A.S.Cornell (Korea Inst. Advanced Study, Seoul) and **Namit Mahajan**, Phys. Lett. **B580**, 177 (2004) [arXiv: hep-ph/0307104].

Preprints:

1. LITTLEST HIGGS MODEL AND UNITARITY CONSTRAINTS, [arXiv:**hep-ph/0310098**].

Conference/Workshops Attended:

1. 6th ACFA meeting, T.I.F.R., Mumbai (December 2003)

2. 8th WHEPP, I.I.T. Mumbai (January 2004).

Visits to other Institutes:

Department of Physics and Astrophysics, University of Delhi, Delhi.

Other Activities:

1. Two lectures on "Fermat Principle and applications in daily life" under the Raj-Bhasha programme, 2003.
2. Seminar on "PCT theorem and its status in Non-commutative Field Theory", August 2003.
3. Journal Club talk on "Renormalization aspects in Non-anticommuting field theories", September 2003.
4. Journal Club talk on "Littlest Higgs Model" in September 2003.
5. Helped in the organisation of the Talent Search Exam (Physics Part) conducted by HRI in November 2003.
6. An overview talk on "Nucleosynthesis", November 2003.
7. Seminar on "Some two photon decay modes of B-mesons", February 2004.

Pinaki Majumdar

Research Summary:

The work over the last academic year continues our studies on magnetism and transport in correlated and disordered electron systems. We have formulated a new approach for lattice fermions strongly coupled to classical degrees of freedom, which allows a breakthrough in the simulation of these complex systems. We call this the 'travelling cluster approximation' (TCA). This paper, as well as several studies on electron-phonon systems and magnetism using TCA, are listed below.

1. THE TRAVELLING CLUSTER APPROXIMATION FOR STRONG CORRELATION MODELS OF LATTICE FERMIONS COUPLED TO CLASSICAL FIELDS.
We suggest and implement a new Monte Carlo strategy for correlated models involving fermions strongly coupled to classical degrees of freedom, with accurate handling of quenched disorder as well. Current methods iteratively diagonalise the full Hamiltonian for a system of N sites with computation time $\tau_N \propto N^4$. This limits achievable sizes to $N \sim 100$. In our method the energy cost of a Monte Carlo update is computed from the Hamiltonian of a cluster, of size N_c, constructed around the reference site, and embedded in the larger system. As MC steps sweep over the system, the cluster Hamiltonian also moves, being reconstructed at each site where an update is attempted. In this method τ_{N,N_c} is proportional to NN_c^3. Our results are obviously exact when $N_c = N$, and converge quickly to this asymptote with increasing N_c. The accuracy improves in systems where the effective disorder seen by the fermions is large. We provided results of preliminary calculations on the Holstein model and the Double Exchange model. The 'locality' of the energy cost, as evidenced by our results, suggests that several important but inaccessible problems can now be handled with control.

2. THE MANY ELECTRON GROUND STATE OF THE ADIABATIC HOLSTEIN MODEL IN TWO AND THREE DIMENSIONS.
We present the complete ground state phase diagram of the Holstein model in two and three dimension considering the phonon variables to be classical. We first establish the overall structure of the phase diagram by using exact diagonalisation based Monte Carlo (ED-MC) on small lattices and then use the TCA for annealing the phonon degrees of freedom on large lattices. The phases that emerge include a Fermi liquid (FL), with no lattice distortions, an insulating polaron liquid (PL) at strong coupling, and a charge ordered insulating (COI) phase around half- filling. The COI phase is separated from the Fermi liquid by a regime of phase coexistence whose width grows with increasing electron-phonon coupling. We provide results on the electronic density of states, the COI order parameter, and the spatial organisation of polaronic states, for arbitrary density and electron-phonon coupling. The results highlight the crucial role of spatial correlations in this strong coupling problem.

3. THE INTERPLAY OF DISORDER AND THERMAL FLUCTUATIONS IN STRONGLY COUPLED ELECTRON-PHONON SYSTEMS.
We solve the disordered Holstein model in three dimension considering the phonon degrees of freedom to be classical. We map out the various phases of the 'clean' strong coupling problem, study the formation and 'melting' of the charge ordered (CO) state with temperature (T) and electron density, and uncover a wide regime of phase separation between the CO state and the Fermi liquid. We then quantify the effect of moderate disorder at strong coupling. In the metallic regime, the interplay of disorder and electron-phonon coupling (i) enormously enhances the resistivity (ρ) at $T = 0$, (ii) suppresses the temperature dependent increase of ρ, and (iii) leads to a regime with $d\rho/dT < 0$. Close to half-filling, the CO phase is rapidly suppressed with increasing disorder. These effects underlie phenomena in materials ranging from the A-15 compounds to transition metal oxides.

4. METAL-INSULATOR TRANSITIONS IN THE DISORDERED HOLSTEIN-DOUBLE EXCHANGE MODEL IN THREE DIMENSION.
We study a three dimensional model of electrons strongly coupled to classical phonons and core spins in the presence of substitutional disorder. We establish the phase diagram using a Monte Carlo technique on large lattices and present results on transport using exact linear response theory. We demonstrate how thermally driven metal-insulator transitions arise in this model from the interplay of lattice polaron effects, spin fluctuations, and extrinsic disorder. We also map out the dependence of the ferromagnetic T_c, the residual resistivity, and the optical spectral weight, on electron-phonon (EP) coupling and disorder. The results highlight the crucial role of both EP coupling and disorder, in addition to double exchange, for even a qualitative understanding of the metallic manganites, and help organise a wide variety of experimental results.

Publications:

1. *Inhomogeneous Ferromagnetism and Unconventional Charge Dynamics in Disordered Double Exchange Magnets*,
Sanjeev Kumar and Pinaki Majumdar,
Phys. Rev. Lett. **91**, 246602-1 (2003).

2. *Nanoscale Phase Coexistence and Percolative Quantum Transport*,
Sanjeev Kumar and Pinaki Majumdar,
Phys. Rev. Lett. **92**, 126602 (2004).

3. *Anti-localisation to Strong Localisation: the Interplay of Magnetic Scattering and Structural Disorder*,
Sanjeev Kumar and Pinaki Majumdar,
Europhys. Lett. **65**, 75 (2004).

Preprints:

1. *The Travelling Cluster Approximation for Strong Correlation Models of Lattice Fermions Coupled to Classical Fields*, Sanjeev Kumar and Pinaki Majumdar, cond-mat 0406082.

2. *The Many Electron Ground State of the Adiabatic Holstein Model in Two and Three Dimensions*, B. Poornachandra Sekhar, Sanjeev Kumar and Pinaki Majumdar, cond-mat 0406083.

3. *The Interplay of Disorder and Thermal Fluctuations in Strongly Coupled Electron-Phonon Systems*, Sanjeev Kumar and Pinaki Majumdar, preprint, cond-mat 0406084.

4. *Metal-Insulator Transitions in the Disordered Holstein-Double Exchange Model in Three Dimension*, Sanjeev Kumar and Pinaki Majumdar, cond-mat 0406085.

Other Activities:

I taught the graduate course in Statistical Mechanics (Jan-May 2004), and organised the Physics Talent Search test.

Invited Lectures/Seminars:

1. Two lectures at I.I.Sc Bangalore in Aug 2003: (i) *Strong Correlation Models of Fermions Coupled to Classical Degrees of Freedom* and (ii) *Nanoscale Phase Coexistence*.
2. Lecture ay I.M.Sc Chennai: *Nanoscale Phase Coexistence, Percolative Transport, and Memory Effects*, Aug. 2003.
3. Lecture in the 'Novel Materials' Conference, Jan 2004 at SNBNCBS Calcutta, *Phase Coexistence and Percolative Quantum Transport*.
4. Lecture at I.I.T Roorkee, March 2004: *Phase Competetion and Quantum Transport in Correlated Electron Systems.*

Satchidananda Naik

Research Summary:

The Non-Perturbative $\mathcal{N} = 2$ SUSY Yang-Mills Theory from Semiclassical Absorption of Supergravity by Wrapped D Branes

Recently the gauge theory/gravity duality , which is commonly known as Ads/CFT duality is extended to non-conformal pure $\mathcal{N} = 1$ or $\mathcal{N} = 2$ supersymmetric Yang -Mills (SYM) theories. So far the perturbative behavior of the $\mathcal{N} = 2$ SYM is produced by this duality. The conventional folklore is that the instantons which are responsible for the non-perturbative part of the pre-potential are suppressed in the large N limit (since the gauge gravity duality is valid only in the large N limit). Since the wrapped D5 branes are far from being conformal, the usual holographic description of bulk-boundary connection is quite subtle to extract all the properties of SUSY Yang-Mills theories. This fact led us to wonder about other ways of getting complete picture of the non-perturbative solution of the SUSY Yang-Mills from gravity. It is a fact in quantum field theory that the absorption/emission cross section of particles is always given by the discontinuities of the two point functions of the currents to which the field couples. To be precise, if the interaction Lagrangian is $S_{\rm int} = \int d^4x\, \varphi(x)\, \mathcal{J}(x)$ then the cross section is

$$\sigma = \frac{1}{2i\omega} Disc\, \Pi(p)\Big|_{\substack{p^0=\omega \\ \vec{p}=0}}, \tag{0.1}$$

where

$$\Pi(p) = \int d^4x\, e^{ip\cdot x} \langle \mathcal{J}(x)\mathcal{J}(0)\rangle. \tag{0.2}$$

The trace of the energy-momentum tensor, the γ trace of the super current and the divergence of $U(1)$ axial current due to the R-symmetry form different components of the superconformal anomalous current $J_{\alpha\dot{\alpha}}$ and its super divergence $\bar{D}^{\dot{\alpha}} J_{\alpha\dot{\alpha}}$ is classically zero however possesses anomaly. More explicitly

$$\begin{aligned}
\langle \sqrt{g}\ \theta^{\mu}_{\mu}\rangle \quad &= \frac{1}{2}\frac{\beta(g)}{g^3}\left(F^a_{\mu\nu}\right)^2 \ + \frac{c(g^2)}{16\pi^2}\left(W_{\mu\nu\rho\sigma}\right)^2 \ - \frac{a(g^2)}{16\pi^2}\left(\tilde{R}_{\mu\nu\rho\sigma}\right)^2 \\
\langle \partial^{\mu}\sqrt{g}R_{\mu}\rangle \quad &= -\frac{\beta(g)}{3g^3}\left(F^a_{\mu\nu}\tilde{F}^{a\,\mu\nu}\right) + \frac{c(g^2)-a(g^2)}{24\pi^2}\left(\tilde{R}R\right) \\
\langle \sqrt{g}\gamma^{\mu}\mathcal{S}_{\mu}\rangle \quad &= \frac{1}{2}\frac{\beta(g)}{g^3}\left[(\sigma_{\mu\nu}\lambda^a F^{a\mu\nu}) + \frac{1}{2}R^{\mu\nu\rho\sigma}\sigma_{\rho\sigma}\left(D_{\mu}\psi_{\nu} - D_{\nu}\psi_{\mu}\right) - \left(\epsilon^{\mu\nu\rho\sigma}\gamma_5\psi_{\mu}A^a_{\nu}F^a_{\rho\sigma}\right)\right].
\end{aligned} \tag{0.3}$$

where $\beta(g)$ is the beta function of SYM, $a(g)$ and $c(g)$ are central functions near the criticality, $W_{\mu\nu\rho\sigma}$ is the Weyl tensor and $\tilde{R}_{\mu\nu\rho\sigma}$ is the dual of the curvature

tensor and ψ_μ is the gravitino field. We first derive the world volume action of the wrapped D5 brane where these currents are minimally coupled to the ten dimensional supergravity fields. We show the absorption of dilaton, fluctuating part of RR-2 forms and the gravitino by the world volume of wrapped D5 branes and evaluate the central functions. Consequently we derive the equation relating the pre-potential with the vacuum expectation of the anomaly multiplet.

Publications:

The Non-Perturbative $\mathcal{N} = 2$ SUSY Yang-Mills Theory from Semiclassical Absorption of Supergravity by Wrapped D Branes [JHEP 06 (2004) 022]

Invited Lectures/Seminars:

The Non-Perturbative $N = 2$ SUSY Yang-Mills from Supergravity,
seminar given at Institute of Physics Bhubaneswar

Courses given:
Advanced Particle Physics at HRI in 1st Semester

Sudhakar Panda

Research Summary: We studied a String theory inspired model for hybrid inflation in the context of a brane-antibrane system partially compactified on a compact submanifold of a Calabi-Yau manifold.Inthis scenario, the time dependent scalar field representing the interbrane separation plays the role of an inflaton field, whereas, the end of the inflationary epoch is brought about by the rapid rolling of the tachyon field. The number of e-foldings is sufficiently large and is controlled by the initial conditions. However, the slow-roll parameters are determined by the geometry. The primordial density fluctuation is found to be consistent with current observational data for reduced string scale. (work with D. Choudhury, D. Ghoshal and D.P. Jatkar).

We continued our investigation on De Sitter solution by analysing the scalar potential and mass-matrix of gauged N=4 supergravity with matter (with six matter multiplets), extending our previous work by including the dependence of all the scalars describing the scalar manifold of the theory. We considered various semi-simple groups for gauging and studied the corresponding potential, its first and second derivatives at the origin of the scalar manifold. For a number of gauge groups, we found extrema with positive cosmological constant. (work with M. deRoo, D. B. Westra and M. Trigiante).

Publications:

(1) Choudhury D., Ghoshal D, Jatkar D.P. and Panda S., Hybrid Inflation and Brane-Antibrane System, JCAP 07 (2003) 009.

(2) de Roo M., Panda S., Trigiante M. and Westra D.B., Potential and mass-matrix in gauged $N = 4$ supergravity, JHEP 11 (2003) 022.

Preprints:

(1) Hybrid Inflation and Brane-antibrane system, D. Choudhury, D. Ghoshal, D.P. Jatkar and S. Panda, hep-th/0305104.

(2) Potential and mass-matrix in gauged N=4 supergravity, M. de Roo, S. Panda, D.B. Westra and M.Trigiante, hep-th/0310187.

Conference/Workshops Attended:

(1) Field Theory Aspects of Gravity, Pelling, Sikim India (2004).

(2) "Dirac Centenary Seminar" on Contemporary Trend in Physics, Sambalpur Univ. Orissa, India (2004).

Visits to other Institutes:

(1) TIFR, Mumbai (2003).

(2) University of Groningen, The Netherlands (2003).

(3) Abdus Salam ICTP, Trieste, Italy (2003)

(4) Sambalpur Univ, Orissa (2004).

Invited Lectures/Seminars:

(1) De Sitter Solution in four dimensional SUGRA Theory; TIFR, Mumbai.

(2) De Sitter solution in gauged N=4 supergravity; ICTP, Trieste.

(3) In Search of Unified Theory; Sambalpur University, Orissa.

Other Activities:

Taught Advanced Quantum Mechanics, 2nd Sem. Course at HRI.

Tribhuvan P. Pareek

Research Summary:

My main research has been focused on spin and charge transport in mesoscopic systems. Though the charge transport has been well studied using Landauer-Büttiker formalism but for spin transport there is no consistent theory yet. The main question has been the what is the spin current for mesoscopic devices. The standard way to define spin currents is to subtract up spin current from down spin current for a given quantization axis. However this only gives a part of spin current. To resolve these issues I generalized Landauer Buttiker theory for multi-terminal spin transport as well [1]. This study led to the following important results namely a) One can have equilibrium spin currents consistent with charge conservation and time reversal symmetry. b) The spin currents can be generated intrinsically using spin orbit interaction, hence one can avoid the spin injection problem altogether c) further in multi-terminal transport , pure spin currents (no accompanying charge current) can be generated and measured.

Further I am looking at equilibrium spin currents in mesoscopic systems and the work is under progress. The published work[1] just argues that it can exist without violating any basic physics. However to have a better understanding a detailed study is required which is under progress.

I have also proposed a new absolute spin valve device[2]. In the standard spin valve devices a two ferromagnetic contact are attached to a non-magnetic spacer layer. The conductance of such device depends on the relative orientation of magnetization direction. However in presence of spin orbit interaction, one does not need two ferromagnetic contacts rather one ferromagnetic contact is enough to show spin valve effect. Now it depends on the absolute direction of magnetization since the presence of spin orbit interaction breaks the rotational invariance in spin space.

Further I am at present in the processes of completing a manuscript on three terminal analog spin transistor. This again exploits the analog freedom available for magnetization to point in any arbitrary direction which is rather different from digital. The manuscript is under preparation and would be soon submitted for publication.

Publications:

1. Pure spin currents and associated electrical voltage, T. P. Pareek, Phys. Rev. Lett. **92**, 076601 (2004).

2. Absolute spin valve effect: Charge transport in two dimensional hybrid system, T. P. Pareek, accepted for publication in PRB.

Preprints:

Quantum Beating of Ballistic conductance, T. P. Pareek submitted for publication.

Invited Lectures/Seminars:

A seminar on "decoherence and dephasing in four terminal mesoscopic rings" was given in the Literature Chat prog. at HRI.

Other Activities:

Four students spent four weeks each here during summer and winter and did reading projects on the following topics a) Negative refractive index and Left handed materials b) Quantum computation and no cloning theorem and its relation with Heisenberg uncertainty relation c)Spintronics and d) Berry phase due to spin orbit interaction. These are the topics where I would like to diversify in future. The students were Moitri Maiti (Jadavpur University), Manhoar Shivum (Dhanbad) T. V. Chandrasekhar (Madaras), K. Malathi (Hyderabad) and a student from Indian Institute of Information Technology Gawalior.

Jayanti Prasad

Research Summary:

I have been working on a problems related to formation of large scale structure in the Universe. This work is mainly done numerically, for which we are using N-body codes. Under this study I have done following short projects.

- PM code :- I wrote a particle mesh (PM) code and checked it for various power law models.

- Adhesion approximation :- Adhesion approximation gives a way to prevent the thickening of pancake in the Zeldovich approximation by invoking an artificial viscosity. In this approximation particles stick together when they come close to each other in place of crossing, due to viscosity and pancake remains thin. Mathematically this leads to the Burger's equation. In the small viscosity limit it exactly matches with the the Zeldovich approximation. In N body simulation whenever pancake is formed there are some particles which have the same Eulerian positions but they have reached there from different Lagrangian positions, as a result they have different velocities and multi-stream regions are formed. In the early stage (linear) of simulation when the strength of perturbations is small we have single stream regions, then it becomes three stream and so on. This artifical viscosity works mainly in the dense multi-stream regions. Outside the multi-streams regions Zeldovich approximation keeps giving the right results. We are studying the viscosity in the multi-stream regions with a series of numerical experiments. We have found that N-body curve for the mass inside pancake jumps from one value of ν to another when the number of streams in multi-stream region are increased. In this experiments we have studied the collapse of a plane wave in n-Body simulations and the Adhesion approximation.

- Effect of large scale fluctuation on small scales and vice versa :- In one of the studies we are looking at the effect of small scale density fluctuations on large scales and effect of large scales on small scales. A single plane wave of a long wave length is taken for the large scales and a rectangular box power spectrum centered at a wavelength of eight grid lengths for small scales. What we have found is that the presence of small scale fluctuations does changes the size of the multi-stream flow if the amplitude of these fluctuations is large. Presence of large scales does make a big difference to perturbations at small scales.

  This work is in collaboration with Suryadeep Ray and J.S.Bagla.

Conference/Workshops Attended:

1. An advanced school on the physics of galaxy formation
   Harish-Chandra Research Institute, Allahabad ,India
   (Dec.16-30, 2003)

2. International Conference on Gravitation and cosmology
   January5 -10, 2004
   Department of Physics
   Cochin University of Science and Technology
   Kochi - 682022, INDIA.

Other Activities:

I was tutor for a course on Astrophysics given by Jasjeet Bagla in HRI

Sumathi Rao

Research Summary:

I have mainly been working in the area of electronic transport in quantum wires and quantum dots. The aim is to compute conductances in these low-dimensional systems. The new approach that we have taken in the last few years has been to generalise the standard Landauer-Buttiker approach to include inter-electron interactions perturbatively. This method reproduces the results of using Luttinger liquid theory and the formalism of bosonisation in most cases, and is useful, because it can directly be related to experiments. But there are certain kind of tunneling processes, which cannot be completely understood in terms of this approach and in those cases, we are forced to use the formalism of bosonisation and Luttinger liquid theory.

Using the generalisation of the two-terminal junction of interacting quantum wires to N-terminals and renormalisation group flow of the S-matrix for $N \geq 3$, we study conductances in different geometries of quantum wires and obtain results for different temperatures, different lengths of wires and different magnetic fluxes through rings. Surprisingly, in some geometries, we find that the back-scattering decreases and conductance increases due to interactions, contrary to the experience of two-terminal junctions.

We also study conductances through two resonant levels using a mapping to the generalised Coulomb gas model and show that there exists a non-trivial fixed point, where conductance is generically different from that through a single resonant level and the conductance exhibits a non-linear dependence on the interaction parameter, again, unlike the case of a single resonant level.

Publications in refereed journals:

- **1.** Effective action and interaction energy of coupled quantum dots (with Sourin Das), Phys. Rev. **B68** 073301 (2003).
- **2.** Transport through multiply connected carbon nano-tubes (with Sourin Das), to be published in Phys. Rev. **B**.
- **3.** Renormalisation group study of the conductances of interacting quantum wire systems with different geometries (with Sourin Das and Diptiman Sen), to be published in Phys. Rev. **B**.

Publications in Conference Proceedings:

- **1.** Transport through quantum dots, to be published in Proceedings of National Seminar on 'Recent Advances in Physics', 19-20 September 2003, Gopalpur-on-sea, organised by Berhampur University and Institute of Physics, Bhubaneswar.

- **2.** Effects of interactions and different geometries on conductances of quantum wires : the ring and the stub systems, (with S. Das and D. Sen), to be published in International Conference on Nanoscience and Technology, Kolkatta, December 2003.

Preprints:

- **1.** Tunneling through two resonant levels: fixed points and conductances (with D. Sen), cond-mat/0404010.

Conference/Workshops Attended:

- **1.** National Seminar on 'Recent Advances in Physics', 19-20 September 2003, Gopalpur-on-sea, organised by Berhampur University and Institute of Physics, Bhubaneswar.
- **2.** One day conference on theoretical physics, Jawaharlal Nehru University, 9th March 2003.

Visits to other Institutes:

- **1.** Institute of Physics, Bhubaneswar, 16-18 September 2003.
- **2.** Indian Institute of Science, Bangalore, Summer 2003.

Invited Lectures/Seminars:

- **1.** 'Transport in Quantum wires' , 17th September 2003, Institute of Physics, Bhubaneswar.
- **2.** 'Transport through quantum dots' 19th september,2003, Gopalpur-on-sea.
- **3.** 'Transport through coupled quantum wires and dots', 9 March 2004, Jawaharlal Nehru University, New Delhi.

Other Activities:

- **1.** Acting director, August 2003 - December 2003.
- **3.** Member of National Organising Committee, Statphys 22, to be held in Bangalore in July 2004.
- **4.** Member of the International Union of Pure and Applied Physics working group on 'Women in physics'.

V. Ravindran

Research Summary:

Higgs physics at LHC is going to be one of the main interests to the particle physics community in the coming years when the LHC machine starts operating. In this context [1,2] I have computed the full next-to-leading order corrected differential distributions $d^2\sigma/dp_T/dy$, $d\sigma/dp_T$ and $d\sigma/dy$ for the semi-inclusive process $p+p \to H+'X'$ and the full next to next to leading order correction to the total cross section for the fully inclusive Higgs production. Here X denotes the inclusive hadronic state and p_T and y are the transverse momentum and rapidity of the Higgs-boson H respectively. All QCD partonic subprocesses have been included. The computation is carried out in the limit that the top-quark mass $m_t \to \infty$ which is a very good approximation as long as $m_H, p_T < 200$ GeV. Our calculations reveal that the dominant subprocess is given by $g + g \to H +' X'$ but the reaction $g + q(\bar{q}) \to H +' X'$ is not negligible. Another feature is that the K-factor representing the ratio between the next-to-leading order and leading order differential distributions is large. It varies from 1.4 to 1.7 depending on the kinematic region and choice of parton densities. These corrections reduce the theoretical uncertainties coming from factorization and renormalization scales significantly making the prediction reliable.

The other topic which is very relevant is the study of the spin structure of the hadrons. RHIC at BNL is already at operational to do this important task. In this context, a precise computation of the spin observables is very important from the theory side to reduce various theoretical uncertainties. So I have computed the full next-to-next-to-leading order (NNLO) coefficient functions[3] for the polarized cross section $d\Delta\sigma/dQ$ for the Drell-Yan process $p + p \to l^+l^- +' X'$. Here $'X'$ denotes any inclusive hadronic state and Q represents the invariant mass of the lepton pair. All QCD partonic subprocesses have been included provided the lepton pair is created by a virtual photon, which is a valid approximation for $Q < 50$ GeV. Unlike the differential distribution w.r.t. transverse momentum the dominant subprocess for the integrated cross section is given by $q + \bar{q} \to \gamma^* +' X'$ and its higher order corrections so that massive lepton pair production provides us with an excellent tool to measure the polarized anti-quark densities. We give predictions for double longitudinal spin asymmetry measurements at the RHIC.

The spin dependent structure function $g_2(x, Q^2)$ can be measured in deep inelastic scattering experiments. Since the level of precision increases, a precise theoretical study on this becomes important. In this context I have studied[4] the twist–2 heavy flavor contributions to the polarized structure function $g_2(x, Q^2)$. We show that this part of $g_2(x, Q^2)$ is related to the heavy flavor contribution to $g_1(x, Q^2)$ by the Wandzura–Wilczek relation to all orders in the strong coupling constant. Numerical results are presented.

Publications:

1. V. Ravindran, J. Smith and W. L. van Neerven, "Differential cross sections for Higgs production," Mod. Phys. Lett. A **18**, 1721 (2003) [arXiv:hep-ph/0307005].
2. V. Ravindran, J. Smith and W. L. van Neerven, "Higgs production at NNLO," Pramana **62**, 683 (2004) [arXiv:hep-ph/0304005].
3. V. Ravindran, J. Smith and W. L. van Neerven, "NNLO corrections to massive lepton-pair production in longitudinally polarized proton proton collisions," Nucl. Phys. B **682**, 421 (2004) [arXiv:hep-ph/0311304].
4. J. Blumlein, V. Ravindran and W. L. van Neerven, "Twist-2 heavy flavor contributions to the structure function g2(x,Q**2)," Phys. Rev. D **68**, 114004 (2003) [arXiv:hep-ph/0304292].
5. R. Basu and V. Ravindran, "Working Group Report: Quantum Chromodynamics (QCD) And Hadronic Structure," Pramana **60**, 401 (2003).

Conference/Workshops Attended:

1. Linear Collider meeting (May'03) at TIFR, Mumbai.
2. Linear Collider meeting (Oct'03) at CTS, Bangalore.
3. International meeting on Linear Collider (Nov'03) at INSA, New Delhi.
4. Linear Collider meeting (Dec'03) at TIFR, Mumbai.
5. WHEPP (Jan'04) at IIT, Mumbai

Visits to other Institutes:

1. Visited TIFR, Mumbai during the month of May from 6 to 24th.
2. Visited IMSc, Chennai during the month of May from 26th to 30th.
3. Visited University of Hyderabad during the month of December from 12th to 22nd.

Invited Lectures/Seminars:

1. Invited talk at Linear Collider meeting at TIFR, Mumbai.
2. Invited talk at Linear Collider meeting at CTS, Bangalore.
3. Invited talk at the work group of WHEPP, IIT, Mumbai.

Other Activities:

Guiding Student: I guided two summer students.

Graduate Courses taught:

I taught the course on Electrodynamics to first year Ph.D students.

Participation in Committees:

Convener of the Transport committee.

Arnab Kumar Ray

Research Summary:

The following is the summary of the research work done after having joined the HRI on 16th. February, 2004.

The inviscid and thin accretion disc is a well understood model system in accretion studies. Modelling such a disc like a dynamical system in a mathematical parameter space, gives a clear idea of the nature of the critical points of the stationary solutions of the flow. The outer critical point is saddle type while the inner critical point is centre type. This fact, coupled with the outer boundary condition of the flow, allows for a complete understanding of all the important qualitative features of the flow solutions, which conventionally would only be achieved by numerical integration. Furthermore, this analysis also gives a tighter upper bound on the admissible range of values for the angular momentum of the sub-Keplerian flow through the saddle point. To address the adverse implications regarding the physical realizability of a solution passing through the saddle point, it has then been demonstrated by use of a mathematical model, that a temporal evolution of the flow is a very likely non-perturbative mechanism for the selection of an inflow solution that passes through the saddle type critical point.

Preprints:

A dynamical systems approach to an inviscid and thin accretion disc, Arnab K. Ray and J. K. Bhattacharjee, 2004 (submitted).

Other Activities:

Presented a seminar on the topic of *An Accretion Disc as a Dynamical System* at the HRI on 17th. March, 2004.

Ashoke Sen

Research Summary

The main theme of my research during 2003-04 has been on the understanding of the dynamics of open string theory on unstable D-branes and the relation between open and closed string description of various physical processes. In particular by carefully comparing the results based on open string and closed string calculations I argued that the classical open string results on the decay of unstable D-branes in string theory provide dual description of the closed string state into which the D-brane decays. This gave rise to a new type of open-closed string duality conjecture according to which tree level open string theory can contain information about the closed string theory. This conjecture was put on a firm footing by testing it in the context of two dimensional string theory. In this case the theory can be mapped to a theory of free non-relativistic fermions moving under the influence of an inverted harmonic oscillator potential, and is exactly solvable. One sees that in this theory the open-closed duality conjecture reduces to the statement of equivalence between a bosonic and a fermionic field in two dimensions.

A better understanding of the open-closed string duality in critical string theory undoubtedly requires a better understanding of the dynamics of open string theory on unstable D-brane systems. Keeping this in view I studied the role of conservation laws in the study of open string dynamics and constructed infinite set of conserved charges which characterize time dependent classical solutions on an unstable D-brane. In two dimensional string theory these charges can be identified as appropriate linear combinations of the infinite set of conserved charges which are known to exist for the inverted harmonic oscillator system. We also developed a general method for constructing the energy-momentum tensor of a non-local field theory and applied it to construct the energy-momentum tensor of open string field theory.

Although open string field theory is required for describing the complete dynamics of unstable D-branes, an effective field theory with square root type action seems to capture qualitatively many aspects of the dynamics of this system. We provide further evidence for this by showing that it reproduces the qualitative features of the moduli space of classical solutions in this theory. We also use this effective action, coupled to gravity, to examine possible cosmological consequences of the evolution of the tachyon and construct non-singular cosmological solutions with a bounce. Although these solutions require fine tuning of initial conditions from the closed string viewpoint, we argue that this may be natural from the open string viewpoint.

Publications

1. A. Sen, "Open and closed strings from unstable D-branes," Phys. Rev. D **68**, 106003 (2003) [arXiv:hep-th/0305011].

2. A. Sen, "Open-closed duality at tree level," Phys. Rev. Lett. **91**, 181601 (2003) [arXiv:hep-th/0306137].

3. A. Sen, "Open-closed duality: Lessons from matrix model," Mod. Phys. Lett. A **19**, 841 (2004) [arXiv:hep-th/0308068].

4. A. Sen, "Moduli space of unstable D-branes on a circle of critical radius," JHEP **0403**, 070 (2004) [arXiv:hep-th/0312003].

5. A. Sen, "Remarks on tachyon driven cosmology," arXiv:hep-th/0312153.

6. A. Sen, "Rolling tachyon boundary state, conserved charges and two dimensional string theory," JHEP **0405**, 076 (2004) [arXiv:hep-th/0402157].

7. A. Sen, "Energy momentum tensor and marginal deformations in open string field theory," arXiv:hep-th/0403200.

Courses given

1. Spring, 2003: Quantum Field Theory 1

2. Fall, 2003: Quantum Field Theory 2

3. Spring, 2004: Quantum Field Theory 1

Distinctions

Awarded D.Sc. (Hon.) by Calcutta University

Technical talks at conferences / schools

1. Tachyon dynamics in open string theory, 4 lectures at ICTP Spring School On Superstring Theory And Related Topics, 31 Mar - 8 Apr 2003, Trieste, Italy

2. Tachyon dynamics in open string theory, 4 lectures at the Theoretical Advanced Study Institute In Elementary Particle Physics (TASI 2003): Recent Trends In String Theory, 1-27 Jun 2003, Boulder, Colorado

3. Closed Strings and Unstable D-Branes, Strings 2003, July 6-11 2003, Kyoto, JAPAN.

4. Tachyon dynamics in open string theory, 4 lectures at the Summer School on Strings, Gravity and Cosmology, July 14-25, 2003, PIMS at the University of British Columbia Vancouver, Canada.

5. Tachyon dynamics in open string theory, 4 lectures at the IPM String School And Workshop 2003, 29 Sep - 9 Oct 2003, Caspian Sea, Iran

6. Dynamics of D-brane decay, Nobel Symposium 2003, Cosmology and String Theory, August 14-19, 2003, Sigtuna, Sweden

7. Tachyons in string theory, 4 lectures at the 3rd ICTP Latin American String School (LASS 2003), 1-19 Dec 2003, Sao Paulo, Brazil

8. Review of Tachyon Condensation, National Workshop on String Theory, IIT Kanpur, December 8 - 21, 2003

9. Time dependent classical solutions in open string theory, 2 lectures at the Spring School on Superstring Theory and Related Topics, 15-23 Mar 2004, Trieste, Italy

Endowment lectures / General Lectures

1. Search for a unified theory (4 lectures), Popli memorial lectures at the St. Stephen's College, Delhi, Nov. 17-20, 2003.

2. Search for a unified theory, Special lecture at the Guwahati meeting of the Indian Academy of Sciences, 21-23 Nov. 2003.

3. Search for a unified theory, B.B. Roy memorial lecture at Calcutta University, 24 Nov 2003

4. Search for a unified theory, Subhashis Nag memorial lecture, IMSc. Chennai, Nov. 29, 2003.

5. Search for a unified theory, 8th Public Lecture of the TIFR Alumni Association, TIFR, Mumbai, Feb 27, 2004.

6. Search for a unified theory, Public lecture at the National Chemical Laboratory, Pune, Feb 28, 2004.

Prasenjit Sen

Research Summary:

Over the past year (and in HRI since February 2004) the primary aim of my research has been to understand properties of materials from first-principles, i.e., by solving the Schrödinger equation for the interacting ion-electron system for specific materials. For this I use both effective one-body methods like Hartree-Fock (HF) approximation and density functional theory (DFT), and explicit many-body methods of variational and diffusion quantum Monte Carlo (QMC). I have used these methods, sometimes combination of them, to study surfaces, clusters and periodic solids.

Si(211) surface[1]

Si is the most widely used material in microelectronic industry and it is often used as a substrate to grow devices on. For this purpose, Si surfaces are extremely important for material scientists, and microscopic understanding of their properties are very crucial. Si(100) surface has been studied extensively and its low temperature properties are more or less well understood. However, higher index surfaces of Si have not been studied so well, though they are ideal to grow polar semiconductors (III-V or II-VI) on them. This prompted us to study the Si(211) surface using plane-wave pseudopotential DFT. We studied the possible reconstructions of this surface, which compare well with experimental suggestions. We also studied adsorption of Te and As on this surface. Adsorption properties of Te on this surface is important in the context of growth of II-VI semiconductors like CdTe, HgTe or HgCdTe, while As acts as a good surfactant for growth of other materials. We found the most favorable points for adsorption of an isolated Te or As atom on the ideal (bulk-terminated) and (2×1) reconstructed Si(211) surfaces. More importantly, we found that there are more than one points on the surface with comparable binding energy values for adsorption of Te and As. This can have important consequences for growth on this surface. We also found that on the (2×1) reconstructed surface, at 0.5 monolayer coverage, As adatoms dimerize on this surface, while Te adatoms do not. In this respect their behaviour is exactly similar to that on the Si(100) surface.

Metal encapsulated Si clusters[1]

Recently there is a lot of research interest in clusters. The motivation stems primarily from the possibility of being able to build cluster-assembled (solid) materials whose properties can be tuned by tuning the clusters. Successes with carbon fullerenes has given a big boost to such efforts. However, the motivation also comes from the experimental finding of luminosity in very stable Si clusters of certain sizes in the visible range of the spectrum. This holds promise for their use as new dyes, much longer lived than the organic ones currently used, in various medical applications. Experiments have found that in the small size range

(10-16 Si atoms), Si clusters encapsulating a transition metal (TM) atom is more stable than a bare Si cluster. This motivated us to study electronic and geometric properties of TM encapsulated Si_n clusters–mostly Si_{12}, but also Si_{10} and Si_{11} in certain cases. We explained the properties of clusters involving a whole range of TM atoms from the $3d$, $4d$ and $5d$ series. Apart from explaining the observed stability of certain clusters, we predicted other stable structures not synthesized so far. While most of the calculations were done using HF and/or DFT methods, for $TiSi_{12}$ clusters we used QMC methods to confirm that the ground state of this cluster is really a spin-triplet (while that of all the other clusters are spin-singlets). We explained this in terms of different degree of overlap between the Si sp and TM d orbitals in different clusters. Our further DFT calculations indicated that some of these clusters may form stable extended solids. However, we could not make very definitive statements on that.

1. *These works were completed before I joined HRI.*

Magnetism in CaB_6[2]

CaB_6 is very much a focus of current research interest because of the observation of rather unusual ferromagnetism (FM) in the system. Initial observations indicated that the La-doped compound, $Ca_{1-x}La_xB_6$, show FM with a small moment ($< 0.07\mu_B$ per La atom), but a high Curie temperature of ~ 600K. A number of theories were proposed to explain such an unusual FM state. One of them (the excitonic insulator model) is based on the assumption that the pure system is a semi-metal with a small band overlap at the X-point of the primitive Brillouin zone (BZ). This was suggested by local density approximation (LDA) band structure calculations. Given that LDA always underestimates band gaps, this is questionable. Experiments also produced conflicting results regarding whether the system is (semi-)metallic or semiconducting. Later it was also suggested that the origin of FM was probably extrinsic–due to some magnetic impurities such as Fe or Ni. To clarify this confusing scenario regarding the electronic structure of pure CaB_6 and the origin of FM in the system, I did a detailed calculation of the system in collaboration with the group of Prof. Lubos Mitas at the North Carolina State University, USA, using HF, DFT and QMC methods. Using explicitly correlated many-body wavefunctions in QMC, we have convincingly showed that the pure compound is a semiconductor. We have also found that La impurity does not give rise to FM in the system while Fe impurity does. On the other hand, presence of a B vacancy destroys the FM due to any Fe impurity. With these results, our calculations explain almost all the experimentally observed phenomena in the CaB_6 system. We are in the process of writing up our results.

2. *The computations were done on the cluster in Prof. Mitas's group at the North Carolina State University.*

Publications:

- Electronic structure of Te- and As-covered Si(211), Prasenjit Sen, Inder P. Batra, S. Sivananthan, C. H. Grein, Nibir Dhar, and S. Ciraci, Phys. Rev. B 68, 045314 (2003)[3].

- Electronic structure and ground states of transition metals encapsulated in a Si_{12} hexagonal prism cage, Prasenjit Sen and Lubos Mitas, Phys. Rev. B 68, 155404 (2003)[3].

3. *These papers were published before I joined HRI in Feb. 2004.*

Ashok Sethia

Research Summary: The behavior of an excess electron in a one, two and three dimensional classical liquid has been studied with the aid of Chandler, Singh and Richardson (CSR) theory [J. Chem. Phys. **81** 1975 (1984)] . The size or dispersion of the wavepacket associated with the solvated electron is very sensitive to the interaction between the electron and fluid atoms, and exhibits complicated behavior in its density dependence. The behavior is interpreted in terms of an interplay among four causes: the excluded volume effect due to solvent, the pair attractive interaction between the electron and a solvent atom, the thermal wavelength of the electron (λ_e), a balance of the attractive interactions from different solvent atoms and the range of repulsive interaction between electron and solvent atom. Electron self-trapping behavior in all the dimensions has been studied for the same solvent-solvent and electron-solvent interaction potential and the results are presented for the same parameter in every dimension to show the comparison between the various dimensions.
Using CSR theory equilibrium properties of Helium-4 at low temperature has been evaluated and we are trying to study the B-E condensation.

Using the path integral method many identical bosons has been studied and the work will be completed soon.

Publications:

1. Title: Interplay between the repulsive and attractive interaction and the spacial dimensionality of an excess electron in a simple fluid.

Authors: A. Sethia, E. R. Bittner and F . Hirata
Journal: Journal of theoretical and computational Chemistry.
Vol.2, Page:129-138 Year:2003.

2. Quantum properties of many identical boson system: Path integral approach (in preparation)
S. Sanyal and A. Sethia

L. Sriramkumar

Research Summary:
The enormous red-shifting of the modes during the inflationary epoch suggests that physics at the very high energy scales (at the Planck scale and beyond?) may manifest itself at much lower energies thereby possibly providing us with an opportunity to utilize cosmological observations to test fundamental physics. In particular, the measurement of anisotropies in the Cosmic Microwave Background (CMB) to a higher and higher precision has led to the hope that, maybe, we are on the threshold of observing Planck scale effects in the CMB. Most of my research work during the last year was focused on understanding the effects of Planck scale physics on the inflationary density perturbation spectrum and the CMB. Being a closely related issue, I have also been analyzing the effects of very high energy modes on entropy bounds in the early universe.

In addition, I have also been working on understanding the thermodynamical properties of black hole and cosmological horizons in brane-world scenarios.

I have briefly described below the work I have been involved in on these issues.

Planck scale corrections to the primordial spectrum: Over the last few years, considerable amount of attention has been devoted to evaluating the Planckian corrections to the inflationary perturbation spectrum, often using high energy models that violate Lorentz invariance locally. However, certain astrophysical observations seem to indicate that Lorentz invariance may be preserved to extremely high energies. In such a situation, to study the Planck scale effects, it becomes important to consider models that preserve Lorentz invariance even as they contain a fundamental scale. In this work, we construct one such model and evaluate the resulting spectrum of density perturbations in the power-law inflationary scenario. While our model reproduces the standard spectrum on small scales, it *naturally* predicts a suppression of power on large scales—a feature that seems to be necessary to explain lower power in the quadrupole and the octopole moments of the CMB. We find that the spectrum we obtain is very similar in form to the one that has recently been obtained from non-commutative inflation. Interestingly, with a suitable choice of initial conditions, our approach can lead to corrections at the infra-red as well as at the ultra-violet ends of the spectrum.

High energy modes and entropy bounds: Very high energy effects may, in addition to modifying the energy associated with each mode of a quantum field (such as in models involving high frequency dispersion), alter the density of states of these modes. These effects, in turn, will modify the entropy associated with the matter fields. We are currently investigating the generic effects of the high energy modes on different entropy bounds, such as, for e.g., the holographic and the Hubble bounds, in the early universe.

Entropy of horizons in brane-world scenarios: Recently, exact solutions that de-

scribe black holes as well as cosmological models that are bound to a brane in a higher dimensional bulk have been constructed. These brane-world models provide interesting situations to examine the thermodynamical properties of horizons. We are presently involved in evaluating the entropy of black hole and cosmological horizons in brane-world scenarios through the brick wall approach.

Publications:

1. **L. Sriramkumar**, *Interpolating between the Bose-Einstein and the Fermi-Dirac distributions in odd dimensions*, Gen. Rel. Grav. **35**, 1699–1705 (2003).

Preprints:

1. S. Shankaranarayanan and **L. Sriramkumar**, *Trans-Planckian corrections to the primordial spectrum in the infra-red and the ultra-violet*, hep-th/0403236.

Conference/Workshops Attended:

1. *Advanced School on the Physics of Galaxy Formation*, Harish-Chandra Research Institute, Allahabad, December 16–26, 2003.

2. *International Conference on Gravitation and Cosmology*, Cochin University for Science and Technology, Kochi, January 5–10, 2004.

Visits to other Institutes:

1. *Inter-University Centre for Astronomy and Astrophysics*, Pune, July 20–28, 2003.

2. *High Energy Section*, The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, February 26–March 25, 2004.

Invited Lectures/Seminars:

1. *On trans-Planckian signatures in the inflationary density perturbation spectrum*, Invited presentation in the Cosmology Session at the International Conference on Gravitation and Cosmology, Cochin University for Science and Technology, Kochi, January 5–10, 2004.

2. Guest Lecturer for Prof. T. Padmanabhan's course on *Introduction to Standard Model of Cosmology* at the SERC Main School in Theoretical High Energy Physics, Department of Physics, University of Rajasthan, Jaipur, February 9–17, 2004.

Other Activities:

1. Was involved in conducting (the Physics part of) the HRI Science Talent Test 2003.

2. Taught a course on Classical Mechanics to first year physics graduate students at HRI during August–December, 2003.

3. Guided the following M.Sc. Physics students on projects under the Visiting Students' Program: (1) Prabhanshu Shekhar, Indian Institute of Technology, Kharagpur, (2) Anwesha Tapadar, Indian Institute of Technology, Kanpur and (3) P. C. Bharadwaj, Indian Institute of Technology, Chennai.

K.P Yogendran

Research Summary:

Since joining HRI in August, I have been working on three projects.

1. The first of these involves constructing D-branes in the 2-D Lorentzian black hole which forms an exact string theory background. I have constructed the open string CFT's associated to the branes, many of which are time dependent, and analysed their semiclassics. This work is nearing completion.

   The next step in the project is to write down the boundary states corresponding to these branes. Work is in progress on constructing the boundary states, and studying the properties of these branes including their relations to other time dependent configurations in $c = 1$ string theory and the $c = 1$ matrix model.

2. During a visit to CTS-IISc, I have started on a collaboration with Prof. Sachin Vaidya (CTS) in studying tachyon condensation in fuzzy spheres. We have constructed a classical solution, in the large N limit, that describes the fusion of multiple spheres, and work is in progress to uplift this solution to string theory by finding a marginal deformation of the fuzzy sphere BCFT.

3. In collaboration with Joris Raeymakers, I am investigating the possibility of inflation in string theory. Following earlier work, we are studying whether inflation can be realised by tachyon condensation in the KKLT scenario.

Conference/Workshops Attended:

Winter Workshop on String theory, IIT-Kanpur (Dec 2003)

Visits to other Institutes:

1. IIT-Kanpur, (Workshop on String theory) (Dec, 2003)
2. CTS-IISc, Bangalore (TPSC Visit) (Dec 2003 - Jan 2004)
3. IMSc, Chennai (TPSC Visit) (Dec 2003 - Jan 2004)
4. T.I.F.R Mumbai, (PhD Viva Voce examination) (Dec2003 - Jan 2004)

Invited Lectures/Seminars:

1. TPSC Seminars in CTS and in IMSc titled "Topology and Dynamics of fuzzy spheres" (Dec, 2003 -Jan, 2004)
2. Lectures on Black holes and thermodynamics in SSGC, (May, 2004)

LECTURES / TALKS / SEMINARS AT THE INSTITUTE

MATHEMATICS

By Academic Members :

Dr. Punita Batra	Lie Algebra
Dr. Kalyan Chakraborty	Number Theory and Cryptography
Prof. I.B.S. Passi	Group Rings
Shripad M. Garge	Alebraic K. Theory
Dr. Roman Mikhailov	(Co) Homological (Co) localizations and Solenoids
Prof. I.B.S. Passi	Asymptotic Group Theory
Prof. I.B.S. Passi	Augmentation Powers and Group Homology
Anupam Kr. Singh	Character Theory and Burnsides Pq Theorem
Dr. Roman Mikhailov	Projective Modules Over Group Rings
Dr. Maneesh K. Thakur	Algebras with Involutions and Classical Groups-II

By Visitors :

Dr. A.K. Singh	Algebraic Groups
Prof. N. Sankaran	Local Fields
Dr. M. Manickam	A Survey on Jacobi Forms
Dr. Biswaranjan Behera	An Equivalence Relation on Wavelets in Higher Dimensions
Mr. Gyan Prakash	An Additive Representation Function
Dr. Parasar Mohanty	Restrictions and Extensions of Fourier Multipliers
Dr. Indira Chatterjee	Euler Characteristics for Groups
Prof. Francesco Pappalardi	Power Free Values of Classical Functions
Prof. K.W. Gruenberg	Capitulation in Number Theory and Transfer Group Theory
Prof. S. Eswara Rao	Representation of Witt Algebras
Prof. Victor Kac	Infinite Dimensional Lie Super Algebras and the Standard Model
Prof. N. Sankaran	Local Fields
Prof. S.T. Yau	Geometry, Its Charm and Applications
Prof. S.T. Yau	On Positivity of Local Mass in General Relativity
Prof. Amiya Mukherjee	Morse Theorem and Its Applications
Prof. R. Sujatha	Iwasawa Algebras and Arithmetic
Prof. J.H. Coates	Iwasawa Algebras and Arithmetic
Prof. A.W. Hales	Jordan decomposition

LECTURES / TALKS / SEMINARS AT THE INSTITUTE

PHYSICS

By Academic Members :

Dr. Pravabati Chingangbam	Action in Quantum Mechanics
Dr. L. Sriram Kumar	Detectable Trans - Planckian Signatures in the CMBR?
Suvankar Datta	Bose Einstein Condensation in Confined Systems
Srikant	Yang and Lee Theorems
Sudhir Kr. Gupta	Hard Sphere Bose Gas
S.K. Majhi	Methods of Higher Order QCD Corrections
Dr. Hiroyuki Takata	Group Eelements Approach to Geometry of Boundary condition for Brains with Distance
Chandrima Paul	Study of Inflation from Tachyon Effective Action
Dr. Namit Mahajan	PCT Theorem and Its Status in Non Commutative Field Theories
Dr. J.S. Bagla	The Statistical significance of the Low CMB Multipoles
Dr. Namit Mahajan	Renormalization of Field Theories in Non - Anticommutative Superspace
Prof. Rajesh Gopakumar	From Fields to Strings
Dr. J.S. Bagla	Cluster Computing at HRI
Dr. Namit Mahajan	Study of Some Exclusive Two Photon B-Decays
Poonam Mehta	Atmoshperic Neutrinos as a Probe of CPT and Lorentz Violation

By Visitors :

Arnab Kr. Ray	Realizability of Stationary Spherically Symmetric Transonic Accretion
Abhijit Samanta	Can Vacumm Stability Improve supersymmetry Search
Prabhanshu Shekhar	Why do we need a Cosmological Constant?
Somnath Bharadwaj	Modellling Galaxy Halos using dark Matter with Pressure
Debrupa Chakrabarty	Phenomenology of Universal Extra Dimensions
Anindya Dutta	Supersymmetry Search in Gauge Boson Fusion
Arnab Kundu	Discrete Symmetries and the Weinberg Salam Model
Amitabh Virmani	A rotating Black Ring in Five Dimension
Anjan Ananda Sen	Generalised Chaplygin Gas Model, Accelerating Universe and Dark Matter Energy Unification
Allan Adams	Hori Vafa and the Sorcerers Sheaf
Girish S. Setlur	A Unified Theory of Landau - Fermi Liquids Luttinger Liquids and Wigner Crystals
Subir Sarkar	Cosmic Ray Probe of String Relics
Sourav Ray	Effective R-parity Violation for Scalar Potential
Girish S. Setlur	U(I) Gauge Theory as Quantum Hydrodynamics
Sankalpa Ghosh	Vortices in Bose - Einstein Condensates
Sreejith Sukumaran	Rheology of Disordered Lamellar Phases
Mathew Headrick	Closed String Tachyon Condensation on C/Zn
Sukanta Panda	Signatures of Low Scale Gravity in Ultra High Energy Cosmic Rays
Supurna Sinha	Stastical Mechanics of Semiflexible Polymers
G.C. Anupama	Supernovae and their Cosmological Uses
G.C. Anupama	The Indian Astronomical Observatory at Hanler Astronomy from the Himalayas
Partha Mukhopadhay	Matix Cosmology
Tapas Das	Behaviour of Matter Near Event Horizon
Justin David	Partial Supersymmetry Breaking Gravity Deformed Chiral Rings
Arghya Traphder	Electron Doped Manganites
Arnab Kr. Ray	An Accretion Disc as a Dynamical System
V.B. Johri	Dark Energy

COLLOQUIUM

JOINTLY ORGANISED BY MATHS & PHYSICS

Prof. H.P. Dikshit	Bézier' Methods for Curves and Surfaces of Shape
Prof. Shobo Bhattacharya	Vortex - Matter Phases: Pinned and Moving
Prof. Subir Sarkar	The World According to WMAP Does Cosmology now have a Standard Model?
Prof. K.W. Gruenberg	Invariants of Finite Groups Associated with Free Resolutions
Prof. Diptiman Sen	Quantum Bound States of a Derivative non lineear Schrodinger Model and Number Theory
Prof. Krishnasawmy Alladi	A Theorem of Gollnitz and its Place is the Theory of Partitions
Prof. Richard M. Weiss	Sperical Buildings
Prof. S.T. Yau	Local Positive Mass in General Relativity
Prof. Norbert Schlomiuks	Andre Weil Remembered
Prof. Dana Scholomiuks	Connections Among Three Longstanding Open Problems on Planar Vector Fields

PUBLICATIONS AND PREPRINTS IN MATHEMATICS

PUBLICATIONS :

Sukumar Das Adhikari

1. **Remarks on some zero-sum problems**
(Jointly with Purusottam Rath)
Expo. Math. 21, no. 2, 185 – 191 (2003).

2. **Monochromatic configurations for finite colourings of the plane**
(Jointly with Purusottam Rath)
Note di Matematica, to appear.

3. **Remarks on some zero-sum problems**
(Jointly with Purusottam Rath)
Expositiones Mathematicae, to appear.

4. **Some questions regarding visibility of integer lattice points in** $\mathbb{R}^d$, Proceedings of the Session in analytic number theory and Diophantine equations (Bonn, January – June 2002) (Eds. D. R. Heath-Brown and B. Z. Moroz), Bonner Mathematische Schriften, **Nr. 360**.

Punita Batra

1. Representations of twisted multi-loop Lie algebras, Journal of Algebra, 272(404-416), 2004.

Kalyan Chakraborty

1. Exponents of class groups of real quadratic function fields; to appear in Proc. of Amer. Math. Soc.

E. K. Narayanan

1. *Multipliers for the twisted Laplacian* Colloq. Math., 97 (2003), no.2, 189-205.

I.B.S. Passi

1. *A contribution to Bass' conjecture* [jointly with Ioannis Emmanouil], *J. Group Theory* (to appear).

2. *Hyperbolic unit groups* [jointly with S. O. Juriaans and Dipendra Prasad], *Proc. Amer. Math. Soc.* (to appear).

3. *Augmentation powers and group homology* [jointly with Roman Mikhailov], *Journal of Pure and Applied Algebra* (to appear).

4. Book: *Algebra* Vol. 4: Field Theory [jointly with I. S. Luthar], Narosa Publishing House, New Delhi (to appear).

5. Book review: *Subgroup Growth* by Alexander Lubotzky and Dan Segal, Progress in Mathematics Vol. **212**, Birkhäuser Verlag, Basel, 2003. *Journal of the Indian Institute of Science* (to appear).

D. Surya Ramana

1. Adhikari, S. D. and Ramana, D. S. *Siegel's theorem : finiteness of integral points*, Elliptic curves, modular forms and cryptography (Allahabad, 2000), 139–149, Hindustan Book Agency, New Delhi, 2003.

B. Ramakrishnan

1. An Introduction to Modular Forms and Hecke Operators, (with M. Manickam), in *Elliptic Curves, Modular Forms and Cryptography*, Hindustan Book Agency (2003), 223–245.

2. Elliptic Curves, Modular Forms and Cryptography, Edited by A. K. Bhandari, D. S. Nagaraj, B. Ramakrishnan, and T. N. Venkataramana, Hindustan Book Agency 2003.

Purusottam Rath

1. Remarks on some zero-sum problems, (Jointly with S.D.Adhikari), *Expo. Math.* 21, no. 2, 185 – 191 (2003).

2. Monochromatic configurations for finite colourings of the plane, (Jointly with S.D.Adhikari), Note di Matematica, to appear.

Maneesh Kumar Laxman Thakur

1. The etale Tits' Process of Jordan algebras revisited (with H. P. Petersson), Journal of Algebra, 273 (2004) 88-107.

R. Thangadurai

1. On the structure of sequences with forbidden zero-sum subsequences, (with W. D. Gao), *Colloquim Mathematicum,* **98** , No. 2, (2003), 213-222.

2. Adams Theorem on Bernoulli Numbers Revisited, Journal of Number Theory, **106**, (2004), 169-177.

3. On a variant of Kemnitz Conjecture, (with W. D. Gao), Journal of Combinatorial Theory, Series A, **107**, (2004), 69-86.

4. Olson's Constant for the group $\mathbb{Z}_p \oplus \mathbb{Z}_p$, (with W. D. Gao and I. Z. Ruzsa), Journal of Combinatorial Theory, Series A, **107**, (2004), 49-67.

PREPRINTS :

Punita Batra

1. Integrable modules for the twisted affine Kac-moody Lie algebras, In Preparation.

2. (With S. Eswara Rao) Realization of Lie-n-tori of type B_n, F_4 and G_2, In Preparation.

Kalyan Chakraborty

1. Exponents of class groups of real quadratic function fields(II).

2. On the divisibility of class numbers of real quadratic fields.

Shripad M. Garge

1. Maximal tori determining the algebraic group (to appear in the Pacific Journal of Mathematics).

2. On the order of finite semisimple groups (submitted).

3. Excellence properties of F_4.

E. K. Narayanan

1. *An optimal theorem for the spherical maximal operator on the Heisenberg group (jointly with S. Thangavelu)* (jointly with S. Thangavelu)., to appear in Contemporary Mathematics series.

2. *A local two radius theorem for the twisted spherical means on* C^n (jointly with M. L. Agranovsky), to appear in Contemporary Mathematics series.

3. *Injectivity of the spherical mean operator on conical manifolds of spheres* (jointly with M. L. Agranovsky).

I.B.S. Passi

1. *A transfinite filtration of Schur multiplicator* (jointly with R. Mikhailov).

2. *Higher traces on group rings* (jointly with R. Mikhailov).

3. *Homology of Centralizers* (jointly with R. Mikhailov).

D. Surya Ramana

1. Suresh Nayak and D.S. Ramana, *Tarski's Plank Problem for the Disc*.

Purusottam Rath

1. Method of approximation in Transcendental Number Theory.

Anupam Kumar Singh

1. Reality properties of conjugacy classes in G_2 (submitted).
2. Conjugacy classes in anisotropic G_2 (in preparation).

Maneesh Kumar Laxman Thakur

1. Reality Properties of Conjugacy Classes in G_2 (with Anupam Singh), submitted.
2. Coxeter Groups, Preprint (with R. P. Shukla).
3. Some topics in Pseudo Reflection Groups, Preprint (with R. P. Shukla).
4. A note on Hermitian forms, Preprint.
5. Conjugacy Classes in G_2 (in progress).
6. Rational subgroups of G_2 and F_4 (work in progress).

R. Thangadurai

1. On a structure of p-zero-sum free sequences, (with W. D. Gao and A. Panigrahi), *Preprint*, 2004.
2. Distribution of Quadratic non-residues which are not primitive roots, (with S. Gun, B. Ramakrishnan and B. Sahu), *Preprint*, 2004.

PUBLICATIONS AND PREPRINTS IN PHYSICS

PUBLICATIONS :

Jasjeet Singh Bagla

1. Bagla J.S. and Ray S. : *Performance characteristics of the TreePM method*, New Astronomy 8, 665, 2003.

2. Bagla J.S. : *A parallel TreePM code*, *Numerical Simulations in Astronomy*, ed. K.Tomisaka and T.Hanawa, 2003, p.32.

3. Bagla J.S. : *Cluster Computing at HRI*, Proceedings of DAE meeting on Parallel computing and its applications in science and engineering, BARC, p.219, 2003.

4. Bagla J.S. and White M. : *Prospects for Detecting Neutral Hydrogen Using 21-cm Radiation from Large Scale Structure at High Redshifts*, *the IAU 8th Asian-Pacific Regional Meeting, Proceedings volume I, Eds. Satoru Ikeuchi, John Hearnshaw, and Tomoyuki Hanawa; ASP conference series, vol.289, p.251*, 2003.

Debajyoti Choudhury

1. ZZH Coupling: A Probe to the origin of EWSB?
   D. Choudhury, *A. Datta* and *K. Huitu*
   Nucl. Phys. **B673** 385 (2003).

2. Slepton production from gauge boson fusion
   D. Choudhury, *A. Datta, K. Huitu, P. Konar, S. Moretti* and *B. Mukhopadhyaya*
   Phys. Rev. **D68**:075007,2003

3. Hybrid Inflation and Brane-Antibrane System
   D. Choudhury, *D. Ghoshal, D.P. Jatkar* and *S. Panda*
   Jour. Cosmology and Astropart Phys. **07**, 009 (2003).

Prasanta Kumar Das

1. "Implications of a light radion on $\beta(\lambda)$ and $\beta(g_t)$ and a lower bound on radion vev" –**Prasanta Kr. Das** and Uma Mahanta (published in MPLA)/hep-ph/0110309.

Raj Gandhi

1. A. Datta, R. Gandhi, P. Mehta and S. U. Sankar, "Atmospheric neutrinos as a probe of CPT and Lorentz violation," arXiv:hep-ph/0312027.(to appear in Physics Lett B)

2. R. Gandhi, K. Kar and S. Uma Sankar, "Working Group Report: Neutrino And Astroparticle Physics," Pramana **60**, 405 (2003).

Debashish Ghoshal

1. *Hybrid inflation and the brane-antibrane system*
   J. Cosmology & Astrophys. **0307**: 009 (2003)
   (in collaboration with D. Choudhury, D.P. Jatkar and S. Panda)

Rajesh Gopakumar

1. R. Gopakumar, "From Free Fields to AdS", hep-th/0308184, (To appear in Phys. Rev. **D** .)

2. R. Gopakumar, "From Free Fields to AdS -II", hep-th/0402063, (To appear in Phys. Rev. **D** .)

Srubabati Goswami

1. Constraints on neutrino oscillation parameters from the SNO salt phase data. A. Bandyopadhyay, S. Choubey, S. Goswami, S. T. Petcov and D. P. Roy, Phys. Lett. B **583**, 134.

2. On the measurement of solar neutrino oscillation parameters with KamLAND
   A. Bandyopadhyay, S. Choubey, S. Goswami and S. T. Petcov,
   arXiv:hep-ph/0309236,
   Phys. Lett. B 581, 62, (2003).

3. Exploring the sensitivity of current and future experiments to $\theta(\odot)$
   A. Bandyopadhyay, S. Choubey,S. Goswami, arXiv:hep-ph/0302243, to appear in Phys. Rev. D. Phys. Rev. D **67** 113011, (2003).

Alok Chandra Gupta

1. Optical Photometric Observations of $\gamma-$Ray Loud Blazars, J. H. Fan, O. M. Kurtanidze, M. G. Nikolashvili, **A. C. Gupta**, J. S. Zhang & Y. H. Yuan (2004), Chin. J. Astron. Astrophys., **4**, 133-142

2. Near Infrared Intraday Variability of Mrk 421, **A. C. Gupta**, D. P. K. Banerjee, N. M. Ashok & U. C. Joshi (2004), *Astronomy & Astrophysics*, (in press)

3. Intra-night Optical Variability of BL Lacs, Radio-Quiet Quasars and Radio-Loud Quasars, C. S. Stalin, **Alok. C. Gupta**, Gopal-Krishna, Paul J. Wiita & Ram Sagar (2004) (submitted to Monthly Notices Roy. Astron. Soc.)

Partha Konar

1. **Slepton production from gauge boson fusion.**
   with *Debajyoti Choudhury, Anindya Datta, Katri Huitu, Stefano Moretti, Biswarup Mukhopadhyaya.*
   e-Print Archive: hep-ph/0304192
   Published in *Phys.Rev.***D68**:075007, 2003

2. **Bhabha Scattering with Radiated Gravitons at Linear Colliders.**
   with *Sukanta Dutta, Biswarup Mukhopadhyaya, Sreerup Raychaudhuri.*
   e-Print Archive: hep-ph/0307117
   Published in *Phys.Rev.***D68**:095005, 2003

Sanjeev Kumar

1. Inhomogeneous Ferromagnetism and Unconventional Charge Dynamics in Disordered Double Exchange Magnets: Sanjeev Kumar and Pinaki Majumdar
   Phys. Rev. Lett. vol 91, 246602-1 (2003)

2. Nanoscale Phase Coexistence and Percolative Quantum Transport: Sanjeev Kumar and Pinaki Majumdar
   Phys. Rev. Lett. vol 92, 126602 (2004)

3. Anti-Localisation to Strong Localisation: The Interplay of Magnetic Scattering and Structural Disorder: Sanjeev Kumar and Pinaki Majumdar
   Europhys. Lett. vol 65, 75 (2004)

Namit Mahajan

1. $t \to bW$ IN NONCOMMUTATIVE STANDARD MODEL, **Namit Mahajan**, Phys. Rev. **D68**, 095001,2003 [arXiv: hep-ph/0304235].

2. PCT THEOREM IN FIELD THEORY ON NONCOMMUTATIVE SPACE , **Namit Mahajan**, Phys. Lett. **B569**, 85 ,2003 [arXiv: hep-th/0305105].

3. CP VIOLATION IN THE DECAY MODE $B \to \pi\gamma\gamma$. with S.R.Choudhury (Delhi U.), G.C. Joshi (Melbourne U.), **Namit Mahajan** and B.H.J.McKellar (Melbourne U.), Phys. Rev. **D69**, 054011,2004 [arXiv: hep-ph/0306293].

4. SHORT AND LONG DISTANCE CONTRIBUTIONS TO $B \to K^*\gamma\gamma$. with S.R.Choudhury (Delhi U.), A.S.Cornell (Korea Inst. Advanced Study, Seoul) and **Namit Mahajan**, Phys. Lett. **B580**, 177 (2004) [arXiv: hep-ph/0307104].

Pinaki Majumdar

1. *Inhomogeneous Ferromagnetism and Unconventional Charge Dynamics in Disordered Double Exchange Magnets*,
   Sanjeev Kumar and Pinaki Majumdar,
   Phys. Rev. Lett. **91**, 246602-1 (2003).

2. *Nanoscale Phase Coexistence and Percolative Quantum Transport*,
   Sanjeev Kumar and Pinaki Majumdar,
   Phys. Rev. Lett. **92**, 126602 (2004).

3. *Anti-localisation to Strong Localisation: the Interplay of Magnetic Scattering and Structural Disorder*,
   Sanjeev Kumar and Pinaki Majumdar,
   Europhys. Lett. **65**, 75 (2004).

Satchidananda Naik

1. The Non-Perturbative $\mathcal{N} = 2$ SUSY Yang-Mills Theory from Semiclassical Absorption of Supergravity by Wrapped D Branes [JHEP 06 (2004) 022]

Sudhakar Panda

1. The Non-Perturbative $\mathcal{N} = 2$ SUSY Yang-Mills Theory from Semiclassical Absorption of Supergravity by Wrapped D Branes [JHEP 06 (2004) 022]

2. de Roo M., Panda S., Trigiante M. and Westra D.B., Potential and mass-matrix in gauged N=4 supergravity, JHEP 11 (2003) 022.

Tribhuvan P. Pareek

1. Pure spin currents and associated electrical voltage, T. P. Pareek, Phys. Rev. Lett. **92**, 076601 (2004).

2. Absolute spin valve effect: Charge transport in two dimensional hybrid system, T. P. Pareek, accepted for publication in PRB.

Sumathi Rao

1. Effective action and interaction energy of coupled quantum dots (with Sourin Das), Phys. Rev. **B68** 073301 (2003).

2. Transport through multiply connected carbon nano-tubes (with Sourin Das), to be published in Phys. Rev. **B**.

3. Renormalisation group study of the conductances of interacting quantum wire systems with different geometries (with Sourin Das and Diptiman Sen), to be published in Phys. Rev. **B**.

4. Transport through quantum dots, to be published in Proceedings of National Seminar on 'Recent Advances in Physics', 19-20 September 2003, Gopalpur-on-sea, organised by Berhampur University and Institute of Physics, Bhubaneswar.

5. Effects of interactions and different geometries on conductances of quantum wires : the ring and the stub systems, (with S. Das and D. Sen), to be published in International Conference on Nanoscience and Technology, Kolkata, December 2003.

V. Ravindran

1. V. Ravindran, J. Smith and W. L. van Neerven, "Differential cross sections for Higgs production," Mod. Phys. Lett. A **18**, 1721 (2003) [arXiv:hep-ph/0307005].

2. V. Ravindran, J. Smith and W. L. van Neerven, "Higgs production at NNLO," Pramana **62**, 683 (2004) [arXiv:hep-ph/0304005].

3. V. Ravindran, J. Smith and W. L. van Neerven, "NNLO corrections to massive lepton-pair production in longitudinally polarized proton proton collisions," Nucl. Phys. B **682**, 421 (2004) [arXiv:hep-ph/0311304].

4. J. Blumlein, V. Ravindran and W. L. van Neerven, "Twist-2 heavy flavor contributions to the structure function g2(x,Q**2)," Phys. Rev. D **68**, 114004 (2003) [arXiv:hep-ph/0304292].

5. R. Basu and V. Ravindran, "Working Group Report: Quantum Chromodynamics (QCD) And Hadronic Structure," Pramana **60**, 401 (2003).

Ashoke Sen

1. A. Sen, "Open and closed strings from unstable D-branes," Phys. Rev. D **68**, 106003 (2003) [arXiv:hep-th/0305011].

2. A. Sen, "Open-closed duality at tree level," Phys. Rev. Lett. **91**, 181601 (2003) [arXiv:hep-th/0306137].

3. A. Sen, "Open-closed duality: Lessons from matrix model," Mod. Phys. Lett. A **19**, 841 (2004) [arXiv:hep-th/0308068].

4. A. Sen, "Moduli space of unstable D-branes on a circle of critical radius," JHEP **0403**, 070 (2004) [arXiv:hep-th/0312003].

5. A. Sen, "Remarks on tachyon driven cosmology," arXiv:hep-th/0312153.

6. A. Sen, "Rolling tachyon boundary state, conserved charges and two dimensional string theory," JHEP **0405**, 076 (2004) [arXiv:hep-th/0402157].

7. A. Sen, "Energy momentum tensor and marginal deformations in open string field theory," arXiv:hep-th/0403200.

Prasenjit Sen

1. Electronic structure of Te- and As-covered Si(211), Prasenjit Sen, Inder P. Batra, S. Sivananthan, C. H. Grein, Nibir Dhar, and S. Ciraci, Phys. Rev. B 68, 045314 (2003)[3].

2. Electronic structure and ground states of transition metals encapsulated in a Si_{12} hexagonal prism cage, Prasenjit Sen and Lubos Mitas, Phys. Rev. B 68, 155404 (2003)[3].

Ashok Sethia

Interplay between the repulsive and attractive interaction and the spacial dimensionality of an excess electron in a simple fluid, A. Sethia, E. R. Bittner and F . Hirata , Journal of theoretical and computational Chemistry.
Vol.2, Page:129-138 Year:2003.

L. Sriramkumar

L. Sriramkumar, *Interpolating between the Bose-Einstein and the Fermi-Dirac distributions in odd dimensions*, Gen. Rel. Grav. **35**, 1699–1705 (2003).

PREPRINTS :

Debajyoti Choudhury

1. Higgs production in association with top quark pair at e^+e- colliders in theories of higher dimensional gravity
D. Choudhury, *N.G. Deshpande* and *D.K. Ghosh*
hep-ph/0311284

Prasanta Das

1. "Muon anomalous magnetic moment and a lower bound on the Higgs mass due to a stabilized radion in the Randall-Sundrum model "- **Prasanta Kr. Das** (submitted to PRD).

2. "Higgs pair production due to radion resonance in Randall-Sundrum model: prospects at the Large Hadron Collider"– **Prasanta Kr. Das** and Biswarup Mukhopadhyaya (submitted to EPJC), hep-ph/0303135.

Raj Gandhi

1. *Matter effects in* $P_{\nu_\mu \to \nu_\tau}$ with A. Datta,P. Ghoshal, S.Goswami, P. Mehta and S. Uma Sankar, in preparation.

2. *Atmospheric Neutrino Physics Sensitivity studies for a Large Mass Iron Calorimeter*, with A. Datta,P. Ghoshal, S.Goswami, P. Mehta and S. Uma Sankar, in preparation.

Debashish Ghoshal

1. *Noncommutative p-tachyon*
HRI-P/031101 (To be published in the proceedings of *p-Adic MathPhys 2003*)

2. *NS fivebrane and tachyon condensation*
HRI-P-0312001, hep-th/0312245
(in collaboration with D.P. Jatkar and M. Kreuzer)

Srubabati Goswami

1. Prospects of probing theta(13) and neutrino mass hierarchy by supernova neutrinos in KamLAND, A. Bandyopadhyay, S. Choubey, S. Goswami and K. Kar, arXiv:hep-ph/0312315

2. Solar neutrino oscillation parameters after KamLAND S. Goswami, A. Bandyopadhyay and S. Choubey, arXiv:hep-ph/0312028.

3. Solar Neutrinos and 1-3 mixing S. Goswami and A. Y. Smirnov, (in preparation).

Alok Chandra Gupta

1. CCD Photometric Observations of the Galactic Globular Clusters NGC 1904 and NGC 6341, **A. C. Gupta** (astro-ph 0311443)

2. Near Infrared Intraday Variability of Mrk 421, **A. C. Gupta**, D. P. K. Banerjee, N. M. Ashok & U. C. Joshi (astro-ph 0405186)

Partha Konar

1. **Gauge boson fusion as a probe of inverted hierarchies in supersymmetry.** with *Biswarup Mukhopadhyaya.*
e-Print Archive: hep-ph/0311347

Sanjeev Kumar

1. The Travelling Cluster Approximation for Strong Correlation Models of Lattice Fermions Coupled to Classical Fields: Sanjeev Kumar and Pinaki Majumdar
cond-mat/0406082

2. The Many Electron Ground State of the Adiabatic Holstein Model in Two and Three Dimensions: B. Poornachandra Sekhar, Sanjeev Kumar, Pinaki Majumdar
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3. The Interplay of Disorder and Thermal Fluctuations in Strongly Coupled Electron-Phonon Systems: Sanjeev Kumar and Pinaki Majumdar
cond-mat/0406084

4. Metal-Insulator Transitions in the Disordered Holstein-Double Exchange Model in Three Dimension: Sanjeev Kumar and Pinaki Majumdar
cond-mat/0406085

Namit Mahajan

1. LITTLEST HIGGS MODEL AND UNITARITY CONSTRAINTS, [arXiv:**hep-ph/0310098**].

Pinaki Majumdar

1. *The Travelling Cluster Approximation for Strong Correlation Models of Lattice Fermions Coupled to Classical Fields*, Sanjeev Kumar and Pinaki Majumdar, cond-mat 0406082.

2. *The Many Electron Ground State of the Adiabatic Holstein Model in Two and Three Dimensions*, B. Poornachandra Sekhar, Sanjeev Kumar and Pinaki Majumdar, cond-mat 0406083.

3. *The Interplay of Disorder and Thermal Fluctuations in Strongly Coupled Electron-Phonon Systems*, Sanjeev Kumar and Pinaki Majumdar, preprint, cond-mat 0406084.

4. *Metal-Insulator Transitions in the Disordered Holstein-Double Exchange Model in Three Dimension*, Sanjeev Kumar and Pinaki Majumdar, cond-mat 0406085.

Sudhakar Panda

1. Hybrid Inflation and Brane-antibrane system, D. Choudhury, D. Ghoshal, D.P. Jatkar and S. Panda, hep-th/0305104.

2. Potential and mass-matrix in gauged N=4 supergravity, M. de Roo, S. Panda, D.B. Westra and M.Trigiante, hep-th/0310187.

Tribhuvan P. Pareek

1. Quantum Beating of Ballistic conductance, T. P. Pareek submitted for publication.

Sumathi Rao

1. Tunneling through two resonant levels: fixed points and conductances (with D. Sen), cond-mat/0404010.

Arnab Kumar Ray

1. *A dynamical systems approach to an inviscid and thin accretion disc*, Arnab K. Ray and J. K. Bhattacharjee, 2004 (submitted).

Ashok Sethia

Quantum properties of many identical boson system: Path integral approach (in preparation) , S. Sanyal and A. Sethia

L. Sriramkumar

1. S. Shankaranarayanan and **L. Sriramkumar**, *Trans-Planckian corrections to the primordial spectrum in the infra-red and the ultra-violet*, hep-th/0403236.

ABOUT THE LIBRARY

The Institute library is one of the best equipped libraries in the region. Being a research oriented institute, it provided the required support to the academic and research activities. It remained open on all working days from 8 am to 2 pm including the Saturdays. It also remained open during the Sundays and the Gazetted holidays from 10 am to 6 pm. It had added 1319 number of books including 37 gifted books. It subscribed 198 titles in periodicals. it has processed the back valumes/issues of periodicals worth Rs.62 Lakhs.

During the last year basic emphasis had been provided to the conversion of the Video Cassettes to VCD format because of more durability and user friendliness. The emphasis was also given to procure maximum number of journals on-line. We have been providing on-line access of the periodicals to our users of 85 journals.

We had provided the Web Enabled library catalogue to our users. The library can be termed as completely automated library system, which includes acquisition, cataloguing, circulation, search modules etc. This on-line catalogue had increased the opportunities of the use of our library resources by the neighbouring organisations such as INSDOC, TIFR etc. through the Document Delivery Services. Normally we provide the DDS on request through post, at a very nominal cost, but rquest had also been honoured through e-mail. We had encouraged the use of the library consultation facilities by the research scholars from the neighbouring institutes.

ABOUT COMPUTER SECTION

1. Campus Networking: Campus networking to connect all the buildings in the institute to computer center and main institute network is going to start.The networking backbone is on the optical fibre and the bandwidth for every computer is 100 MBps.

2. Few laptops were procured to be used for giving presentations and doing computing work when on a visit.

3. New Ups room is constructed with the adequate facilities for the change-over of load to another ups. 3 nos. 20 KVA ups are also shifted in this which are providing the power to computers and related devices in the main institute building.

4. Softwares like Mathematica were upgraded and no. of user licenses were also increased. Newer versions of SuSe, Redhat and Openbsd were purchased so as to upgrade the users desktop operating systems and other systems.

5. Firewall with the systems having OpenBsd operating system is placed.

6. 2 Nos. Intel Xeon based machines for the Ino project were procured.

7. Hri's new domain name was registered as hri.res.in. Existing domain name mri.ernet.in will also continue for atleast an year.

8. Webmail service was also started on system connected to internet via ERNET link. (this is besides the existing webmail which is on VSNL link)

9. Hri's name server, mail server were upgraded to latest operating system.

10. Seismic station was established by the BARC, Bombay and the seismic related data is being transferred via the ANUNET VSAT facility.

11. 2 Nos. Sun Blade 2000 workstations are procured under the HEP project.

12. File Server SUN Fire 280R with storage A1000 with RAID and Super DLT (320 GB) is purchased.

13. Conversion of large nos. of video tapes into the video files is already done.

14. Anti-Virus software is installed on all the windows computers and on the central mail-server for preventing the entry of virus infected mails/files in our network.

15. Computing related to conferences were held in the conference computer center.

Current Activities and plans

1. Upgradation of computers and procuring few more laptops is in process.
2. Upgradation of computer center is being planned.
3. Upgradation of printers in computer center and hub rooms is also being planned.
4. One high end Compaq Alpha Server is being purchased under the cryptography project.
5. Shifting of all the ups in the new ups room.
6. Secure channel installation in the ANUNET and expanding the usuage of ANUNET for other services also.
7. Procurement of the softwares like Crystal etc are also being planned.
8. Upgradation of internet bandwidth is being planned.

CONSTRUCTION WORK AT THE CAMPUS

Construction of additinal bedroom in Type IV/D quarters, extension of Gym area, Toilet for Store Purchase Office are in progress and expected to be completed by the end of June 2004.

Construction of 6 Nos. New Type V/E quarters work is in progress.

Setup of new EPABX exchange and replacement of 180 KVA DG set by 250 KVA

DG set is completed and made fully functional and are in use.

400 KVA Servo Stabilizer has been installed and made fully functional and is in use.

The work "Providing power supply to UPS room, area lighting and other miscellaneous electrical works" are completed.

The work "Internal electrification and table for conference machine room in Library building" is completed.

Certain other projects relating to main Institute Building i.e. Vertical Blinds for windows is complete and renovation and discussion of class room work is in progress and expected to be completed by the 2nd week of June 2004.