# HARISH-CHANDRA RESEARCH INSTITUTE

# ACADEMIC REPORT
# ( 2004 - 2005 )

**Chhatnag Road , Jhunsi , Allahabad - 211 019 , India**

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# 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 Jhunsi, 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 Jhunsi 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 and the INSA S. N. Bose Medal in 2004. Prof. B. Mukhopadhyaya was awarded the prestigious S. S. Bhatnagar award in the year 2003. Prof. I.B.S. Passi was conferred The *Distinguished Service Award* for the year 2003 on April 13, 2004 from The Mathematical Association of India and awarded the Life-time Service Award by INSA, New Delhi in 2004.

The Institute has a residential campus in Jhunsi, 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 AND FAREWELL ADDRESS

Founder's Day, 19.7.2005

First and foremost I welcome Professor Amitava Raychaudhuri as the new Director of the Institute. He comes here from Kolkata University, where he holds the Sir Tarak Nath Palit Professorship in Physics. Previous occupants of the chair in physics include Sir C.V. Raman, Meghnad Saha, and C.K. Majumdar. Amitava was appointed to this chair at a young age of 44 in 1996. In fact he also holds an Adjunct Professorship in Physics at HRI. I understand that three of his students working on their doctorates are likely to join HRI, and he wishes to maintain his research/teaching/mentoring programme in full swing. His appointment at HRI significantly strengthens our group in High Energy Physics. I welcome him warmly, and wish him success in his new job.

Let me take this opportunity, on behalf of all of you, to recall Professor H.S. Mani, the Director of HRI before me. We all know, he put his heart and soul in building up this Institute literally brick by brick. It required a great deal of energy, imagination, and patience. He and I have become good friends in the last 4 years. As many of us know, Prof. Mani has gone back to research and teaching, first at the S.N. Bose Center at Kolkata, and now at the IMSc in Chennai. He was to come here on this joyous occasion. But he wrote to me that due to some prior commitments he could not make it.

As for myself, at the moment, I feel a sense of relief in handing over the responsibilities of directorship in the able hands of Prof. Raychaudhuri. The authority invested in such a position is intertwined with a lot of restrictions. So for the past four years I often had a feeling of sitting in a pavilion and watching the game. Now I feel that I am back in the field!

Let me take this opportunity to thank many people who have helped me in my director's role in the last 4 years.

First, in my absences from Allahabad, many faculty members worked as interim directors. These include Professors Passi, Rao, Gandhi, Panda, Naik, Mukhopadhyaya, Adhikari, and Ramakrishnan.

All these people and I know Prabhatji, who has been with the former MRI, now HRI, since 1993. He is always available, even on Saturdays and Sundays, always calm and cheerful, and competently making necessary arrangements for various meetings, and other work as needed by the Director and the Registrar.

It is a particular pleasure to thank Shri Kashalkar and Dr. S.N. Rai. We are really fortunate to have Shri Kashalkar as a Registrar with wide-ranging knowledge of office work as well as law. He is competent, versatile, has flair for Hindi and English, and totally unexpected field the expertise of which is not easily found in a Registrar, namely, music. Dr. Rai has been with the former MRI, now HRI, from its very beginning through all its ups and downs. His savvy about social/political life in Allahabad has been very helpful to directors of HRI.

I really need to thank many people in the administration and technical staff. Only a few of them come in direct contact with the director, but without whom the Institute would not run. I can only mention a few who came in direct contact with me.

Gulatiji brings his superb competence as an AO with a smiling face, knowing full well that it is difficult to be popular as an AO.

V.R. Tiwariji similarly brings his superb competence as a librarian. I know, he really enjoys and takes pride in his job.

Amitji has helped me a great deal in setting up and maintaining the affairs of the HRI Welfare Trust. Although officially delinked from HRI. I think, the HRI Welfare Trust is a good development. When we are in happy times, we should share our happiness, and try to wipe out a tear in somebody else.s eye, so that when sad times hit us, we deserve help from others.

Manish Sharmaji, and Ajay Srivastavaji in their quiet, yet effective, manner are providing their engineering skills in the civil and electrical sides respectively.

Sanjai and Anju Vermaji are managing the computer services. We really need one more person in this area. Somehow the appointment of a person in this area made three years ago did not work out well. So we have to try again. We need to find some innovative solution for the problems in this area.

R.P. Sharmaji looks after our guest house with dedication. The number of visitors to HRI from within India and abroad has significantly increased. This number is only going to grow further. So maintaining a good guest house in terms of food, service, and a fair competence in English are very important for us.

Archanaji and Seemaji are the first persons one comes to know when one visits HRI. Many visitors have personally remarked to me the helpful nature of these two ladies.

V.P. Tiwariji brings his energy and enthusiasm for the Rajbhasha programme with dedication, enough to learn latexing in English.

Last but not the least, Yashpalji manages to bend both the roads and buses without breaking, carrying the people to their desired destinations.

I think, I have covered most people in administration whom I have come to know in the last 4 years. Any omission is unintentional.

Now let me come to the academic side, which as an academic myself, is closer to my heart. Without the help of the people in administration, complemented by the academics as well, it would have been impossible for me to achieve whatever little I have been able to achieve.

As you well know, I have first hand contacts with the mathematics community in the US, Europe and Asia extending over thirty years. I was also visiting India from time to time. The connection with HRI provided to me a welcome opportunity to bring together the mathematics communities in the US, Europe and Asia. During my tenure, I have fully encouraged, and myself contributed to developing such contacts.

I summarize four such initiatives below:

1. An initiative I am presently personally engaged in is the .Year in Teichmuller Theory and Moduli Problems.. This initiative started in January 2005. Already Professors Earle, Gardiner, Harvey, M.S. Narasimhan and Siddhartha Gadgil, each has delivered a series of 6 to 8 lectures each of 1.5 hrs. (except Prof. Narasimhan who delivered 3 lectures each of 1.5 hrs). Next month Prof. Hubbard will deliver 8 lectures of 1.5 hrs on Holomorphic Dynamics in addition to an HRI colloquium. There will be a major workshop in January 2006 for which we expect to get about 15 participants from the US, and 15 from Europe and Asia. We are expecting a major funding from NSF-DST International Programme. Interestingly a private donor donated US $1000 specifically for supporting this Teichmuller Workshop. If successful, this effort will go a long way in combining an established mathematical tradition in India (namely Moduli problems of vector bundles) and the American-European-Japanese tradition in Teichmuller theory with its connections to 2- and 3- dimensional topology, and conformal field theory in physics. It will also start a significantly new direction at HRI. Three students at HRI associated with me have chosen projects related to this broad area which may result in their theses in 1 to 2 years.

2. Another initiative is the Advanced Training in Mathematics (ATM)-Schools, generously supported by the National Board of Higher Mathematics. This project may run for 3 to 5 years, and may continue beyond. It is meant basically for motivated students interested in research careers in mathematics.

Besides the exposure to the high point of the three basic mathematical disciplines, namely algebra, analysis, topology, the aim is also to point out the internal connections among different disciplines.

Already two month-long schools, one in IIT (Bombay) and the other at HRI have taken place. The third one is currently going on in IIT (Bombay). Fourth and Fifth will take place in Pune and Kolkata respectively in December 2005.

3. The Ramanujan Mathematical Society appointed me on the Editorial Board of its journal some years ago, and more recently also as the Chief Editor of their Lecture Notes series. The main office of the latter activity will be at HRI. DST will be providing funding of 35 lakhs over the next 5 years.

   One volume edited by Adhikari, Balasubramanian and Srinivas has already come out. Two or three more are in the pipeline.

   A related project is the "Collected Works" series. The Collected Works of Minakshisundaram, and Hansraj Gupta, are in the pipeline. I fervently hope that in a year or two we shall be able to bring out at least some of these works. This will be an important service to the cause of development of mathematics in India. True, mathematics knows no national boundaries. Yet it is important to have the role models, whom we can easily relate to.

4. HRI-IMSc-TIFR and three major research institutes in mathematics in Beijing, Zhejiang, and Hong Kong in China have established a faculty/students exchange programme for 5 faculty/students from each side visiting the other side. Three Indian faculty including myself already visited China. We are expecting some visits from China this year.

Besides these initiatives, I have tried to build up the academic programme at HRI. One consistent desire has been to bring mathematics and theoretical physics together.

A joint Mathematics/Physics HRI colloquium was established in 2001. It has brought in many distinguished visitors, national and international. I request Prof. Raychaudhuri to continue the tradition.

In order to bring in some distinguished faculty for an extended period, we have established Adjunct Faculty positions. These include Profs. Indranil Biswas (TIFR) in Mathematics, and T. Padmanabhan (IUCAA), S. Mukhi (TIFR), A. Raychaudhuri (Calcutta U), Diptiman Sen (CTS, Banglore) in Physics. In addition there are three Faculty Associates in Mathematics: Prof.s Katre (Pune U), Manickam (Vivekananda C, Chennai), and Bhandari (PU, Chandigarh).

The HRI faculty have represented HRI at many international meetings. HRI provides support for about one-and a half international travel every two years. This support is in addition to the support a faculty member may receive from his/her host institutions, or other funding agencies such as DST, NBHM etc. During my first year as a Director we managed to increase the support for international travel from Rs. 70,000 to Rs. 85,000 for a two year period. So practically every faculty member has been able to make at least one international trip almost every year. Also practically every research fellow has been awarded an opportuniety to make one international trip at least once during his/her doctoral studies at HRI. May we say, this is truly a globalization of higher knowledge! In concrete terms, this globalization is reflected in the research output, the number of Ph.D.s produced, the number of conferences conducted (at HRI), the citations indices and impact-factors, the number of prestigious awards and honors won by the faculty and students, etc.

Here are some statistics:

During 2000-2004, the number of faculty increased from 9 to 11 in Mathematics and from 17 to 24 in Physics. During the same years the total number of publications in refereed journals is 78 in Mathematics and 216 in Physics. During the same years, the number of research scholars increased from 9 to 16 in Mathematics, and from 12 to 23 in Physics. The number of Ph.D.s produced during these years is 4 in Mathematics and 10 in Physics. Among the major honors during the same years include:

Padmashree, D.Sc. (Kolkata University), and S.N. Bose Medal to Prof. Ashoke Sen; S. S. Bhatnagar awards to Profs. D. Prasad, and B. Mukhopadhyaya; Swarnajayanti fellowship to Prof. Debajyoti Choudhury, Distinguished Service Award from the Mathematical Association of India, and Indian National Science Academy Senior Scientist Position to Prof. I. B. S. Passi, Fellowship of Japan Society for Promotion of Sciences (JSPS) for Dr. Debashis Ghoshal, and Alexander Von Humboldt Fellowship for Dr. Srubabati Goswami.

DAE is providing us a generous support. Yet, a major technical problem is to find support for international travel of distinguished visitors from abroad. In this regard, we are grateful that one New York-US-based organisation, the Foundation for the Advancement of Arts and Sciences from India (ARSI), and the Infosys Foundation from Bangalore, India provided us support in the amounts of $8000 and Rs. 6 lakhs respectively. The Infosys Foundation has also provided us support of Rs. 6 lakhs towards support for our research scholars.

Considering that HRI is an apex research institute in Mathematics and Physics, I feel that a lot more can be done to attract support from the Mathematics and

Physics communities in the West, and also a very sizable community of people of Indian origin abroad and from the Foundations such as the Infosys Foundation within India. I strongly suggest to the new Director and the Council to make conscious efforts in this regard.

I would also like to add that I made a determined effort to get the missing back-volumes of journals (especially in mathematics), and the Collected Works of eminent mathematicians and physicists. At present the HRI library is perhaps the best library for mathematics and physics in northern India.

In my mathematics career extending over three decades I have spent about a quarter of my time at the research institutes and the rest in research/mentoring/ teaching positions at the universities. With such life-experiences, I have come to value research as well as mentoring/ teaching. I do believe that these activities are intrinsically contributing to each other. Barring some isolated geniuses who made their singular contributions and died at a young age, a vast majority of the top research scientists are involved in mentoring/teaching, and fairly excel in it.

A significant difference between the research institutes in the West, whose working I know, and the DAE-aided institutes, which I have come to know in the last 4 years, is that the Western research institutes do not support students towards their doctoral degrees. There are very few, and very distinguished, permanent members in the Western research institutes. They are recruited in their mid-or later-careers. They have long-time appointments without a formal teaching load. But many (like Harish-Chandra) continue to hold weekly seminars, or (like Milnor, Borel) involve themselves in large-scale seminar activity.

In the DAE-institutes we admit students for doctoral degrees. Yet when I started as a director, I noticed that the mentoring/teaching was not expected from the faculty, nor was it a part of the reward system.

When I came to HRI, I found that the actual teaching programme was not at par at all with those in the good universities in the West. The number of students was very small. The arrangements with the universities to get them doctoral degrees were really in a poor shape.

With the TIFR getting for itself a deemed university status, and the rest of the DAE-aided research institutes in the process of constructing the Homi Bhabha National Institute, which has received a deemed university status, we see that slowly a paradigm shift is taking place.

Initially, a lot of my energy was spent in trying to solve these problems in the context of HRI. Prof. Raghunathan introduced me to Prof. H. P. Dikshit, Vice-

Chancellor of IGNOU. He was very co-operative. I am happy to say that the faculty also accepted the idea, despite the fact that their formal teaching responsibilities have increased. All the faculty contributed to making up of the syllabus, and constructing a structure. But special mention must be made of Professors Passi and Adhikari in Mathematics and Sen and Gopakumar in Physics.

The HRI-IGNOU Integrated Prorgamme is now established and is operating in its second year. This year, in all 12 courses in mathematics, and 16 courses in physics have run. The projected numbers in the next few years are about 20 courses each in Mathemathetics and Physics, and in addition two experimental courses in physics.

Now the Homi Bhabha National Institute, a deemed university has also become a reality. HRI is a constituent institute of HBNI. As yet HBNI does not allow us to admit students with a bachelor's degree. But it is expected that this will be possible after the relevant bodies are constituted. This process may take six months to a year. Then it is mostly up to us whether to join HBNI or continue with the present integrated doctoral programme. It is likely, we shall be in the HBNI in about a year's time. But the basic structure is already on paper. The HRI may well be able to contribute significantly to the development of HBNI.

The number of visitors from abroad, and our faculty's and students. Visits abroad have substantially increased. The total faculty strength is now 35, close to the sanctioned strength of 40. The number of students has substantially increased to about 40, and is likely to go up to 50 when the new students join. It is projected to go between 80 to 100 in 3 to 5 years. So it is time to start building a new student hostel!

Now I would like to share some of my concerns.

1. First and foremost concern is about the nature of the director's job at a small research institute like HRI. I believe that the faculty and students as well as the public at large would like to see a well-established academic at the helm of affairs of an apex research institute like HRI. But then the issue is: Is the director's job primarily administration, or should he or she primarily pursue his or her academic activity, and take only a short time off to provide a general supervision with the help of a well-established middle-level administration?

   I have already raised this question with the Council, and also the Council has said: let it be left to the new director to assess the situation, and come up with a recommendation.

2. Secondly as a practical matter let me say something about parity between

mathematics and physics at HRI. HRI has 40 sanctioned posts. At present there are 11 faculty in mathematics and 24 in physics. I would certainly say that we should be open in getting a well-established researcher at the G-grade or preferably H-grade levels, be in mathematics or physics. But otherwise at the E-grade or F-grade levels we should go slow in Physics. The parity-issue shows up in a societal way. HRI is a residential institute. At the moment out of the 9 E-flats for example, excluding the very special case of Professor Passi, only 2 out of the remaining 8 were occupied by the mathematics faculty until recently, and even these 2 have moved to D.-flats.

3. A related issue is that the Housing Allotment Rules need to be reviewed. One aspect is the allotment of the 6 new E-flats. I feel that it is very important for a small apex research institute like HRI, that it should be able to attract a senior established person at G- or H- level, or as a senior level distinguished visitor, who comes to HRI with his/her family for longer periods. In such a situation it is essential for psychological-societal reasons, if not for anything else, that we should be able to provide him or her the best type of accommodation we are able to offer. So I would strongly recommend to the new director, faculty and finally the Council to keep at least 2 of these new 6 E-flats for eventually attracting the senior level faculty at the G- or H- levels or using them for the distinguished visitors.

4. Credits for Mentoring/Teaching: Since the paradigm shift seems to suggest new emphasis on mentoring/teaching as a part of faculty.s duties it is but natural that the faculty has also started asking for a reward system which reflects this paradigm shift. I strongly recommend to the new director and Council to look into this aspect.

After this expression of these concrete concerns let me take up a philosophical point which is very close to my heart. I wish to speak to everybody but especially to the young research scholars and pdfs.

Just in the last couple of days Prof. Passi sent us an e-mail drawing our attention to a recent issue of Current Science with several articles on the role of mathematics in sciences including, in particular, physics. As I have said earlier, I have consciously tried to bring together mathematics and theoretical physics at HRI. Let me add that this was exactly one of the suggestions made by Professor Atiyah in his recent review of the School of Mathematics at TIFR. In concrete terms, it means bringing out the role of differential geometry in Astrophysics and String Theory. Also the role of Lie groups, Lie algebras, and their representations in High Energy Physics. Also the role of complex analysis and Riemann surfaces in many branches of physics.

In more abstract terms: space, number, and symmetry are basic categories of mathematical thought. In the same way, space, time, and matter are the basic categories of physical thought. The space, time, and matter categories are expressed in terms of space, number, and symmetry categories . A slight change in the interpretation of space-time-matter in terms of space-number-symmetry categories entails major revision in the formulation of the theories in physics. The Einstein.s theory of special and general relativity is one such example. Similar comments apply to the role of mathematics in other sciences.

I truly believe that mathematics represents something close to what we call divine. In Vedantic terms, the divine is experientiable but cannot be fully captured by words or sounds. The Platonic-Cartesian formulation does not allow this possibility. No matter to which school of thought one feels close to, mathematics remains a common thread. It is the highest art and science of all communicable knowledge.

We all have heard the story of Prahlada, Hiranyakashipu, and Narasimha. In the final episode, the proud, egotistical Hiranyakashipu asks Prahlada: "if God is everywhere, show me your God. Is It in this pillar?". Prahlada says "yes". As Hiranyakashipu breaks the pillar, Narasimha appears and kills Hiranyakashipu, or rather, his separate ego.

The allegories apart, the deeper meaning is revealed in Prahlada's ode in praise to Narasimha. It is a less known but a fantastic piece of philosophical poetry. In that poem, Prahlada poses the question: if God is everywhere, why do people not recognize It? He himself answers:

जातेंकुरे कथमिहोपलभेत बीजम्

"From the seed the tree sprouts and manifests in the form of a trunk, the leaves, and the fruits. But our mind gets entangled in the leaves and fruits. One has to make special efforts to go back to the seed."

That is exactly the mathematical process of theory-building.

So the unified field theory is not some platonic bird sitting over there, and we are going to catch it in some clever way. From a cognitive viewpoint, the theoriser, the data and the experiments, and the process of theory-building form a unified whole.

The divine spark lies in each one of us. The only thing is that it is like a light shining in a dark room whose door is closed. The role of a teacher is just to open

the door and let the student enjoy the light. Eventually, the student becomes the teacher's teacher!

So at HRI, we shall do cutting edge research, but also participate avidly in increasing the awareness of mathematics and physics in the society at large.

My best wishes to Prof. Amitava Raychaudhuri, that under his leadership may HRI attain greater heights.

Finally, I would like to take the opportunity to inform the Council of the specific activites of the Institute and events which took place during the last one year.

Faculty joined : Dr.s Tapas Kumar Das and Anindya Datta joined the Institute as Fellow E, Physics.

Faculty retired : Dr. S.N. Rai, Professor Maths and Dean (Administration).

Like the previous year, the Institute has made good progress in attracting research scholars.

**The Institute hosted the following major scientific meetings :**

1. SERC School : Under the Coordinatorship of Dr. Pinaki Majumdar, SERC school in Physics was conducted during 15th Nov. to 27th Nov. 2004. About 60 participants, including 11 HRI members, attended the school. Profs. Nandini Trivedi, T.V. Ramakrishnan, Vijay Shenoi, D.D. Sharma were amongst the main speakers.

2. AFS II : Annual Foundation School II in Mathematics sponsored by NBHM was held during the period 3rd Dec. to 30th Dec. 2004. About 44 students including 11 HRI participants took part in the school. Prof. I.B.S. Passi was the Convenor of the School. Profs. A.R. Shastri, J.K. Verma, Amit Roy, R.R. Simha, D. Prasad, Gautam Mukherjee were among the main instructors outside HRI. From HRI the instructors were Profs. Passi, Adhikari, Ramakrishnan, Raghavendra, Satya Deo, Punita Batra and Prof. Kulkarni.

3. Symposium: A one day symposium Einstein 1905 was held on 12th April 2005 to mark the centenary of the annus mirabilis 1905, the year in which Einstein wrote three remarkable papers. Among the main speakers were Profs. B. Mukhopadhayaya, Ashoke Sen, S. Naik, T.K. Das, Namit Mahajan, J.S. Bagla, P. Majumdar, R. Gopakumar and S. Rao.

4. A Study Group on Extra Dimensions at the Large Hadron Collider : A study group was organized by Prof. B. Mukhopadhyaya from 7th June to 20th June 2005. Profs. Utpal Sarkar (PRL, Ahmedabad), A. Kundu (Calcutta

University), P. Mathews (SINP, Kolkata), S. R. Choudhury (IIT, Kanpur), R. Godbole (IISc, Bangalore), S. Sengupta (IACS, Kolkata), Drs. P. Konar (TIFR, Mumbai) and Kumar Rao (TIFR, Mumbai) also participated besides the faculty, post-doctoral fellows and scholars of the HRI.

5. VSSP Programme in Mathematics : VSSP was held during 7th June to 28th June 05. About 35 outside students participated in this programme. Main speakers were Profs. Passi, Satya Deo, Adhikari, Ramakrishnan, Kulkarni, Drs. K. Chakraborty, R. Dey, R. Ratnakumar, Batra, Thangadurai, D.S. Ramana, C.S. Dalawat, Mr. A.K. Singh and B. Sahu.

6. Science Talent Search Examinaton : 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. The Institute conducted the annual Science Talent Examination on 18 Sept. 2004 for IX- XII standard students from schools and colleges in and around Allahabad in the subjects of Mathematics and Physics. About 600 students participated in the day long examination. The results have since been declared and the 7 awardees were given the prizes. The topmost among them is Mr. Peeyusha Srivastava, who had made national headlines as a topper in CBSE, IIT and JEE, and a Gold Medalist in the Physics Olympiad. I thank Drs. Surya Ramana (Math), and Pinaki Majumdar (Physics) for their enthusiastic contributions to this programme.

7. RMS Lecture Notes Series : The Ramanujan Mathematical Society has started a Lecture Notes Series. Prof. Ravi Kulkarni is the Chief Editor. Its office is now set up at HRI. It is funded by DST with a grant of Rs. 35 lakhs for a period of 5 years. One volume on Number Theory edited by Adhikari, Balasubramanian, and Srinivas has already come out.

8. ARIES : An MoU between HRI and Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital was singed. It allow faculty-students exchanges.

**HRI Colloquia :**

1. N. Sthanumoorthy, University of Madras . 27.9.04 . Hirota Bilinear Equations, Boson-Fermion Correspondence and Vertex Operators.

2. Pankaj S. Joshi, TIFR, Mumbai . 8.11.04 . The Black Hole Conundrum.

3. Andreas Nyffeler, ETH Zurich . 6.12.04 . The muon g-2 in the Standard Model and beyond.

4. Bikas Chakravarty, SINP, Kolkata . 25.1.05 . A Physical History of Economics and a Kinetic Model of National Wealth Distribution.

5. Cliff Earle, Cornell University . 4.2.05 . Isothermal coordinates, Local and Global.

6. F. Pappalardi, University of Rome 3 . 11.2.05 . Factoring integers, Producing primes and the RSA crypto system.

7. Sunil Mukhi, TIFR, Mumbai . 18.2.05 . Nobel for a minus sign.

8. G. Date, 10.3.05 . Quantum Resolution of Cosmological Singularities.

9. P. Majumdar, SINP, Kolkata . 21.3.05 . Quantum Black Hole Thermodynamics.

10. Denis White . 23.3.05 . Meromorphic Continuation of the Scattering Matrix.

**Visitors to the Institute :**

Profs. Probir Roy, TIFR, Mumbai, Tom Theuns, UK, Amitava Raychaudhuri, Calcutta University, Marc Bourdon, University of Lille, Gautmi Bhomik, University of Lille, Indranil Biswas, TIFR, Mumbaii, Amiya Mukherjee, ISI, Kolkata, A.W. Hales, USA, W.J. Harvey, Kings College, London, J.V. Narlikar, IUCAA, Pune, M.S. Narasimhan, TIFR, Denis White, University of Ohio, USA, T. Padmanabhan, IUCAA, Pune, Frank Neumann, University of Leicester, U.K., Siddhartha Gadgil, ISI, Bangalore and Urmie Ray, France were visitors to the Institute.

**A special feature of this year is that a large number of Lecture-Series were delivered:**

1. Prof. J. Oesterle, University of Paris gave a course of lectures on Branched Coverings of $P^1$ during Dec. 04 . Jan. 05.

2. Prof. C. Earle and Prof. F. Gardiner gave a series of 8 lecturers each during Jan. 14 to Feb. 11, 2005, on Introduction to Teichmuller Theory.

3. Prof. O. Ramare gave a series of lectures in Number Theory from 3rd Feb. 05 to 21st Feb. 05.

4. Prof. Sunil Mukhi, an Adjunct Professor of the Institute, visited the Institute from 9th Feb. 05 to 18th Feb. 05, and gave a series of 3lectures.

5. Prof. M.S. Narasimhan, TIFR, Mumbai visited during 7th March to 14th March, 2005 and gave a series of 3 lectures on Moduli of Vector Bundles.

6. Prof. W.J. Harvey, Kings College, London gave a lecture series on Mapping Class Groups during 14th March to 30th March, 2005.

7. Prof. J.V. Narlikar, IUCAA, Pune give a series of lectures on Cosmology from Sidelines.

8. Prof. Siddhartha Gadgil, ISI, Bangalore, gave a series of 6 lectures on Automorphsims of Surfaces.

9. Prof. Urmie Ray, France, gave a series of 3 lectures on Borcherds-Kac-Moody Algebras.

**Academic Honours and Special Awards :**

- Prof. Ashoke Sen was awarded the Satyendranath Bose Medal of INSA for theoretical physics.

- INSA, New Delhi has awarded a Senior-Scientist-ship for five years to Prof. I.B.S. Passi. It will support his stay at a research institute of his choice for the next five years to continue his research.

**Other Activities and Events Organised :**

1. Tsumani - On the appeal of Dr. Anil Kakodkar, Secretary, DAE, members donated one (two, three or more) day.s salary in PM.s National Relief Fund.

2. Rajbhasha - One shield each from the Nagar Rajbhasha Samiti and the DAE were received. A programme for school children in Hindi medium was also organised during 4th to 8th July 2005.

3. HRI Public Welfare Trust - HRI community collected a sum of Rs. 40,950/- to help out Mr. S.K. Samantaray, Engineer, IGCAR, Kalpakkam, who suffered in the Tsumani disaster. In addition Prof. F. Gardiner donated $100 to help Mr. Samantaray and $ 500 in the Endowment. Prof. W. Harvey donated Rs. 5000/- to the Endowment. Many members of the HRI community are contributing to the Endowment from their salaries, and the Trust has started giving help to needy, deserving persons in the HRI community.

4. SPICMACAY Chapter - A SPICMACAY Chapter has been established in the Institute. The Chapter was inaugurated by Pandit Bhajan Sopori on 15.02.05.

5. Infosys Foundation - It was a pleasant surprise that sometimes in April I received a call from Mrs. Sudha Murty, the Chairman of the Infosys Foundation. She wanted to know the state of higher mathematics in India. Since

they have made money in the IT revolution and they understand that mathematics is at the basis of IT, they would like to support mathematics. I had a meeting with her in her office in Bangalore. I explained to her the situation of higher mathematics in India. As reported earlier, the Infosys Foundation has given a total donation of Rs 12 lakhs to HRI for this year. Mrs. Sudha Murty is likely to visit us in the latter part of this year.

Dated : 19th July, 2005

Ravi S. Kulkarni
Director

# GOVERNING COUNCIL

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

| | | |
|---|---|---|
| 8. | Dr. J.N. De<br>(Member) | BH-135, Sector-III<br>Salt Lake<br>Kolkata - 700 091 |
| 9. | Prof. Narendra Kumar<br>(Member) | Director<br>Raman Research Institute<br>C.V. Raman Avenue, Sadashivanagar<br>Bangalore - 560 080 |
| 10. | Prof. H.S. Mani<br>(Member) | Visiting Professor<br>Institute of Mathematical Seiences<br>CIT Campus, Taramani<br>Chennai - 600 113 |
| 11. | Mr. O.P. Srivastava<br>(Member) | Director of Higher Education<br>Uttar Pradesh<br>Allahabad - 211 001 |
| 12. | Prof. Ravi S. Kulkarni<br>(Ex-Officio Member) | Director<br>Harish-Chandra Research Institute<br>Allahabad - 211 019 |

# ACADEMIC STAFF

## Faculty Members (Mathematics)

1. Prof. S. D. Adhikari
2. Dr. Punita Batra
3. Dr. Kalyan Chakraborty
4. Dr. C. S. Dalawat
5. Dr. Rukmini Dey
6. Prof. Ravi S. Kulkarni
7. Dr. N. Raghvendra
8. Prof. B. Ramakrishnan
9. Dr. P. K. RatnaKumar
10. Dr. D. Surya Ramana
11. Prof. Maneesh Kr. L. Thakur ( On lien )
12. Dr. R. Thangadurai

## Visiting Professor (Mathematics)

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

## Visiting Scientist (Mathematics)

1. Dr. Amora Nongkynrih
2. Dr. A. V. Jayanathan

## Visiting Fellow (Mathematics)

1. Dr. Manoj Kumar Keshari
2. Dr. Gyan Prakash

3. Dr. Ritumoni Sarma
4. Dr. Manoj Kumar Yadav

## Research Scholar (Mathematics)

1. Mr. Vikram Aithal
2. Mr. V. V. Awasthi
3. Mr. Kuntal Banerjee
4. Mr. Soumya Das
5. Mr. Krishnendu Gangopadhyaya
6. Ms. Sanoli Gun
7. Mr. Dheeraj Kulkarni
8. Mr. Manish Kumar Misra
9. Ms. Archana S. Morye
10. Ms. Tanusree Pal
11. Ms. Anupama Panigrahi
12. Ms. Supriya A. Pisolkar
13. Mr. Purusottam Rath
14. Mr. Brundaban Sahu
15. Mr. Siddhartha Sarkar
16. Mr. Anupam Kumar Singh
17. Mr. Mahender Singh
18. Ms. K. Srilakshmi

## Faculty Members (Physics)

1. Prof. J. S. Bagla
2. Prof. D. Choudhury (on lien)
3. Dr. Tapas Kumar Das
4. Dr. Anindya Datta
5. Prof. Raj Gandhi
6. Prof. D. Ghoshal
7. Prof. Rajesh Gopakumar
8. Dr. Srubabati Goswami
9. Prof. Dileep Jatkar
10. Prof. Pinaki Majumdar
11. Prof. B. Mukhopadhyay
12. Prof. S. Naik
13. Prof. S. Panda
14. Dr. T. P. Pareek
15. Prof. Sumathi Rao
16. Prof. V. Ravindran
17. Prof. Ashoke Sen
18. Dr. Prasenjit Sen
19. Dr. L. Sriram Kumar

## Sr. Research Associate (CSIR)

1. Dr. Ashok Sethia

## Visiting Fellow (Physics)

1. Dr. Dumitru Asterfanesei

2. Dr. Somdatta Bhattacharya
3. Dr. Pravabati Chingangbam
4. Dr. S. S. Deshingkar
5. Dr. Kazuyuki Furuuchi
6. Dr. H.K. Jassal
7. Dr. Namit Mahajan
8. Ms. Poonam Mehta
9. Dr. Sukanta Panda
10. Dr. S. K. Rai
11. Dr. Arnab Kumar Ray
12. Dr. K. P. Yogendran

## Research Scholar (Physics)

1. Mr. Arjun Bagchi
2. Mr. Priyotosh Bandyopadhyay
3. Ms. Nabamita Banerjee
4. Mr. Subhaditya Bhattacharya
5. Mr. Turbasu Biswas
6. Mr. Anindya Dey
7. Mr. Suvankar Dutta
8. Ms. Pomita Ghoshal
9. Mr. Rajesh Kumar Gupta
10. Mr. Sudhir Kumar Gupta
11. Mr. Rajeev Kumar Jain
12. Mr. Nishikanta Khandai

13. Mr. Girish P. Kulkarni
14. Mr. Anamitra Mukherjee
15. Mr. Ayan Mukhopadhyay
16. Mr. Kalpataru Pradhan
17. Mr. Jayanti Prasad
18. Mr. Arijit Saha
19. Mr. Bindusar Sahoo
20. Mr. H. R. Srikanth
21. Mr. Manoj Kumar Srivastava
22. Mr. Santosh Kumar Swain
23. Mr. Anurag Tripathi

# ADMINISTRATIVE STAFF

| | | |
|---|---|---|
| 1. | Shri Sanjeev Kashalkar | Registrar |
| 2. | Shri Sanjaya Saran | Deputy Registrar |
| 3. | Shri Raaj Kumar Gulati | Accounts Officer |
| 4. | Shri V.R. Tiwari | Librarian |
| 5. | Shri Prabhat Kumar | Senior Private Secretary |
| 6. | Shri Amit Roy | Internal Audit cum Admn. Officer |
| 7. | Shri K.S. Shukla | Professional Assistant |
| 8. | Shri Jagannath Yadav | Accountant |
| 9. | Shri R.P. Sharma | Manager Guest House |
| 10. | Ms. Archana Tandon | Office Superintendent |
| 11. | Shri Deepak Srivastava | Store Purchase Officer |
| 12. | Shri V.P. Tiwari | Jr. Hindi Translator |
| 13. | Shri Uma Kant Dwivedi | Cashier |
| 14. | Shri D. Malhotra | UDC |
| 15. | Shri K.K. Srivastava | UDC |
| 16. | Shri Yashpal Singh | Steno |
| 17. | Mrs Sumitra | UDC |
| 18. | Shri Parmanand Mishra | Jr. Library Assistant |
| 19. | Shri Dharmpal Sharma | Jr. Library Assistant |
| 20. | Mrs Seema Agarwal | Receptionist |
| 21. | Shri Kashi Prasad | Driver |
| 22. | Shri Ram Dulare Maurya | Peon |
| 23. | Shri Dina Nath Dube | Peon |
| 24. | Shri Lalloo Ram | Night Watchman |
| 25. | Shri Kamlesh Thakur | Watchman |
| 26. | Shri Ramakant Dixit | Watchman/Peon |
| 27. | Shri Kamta Prasad | Watchman/Peon |
| 28. | Shri Rajesh Kumar | Sweeper |
| 29. | Shri Munna Lal | Gardener |

**Engineering/Technical Staff:**

| | | |
|---|---|---|
| 1. | Shri K. Venkatraman | Sr. Consultant |
| 2. | Shri Manish Sharma | Scientific Officer 'C' |
| 3. | Shri R.N. Shukla | Scientific Officer 'D' |
| 4. | Shri Sanjai Verma | Systems Manager |
| 5. | Ms. Anju Verma | Scientific Asstt. |
| 6. | Shri Ajay Kumar Srivastava | Jr. Engineer (Electrical) |
| 7. | Shri V.K. Srivastava | Jr. Engineer (Civil) |
| 8. | Shri Ajay Srivastava | Jr. Engineer (Electrical) |

**Medical Consultants:**

| | | |
|---|---|---|
| 1. | Dr. G.S. Sinha | Authorised Medical Consultant |
| 2. | Dr. Bharat Arora | Emergency Medical Officer |
| 3. | Dr. Shanta Arora | Emergency Medical Officer |
| 4. | Dr. Ruchi Rai | Emergency Medical Officer |
| 5. | Dr. R.R. Saraswat | Emergency Medical Officer |
| 6. | Dr. Rakesh Verma | Emergency Medical Officer |
| 7. | Dr. S.D. Pandey | Emergency Medical Officer |
| 8. | Shri S.R. Gautam | Sr. Pharmacist |
| 9. | Shri Piyush Dixit | Pharmacist |
| 10. | Shri Alok Pandey | Pharmacist |
| 11. | Miss Shilpi Srivastava | Pharmacist |

# ACADEMIC REPORT - MATHEMATICS

## Sukumar Das Adhikari

### Research Summary:

In a joint project with P. Rath and N. Saradha, work is in progress with some problems related to some questions posed by Mahler. More precisely, let $\xi > 0$. Suppose $g$ is a distribution function of $\{\xi(p/q)^n\}$ where $p > q > 1$ are positive integers with gcd$(p, q) = 1$. We have exhibited sets $X \subset [0, 1]$ of measure $1 - \frac{1}{p}$ such that if $g$ is defined on $X$, then $g$ is uniquely determined on the whole of $[0, 1]$. For example, $X$ can be taken as any interval $[a, a + \frac{p-1}{p}] \subset [0, 1]$.

In another direction, a theorem of Erdős, Ginzburg and Ziv (often referred to as the EGZ theorem) says that:

*For any positive integer $n$, any sequence $a_1, a_2, \cdots, a_{2n-1}$ of $2n - 1$ integers has a subsequence of $n$ elements whose sum is 0 modulo $n$.*

The higher dimensional analogue of the EGZ theorem, which was considered initially by Harborth and Kemnitz has given rise to a very active area of combinatorics today.

For $n \in \mathbf{N}$ and $A \subset \mathbf{Z}/n\mathbf{Z}$, in a joint work with J. Friedlander, S. Konyagin and F. Pappalardi, we have considered the function $E_A(n)$ defined as the least $t \in \mathbf{N}$ such that for all sequences $(x_1, \ldots, x_t) \in \mathbf{Z}^t$ there exist indices $j_1, \ldots, j_n \in \mathbf{N}, 1 \leq j_1 < \cdots < j_n \leq t$, and $(\vartheta_1, \cdots, \vartheta_n) \in A^n$ with

$$\sum_{i=1}^{n} \vartheta_i x_{j_i} \equiv 0 \pmod{n}.$$

To avoid trivial cases, we always assume that $A$ does not contain $0$ and it is non–empty. It is clear that $E_{\{1\}}(n) = E(n)$ and that

$$E_A(n) \leq E(n) = 2n - 1.$$

Further, if we consider the sequence with $n - 1$ zeros and one $1$, we deduce that

$$E_A(n) \geq n + 1.$$

We proposed the problem of enumerating $E_A(n)$ and considered the case $A = \{1, -1\}$. In this case we denote $E_A = E_\pm$ which is perhaps the most basic one aside from the classical Erdős, Ginzburg, Ziv problem.

It is easy to see that

$$E_\pm(n) \geq n + \lfloor \log n \rfloor,$$

where $\log$ means the base $2$ logarithm. Indeed, if we consider the sequence of integers:

$$(\overbrace{0,0,\ldots,0}^{n-1\text{times}},1,2,\ldots,2^r)$$

where $r$ is defined by $2^{r+1} \leq n < 2^{r+2}$, then any combination with signs of $n$ integers of the sequence gives rise to a number whose absolute value is $\leq 2^{r+1} - 1$ and is not zero by the uniqueness of the binary expansion. Furthermore the sequence has $n + r = n + \lfloor \log n \rfloor - 1$ elements.

We have proved that: *If $n$ is even or $n = p^r$ is the power of an odd prime $p$ or $n = pq$ where $p$ and $q$ are odd primes, then*

$$E_{\pm}(n) = n + \lfloor \log n \rfloor.$$

Furthermore we expect the following to be true:
*For any integer $n$,*

$$E_{\pm}(n) = n + \lfloor \log n \rfloor.$$

Work in some more questions in Combinatorial Number Theory is in progress.

## Publications:

1. *Monochromatic configurations for finite colourings of the plane*
   (Jointly with Purusottam Rath)
   Note di Matematica 22, no. 1, 59 –63 (2003/04).

2. *On the sets of uniqueness of the distribution function of $\{\xi(p/q)^n\}$*
   (Jointly with P. Rath and N. Saradha)
   Acta Arithmetica, to appear.

## Preprints:

1. *Contributions to zero–sum problems*
   (Jointly with J. Friedlander, S. Konyagin and F. Pappalardi)

**Volumes edited:**

**Number Theory**
(proceedings of the international conf. held at The Institute of Mathematical Sciences, Chennai, in January 2002),
(Edited jointly with R. Balasubramanian and K. Srinivas),
Ramanujan Mathematical Society Lecture Notes Series, Number 1, 2005.

## Conference/Workshops Attended:

1. Participated in a Number Theory meeting held at University of Parma, Italy, in May 2004.
2. Participated in the Additive Number Theory Conference, held at University of Florida, Gainesville during November 17-20, 2004.
3. Participated in a workshop on Applications of Dynamical Systems to Number Theory held at the University of Hyderabad in January, 2005.

## Visits to other Institutes:

1. Visited University of Lille, France, in April 2004 under IFCPAR project.
2. Was a GNSGA visiting Professor at University of Rome III for a month during April- May, 2004.
3. Visited TIFR, Mumbai in October, 2004.
4. Visited University of Florida, Gainesville during November, 2004.
5. Visited IMSc, Chennai in January, 2005.

## Invited Lectures/Seminars:

1. Gave an invited talk in a Number Theory meeting held at University of Parma, Italy, in May 2004.
2. Gave a talk at IIT, Kanpur in August 2004.
3. Gave an invited talk in the 'Additive Number Theory Conference', held at University of Florida, Gainesville during November 17-20, 2004.
4. Gave invited talks in a workshop on 'Applications of Dynamical Systems to Number Theory' held at the University of Hyderabad in January, 2005.
5. Gave a talk at ISI, Calcutta in January 2005.

6. Gave a talk at the University of Allahabad in a Refresher Course in February, 2005.

## Other Activities:

1. Gave a course on Discrete Mathematics to the first year students at HRI.
2. Gave lectures in the Visiting Students' Summer Programme in the summer of 2004.

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# Punita Batra

## Research Summary:

I finished the problem of finding irreducible integrable modules for twisted Toroidal Lie algebras with finite dimensional weight spaces. This is a joint work of mine with Prof. S. Eswara Rao.

## Preprints:

1. (With S. Eswara Rao)*Classification of Irreducible Integrable modules for Twisted Toroidal Lie algebras with finite dimensional weight spaces*.

## Conference/Workshops Attended:

1. Workshop and International Conference on Infinite Dimensional Lie Theory Morningside Center of Mathematics, Beijing, China, July 17-23, 2004.

## Visits to other Institutes:

1. Visited Morningside Center of Mathematics, Chinese Academy of Sciences, Beijing, July 18 - 24, 2004.

## Invited Lectures/Seminars:

1. *"Classification of finite dimensional Irreducible modules of twisted multi loop Lie algebras"* on July 18, 2004 at MCM, Beijing, China.

## Other Activities:

1. Gave four lectures on *"Quadratic Forms"* at HRI in VSSP programme in June 2004.

2. Gave one lecture on *"Equations of Line and Inequalities"* in Hindi in the Rajbhasha programme at HRI in July 2004.

3. Gave three lectures on *"Homological Algebra"* in AFS-2 at HRI in December 2004. I was also the Course Coordinator of Algebra Course in AFS-2.

4. Gave a graduate course *"Advanced Topics in algebra"* to second year Ph.D students at HRI during January to May 2005.

5. I am advising a second year Ph.D student since July 2004.

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# Kalyan Chakraborty

## Research Summary:

In a work done jointly with A. Mukhopadhayay, we improved a previous estimate of ours in estimating the number of real quadratic function fields whose class number is divisible by a given integer. This will appear in Proc. of the AMS. Work is in progress in improving this bound further and asking the same question in the non-divisibility case.

Work is in progress in deriving a lower bound on the number of Fourier coefficients that determine a holomorphic Hilbert modular form. This is a generalization of a classical work of Jacob Sturm. Work is also in progress to understand modular symbols in case of number fields and use them to study the L-functions associated to the Hilbert modular forms.

## Publications:

1. *Exponent of the class group of real quadratic function fields II*, jointly with A. Mukhopadhayay, to appear in Proc.of the AMS.

2. *On the divisibility of class numbers of real quadratic fields* , to appear in RIMS (Kyoto University) Conf. Proceedings, 2004.

3. On the number of Fourier coefficients that determine a form, to appear in Waseda University Number Theory Conf. Proceedings, 2005.

## Preprints:

1. *Exponents of class groups of a family of cyclic cubic fields.*

## Conference/Workshops Attended:

1. Analytical Number Theory and surrounding area, 18-22 October 2004 at RIMS, Kyoto, Japan.

2. Workshop in Algebraic Number Theory, 2-4 November 2004, Kochi University, Kochi, Japan.

3. Conference of Number Theory, 15-17 March 2005, Waseda University, Tokyo, Japan.

## Visits to other Institutes:

1. Visited Universite Paris 7, 29th June to 30th July, 2004.
2. Visited Tokyo Metropolitan University, Tokyo, 9th October to 10th November, 2004.
3. Visited Waseda University, Tokyo, 13th March to 19th March, 2005.

## Invited Lectures/Seminars:

1. Gave a one hour seminar at Universite Paris 7 'Number theory Seminar' on *"Divisibility of class numbers of real quadratic fields"*.
2. A one hour seminar at Waseda University ' Number Theory Seminar' on *"On the solutions of a Diophantine Equation"*.
3. A 50 minutes talk at RIMS Conference (18–24 October)2004 on *"On the divisibility of class numbers of real quadratic fields"*.
4. A one hour talk at Kochi University 'Algebraic Number Theory Workshop' on *"Divisibility of class numbers of real quadratic function fields"*.
5. A one hour talk to the undergraduate eng. students at Kinki University (October 26th, 2004), Fukuoka, Japan, on *"Introduction to Diophantine Equations"*.
6. Presented a one hour talk at 'Conference in Number Theory' at Waseda University, 15th March, 2005, *"On the number of Fourier coefficients that determine a form"*.

## Other Activities:

1. Taught a 2nd Semester Course (Algebra II) for the 1st year Ph.D. students.

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# Chandan Singh Dalawat

## Research Summary:

Some years ago, the Chow group of a Châtelet surface over a finite extension $K$ of $\mathbf{Q}_p$ ($p$ being an *odd* prime number) was explicitly determined, even when the surface is not split by an unramified extension. The computation has now been extended to the case $K = \mathbf{Q}_2$, and similar methods should allow us to treat the case of a finite extension of $\mathbf{Q}_2$. It would then become possible to treat the number field case.

It was observed, around the same time, that the restriction and corestriction maps behave rather nicely for Châtelet surfaces over a local field. Colliot-Thélène remarked to us that this observation can be deduced from a general result for rational surfaces over local fields. We were able to show that the same general result holds for rational surfaces over number fields as well.

Along with Dipendra Prasad in Bombay, we provided the simplest possible examples of varieties over local fields which have bad reduction *not* detected by their cohomology. Among such varieties are twisted forms of projective spaces and torsors under abelian varieties.

## Publications:

1. *Le groupe de Chow d'une surface rationnelle sur un corps local,* Compositio Mathematica **141** (2) 2005, pp. 344–358. `math.AG/0302157`.

2. *The Chow group of a del Pezzo surface over a local field,* Japanese Journal of Mathematics, to appear. `math.AG/0302260`.

## Preprints:

1. (with Dipendra Prasad) *Bad varieties with good motives.* In preparation.

2. *Restriction and corestriction on the Chow group of a rational surface.*

3. (with Bas Edixhoven) *Regular proper integral models of ruled surfaces ; applications.* In preparation.

## Conference/Workshops Attended:

1. *Rencontres arithmétiques de Caen*, 14–16 June 2004.

2. *Motives, $K$-theory and arithmetical geometry*, Sestri Levante, 28 June–2 July 2004.

3. *International conference on algebraic $K$-theory and its applications*, Safi, 26–29 July 2004.

## Visits to other Institutes:

1. Université de Caen,
2. International centre for theoretical physics (Trieste),
3. Tata institute of fundamental research (Bombay).

## Invited Lectures/Seminars:

1. Le groupe de Chow d'une surface de Châtelet sur un corps local, *Séminaire de théorie des nombres de Caen*, 18 June 2004.
2. Le groupe de Chow d'une surface rationnelle sur un corps local, *International conference on algebraic $K$-theory and its applications*, Safi, 29 July 2004.
3. Comparison theorems for $p$-adic cohomologies, *Tata institute*, 12 April 2005.

## Academic recognition/Awards:

- Membre étranger de l'Académie des sciences de Limerzel.
- Founding member of the Chhatnag academy of arts and sciences.
- Knight commander of the Order of the cow belt.

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# Satya Deo

## Research Summary:

During the recent past, strict contractibility introduced by E.Michael in 2002, was one of my interests. The example given by Dydak et al of a compact contractible polyhedron which is an AR, but is not strictly contractible at some point has been generalized by myself and V.V.Awasthi. My main interest, however, has been the cohomological study of the group actions on finitistic spaces. These include various generalizations of Smith theorems on the cohomology structure of fixed point sets and Floyd's theorem on acyclicity of orbit spaces. Jointly with J.K.Maitra, we had earlier obtained results as to which groups can act freely on product of spheres. We are now looking at its possible generalizations.

Jointly with V. V. Awasthi, we are also looking at some open problems in cohomological dimension theory, particularly the exact relationship of the cohomological dimension of $X$ and $\beta X$.

We have also been studying the properties of spline modules on various polyhedral complexes embedded in the plane, or more generally, in any Euclidean space $R^n$. In this area, we have proved that under suitable conditions any basis for the spline module on a divided domain can always be extended to a basis when we take a subdivision of that domain. This result seems to be useful in approximation theory. We have also analyzed the freeness of spline modules when we pass on from a divided domain to a subdivided domain.

Jointly with R. Kulkarni, we have studied the following problem using methods of covering projections: Given a group, determine the lattice of all subgroups of that group; determine the set of conjugacy classes of subgroups of that group; determine the index of subgroups in their normalizers. We have solved the problem in a few interesting cases, e.g., for free groups on two or three generators, dihedral groups etc.

## Publications:


1. *Spline modules from a divided domain to a subdivided domain* (with J. K. Maitra) Indian J. Pure Appl. Math 35(2004)1033-1041.

2. *Strongly contractible polyhedra which are not simply contractible at $n$ points for any $n \geq 2$* (with V. V. Awasthi), J. Indian Math Soc (to appear)

3. *Branched coverings, labelled coverings, and transitive permutation groups* (jointly with R.S.Kulkarni), in preparation.

4. *Freeness of homogenized spline module from a divided domain to a subdivided domain* (with J. K. Maitra), submitted.

## Preprints:

1. *Spline modules from a divided domain to a subdivided domain* (with J. K. Maitra) Indian J. Pure Appl. Math 35(2004)1033-1041.

2. *Strongly contractible polyhedra which are not simply contractible at $n$ points for any $n \geq 2$.* (with V. V. Awasthi), J. Indian Math Soc (to appear)

3. *Freeness of homogenized spline module from a divided domain to a subdivided domain* (with J. K. Maitra), submitted.

## Conference/Workshops Attended:

1. Advanced Foundational School (AFS II) in Mathematics, Dec 2004 at HRI.

2. VSSP in Mathematics, Summer 2004

## Visits to other Institutes:

1. Department of Mathematics, University of Jammu, Jammu.

2. Organized a symposium on "Fourier Analysis, Wavelet Analysis and Approximation Theory", at the University of Allahabad, Dec 20-23, 2004 sponsored by the International Academy of Physical Sciences, Allahabad.

## Invited Lectures/Seminars:

1. On the Dynamics of contractibility, Department of Mathematics, University of Jammu, Jammu. Feb 2005

2. Three lectures in AFS II on Simplicial Homology Theory at HRI, Allahabad, December 2004.

3. Three lectures on algebraic topology in VSSP-2004 at HRI, Summer 2004.

## Academic recognition/Awards:

- Presided over Prof R.S.Mishra Memorial Lecture during Coniaps-2004 conference held at the Department of Mathematics, University of Allahabad, Allahabad, Dec 2004

- Continue to serve as member of the NBHM and a member of the University Programmes Committee (UPC) of NBHM.

- Chairman, Peer Team of the National Assessment and Accreditation Council (NAAC), an autonomous body of the UGC, New Delhi.

## Other Activities:

1. Organized a seminar talk by Prof S.P.Singh, University of Western Ontario, Canada.

2. Member, Rajbhasha Samiti, HRI.

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# Rukmini Dey

## Research Summary:

I have been working on quantization problems. In particular, I have shown that a dimensionally reduced Seiberg-Witten moduli space admits geometric prequantization as well as deformation quantization. I have also shown that the moduli space of the self-duality equations on a Riemann surface admit geometric prequantization.

I have been also working on what kind of Gaussian curvatures are possible on Riemann surfaces.

Recently I am interested in finite group actions on topological manifolds, especially on orientable and non-orientable Riemann surfaces.

## Publications:

1. *Deformation quantization of a dimensionally reduced Seiberg-Witten moduli space*, accepted for publication in Reports on Mathematical Physics, as an addendum to a previous paper.

2. *Quantization of a dimensionally reduced Seiberg-Witten moduli spaces*, Mathematical Physics Electronic Journal, vol 10, 2004, paper no.9,

   `http://www.maia.ub.es/mpej/`

3. *A complete conformal metric of preassigned negative Gaussian curvature for a punctured hyperbolic Riemann surfaces*, Proceedings of Indian Academy of Sciences – Math Sci. Vol.114,No.2, May 2004, pg. 141-151

## Preprints:

1. *Geometric Prequantization of the moduli space of the self-duality equations on a Riemann surface*, submitted to Reports on Mathematical Physics.

## Visits to other Institutes:

1. I.I.T. Kanpur, July 2003-Dec 2004 (On lien).

## Other Activities:

1. Instructor, Analysis I, I.I.T. Kanpur, Kanpur, August-December 2004 ( on lien from HRI).

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# Manoj Kumar Keshari

## Research Summary :

Let $R$ be an affine algebra of dimension $n \geq 3$ over an algebraically closed field $k$. Suppose char $k = 0$ or char $k = p \geq n$. Let $g, f_1, \ldots, f_r$ be a $R$-regular sequence and $A = R[f_1/g, \ldots, f_r/g]$. Let $P'$ be a projective $A$-module of rank $n-1$ which is extended from $R$. Let $(a, p) \in (A \oplus P')$ be a unimodular element and $P = A \oplus P'/(a, p)A$. Then, $P$ is extended from $R$.

The above result generalizes a result of Murthy. Similar result for affine algebra over the field of real numbers is also proved.

## Publications :

1. *Stability results for projective modules over blowup rings*. To appear in J. Algebra.

## Preprints :

1. Stability results for projective modules over blowup rings.

## Conference/Workshops Attended :

1. AFS II, December 2004, HRI Allahabad.

## Visits to other Institutes :

1. TIFR Mumbai, 1-9th September 2004.
2. ISI Kolkata, 15-23rd March 2005.

## Invited Lectures/Seminars :

1. Gave a talk in ISI Kolkata on 17th March 2005 on *"Complete intersection ideals and a question of Nori"*.

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# I. B. S. Passi

## Research Summary:

I have been working on problems in group rings involving combinatorial and homological methods.

A number of research projects were undertaken and completed jointly with R. Mikhailov. Motivated by works of D. Quillen and J. Cuntz, higher traces on group rings have been studied and group homology of centralizers in groups has been investigated. A problem of Plotkin, which asks whether the quasi-variety $\mathcal{D}_n$ of groups with trivial $n$th dimension subgroup is finitely based, was answered in the negative by showing that the quasi-variety $\mathcal{D}_4$ is not finitely based. Arising from group-theoretic and topological considerations, certain problems concerning faithful actions and residual properties of groups were studied.

A class of groups, encountered in an investigation of Bass' conjecture via cyclic homology, was studied (jointly with I. Emmanouil).

Work on multiplicative Jordan decomposition property in group rings was continued (jointly with A. W. Hales).

## Publications:


1. Algebra Vol 4: Field Theory, Narosa Publishing House, 2004 (jointly with I. S. Luthar).

2. *A contribution to Bass' conjecture*, J. Group Theory, 7 (2004), 409-420 (jointly with I. Emmanouil).

3. *Hyperbolic unit groups*, Proc. Amer. Math. Soc., 133 (2005), 415-423 (jointly with S. O. Juriaans and D. Prasad).

4. *Augmentation powers and group homology*,J. Pure Appl. Algebra, 192 (2004), 225–238 (jointly with R. Mikhailov).

5. *Higher traces on group rings*,Comm. Algebra, 33 (2005), 987-997 (jointly with R. Mikhailov).

6. *A transfinite filtration of Schur multiplicator*,International J. Algebra and Computation [to appear] (jointly with R. Mikhailov).

7. *Faithfulness of certain modules and residual nilpotence of groups*,International J. Algebra and Computation [to appear] (jointly with R. Mikhailov).

## Preprints:

1. *Group homology and Connes' periodicity in the cyclic homology of group algebras* (jointly with I. Emmanouil).

## Conference/Workshops Attended:

1. Advanced instructional workshop on *Low-dimensional Topology and Geometric Group Theory* held at Indian Statistical Institute, Bangalore Centre, during 12-24 July, 2004 (for the first week).

2. Professor Hansraj Gupta Memorial Symposium organized by Department of Mathematics, Panjab University, Chandigarh during 19-20 November, 2004.

## Visits to other Institutes:

1. Department of Mathematics, Panjab University, Chandigarh, for four weeks during May 2004.

## Invited Lectures/Seminars:

1. Two lectures on *"Group Rings"* at Department of Mathematics, Panjab University, Chandigarh during May 2004.

2. *"Representation Theory of Finite Groups"* at Panjab University in November 2004 and University of Pune in March 2005.

## Academic recognition/Awards:

- The Mathematical Association of India conferred The *Distinguished Service Award* for the year 2003 on April 13, 2004.

## Other Activities:

1. Gave a course on *Algebra* to the first year students during the first semester.

2. Gave a course of lectures on *Linear Groups* during the VSSP Programme 2004.

3. **Annual Foundation School -II 2004**: I was Convener of AFS-II 2004 held at Harish-Chandra Research Institute during 3-30 December 2004, where I also gave a course of seven lectures on *Homological Algebra*. This School was a part of a national level programme of Advanced Training in Mathematics funded by the National Board for Higher Mathematics.

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# N. Raghavendra

## Research Summary:

I was working on the moduli space of triples on a Riemann surface, and on the relation between the determinant line bundles on this space, with work of Macdonald on the cohomology of symmetric products of an algebraic curve.

## Preprints:

1. Indranil Biswas, and N. Raghavendra, *On transversely holomorphic principal bundles*, Submitted for publication.

## Other Activities:

1. Gave four lectures on topology in the VSSP, Summer, 2004.
2. Taught the first year graduate course Topology I, first semester, 2004-05.
3. Gave seven lectures on Complex Analysis in the NBHM Advanced Foundational School in Mathematics, December, 2004.
4. Taught the first year graduate course Topology II, second semester, 2004-05.
5. Was a technical member of the Institute Computer Committee.

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# B. Ramakrishnan

**Research Summary:**

1. (with Shaun Cooper and Sanoli Gun ) : **On the Lacunarity of Two-Eta-Products**.
**Short Summary**: In this work we classify all lacunary two-eta-products of the form $\eta^r(z)\eta^s(mz)$ for $m = 3, 4, 5, 7$, where $r + s$ is even, $rs \neq 0$. We prove the following two theorems and conjecture that for $m > 7$ there are no lacunary two-eta-products other than $(r, s) = (1, 1), (1, 3), (3, 1), (3, 3)$.
**Theorem 1.** *Suppose that $r + s$ is even and $rs \neq 0$. Then $\eta^r(z)\eta^s(mz)$ is lacunary cusp form if and only of $(r, s)$ is one of the following pairs corresponding to $m$:*

| $m$ | $(r, s)$ |
|---|---|
| 3 | $(1,1),\ (-1,5),\ (5,-1),$ $(1,3),\ (3,1),\ (2,2),\ (3,3),\ (-1,9),\ (9,-1),\ (-2,10),$ $(10,-2),\ (-3,11),\ (11,-3),\ (5,3),\ (3,5),\ (7,7).$ |
| 4 | $(1,1),\ (2,2),\ (3,1),\ (1,3),\ (5,-1),$ $(-1,5),\ (3,3),\ (-1,7),\ (7,-1),\ (5,5).$ |
| 5 | $(1,1),\ (3,1),\ (1,3),\ (3,3),(5,1),\ (1,5),$ $(5,5),\ (-1,7),\ (7,-1),\ (11,-1),\ (-1,11).$ |
| 7 | $(1,1),\ (3,1),\ (1,3),\ (3,3),\ (7,1),$ $(1,7),\ (5,3),\ (3,5),\ (9,-1),\ (-1,9).$ |

**Theorem 2.** *If $m \geq 4$, no lacunary non-cusp form exists corresponding to the eta-product $\eta^r(z)\eta^s(mz)$. For $m = 3$, the only lacunary non-cusp forms are those corresponding to the pairs $(-1, 3)$ and $(3, -1)$.*

2. (with Sanoli Gun ) : **On Special Values of Certain Dirichlet $L$-functions**.
**Short Summary**: Let $r_k(n)$ denote the number of ways $n$ can be expressed as a sum of $k$ squares. Recently, S. Cooper [The Ramanujan Journal **6** (2002), 469–490] conjectured a formula for $r_9(t),\ t \equiv 5 \pmod 8$, $r_{11}(t),\ t \equiv 7 \pmod 8$, where $t$ is a square-free positive integer. In this work we observe that these conjectures follow from the works of Lomadze. Further we express $r_9(t)$, $r_{11}(t)$ in terms of certain special values of Dirichlet $L$-functions. Combining these two results we get expressions for these special values of Dirichlet $L$-functions involving Jacobi symbols. More precisely, we prove the following theorem.
**Theorem** *Let $t$ be a square-free positive integer. If $t \equiv 5 \pmod 8$, then*

$$L\left(-3, \left(\frac{t}{\cdot}\right)\right) = \frac{2}{17} \sum_{j=1}^{(t-1)/2} \left(\frac{j}{t}\right) j^2(4j - 3t). \tag{1}$$

*When* $t \equiv 7 \pmod 8$, *we have*

$$L\left(-4, \left(\frac{-t}{\cdot}\right)\right) = \frac{16}{31} \sum_{j=1}^{(t-1)/2} \left(\frac{j}{t}\right) j^3(j-t). \tag{2}$$

3. (with M. Manickam ) : **Eichler-Zagier map for Jacobi forms of half-integral weight**.
**Short Summary**: In this work we construct Eichler-Zagier map in the case of Jacobi cusp forms of half-integral weight. As an application, we show that there is no Hecke equivariant map from index $1$ to index $p$ ($p$ prime) when the weight is half-integral.

## Publications:

1. *An estimate for a certain average of the special values of character twists of modular L-functions* (with M. Manickam), Proc. Amer. Math. Soc. 133 (2005), 2515-2517.

2. *On the representation of integers as sums of an odd number of squares* (with Sanoli Gun), To appear in The Ramanujan Journal.

3. *On special values of certain Dirichlet L-functions* (with Sanoli Gun), To appear in The Ramanujan Journal.

4. *Distribution of Quadratic non-residues which are not primitive roots* (with Sanoli Gun, Brundaban Sahu and R. Thangadurai), Accepted for publication in Math. Bohemica.

## Preprints:

1. *Eichler-Zagier map for Jacobi forms of half-integral weight* (with M. Manickam).

2. *On the Lacunarity of Two-Eta-Products* (with Sanoli Gun).

## Conference/Workshops Attended:

1. Participated and delivered an invited talk at the International Conference on Additive Number Theory held at the University of Florida, Gainesville during November 17-20, 2004.

## Other Activities:

1. Guiding two students (Ms. Sanoli Gun and Mr. Brundaban Sahu) for their Ph.D work.
2. Taught a one semester (first year) course in our Ph.D programme.
3. Lectured in the Annual Foundation School-II organized at HRI during December 2004.
4. Convener of the Graduate studies committee (Mathematics).
5. Member of the Faculty recruitment committee (Mathematics).

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# Ratnakumar P.K.

## Research Summary:

Presently I am studying the oscillatory semigroups associated with certain differential operators $L$ that are of interest in Mathematical Physics and Harmonic Analysis. More specifically oscillatory semigroups of the form $e^{itL}$, which can be defined using spectral theory for $L$. Note that with any self adjoint differential $L$, having the spectral decomposition

$$L = \int_E \lambda \, dP_\lambda$$

we can associate an oscillatory semi group $e^{-itL}$ given by

$$e^{-itL} = \int_E e^{-it\lambda} dP_\lambda$$

where $dP_\lambda$ denotes a projection valued measure on the spectrum $E$ of $L$. The spectrum may be continuous, discrete or a combination of both, in general. Oscillatory semigroup of the above form arises as solution operator to the initial value problem for the Schrödinger equation for $L$ :

$$\begin{aligned} i\partial_t u(x,t) \; - \; & Lu(x,t) = 0, \qquad\qquad x \in \mathbb{R}^n, \; t > 0, & (3) \\ u(x,0) \; = \; & f(x). & (4) \end{aligned}$$

For $f \in L^2(\mathbb{R}^n)$, the solution to this initial value problem is given by

$$u(x,t) = e^{-itL} f(x).$$

Of interest in quantum mechanics are the operators that arise as perturbations of the Laplacian $\Delta$ by a suitable potential $V$ i.e., of the form $L = -\Delta + V$, known as the Schrödinger operator, which is the Hamiltonian for the potential $V$. For a wide class of potentials, it has been known that the operator $L$ is self adjoint and admits a spectral decomposition of the above form.

Presently I am investigating the (global and local) regularity and other properties of the solutions of Schrödinger equation for a general potential $V$. There is some progress in this direction for the quadratic potential $V(x) = |x|^2$ in $\mathbb{R}^n$.

## Publications:

1. *Schrödinger equation and the oscillatory semigroup for the Hermite operator*, jointly with A.K. Nandakumaran, Journal of Functional Analysis, (to appear).

## Preprints:

1. *Schrödinger propagator for the special Hermite operator, a regularity result.*

## Conference/Workshops Attended:

1. Recent trends in Analysis, Ramanujan Institute of Advanced Study in Mathematics, 2nd March to 4th March, 2005. Gave a talk on *"Schrödinger equation and the oscillatory semigroup for the Hermite operator"*.

## Visits to other Institutes:

1. Dept. of Mathematics, Indian Institute of Science, Bangalore. From 25th May to 3rd June 2005.

## Invited Lectures/Seminars:

1. Recent trends in Analysis, Ramanujan Institute of Advanced Study in Mathematics, 2nd March to 4th March, 2005. Gave a talk on *"Schrödinger equation and the oscillatory semigroup for the Hermite operator"*.

## Other Activities:

1. Taught the course on Real analysis, in the first semester of Integrated Ph. D. programme in mathematics.

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# Ritumoni Sarma

## Research Summary:

We (with T. N. Venkataramana) proved that the non-uniform arithmetic subgroups of a semisimple $\mathbf{Q}$-simple linear algebraic group with $\mathbf{Q}$-rank at least 1 and real rank at least 2, contain a subgroup of finite index generated by at most 3 elements (to appear in Geom. Dedicata). I am trying to understand whether the same statement holds for the so called $S$-arithmetic groups. I have proved the result for the $\mathbf{Q}$-group $SL_2(K)$ when $K$ is $\mathbf{Q}$ or is a quadratic extension of $\mathbf{Q}$ and $S$ is any set of finitely many primes of $K$ containing the infinite ones: if $\mathcal{O}_S := \{x \in K : x \in K_p \text{ for } p \in S\}$ (called ring of $S$-integers), then the group $SL_2(\mathcal{O}_S)$ contains a subgroup of finite index generated by at most 3 elements unless the group of units of $\mathcal{O}_S$ is finite. In fact, when $K$ is $\mathbf{Q}$ or is a real quadratic field extension of $\mathbf{Q}$, there exists a unit $u$ in $\mathcal{O}_S$ such that the ring $\mathbf{Z}[u]$ is a subgroup (the additive group of the ring) of finite index in the ring $\mathcal{O}_S$. This ring theoretic statement implies the preceeding group theoretic one.

## Preprints:

1. Ritumoni Sarma, *$S$-Arithmetic Subgroups of $SL_2$* (under preparation).

## Conference/Workshops Attended:

1. I participated in the Annual Foundation School- II (as a tutor and a as a recorder), held in HRI, allahabad, Dec. 3rd to 30th, 2004.

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# D. Surya Ramana

## Research Summary:

An elementary proof, using a discrete version of the circle method, was obtained of the bound $E(\lambda) \ll \lambda^{2/3}$, where $E(\lambda)$ is the difference between the area of a circle of radius $\lambda$ and the number of lattice points contained in it. The present method is a substantial simplification of a method described in a perprint of 2000-2001. This revised version is presented in the preprint *A Method of Vinogradov for Sums of Fractional Parts* listed below.

## Preprints :

1. D.S.Ramana, *A Method of Vinogradov for Sums of Fractional Parts*.

## Invited Lectures/Seminars:

1. Delivered five lectures on *"transcendental extensions"* as a part of a seminar on algebraic curves at H.R.I..
2. Delivered four lectures in the V.S.S.P. 2005 programme at H.R.I. on *"Dirichlet's theorem on primes in arithmetic progression"*.

## Other Activities :

1. Served on the Library Committee of H.R.I. as conveyor and the Local Works Commmitee of H.R.I. as a member.
2. Served on the Lucknow interview panel for the K.V.P.Y. programme of the Department of Science and Technology, Government of India.
3. Organised the Mathematics part of the annual Science Talent Examination conducted by H.R.I. for school students of Allahabad city.
4. **Course Work :**
   - Taught a course on complex analysis from January to May, 2005 as a part of the H.R.I. graduate programme.

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# R. Thangadurai

## Research Summary:

One of the fundamental constants in Zero-sum problems in Combinatorial Number Theory is Davenport's constant. Let $G$ be a finite abelian group. Then $D(G)$ (Davenport's constant) is defined to be the least positive integer $t$ such that given any sequence of $t$ elements from $G$ has a subsequence whose sum is the zero element of $G$. Since the best known upper and lower bound for $D(G)$ does not seem to be tight, there are conjectures about the right value of $D(G)$. Last one year I have studied about this constant and have found an upper bound which improves the best known for most of the groups. Other than this work, I have been exploring the possible criteria for checking the irreducibility over rationales of a given polynomial with integer coefficients.

## Publications:

1. *On Steinhaus sets*, (with S. M. Srivastava),Expositiones Mathematicae, No 2 **23** (2005), 171-178.

2. *On the structure of p-zero-sum free sequences and its application to a variant of Erdös-Ginzburg-Ziv theorem* (with W D Gao and A Panigrahi), Proceedings of the Indian Academy of Sciences (Mathematical Sciences), VOL. 115, NO. 1, FEBRUARY 2005, 67-77.

3. *On the structure of sequence with forbidden zero-sum problems* (with W. D. Gao), To appear in Aequisitiones Mathematicae.

4. *Irreducibility Criterion over* $\mathbb{Z}$, To appear in Elemente Mathematicae.

## Preprints:

1. *On Davenport's Constant*.

## Other Activities:

1. I gave a second year Ph. D course on "p-adic analysis" from August, 2004 to December, 2004.

2. I served in the following committees at HRI

   - Computer Committee
   - Guest House/ Hostel/ Housing Allotment committee
   - Office Furniture committee

- Co-ordinator JEST 2005 Committee
- Co-ordinator VSSP 2004

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# Manoj K. Yadav

## Research Summary:

Let $G$ be a finite group. For $x \in G$, $x^G$ denotes the conjugacy class of $x$ in $G$. I studied relationship between product of conjugacy classes in $G$ and structure of $G$.

Let $G$ be a finite group. An automorphism $\alpha$ of $G$ is called class-preserving if $\alpha(g) \in g^G$ for all $g \in G$. $Aut_c(G)$, the group of all class preserving automorphisms of $G$ is a normal subgroup of $Aut(G)$, the group of all automorphisms of $G$. I am working on the relationship between structure of $Aut_c(G)$ and $G$.

## Publications:

1. (Jointly with Everett C. Dade)*Finite groups with many product conjugacy classes*. to appear in Israel Journal of Mathematics.

## Preprints:

1. *Class preserving automorphisms of finite $p$-groups* (in preparation).

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# Krishnendu Gongopadhyay

## Research Summary:

I studied the dynamics of the group of orientation-preserving isometries of the hyperbolic space, mainly of dimension 4 and 5. Our aim is to find an algebraic characterization of the dynamical types of these isometries and further generalization of the theory.

## Preprints:

1. (with Ravi Kulkarni) *The spaces of $n$-planes and $n$-spheres*.

## Conference/Workshops Attended:

1. I attended the Advanced Foundational School (AFS)-I, 10th May-5th June, 2004.

## Invited Lectures/Seminars:

1. I gave two project seminars at the HRI on Basic Geometry of Hyperbolic Plane and Eilenberg-Maclane Spaces.

## Other Activities:

1. I assisted *Prof Ravi Kulkarni* in preparing course materials for his course in the AFS-II at the HRI. I am also assisting him in maintaining the website of the *Year on Teichmuller Theory and Moduli Problems*.

2. I attended the courses given by *Prof Fred Gardiner* (CUNY),*Prof Cliff Earle* (Cornell University) and *Prof Bill Harvey*(King's College, London), in the *Year on Teichmuller Theory and Moduli Problems*. I also attended the expository lectures by *Prof M. S. Narasimhan* in the above program.

3. I attended Prof Kulkarni's courses to the second year students.

4. I attended the lecture series by $Prof\ Joseph\ Oesterlé$ (Paris) at the HRI.

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# Sanoli Gun

**Research Summary:**

(1) (with Shaun Cooper and B. Ramakrishnan) : **On the Lacunarity of Two-Eta-Products**.
**Short Summary**: In this work we classify all lacunary two-eta-products of the form $\eta^r(z)\eta^s(mz)$ for $m = 3, 4, 5, 7$, where $r + s$ is even, $rs \neq 0$. We prove the following two theorems and conjecture that for $m > 7$ there are no lacunary two-eta-products other than $(r, s) = (1, 1), (1, 3), (3, 1), (3, 3)$.
**Theorem 1.** *Suppose that $r + s$ is even and $rs \neq 0$. Then $\eta^r(z)\eta^s(mz)$ is lacunary cusp form if and only of $(r, s)$ is one of the following pairs corresponding to $m$:*

| $m$ | $(r, s)$ |
|---|---|
| 3 | $(1,1),\ (-1,5),\ (5,-1),$ $(1,3),\ (3,1),\ (2,2),\ (3,3),\ (-1,9),\ (9,-1),\ (-2,10),$ $(10,-2),\ (-3,11),\ (11,-3),\ (5,3),\ (3,5),\ (7,7).$ |
| 4 | $(1,1),\ (2,2),\ (3,1),\ (1,3),\ (5,-1),$ $(-1,5),\ (3,3),\ (-1,7),\ (7,-1),\ (5,5).$ |
| 5 | $(1,1),\ (3,1),\ (1,3),\ (3,3),(5,1),\ (1,5),$ $(5,5),\ (-1,7),\ (7,-1),\ (11,-1),\ (-1,11).$ |
| 7 | $(1,1),\ (3,1),\ (1,3),\ (3,3),\ (7,1),$ $(1,7),\ (5,3),\ (3,5),\ (9,-1),\ (-1,9).$ |

**Theorem 2.** *If $m \geq 4$, no lacunary non-cusp form exists corresponding to the eta-product $\eta^r(z)\eta^s(mz)$. For $m = 3$, the only lacunary non-cusp forms are those corresponding to the pairs $(-1, 3)$ and $(3, -1)$.*

(2) (with B. Ramakrishnan) : **On Special Values of Certain Dirichlet $L$-functions**.
**Short Summary**: Let $r_k(n)$ denote the number of ways $n$ can be expressed as a sum of $k$ squares. Recently, S. Cooper [The Ramanujan Journal **6** (2002), 469–490] conjectured a formula for $r_9(t),\ t \equiv 5 \pmod 8$, $r_{11}(t),\ t \equiv 7 \pmod 8$, where $t$ is a square-free positive integer. In this work, we show that these conjectures follow from the works of Lomadze. Further we express $r_9(t)$, $r_{11}(t)$ in terms of certain special values of Dirichlet $L$-functions. Combining these two results we get expressions for these special values of Dirichlet $L$-functions involving Jacobi symbols. More precisely, we prove the following theorem.

**Theorem** *Let $t$ be a square-free positive integer. If $t \equiv 5 \pmod 8$, then*

$$L\left(-3, \left(\frac{t}{\cdot}\right)\right) = \frac{2}{17} \sum_{j=1}^{(t-1)/2} \left(\frac{j}{t}\right) j^2(4j - 3t).$$

*When $t \equiv 7 \pmod 8$, we have*

$$L\left(-4, \left(\frac{-t}{\cdot}\right)\right) = \frac{16}{31} \sum_{j=1}^{(t-1)/2} \left(\frac{j}{t}\right) j^3(j - t).$$

## Publications:

1. *On the representation of integers as sums of an odd number of squares* (with B. Ramakrishnan), To appear in The Ramanujan Journal.
2. *On special values of certain Dirichlet L-functions* (with B. Ramakrishnan), To appear in The Ramanujan Journal.
3. *Distribution of Quadratic non-residues which are not primitive roots* (with Brundaban Sahu, R. Thangadurai and B. Ramakrishnan), Accepted for publication in Math. Bohemica.

## Preprints:

1. *On the Lacunarity of Two-Eta-Products* (with Shaun Cooper and B. Ramakrishnan).

## Conferences attended :

1. Attended the Summer School on Modular Forms and Their Applications, Nordfjordeid, Norway from 17th Aug. –20th Aug. 2004.

## Other activities:

1. Conducted tutorial sessions in Advanced Foundational School II for Number Theory, 2004.

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# Purusottam Rath

## Research Summary:

We have been studying the distribution of the sequences $\{\xi(p/q)^n\}$ where $p > q > 1$ are positive integers with gcd$(p, q) = 1$. One of the few tools available in understanding these sequences is to study their possible distribution functions. In a joint project with S.D.Adhikari and N. Saradha, work is in progress with some problems related to this aspect. More precisely, let $\xi > 0$. Suppose $g$ is a distribution function of $\{\xi(p/q)^n\}$ where $p > q > 1$ are positive integers with gcd$(p, q) = 1$. We have exhibited sets $X \subset [0, 1]$ of measure $1 - \frac{1}{p}$ such that if $g$ is defined on $X$, then $g$ is uniquely determined on the whole of $[0, 1]$. For example, $X$ can be taken as any interval $[a, a + \frac{p-1}{p}] \subset [0, 1]$. Work is in progress to further refine the above results.

Work related to some questions in Combinatorial Number Theory is in progress. We are now interested in studying what is known as the *Davenport constant* of finite abelian groups. This is a rather important combinatorial invariant associated to finite abelian groups. For instance, the maximal number of prime ideals that can occour in the factorisation of a prime element of the ring of integers of a number field is equal to the Davenport Constant of its class group. We are trying to study the Davenport Constant of abelian groups of rank exceeding $2$ where the current state of knowledge as well as understanding is rather limited.

## Publications:

1. *Monochromatic configurations for finite colourings of the plane*
   (Jointly with S.D.Adhikari) Note di Matematica 22, no. 1, 59 –63 (2003/04).

2. *On the sets of uniqueness of the distribution function of* $\{\xi(p/q)^n\}$ (Jointly with S.D.Adhikari and N. Saradha) Acta Arithmetica, to appear.

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## Brundaban Sahu

**Research Summary:** 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.

### Publications:

1. *Distribution of Quadratic non-residues which are not primitive roots* (with Sanoli Gun, R. Thangadurai and B. Ramakrishnan), Accepeted for publication in Math. Bohemica.

### Other activities:

1. Gave three lectures on *"van der Waerden's Theorem and its applications"* in VSSP 2004.
2. I helped in tutorial sessions in VSSP-2004.
3. Conducted three tutorials in Number Theory, AFS II-2004.

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# Siddhartha Sarkar

## Research Summary:

Let $\Sigma_g$ be a compact and orientable surface of genus $g$. Topologically this is the surface of the sphere with $g$ handles attached. One of the most interesting questions is to study the finite groups $G$ which acts effectively on $\Sigma_g$ and the action preserves the orientation, and we call $G$ a symmetry group of $\Sigma_g$. For $g = 0, 1$ these groups are known since long. Hurwitz proved that if $\mu_g(G)$ is the order of $G$ that acts as above then $\mu_g(G) \leq 84(g-1)$ , $g \geq 2$. Machlachlan proved $(1969)$ that $\mu_g(G) \geq 8(g+1)$ , $g \geq 2$ and moreover both of these bounds can be attained for infinitely many values of $g$. In fact every finite group can be realized as a group of symmetries of $\Sigma_g$.

Now given $g \geq 2$ , a natural question is to find out the symmetry groups of $\Sigma_g$. This means in fact, to classify the groups which acts as a group of bi-holomorphisms of $\Sigma_g$ for some structure of a Riemann Surface on the underlying topological space $\Sigma_g$. However the question is not well posed, since there is no inductive procedure on $g \geq 2$ to answer the question. To understand this better, we can think of the reverse question : given a finite group $G$, what are possible $g \geq 2$ such that $G$ is a symmetry group of $\Sigma_g$.

The first question is known for $g$ upto four. For the second question there are many results known about the minimum genera computation for : (1) cyclic groups, (2) non-cyclic abelian groups, (3) metacyclic groups, (4) many sporadic simple groups, (5) $PSL_2(p)$, (6) $SL_2(F_q)$, (7) Mathieu groups. In $1988$ Kulkarni, proved that there is an $n = n(G)$ so that:
$(1)$ If $G$ acts on $\Sigma_g$, then $g \equiv 1 \bmod n$.
$(2)$ for all but finitely many $g \geq 2$ so that $g \equiv 1 \bmod n$, $G$ acts on $\Sigma_g$.
The number $(g-1)/n$, where $n$ is as above, is called a reduced genus of $G$ corresponding to $g$ . We denote the minimum reduced genus of $G$ by $\mu_0(G)$ and the maximum steady reduced genus by $\sigma_0(G)$ , i.e. whenever $\tilde{g} \geq \sigma_0(G)$, $\tilde{g}$ is a reduced genus of $G$ . Computing generas and non-generas for $\tilde{g}$ ; $\mu_0(G) \leq \tilde{g} \leq \sigma_0(G)$ is an interesting question. The groups on which these computations are known are (1) cyclic $p$-groups, (2) elementary abelian $p$-groups, (3) $p$-groups of cyclic $p$-deficiency $\leq 2$, (4) groups with MEP (Machlachlan-Talu, 1988), (5) semi-direct product of a cyclic group of order $p$ with a cyclic group of order $q$, where $p$ and $q$ are primes (Weaver, 2001). We expect to extend the result for other types of $p$-groups.

## Preprint:

1. *Genus Spectrum for $p$-groups of exponent $p$ and order upto $p^6$.*

## Other Activities:

1. Gave two lectures on *"Branched Covering and infinite dihedral groups"* as a part of the lecture series on Riemann Surfaces for Second year graduate students.

2. Gave four lectures on *"Finite Group actions on Riemann Surfaces"* as a part of the lecture series on Riemann Surfaces for Second year graduate students.

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# Anupam Kumar Singh

## Research Summary:

I have been working with Dr. Maneesh Thakur on problems related to the linear algebraic groups 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.

We determine z-conjugacy classes in an 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 $G_2$.

We have investigated reality question for linear algebraic groups over arbitrary fields. Let $G$ be a semisimple, adjoint group defined over $k$. Suppose that $-1$ belongs to the Weyl group of $G$. Then for regular semisimple element $t$, we prove that $t$ is real in $G(k)$ if and only if $t$ is a product of two involutions in $G(k)$. We give cohomological condition for a semisimple element being real in $G(k)$. Further investigations are on in classical groups and groups of type $F_4$ over arbitrary field $k$.

## Publications:

1. *Reality properties of conjugacy classes in* $G_2$ (with M. Thakur, appeared in Israel Journal of mathematics, vol. 145).

## Preprints:

1. *Conjugacy classes in anisotropic* $G_2$.
2. *Reality properties of conjugacy classes in Linear Algebraic Groups* (with M. Thakur, in preparation).

## Other Activities:

1. I helped in the tutorial sessions in VSSP-2004.
2. I helped as a tutor for Homological Algebra course in AFS-II held in HRI December 2004.
3. I visited ISI, Bangalore from 10 Feb 2005 to 10 May 2005 and participated in a seminar on Algebraic groups.

4. I gave a talk titled *"Reality Properties of Conjugacy Classes in $G_2''$* in HRI on 19th May 2005.

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# 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. The parallel TreePM code developed in collaboration with Suryadeep Ray has been the main workhorse for a large fraction of work presented here. We are working on further improving the code and using it to simulate systems with up to $10^8$ particles.

N-Body simulations, vital tools as they are for the study of galaxy formation, make several approximations in order to make computation tractable. We have studied the impact of some of these approximations on the final results calculated using N-Body simulations. We find that the results can depend on perturbations at large scales, these perturbations are ignored as the simulation volume is finite. We have suggested a method that can be used to estimate the effect of large scales and hence check whether a given simulation volume is sufficiently large for a faithful reproduction of the model of interest. This work has been done with Suryadeep Ray.

Jayanti Prasad and I have been studying the effect of mode-coupling in evolution of density perturbations. Of particular interest is the effect of perturbations at small scales on perturbations at larger scales. This effect is known to be limited if we restrict our attention to the power spectrum or correlation function. However, there is no quantitative analysis of this effect and in particular it is not known how excess perturbations at small scales can influence collapse and dynamical relaxation of larger perturbations. We have studied these issues and have arrived at an analytical approach for estimating such effects. We have verified these effects in N-Body simulations, where we study velocity fields, skewness as well as mass function. We find that for generic perturbations, the effect of small scale fluctuations on larger scales is very limited for all the indicators studied here. This study also justifies the dropping of perturbations at very small scales in N-Body simulations.

Comparison of the observed clustering of galaxies in the non-linear regime with predictions of theoretical models is made complex due to redshift space distortions and the fact that the distribution of galaxies is "biased". It has been suggested that these difficulties can be surmounted if we compute skewness and other higher moments of distribution of galaxies apart from the usual correlation

function. We have studied several models where we model overdense regions as potential hosts for galaxies, the number of galaxies in any overdense region is taken to be proportional to the mass. We find that the combination of red-shift space distortions and bias makes skewness and higher moments redundant in the non-linear regime, i.e., skewness in this regime does not contain any information about the initial conditions or the underlying distribution of matter. This work is being done with Suryadeep Ray.

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 $w \equiv p/\rho < -1/3$. 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 whereas $w = -1$ for the cosmological constant. We have developed optimised numerical methods to explore such models and compare these with the available observations. Due to the large number of cosmological parameters, this comparison is a computationally challenging task. With H. K. Jassal and T. Padmanabhan, we have carried out a detailed study with the help of these methods to see if the variation of $w$ with redshift can be detected or ruled out. While some variation is allowed, the cosmological constant is favoured by many observations.

## Publications:


1. Jassal H. K., Bagla J. S. and Padmanabhan T. 2005, MNRAS Letters 356, L11 (doi: 10.1111/j.1745-3933.2005.08577.x) : *WMAP constraints on low redshift evolution of dark energy.*

2. Bagla J. S. 2004,Current Science 88, 1088 (Special section on cosmology, Guest editor T.Padmanabhan) : *Cosmological N-Body simulation: Techniques, Scope and Status.* (astro-ph/0411043)

3. Bagla J. S. 2004, Resource Summary, Khagol 59, 5 : *Cluster computing in Astronomy.*


## Preprints:


1. Ray Suryadeep and Bagla J. S. 2004,astro-ph/0405220: *A parallel TreePM code.*

2. Bagla J. S., Prasad Jayanti and Ray Suryadeep 2004, astro-ph /0408429: *Gravitational collapse in an expanding background and the role of substructure I: Planar collapse.*

3. Ray Suryadeep, Bagla J. S. and Padmanabhan T. 2005,astro-ph/0410041: *Gravitational collapse in an expanding universe: Scaling relations for two dimensional collapse revisited.*

4. Bagla J. S. and Ray Suryadeep 2005, astro-ph /0410373: *Comments on the size of the simulation box in cosmological N-Body simulations.*

## Conference/Workshops Attended:

1. Summer school on gravitation and cosmology, HRI, Allahabad, May 10–21, 2004.

2. Summer school in Physics, IIA, Kodaikanal, June 7 – July 2, 2004.

3. School on Parallel Computing, IMSc, Chennai, Jan.7 – 14, 2005.

## Visits to other Institutes:

1. IIT Kanpur. Oct. 5–6, 2004.

2. ARIES, Nainital. March 27 — April 1, 2005.

## Invited Lectures/Seminars:

1. Colloquium, IIT Kanpur. Oct. 6, 2004.

2. A course of nine lectures on *"observational cosmology"* and *" thermal history of the universe".*

3. A course of twelve lectures on the *"general theory of relativity"* at the summer school on physics held at the Indian Institute of Astrophysics, Kodaikanal. June 21–26, 2004.

4. A course of six lectures on *"parallel computing"* at the school on Parallel Computation and Clusters, IMSc Chennai. Jan.7–14, 2005.

## Academic recognition/Awards:

- I have been nominated a member of the scientific organisation committee for the Astronomical Society of India (ASI) for 2005–07. This committee plans the scientific content of meetings of the ASI.

## Other Activities:

1. I gave a course on Classical Electrodynamics in Aug.-Dec. 2004. This course is meant for students who join HRI for the PhD programme in Physics.

2. I gave an advanced course on Cosmology in Jan.-May 2005. This course is aimed at students who are planning to do research in this field. Teaching for this course was shared with L. Sriramkumar and H. K. Jassal.

3. Two students did summer project with me in May-July, 2004.

4. The $42$ node Linux cluster, called *Kabir*, was set up at HRI during the summer of 2003. With a measured performance of $290$ Giga flops, *Kabir* is amongst fastest super-computing facilities in India. Its utilisation in the first twenty months after commissioning has been more than $80\%$. Two students have completed their thesis work on this facility and a large number of publications have resulted from work done using *Kabir*. 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/`.

5. I was a co-organiser for the *Summer School on Gravitation and Cosmology* held in May 2004 at HRI. The target audience for this school was M.Sc. students and advanced undergraduate students. About 25 students attended this two week long school.

6. I was a co-organiser for the *school on Parallel Computation and Clusters* (Jan.7–14, 2005) held at IMSc, Chennai.

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# Pravabati Chingangbam

## Research Summary:

In the last year I worked on three projects. The first was a study of the inflationary consequences of the rolling massive scalar field in a braneworld scenario. This field was proposed to be the inflaton in an effective theory described by a Dirac-Born-Infeld action in a warped string background. We found that in order to satisfy observational data of spectral index and density perturbations, the amount of warping required is decreased significantly in comparison to the standard FRW case, from roughly $10^{-9}$ to $10^{-3}$. We also did an analysis of the phase space behaviour, both in braneworld as well as standard FRW cosmology, to show their attractor behaviour. This work was done in collaboration with Tabish Qureshi.

The second project I was involved in was to study the cosmology of the tachyon field non-minimally coupled to gravity in a warped string background. We first refuted an erroneous claim by Piao et al that the tachyon field non-minimally coupled to gravity in conventional compactification can be a viable candidate for the inflaton, satisfying all observational requirements. Then we consider warped string background and do a detalied analysis of the ranges of the string theory parameters, namely the string coupling $g_s$ and the volume of compactified space $v$, and we show that there is indeed a reconcilliation of observational requirements and the string theory constraints on the ranges of the above parameters. This work was done in collaboration with Sudhakar Panda and Atri Deshamukhya.

The third project I did was in quantum mechanics. We gave a theoretical explanation for "ghost interference phenomena" for entangled particles. This work was done in collaboration with Tabish Qureshi.

## Publications:

1. *Non-minimally coupled tachyonic inflation in warped string background*, Pravabati Chingangbam, Sudhakar Panda and Atri Deshamukhya,JHEP 02 (2005) 052.

2. *Dynamics of rolling massive scalar field cosmology*, P.Chingangbam and T. Qureshi, Accepted in IJMPA, hep-th/0409015.

## Preprints:

1. *Two particle ghost interference demystified*, P.Chingangbam and T. Qureshi,quant-ph/0502162 [Submitted to Phys. Rev. A]

## Conference/Workshops Attended:

1. Attended Workshop on Strings and Cosmology, October, 2004, held at IUCAA, Pune.

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# Tapas K. Das

## Research Summary:

My research interest lies in the area of relativistic and high energy astrophysics, and analogue gravity models. During 2004 - 2005, I have been working mostly on the following issues:

### 1) Analogue Hawking radiation

I introduce the analogue model for relativistic black hole accretion in astrophysics (Das, 2004, Class. Quant. Grav., also see gr-qc/0411006 for complete review). This work bridges the long standing gap between two apparently different school of thoughts, the theory of transonic astrophysical accretion, and the theory of analogue Hawking radiation, sharing intrinsically the same physical origin. I show that general relativistic transonic accretion onto astrophysical black holes is a unique example of classical analogue system found naturally in the Universe, because only for such a system, both kind of event horizons, the electromagnetic (gravitational) and the acoustic (generated due to transonicity of accreting fluid) are simultaneously present in the same system. Hence accreting astrophysical black holes are the most ideal candidate to theoretically study and to compare the properties of these two different kind of horizons. Also, such a system is unique in other aspects. I demonstrate that general relativistic spherical accretion onto the Schwarzschild black hole represents the only classical analogue system found in the nature where the analogue Hawking temperature may be higher than the actual Hawking temperature, and analogue white hole solutions may appear for such accretion.

Along with my collaborator from Tata Institute of Fundamental Research, Mumbai, India, and Rudjer Bošković Institute, Zagreb, Croatia, I studied the post-Newtonian limit for such analogue effects as well, are now working on the analogue effects in general relativistic axisymmetric accretion in strong gravity.

The study of analogue effects may be quite important for accretion onto primordial black holes because the hawking temperature may be considerably high for such situations. There may be a possibility that intense Hawking radiation may not allow any accretion due to the domination of strong radiation pressure. However, the situation may be completely different for Randall-Sundrum type II cosmology, where during the high energy regime of braneworld cosmology, accretion may have significant effects on increasing the mass of the primordial black holes. In braneworld scenario, the accretion onto the primordial black holes from surrounding radiation bath may completely dominate over the evaporation

process as long as radiation dominations persists. Along with my collaborator from University of Colorado, Boulder, USA, I have now started working on the analogue effects in primordial black hole accretion in Randall-Sundrum type - II cosmology, to study whether analogue radiation can really dominate over the accretion phase, to enhance the black hole evaporation process.

**2) General relativistic accretion discs and the spectral signature of black hole spin**

One of the most tantalizing issues in relativistic astrophysics is to investigate whether the spin of the black hole (the Kerr parameter $a$) could be determined using any observational means, the spectral signature of the black hole, for example. Investigation of general relativistic accretion flows in Kerr metric may provide an important step toward a better understanding of this problem. For accretion onto the Schwarzschild black holes, I have been able to analytically track the in-falling matter upto the point extremely close to the event horizon. Along with my collaborators from Princeton University and Georgia State University, USA, I computed various dynamical and thermodynamic flow variables upto the point extremely close to the event horizon in Kerr metric, as a function of Kerr parameter $a$. The terminal behaviour of infalling matter (e.g., flow temperature, pressure, density etc. which are responsible to characterize the observed spectra) was studied as a function of black hole spin. By far the most discussed and approach to study the spectral signature of black hole spin was through the study of the skewed shapes of fluorescent iron lines. Our work on general relativistic black hole accretion discs provides an independent approach to this key question for hot, low angular momentum, prograde accretion flows, as well as for retrograde flows with substantial angular momentum.

**3) Formation and dynamics of X-ray and IR flares from our Galactic centre**

Along with my collaborator from N. Copernicus Astronomical Institute, Warsaw, Poland, I propose a coupled accretion-outflow scenario to model the flares emanating out from the central region of Sgr A$^*$. We show that on the way to the Galactic centre, wind-fed accretion may encounter standing shocks and such shock drives outflow from the close vicinity of the Galactic centre super massive black holes. Matter content of such outflow is computed and it is argued that such outflow is responsible for production of the Galactic centre flares. We then self-consistently compute the luminosity and the duration time scale of such flares, as a function of fundamental accretion parameters. Our theoretical calculation are in good agreement with observational results. We are now refining our model to make it more general, so that it incorporates other sources showing the signature

of strong X- ray and IR flares.

**4) Spectral variability in Low Luminosity Active Galactic Nuclei**

Along with my collaborators from Carnegie Melon University, USA, and Tata Institute of Fundamental Research, Mumbai, I have started working on various aspects of the spectral features of the Low Luminosity Active Galactic Nuclei, incorporating warm absorber model, to investigate what physical informations they reveal about the inner part of the accretion flow around massive black holes. We have submitted one paper in the Astrophysical Journal Letters, and working on two other papers to study the spectral variability.

## Publications:

1. Das, T. K., 2004, *Behaviour of matter close to the event horizon*.Monthly Notices of the Royal Astronomical Society. (349, 375)

2. Das, T. K., 2004, *Analogue Hawking Radiation from Astrophysical Black Hole Accretion*. Classical & Quantum Gravity, (21, 5253).

3. Barai, P., Das, T. K., & Wiita, P. J., 2004, *Dependence of General Relativistic Accretion on Black Hole Spin*.Astrophysical Journal Letters. (613, L49).

4. Das, T. K., 2004, *Transonic Black Hole Accretion as Analogue System*. Proceedings of 'Dynamics and Thermodynamics of Black Holes and Naked Singularities', Milan, May 2004 (gr-qc/0411006).

5. Das, T. K., 2005, *Black hole accretion as black hole analogue*. Invited contribution as a chapter of the book '21st Century Astrophysics' eds. S K Saha & V K Rastogi, Anita Publications, New Delhi.

## Preprints:

1. Das, T. K., and Czerny, B., 2004, *Low angular momentum accretion-outflow model of flares from Sgr A*$^*$. Monthly Notices of Royal Astronomical Society Letters (Submitted) (astro-ph/0408416).

2. Das, T. K. (with Dasgupta, S., Rao, A. R., Dewangan, G. C., & Czerny, B.) 2005, *Dramatic X-ray Spectral Variability in the Low-Luminosity Active Nucleus of NGC 4395: Flaring Accretion Disk or Shocked Accretion Flow?*,Astrophysical Journal Letters (Submitted).

3. Das, T. K. (with Dasgupta, S., & Bilić, N.) 2005, *Pseudo-Schwarzschild Spherical Accretion as a Classical Black Hole Analogue*,Monthly Notices of the Royal Astronomical Society (Submitted). (astro-ph/0501410).

## Visits to other Institutes:

1. N. Copernicus Astronomical Centre, Polish Academy of Science, Warsaw, Poland, February 2004 - September 2004.

2. Tata Institute of Fundamental Research, Mumbai, India, October 2004 - December 2004.

3. Three short visits to Physics Department, Burdwan University, Burdwan, West Bengal, India, during October 2004 - March 2005, where, with the active co-operation of some faculty members of the Physics Department and the Vice Chancellor of the Burdwan University, I have been trying to set up a academic counseling centre for students, one of the main aims of which will be to provide the students an exposure to basic research in Astrophysics taking place in India and abroad.

**Invited Lectures/Seminars:**

1. Colloquium at N. Copernicus Astronomical Institute, Warsaw, Poland, on *"Behaviour of matter close to the event horizon"*. May, 2004.

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# Raj Gandhi

**Research Summary:**

My research has mainly focussed on neutrino physics and the particle physics/ astrophysics interface. I summarize my ongoing research below:

Over the past year, in work done with S. Goswami, P. Ghoshal, P. Mehta and Uma Sankar, we have identified new matter resonances in the $\nu_\mu - \nu_\tau$ neutrino oscillation probability, which has important consequences for both atmospheric neutrino and future neutrino factory experiments (*Phys. Rev. Lett.* **94**, *051801 (2005)* and other references listed below). With my collaborators (listed above, and in addition with Anindya Datta)), I am working on detailed studies of matter resonances under a variety of long-baseline conditions related to future superbeam and neutrino factory experiments. This work is underway and will continue over the next year. With Sukanto Panda, I am studying the detection of Ultra-High Energy cosmic-ray muons with a view to understanding the puzzle of the knee at PeV energies and its implications for particle physics. Along with S Uma Sankar, I am Co-ordinator of the Indian group for Physics Studies for the *International Scoping Study (ISS) on Neutrino Factories and Superbeams*, which will submit its report in September 2006. With my student, Pomita Ghoshal, I am working on studies of the effects of muon polarization at neutrino factories.

## Publications:


1. R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar, *Large matter effects in nu/mu → nu/tau oscillations* Phys. Rev. Lett. 94, 051801 (2005) [arXiv:hep-ph/0408361].

2. A. Datta, R. Gandhi, P. Mehta and S. Uma Sankar, *Atmospheric neutrinos as a probe of CPT and Lorentz violation*, Phys. Lett. B 597, 356 (2004) [arXiv:hep-ph/0312027].


## Preprints:


1. R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar, *Probing the nu mass hierarchy via atmospheric nu/mu + anti-nu/mu survival rates in Megaton water Cerenkov detectors*, [arXiv:hep-ph/0506145].

2. R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar, *Earth matter effects at very long baselines and the neutrino mass hierarchy*, [arXiv:hep-ph/0411252], submitted to Phys. Rev D.

## Invitated Talks And Seminars

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| May 26, 2004 | Theory Seminar, Fermilab |
| May 24, 2004 | Theory Seminar, UCLA |
| May 20, 2004 | Theory Seminar, University of Oregon, Eugene |
| May 18, 2004 | Theory Seminar, University of Iowa, Ames |

## Other Activities:

- **Teaching and Mentoring Activity**
  I have taught the Advanced Quantum Mechanics course for first year students in Spring 2005. I am guiding Pomita Ghoshal towards her Ph.D. Nijil M, a project Associate with the INO project, has been working under my supervision from July 2004 to date. I also supervised Vaibhav Tewari, a student from IIT Kharagpur, who worked on a project on "The EPR Paradox and Bell's Inequalities" in Dec 04-Jan 05.

- **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. A detailed Interim Report has been prepared by the collaboration, and can be viewed on

  `http://www.imsc.res.in/~ino/OpenReports/report.html`

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# Debashis Ghoshal

## Research Summary:

Open strings in the noncritical $c = 1$ bosonic string theory compactified on a circle at the self-dual radius was studied (in collaboration with S. Mukhi and S. Murthy). These strings define D-branes that are extended along the Liouville direction and are known as FZZT branes. The disc correlators of the boundary operators on the FZZT branes were computed explicitly. These were regularised and renormalised suitably and then used to initiate a study of the string field theory. The FZZT correlators were also computed for a class of topological $c < 1$ models (unpublished).

A noncommutative deformation of the $p$-adic open string theory was studied, both at the level of the effective action and as coupling of the $B$-field to the worldsheet. A family of solitons that interpolates smoothly between the commutative theory to that at infinite noncommutativity was obtained. In the limit $p \to 1$, these were shown to reduce to the solitons of the bosonic string theory. The worldsheet origin of the noncommutativity was examined (in collaboration with T. Kawano). We showed that a term corresponding to the background of the antisymmetric second rank tensor field $B$ can be added to the non-local action on the $p$-adic line $\mathbf{Q}_p$, thought of as the boundary of the 'worldsheet. The consequences of this term were examined in detail, in particular, the modified amplitudes and projective invariance were analysed.

## Publications:


1. D. Ghoshal,
   *Noncommutative $p$-tachyon*,
   Proc. Steklov Inst. Math. 245 83–90 (2004),
   Proceedings of the First International Conference $p$-Adic MathPhys.2003, Moscow, Russia.

2. D. Ghoshal, S. Mukhi and S. Murthy,
   *Liouville D-branes in two-dimensional strings and open string field theory*,
   JHEP 0411, 027 (2004) [hep-th/0406106].

3. D. Ghoshal,
   *Exact noncommutative solitons in p-adic strings and BSFT*,
   JHEP 0409, 041 (2004) [hep-th/0406259].

4. D. Ghoshal and T. Kawano,
   *Towards p-adic string in constant B-field*,
   Nucl. Phys. B710, 577–598 (2005) [hep-th/0409311].

5. D. Ghoshal (Editor)
Current Perspectives in High Energy Physics: Lectures from SERC Schools
Hindustan Book Agency, New Delhi (2005).

## Visits to other Institutes:

1. Department of Physics, Tokyo University, Tokyo, Japan,
on sabbatical leave during April 2004–January 2005.
2. Tokyo Institute of Technology, Tokyo, Japan.
3. Department of Physics, Kyushu University, Fukuoka, Japan.
4. Yukawa Institute of Theoretical Physics, Kyoto, Japan.
5. Department of Mathematics, Nagoya University, Nagoya, Japan.
6. RIKEN Laboratories, Wakoshi, Japan.

## Invited Lectures/Seminars:

1. *"Exact noncommutative p-soliton"*, seminars at the Tokyo Institute of Technology and at the University of Tokyo, Komaba Campus, Japan.
2. *"Liouville D-branes of 2D string theory: correlators and string field theory"*, seminars at the Kyushu University, Yukawa Institute of Physics, Kyoto, Nagoya University and RIKEN Laboratories, Japan.

## Academic recognition/Awards:

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

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# Rajesh Gopakumar

## Research Summary:

I have been pursuing a program of constructing the dual string theory to strongly interacting gauge theories. The approach has been to start from the field theory and identify the worldline schwinger representation with the moduli space representation of the string amplitude. I have proposed a defintie dictionary between the worldline parameters and that of the worldsheet. This proposal allows one to construct a string amplitude from the field theory expressions in Schwinger representation. In particular, I have given a prescription to extract the worldsheet dynamics as encoded in its operator product expansion by starting from the OPE of the field theory correlator.

With various postdocs in the string theory group, I have also been examining the implementation of these ideas in the case of thermal field theories.

I have also been studying the relation between the strongly interacting conformal phase of QCD that seems to be evident in heavy ion collision experiments and the gravitational dual suggested by AdS/CFT.

Finally, with R. Dijkgraaf, H. Ooguri and C. Vafa, I have looked at the consequences of open-closed string dualities in concluding about non-perturbative effects in toy models of string compactifications. We find that this simple case exhibits some interesting features such as that of baby universes, all of which are encoded in the dynamics of free nonrelativistic fermions.

## Publications:


1. R. Gopakumar, *From free fields to AdS*, Phys. Rev. D 70, 025009 (2004).
2. R. Gopakumar, *From free fields to AdS. II*, Phys. Rev. D 70, 025010 (2004).
3. R. Gopakumar, *Free field theory as a string theory?*, Comptes Rendus Physique 5, 1111 (2004).
4. R. Gopakumar, *Large N and Topological Strings*, Encyclopedia of Mathematical Physics, Elsevier (to appear).


## Preprints:


1. R. Gopakumar, *From free fields to AdS. III*, arXiv:hep-th/0504229.
2. R. Dijkgraaf, R. Gopakumar, H. Ooguri and C. Vafa, *Baby universes in string theory*, arXiv:hep-th/0504221.

## Conference/Workshops Attended:

1. Strings 2004, College de France, Paris (Jul. 2004).
2. Strings at CERN, Geneva, (Jul. 2004).
3. Workshop on Strings and cosmology, IUCAA, Pune (Oct. 2004).
4. DAE Symposium, SINP, Kolkata (Dec. 2004).
5. Indian Strings Meeting ISM04, Khajuraho (Dec. 2004).
6. THEP-1, IIT, Roorkee (Mar. 2005).

## Visits to other Institutes:

1. University of Paris VI (Mar. 17-19, 2004).
2. Hamilton Institute, Trinity College, Dublin, Ireland (Mar. 19-29, 2004).
3. Institute of Theoretical Physics, University of Amsterdam (Mar 30-Apr.7, 2004)).
4. I.I.T. Guwahati (Apr. 23-25, 2004)
5. University of Wisconsin, Madison (May 1-8, 2004).
6. Institute for Advanced Study, Princeton (May 9-Jun. 27, 2004).
7. CERN, Geneva (Jul 3-15).
8. Centre for Mat. Sciences, Zhejiang University, Hangzhou, China (Jul. 16-23) .
9. Morningside Centre for Mathematics, Academia Sinica, Beijing, (Jul. 23-30)

## Invited Lectures/Seminars:

1. University of Paris VI. (seminar)
2. Dept. of Maths., Trinity College, Dublin, Ireland. (seminar)
3. March Meeting at Hamilton Institute, Trinity college Dublin (3 lectures).
4. Institute of Theoretical Physics, University of Amsterdam. (seminar)
5. I.I.T. Guwahati (TPSC Seminar)

6. Gauhati University (TPSC Seminar)
7. University of Wisconsin, Madison. (3 lectures)
8. Strings 2004, College de France, Paris (plenary talk)
9. Strings at CERN, Geneva (lecture).
10. Summer School in Mathematical Physics, Centre for Mat. Sciences, Zhejiang University, Hangzhou, China. (4 lectures) and Morningside Centre for Mathematics, Academia Sinica, Beijing, (4 lectures)
11. Workshop on Strings and Cosmology, IUCAA Pune, (opening talk).
12. IOP, Bhubaneswar (Colloquium and Seminar)
13. DAE Symposium, SINP, Kolkata (plenary talk).
14. SERC school in High Energy Physics, IIT Kanpur (9 lectures)
15. ISM04, Khajuraho (plenary talk).
16. THEP-I, IIT Roorkee (plenary talk).

## Academic recognition/Awards:

- Distinguished String Theory Visiting Lecturership, University of Wisconsin, Madison, USA
- Appointed Adjunct Faculty, IIT Kanpur.
- Appointed Adjunct Faculty in Faculty of Natural Sciences, at TIFR, Mumbai.
- Invited article on "Large N and Topological Strings" for Encyclopedia of Mathematical Physics, Elsevier.
- Member of Organising committee of 2005 APCTP school on String Theory and Quantum Gravity, Seoul, Korea.

## Other Activities:

1. I have also guided visiting students at HRI and taught a graduate course on General Relativity as well as given string theory seminars and journal club talks.

2. I have also been a member of various administrative committees in the institute.

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# Srubabati Goswami

## Research Summary:

We investigate the impact of 766.3 Ty KamLAND spectrum data on the determination of the solar neutrino oscillation parameters. We show that the observed spectrum distortion in the KamLAND experiment firmly establishes $\Delta m^2_{21}$ to lie in the low-LMA solution region. The high-LMA solution is excluded at more than $4\sigma$ by the global solar neutrino and KamLAND spectrum data. The maximal solar neutrino mixing is ruled out at $6\sigma$ level. The $3\sigma$ allowed region in the $\Delta m^2_{21}$ $-\sin^2 2\theta$ plane is found to be remarkably stable with respect to leaving out the data from one of the solar neutrino experiments from the global analysis. We perform a three flavor neutrino oscillation analysis of the global solar neutrino and KamLAND spectrum data as well.

The improvements in the determination of $\sin^2\theta_{12}$, which can be achieved with the expected increase of statistics and reduction of systematic errors in the currently operating solar and KamLAND experiments, are studied during this period. The potential of LowNu $\nu - e$ elastic scattering experiment, designed to measure the $pp$ solar neutrino flux, for high precision determination of $\sin^2\theta_{12}$, is investigated in detail. The accuracy in the measurement of $\sin^2\theta_{12}$, which can be achieved in a reactor experiment with a baseline $L \sim (50-70)$ km, corresponding to a Survival Probability MINimum (SPMIN), is thoroughly studied. We include the effect of the uncertainty in the value of $\sin^2\theta_{13}$ in the analyses. We find that the effect of $\sin^2\theta_{13}$ uncertainty on the $\sin^2\theta_{12}$ measurement in both types of experiments is considerably smaller than naively expected.

Effects of the 1-3 leptonic mixing on the solar neutrino observables are studied and the signatures of non-zero $\theta_{13}$ are identified. For this we have re-derived the formula for $3\nu$-survival probability including all relevant corrections and constructed the iso-contours of observables in the $\sin^2\theta_{12} - \sin^2\theta_{13}$ plane. The sensitivity of future solar neutrino studies to $\sin^2\theta_{13}$ can be improved down to 0.01 - 0.02 ($1\sigma$) by precise measurements of the pp-neutrino flux and the CC/NC ratio as well as spectrum distortion at high ($E > 4$ MeV) energies. Combination of experimental results sensitive to the low and high energy parts of the solar neutrino spectrum resolves the degeneracy of angles $\theta_{13}$ and $\theta_{12}$. Comparison of $\sin^2\theta_{13}$ as well as $\sin^2\theta_{12}$ measured in the solar neutrinos and in the reactor/accelerator experiments may reveal new effects which can not be seen otherwise.

We study matter effects which arise in the muon neutrino oscillation and survival probabilities relevant to atmospheric neutrino and very long baseline ($> 4000$ Km) beam experiments. The inter-relations between the three probabilities $\mathrm{P}_{\mu e}$, $\mathrm{P}_{\mu\tau}$ and $\mathrm{P}_{\mu\mu}$ are examined. We showed that matter effects change the $\nu_\mu \to \nu_\tau$ oscillation probability by as much as $70\%$ for certain ranges of energies

and pathlengths. Consequently, the $\nu_\mu \to \nu_\mu$ survival probability also undergoes large changes. We use these matter effects for determining the mass hierarchy via atmospheric neutrinos. Realistic event rate calculations are performed for a charge discriminating 100 kT iron calorimeter which demonstrate the possibility of realising this very important goal in neutrino physics. It is shown that for atmospheric neutrinos, a careful selection of energy and baseline necessary in order to obtain a statistically significant signal, and that the effects are largest in bins where matter effects in both $\mathrm{P}_{\mu\mathrm{e}}$ and $\mathrm{P}_{\mu\tau}$ combine constructively.

## Publications:

1. *Large Matter Effects in $\nu_\mu \to \nu_\tau$ Oscillations*
   R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S Uma Sankar Phys. Rev. Lett. 94, 051801 (2005), arXiv:hep-ph/0408361, (2004).

2. *Update of the solar neutrino oscillation analysis with the 766-Ty KamLAND spectrum*
   A. Bandyopadhyay, S. Choubey, S. Goswami, S. T. Petcov and D. P. Roy Phys. Lett. B 608, 115 (2005)' arXiv:hep-ph/0406328.

3. *Global Analysis of Neutrino Oscillation*
   S. Goswami, A. Bandyopadhyay, S. Choubey,
   Nucl. Phys. Proc. Suppl. 143, 121 (2005), e-Print Archive:hep-ph/0409224.

4. *Working group report: Neutrino and astroparticle physics. (WHEPP-8)*
   S. Goswami *et al.*, Pramana 63, 1391 (2004) [arXiv:hep-ph/0409225].

## Preprints:

1. *Solar neutrinos and 1-3 leptonic mixing*
   S. Goswami and A. Y. Smirnov,
   arXiv:hep-ph/0411359, submitted for publication.

2. *Earth matter effects at very long baselines and the neutrino mass hierarchy,*
   R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. U. Sankar,
   arXiv:hep-ph/0411252, submitted for publication.

3. *High Precision Measurements of $\theta_\odot$ in Solar and Reactor Neutrino Experiments*
   A. Bandyopadhyay, S. Choubey, S. Goswami, S. T. Petcov
   arXiv:hep-ph/0410283, submitted for publication.

## Conference/Workshops Attended:

1. Neutrino 2004, College-de-France, Paris, June 2004

## Visits to other Institutes:

1. College-de-France, June 2004
2. SISSA, Trieste, June, 2004
3. IIT Mumbai, January 2005
4. IMSc, Chennai March 2005

## Invited Lectures/Seminars:

1. *"Global Analysis of Neutrino Oscillation"* – Invited Plenary Talk, Neutrino 2004, College-de-France, Paris, June 2004.
2. *"Global Analysis of Neutrino Oscillation"* IIT, Mumbai, January 2005.
3. *"Global Analysis of Neutrino Oscillation"* IMSc., Cennai, March 2005.

## Academic recognition/Awards:

- Awarded the Humboldt Fellowship for one year from Humboldt Foundation, Germany.

## Other Activities:

1. I have taught the course on Mathematical Methods-II to first year graduate students.
2. Ayangsha Sen of IIT Kharagpur has done project work with me on "Neutrino Oscillation in Vaccum and Matter. Pomita Ghosal, PhD. student of Raj Gandhi and Poonam Mehta, a PhD. student from University of Delhi and currently a Post doctoral Fellow in HRI has been closely working with me. I have also interacted with Nijil, M in relation to the Indian Neurino Observatory Project. Abhijit Bandyopadhyay a Ph.D. student from Saha Institute of Nuclear Physics has also worked with me and I have done partial supervision of his thesis work.
3. Served in the computer committee and the medical committee as convener and Transport committee as member.
4. Member of National Organising Committee of WHEPP 9

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# Harvinder Kaur Jassal

## Research Summary:

The present day acceleration of the universe has been described by the presence of dark energy, typically a cosmological constant or a scalar field. In the absence of significant spatial variation in the dark energy, the key difference between scalar field models and the one with the cosmological constant is that, in general, the equation of state of dark energy is a function of redshift in the former. Since cosmological constant id ruled out by observations, direct exploration of the equation of state at different redshifts is of importance. It has been known for some time that supernova observations and constraints from structure formation can be combined to put stringent limits on models for dark energy. Several attempts have been made in the past to constrain the equation of state for dark energy, along with other cosmological parameters, using the observations of galaxy clustering, temperature anisotropies in the CMBR and the high redshift supernova. We focus exclusively on constraining the variation of equation of state for dark energy by using a combination of such observations. In particular, we study the effect of a varying equation of state on the angular power spectrum of the CMBR fluctuations. Dark energy is not expected to be dynamically significant at the time of decoupling and — in fact — models in which this is not true are plagued by slow growth of density perturbation. Nevertheless, evolving dark energy affects the features of temperature anisotropies in the CMBR in at least two ways: (1)The angular scale of features in temperature anisotropy, like the peaks, will change since the angular diameter distance depends on the form of $w(z)$. (2)The integrated Sachs-Wolfe (ISW) effect also depends on the nature of dark energy and its evolution, this effect is more relevant at small $l$. Thus observations of temperature anisotropies in the CMBR can be used to constrain the evolution of dark energy. Combined with the fact that supernova observations constrain the low redshift expansion of the universe, this allows us to put tight constraints on the equation of state of dark energy and its evolution. We use the full WMAP angular power spectrum in order to ensure that both the effects mentioned above are captured in the analysis. We demonstrate that the combination of WMAP observations and high redshift supernova observations is a very powerful constraint on variations in dark energy, certainly more powerful that either of the observations used in isolation.

In a detailed extension of this analysis, we allow other cosmological parameters to vary. We include constraints from cluster abundance in addition to the supernova and WMAP constraints. Apart from the obvious generalisation, the issues we address in this paper are: 1. Does allowing these parameters to vary weaken constraints on dark energy models? 2. Conversely, does a departure from

the cosmological constant modify the allowed range of these parameters? o carry out this study we first consider a Universe with cold dark matter and cosmological constant, with neutrinos contributing a negligible amount to the energy density of the Universe. We assume that the Universe is flat and restrict ourselves to an unbroken power law for the primordial power spectrum of density fluctuations and we assume that the perturbations are adiabatic. We choose this to be our fiducial or standard model as this can be described by a compact set of parameters. We study dark energy models with a constant equation of state parameter (apart from the cosmological constant) and address the two issues listed above. We also study the effect of perturbations in dark energy here. We then generalise to models where the equation of state parameter is allowed to vary in a parameterised form and again study these issues. To include constraints from requirements of structure formation, we use the X-ray observations of rich clusters of galaxies. In the combined analysis, we show that allowing dark energy to vary allows for a larger range in other cosmological parameters.

The above approach is for generic models which can be parameterised, clearly in such an approach all the details of a specific model cannot be included and the conclusions are of a more general nature. I am presently working on applying the methods developed here to a particular class of models, e.g., the quintessence models, to make definitive statements on their viability. Details like including the perturbations in dark energy that cannot be studied in the general approach can be analysed here.

Recently, exact solutions that describe black holes that are bound to a two-brane in a four dimensional anti-de Sitter bulk have been constructed. In situations wherein there is a negative cosmological constant on the brane, for large masses, these solutions are precisely the rotating BTZ black holes on the brane and, in fact, describe rotating BTZ black strings in the bulk. In this work, we evaluate the canonical entropy of a massless scalar field (at the Hawking temperature) around the rotating BTZ black string in the brick wall model. We find that, in spite of the additional contribution due to the bulk modes, we are able to recover the Bekenstein-Hawking entropy law for the black string.

## Publications:

1. H. K. Jassal, J. S. Bagla and T. Padmanabhan, *WMAP constraints on low redshift evolution of dark energy*, astro-ph/0404378, Mon. Not. Roy. Astron. Soc. Letters. 356, L11-L16, 2005

## Conference/Workshops Attended:

1. School on Gravitation and Cosmology, H. R. I., May 2004.

2. Workshop on String theory and Cosmology, I.U.C.A.A., Pune, October 2004.

3. School on Parallel computing, I.M.S.C., Chennai, January, 2005.

## Invited Lectures/Seminars:

1. *"Constraining cosmological models"*, (invited) talk presented at School on parallel computing, IMSC, Chennai, January, 2005.

## Other Activities:

1. Taught General Relativity (8 lectures) and Dark Energy (1 lecture) in Summer School on Gravitation and Cosmology, Harish-Chandra Research Institute, Allahabad,May, 2004.

2. Talk on 'Dhoomketu' (comets) in Rajbhasha School, H.R.I., July 2004.

3. Taught Physics of Cosmic Microwave background Radiation (5 lectures) as part of Cosmology course in H.R.I., April, 2005.

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# Dileep Jatkar

## Research Summary:

For last one year I have been studying brane configurations in M-theory and their relation with the corresponding configurations in string theory.

## Publications:

1. *ONE DIMENSIONAL M5-BRANE INTERSECTIONS*.
   with Ansar Fayyazuddin and Tasneem Zehra Husain
   Published in Phys.Rev.D71:106003,2005
   e-Print Archive:hep-th/0407129

## Conference/Workshops Attended:

1. SERC School on High Energy Physics, IIT, Kanpur, Dec. 3-12, 2004
2. Indian String Meeting, Khajuraho, Dec. 15-22, 2004

## Visits to other Institutes:

1. Harvard University, March 2004-June 2004.
2. IIT, Kanpur, Feb. 2005.

## Invited Lectures/Seminars:

1. *"Lectures on Supersymmetry and Supergravity"*, SERC School, IIT, Kanpur.

## Other Activities:

Academic part:

1. Lectured on Quantum Mechanics in Aug. 2004 - Dec. 2004 semester.
2. Lectured on String theory in Jan. 2005 - May. 2005 semester.
3. 2 reading courses were offered: i) conformal field theory, ii) Supersymmetric gauge theories to second year students.

Non-academic part:

1. Member of national organising committee of ISM04 held at Khajuraho.
2. Member of Computer committee and building works committee.

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# Namit Mahajan

## Research Summary:

During the last one year, my research interests have mainly been focused on QCD aspects applied to heavy meson systems, specifically B-meson decays. The experiments now indicate that one can no longer work within naive factorization approximation; the need for going beyond and estimating the sub-leading terms in B-meson decays is immediate and unavoidable. Various theoretical issues are involved in such an estimation and calculations become very complicated and involved. In the perturbative QCD (PQCD) approach, the $B \to \rho$ form factors were studied with the emphasis on testing the reliability of such a calculation. In this study, terms earlier not taken into account (even by some papers on the same subject) were considered and it was found that atleast in this particular case, the calculation seems reliable.
Apart from this, I was also involved in estimating corrections to B-meson mass difference in the context of Little Higgs models. These new models have been proposed to circumvent the hierarchy problem and low energy investigations, such as the one considered, can serve as immediate important discriminators for any new theory.

## Publications:

1. *$B_d - \bar{B}_d$ mass difference in Little Higgs model*, S. R. Choudhury, N. Gaur, A. Goyal and Namit Mahajan, Phys. Lett. B601, 164 (2004).

## Preprints:

1. *$B \to \rho$ form factors including higher twist contributions and reliability of pQCD approach*, Namit Mahajan, hep-ph/0405161.

## Visits to other Institutes:

1. T.I.F.R., Mumbai, December 2004

## Other Activities:

1. One lecture on "Mechanism of colour vision and optical illusions" under the Raj-Bhasha programme, 2004.

2. Astrophysics Journal Club talk on "New limits on BBN".

3. Seminar on "$B \to \rho$ form factors in pQCD", January 2005.

4. Regular speaker at the Pheno-Lunch (HEP Journal Club)

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# Pinaki Majumdar

## Research Summary:

I have been involved mainly in the study of disordered interacting electron systems, focusing on the aspects of spatial inhomogeneity, clustering, memory effects and glassiness. As methods we have used Monte Carlo techniques, including recent algorithms developed by us.

1. STRUCTURAL DISORDER INDUCED POLARON FORMATION AND MAGNETIC SCATTERING IN THE DISORDERED HOLSTEIN-DOUBLE EXCHANGE MODEL: We followed up on our earlier work to provide a microscopic picture of the thermally driven metal-insulator transition (MIT) that arises close to the ferromagnet to paramagnet transition in the disordered Holstein-Double Exchange model. We clarified the origin of the effective disorder that drives the MIT in this system, and discussed the thermal evolution of the distributions of (i) lattice distortions, (ii) the net 'structural disorder' and (iii) the 'hopping disorder'. These arise from spin randomness feeding back through the Hunds coupling. We suggested a phenomenology for the thermally driven MIT, viewing it as an 'Anderson-Holstein' transition.

2. TUNNELING MAGNETORESISTANCE, GLASSINESS, AND THE ENERGY LANDSCAPE AT NANOSCALE CLUSTER COEXISTENCE: We studied the giant tunneling magnetoresistance that arises from the nanoscale coexistence of ferromagnetic metallic (FMM) and antiferromagnetic insulating (AFI) clusters in a disordered two dimensional electron system with competing double exchange and superexchange interactions. Our Monte Carlo study allowed us to map out the different field regimes in magnetotransport and correlate it with the evolution of spatial structures. At coexistence, the isotropic $O(3)$ model shows signs of slow relaxation, and has a high density of low energy metastable states, but no genuine glassiness. However, in the presence of weak magnetic anisotropy, and below a field dependent irreversibility temperature $T_{irr}$, the response on field cooling (FC) differs distinctly from that on zero field cooling (ZFC). We mapped out the phase diagram of this 'phase coexistence glass' and compared our results with data on the manganites.

3. THE TWO BAND JAHN-TELLER MODEL FOR MANGANITES WITH QUENCHED DISORDER: We have started work on the full two band model using our travelling cluster approximation. We plan to incorporate the cooperative nature of lattice distortions in a 3D framework to study the metal-insulator transitions in the problem. The combination of Hunds coupling, strong electron-phonon interactions, disorder, and cooperative distortions makes this model the most accurate and detailed description of the manganites available to date.

## Publications:

1. *Singular Effect of Disorder on Electronic Transport in Strong Coupling Electron-Phonon Systems*, Sanjeev Kumar and Pinaki Majumdar,
Phys. Rev. Lett. 94, 136601 (2005).

2. *The Many Electron Ground State of the Adiabatic Holstein Model in Two and Three Dimensions*, B. Poornachandra Sekhar, Sanjeev Kumar and Pinaki Majumdar,
Europhys. Lett. 68, 564 (2004).

3. *Structural Disorder Induced Polaron Formation and Magnetic Scattering in the Disordered Holstein-Double Exchange Model*, Pinaki Majumdar and Sanjeev Kumar,
J. Phys. Soc. Jpn. Suppl. XX, 217 (2005).

## Preprints:

1. *Transport and Localisation in the Presence of Strong Structural and Spin Disorder*, Sanjeev Kumar and Pinaki Majumdar,
cond-mat 0504656.

2. *Tunneling Magnetoresistance, Glassiness, and the Energy Landscape at Nanoscale Cluster Coexistence*, Sanjeev Kumar, Chandra Shekhar Mohapatra, and Pinaki Majumdar,
cond-mat 0503735.

## Invited Lectures/Seminars:

1. A set four lectures and one colloquium at I. I. T Kanpur on *"Dynamical Mean Field Theory"*, in March 2005.

2. Invited talk at the International Conference on Statistical Physics of Quantum Systems, at Sendai, Japan, in July 2004: *"Metal-insulator transitions in the disordered Holstein-Double Exchange model"*.

## Other Activities:

1. I organised and directed a SERC School on 'Correlated Electron Systems' at HRI between 15-27 Nov 2004. The co-director was Prof. Nandini Trivedi from TIFR. There were about 50 outstation participants. I gave five lectures on *Electron systems strongly coupled to classical fields*.

2. I taught the graduate course in Statistical Mechanics (Jan-May 2005).

3. I helped organise the Physics Science Talent Test (with Dr. Sriramkumar).

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# Poonam Mehta

## Research Summary :

Most of my research activity during the last one year was focussed on studies pertaining to physics and phenomenological aspects of neutrino oscillations and effects due to propagation in earth matter. We have addressed the question of how can the neutrino mass hierarchy or Sign of $\Delta m^2_{31}$ be unveiled experimentally by establishing matter effects in atmospheric or long baseline neutrinos since current data is unable to distinguish positive from negative $\Delta m^2_{31}$. In particular, we have concentrated on matter affected oscillations in the 13 sector. This requires a non-zero value of $|U_{e3}|$ and the electron number density, $N_e$ should be such that the matter potential $A = 2\sqrt{2}G_F N_e$ is of the order of the 13 frequency, $|\Delta m^2_{31}|/2E$ for the matter term to be important.

- **Atmospheric and long baseline oscillations through the earth :**
  Oscillations of neutrinos are affected by the electrons in the earth if the path-length is an appreciable fraction of the diameter of earth. We have shown that matter effects change the $\nu_\mu \to \nu_\tau$ oscillation probability by as much as 70% for certain ranges of energies and pathlengths. We also examined the interplay of the various oscillation channels and survival probability of the muon neutrinos which can result in a large and observable sensitivity to matter-related phenomena in $P(\nu_\mu \to \nu_\mu)$.
  [Ref : Phys. Rev. Lett. **94**, 051801 (2005)]

- **Resolving the neutrino mass hierarchy at future experiments :**
  Having established that there are large matter effects in $\nu_\mu \to \nu_\tau$ transition probability, and that muon survival rates in experiments with very long baselines depend on matter effects in both $P(\nu_\mu \to \nu_\tau)$ as well as $P(\nu_\mu \to \nu_e)$, by doing realistic event rate calculations for (i) a charge discriminating iron calorimeter at INO and (ii) a megaton water cerenkov detector like Hyper-Kamiokande, we have demonstrated the feasibility of realising the important goal of determining the neutrino mass hierarchy using matter effects and atmospheric neutrinos, within a timescale appreciably shorter than the one anticipated for neutrino factories.
  [Ref : hep-ph/0411252; hep-ph/0506145].

- **Work related to India-based Neutrino Observatory (INO) :**
  I have been involved in the feasibility studies pertaining to physics and simulations for INO at HRI. With my collaborators, I have done detailed studies of the physics possibilities and potential of ICAL, the iron calorimeter detector at INO.

[Ref : Nucl. Phys. B. (Proc. Suppl.) **143**, 503 (2005); HRI-P-04-001; hep-ph/0411252; INO/HRI/2005/01; http://www.imsc.res.in/∼ino ].

## Publications in Refereed Journals :

1. *Large matter effects in $\nu_\mu \to \nu_\tau$ oscillatons*,
   R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar,
   Phys. Rev. Lett. 94, 051801 (2005).

## Publications in Conference Proceedings :

1. *Atmospheric neutrinos as a probe of CPT violation*,
   P. Mehta, Poster presented at Neutrino 2004,
   Nucl. Phys. B. (Proc. Suppl.) 143, 503 (2005).

## Preprints :

1. *Probing the $\nu$ mass hierarchy via atmospheric $\nu_\mu + \bar{\nu}_\mu$ survival rates in megaton water cerenkov detectors*,
   R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar,
   hep-ph/0506145.

2. *Earth matter effects at very long baselines and the neutrino mass hierarchy*,
   R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar,
   hep-ph/0411252, Submitted to Phys. Rev. D.

## Preprints (INO Related):

1. *Neutrino detectors of the future : A comparison table*,
   R. Gandhi, P. Mehta and S. Uma Sankar,
   INO/HRI/2005/01.

2. *Matter effects in atmospheric $\mu^-/\mu^+$ in magnetized iron calorimeters*,
   R. Gandhi, P. Mehta and S. Uma Sankar,
   HRI-P-04-10-001.

## Working Group Reports :

- INO Collaboration, *Interim Project Report on the Feasibility Studies*, submitted to the funding agencies on 01 May, 2005.
  For more details see, `http://www.imsc.res.in/∼ino`.

- S. Goswami *et al.*, *Working group report: Neutrino and Astroparticle Physics*, The proceedings of WHEPP-8, IIT Mumbai, India 5 - 16 January 2004, Pramana **63**, 1391 (2004).

## Conference/Workshops Attended:

1. The Les Houches School on Particle Physics beyond the Standard Model, Les Houches, France. (01 - 26 August, 2005)
2. INO Simulations Meeting, IMSc, Chennai. (28 - 30 March, 2005)
3. School on Astroparticle Physics and Cosmology, ICTP, Trieste, Italy. (28 June - 10 July, 2004)
4. XXIst International Conference on Neutrino Physics and Astrophysics (Neutrino 2004), Collége de France, Paris, France. (14 - 19 June, 2004)

## Visits to other Institutes :

1. Department of Particle Physics (visited Professor Yossi Nir), The Weizmann Institute of Science, Rehovot, Israel. (02 June - 02 September, 2005)
2. IMSc, Chennai. (26 March - 03 April, 2005)
3. High Energy Section, ICTP, Trieste, Italy. (19 June - 12 July, 2004)

## Invited Lectures/Seminars/Posters :

1. Talk given on *"New physics issues for simulations @ INO"* at INO Simulations Meeting, IMSc, Chennai, India. (March 28 - 30, 2005)
2. Talk given on *"Atmospheric neutrinos as a probe of CPT violation"* at TIFR, Mumbai, India. (July 20, 2004)
3. Poster presented on *"Atmospheric neutrinos as a probe of CPT violation"* at Neutrino 2004, Paris, France. (14 - 19, June 2004)

## Other Activities :

1. I am a member of the INO Collaboration. I have helped in writing of the Physics Issues chapter of the INO Interim Report. I have also guided Nijil M, an INO project student at HRI.

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# Biswarup Mukhopadhyaya

## Research Summary:

- **Split supersymmetry:** Ever since the controversial idea of split supersymmetry has been proposed, various aspects, both theoretical and phenomenological, of such theories have been examined in a series of studies. These include the role of hidden sector fields in the supersymmetric spectrum, some general conclusions about supergravity scenarios in which a splitting of the spectrum can be envisioned, possibilities including additional Abelian symmetries, dark matter candidates in a split scenario, and signals in high-energy colliders (B. Mukhopadhyaya, S. Sengupta, P. Konar, S. K. Gupta, K. S. Babu and Ts. Enkhbat).

- **Little Higgs theories:** The generation of neutrino masses in a class of Little Higgs models has been studied. It has been shown how the features of the theory leading to massive neutrinos can have distinct signature in accelerator experiments (B. Mukhopadhyaya, R. Srikanth, T. Han and H. Logan).

- **Phenomenology of extra dimensions:** Collider signals of extra dimensions have been studied from various angles. In particular, some interesting aspects of cases where a Higgs can become invisible as a result of graviscalars from extra dimensions being preset have been pointed out (B. Mukhopadhyaya, A. Datta, K. Huitu, J. Laamanen).

- **Theories of gravitation:** The role of Kalb-Ramond fields in a Randall-Sundrum scenario has been studied. Some consequences of a topological term in the Lagrangian involving the Kalb-Ramond field have been derived (B. Mukhopadhyaya, S. SenGupta, Somasri Sen, Siddhartha Sen).

## Publications:


1. *BULK KALB-RAMOND FIELD IN RANDALL-SUNDRUM SCENARIO*
   By Biswarup Mukhopadhyaya, Siddhartha Sen, Somasri Sen, Soumitra SenGupta
   Published in Phys.Rev.D70:066009,2004

2. *INVISIBLE HIGGS IN THEORIES OF LARGE EXTRA DIMENSIONS*
   By Anindya Datta, Katri Huitu, Jari Laamanen, Biswarup Mukhopadhyaya
   Published in Phys.Rev.D70:075003,2004

3. *SPARTICLE SPECTRUM AND PHENOMENOLOGY IN SPLIT SUPERSYMMETRY: SOME POSSIBILITIES*
   By Biswarup Mukhopadhyaya, Soumitra SenGupta
   Published in Phys.Rev.D71:035004,2005

4. *R-PARITY VIOLATION IN SPLIT SUPERSYMMETRY AND NEUTRALINO DARK MATTER: TO BE OR NOT TO BE*
   By Sudhir Kumar Gupta, Partha Konar, Biswarup Mukhopadhyaya
   Published in Phys.Lett.B606:384-390,2005

5. *SPLIT SUPERSYMMETRY FROM ANOMALOUS U(1)*
   By K.S. Babu, Ts. Enkhbat, Biswarup Mukhopadhyaya, (Appeared in Nuclear Physics B)

## Preprints:

1. *SPLIT SUPERSYMMETRY AND THE ROLE OF A LIGHT FERMION IN A GENERAL SUPERGRAVITY THEORY*
   By Biswarup Mukhopadhyaya, Soumitra SenGupta
   e-Print Archive:hep-ph/0503167

2. *NEUTRINO MASSES AND LEPTON-NUMBER VIOLATION IN THE LITTLEST HIGGS SCENARIO*
   By Tao Han, Heather E. Logan, Biswarup Mukhopadhyaya, Raghavendra Srikanth
   e-Print Archive:hep-ph/050526

## Conference/Workshops Attended:

1. DAE symposium on High Energy Physics, Saha Institute of Nuclear Physics, Kolkata (November-December, 2004)
   As member, National Organising Committee, and session co-ordinator, Beyond the Standard Model.

2. SERC school on high energy physics, Indian Institute of Technology, Kanpur (December, 2004)
   As instructor.

3. Current Trends in Nuclear and Particle Physics, Jadavpur University, Kolkata (February, 2005).

4. March Meeting on Fundamental Problems and Challenges, Trinity College, Dublin, Ireland (March, 2005).

## Visits to other Institutes:

1. Indian Association for the Cultivation of Science, Kolkata.
2. Saha Institute of Nuclear Physics, Kolkata.
3. University of Wisconsin, Madison, USA.
4. University of Michigan, Ann Arbor, USA.
5. Oklahoma State University, USA.
6. Indian Institute of Technology, Kanpur.
7. Hamilton Mathematics Institute, Trinity College, Dublin, Ireland.

## Invited Lectures/Seminars:

1. *"Gauge Boson Fusion at the LHC"*– Invited seminar given at Saha Institute of Nuclear Physics, Kolkata.
2. *" The search for lumps of curled-up space in the laboratory"*– A. Ray Memorial Lecture, Indian Association for the Cultivation of Science, Kolkata.
3. *"New physics in the world of elementary particles: an ever-inward journey"* – Invited talk given at Bhatnagar Laureates' Symposium, National Physical Laboratory, New Delhi.
4. *"Some Implications of split supersymmetry"*– seminar given at the University of Wisconsin, Madison, USA.
5. *"Some Implications of split supersymmetry"*– seminar given at Oklahoma State University, Stillwater, USA.
6. *"Curled-up space in the laboratory"*– Invited colloquium at Oklahoma State University, Stillwater, USA.
7. *"Supersymmetric models and phenomenology"*– Course of 9 lectures given at the SERC school on high energy physics, Indian Institute of Technology, Kanpur.
8. *"Split supersymmetry"*– Invited talk given at the conference on Current Trends in Nuclear and Particle Physics, Jadavpur University, Kolkata.

9. *"The search for curled-up space in the laboratory– observable consequences of extra dimensions (I and II)"*– Set of invited lectures delivered at the March Meeting on Fundamental Problems and Challenges, Trinity College, Dublin, Ireland.

## Academic recognition/Awards:

- Awarded Shanti Swarup Bhatnagar Prize for Physical Sciences, 2003 (award ceremony took place in September, 2004).

## Other Activities:

1. Member, National Organising Committee, DAE Symposium on High Energy Physics.
2. Member, library committee, HRI.
3. Member, graduate committee in physics, HRI.

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# Sudhakar Panda

## Research Summary:

We proposed an inflationary scenario in the context of cosmology. In this scenario, we considered a non-minimal coupling of the tachyon field to gravity which ensures the slow roll inflation. However, the physical observables in cosmology were found not to be consistent with observational data. It is shown that, if we invoke a warped string background with varying dilaton field over the compact manifold for the above setup, then the observed parameter space could be ensured. (work with Pravabati Chingangbam and Atri Deshamukhya).

We performed a group manifold reduction of the dual version of $N = 1$ $d = 10$ supergravity to four dimensions. In particular we studied the effect of the three and four form gauge fields in the resulting gauged $N = 4$ $d = 4$ supergravity. We worked out in detail the example of the group manifold $SU(2) \times SU(2)$ and compared for this case the four -dimensional scalar potential with gauged $N = 4$ supergravity.(work with M. de Roo, M.G.C. Eenink and D. B. Westra).

## Publications:


1. Chingangbam P., Deshamukhya A. and Panda S.,*Non-minimally Coupled Tachyonic Inflation in Warped String Background*,JHEP 02 (2005) 052.

2. de Roo M., Eenink M.G.C., Panda S., and Westra D.B.,*Group Manifold Reduction of Dual N=1 d=10 Supergravity*,JHEP 06 (2005) 077.


## Preprints:


1. *Non-minimally Coupled Tachyonic Inflation in Warped String Background*, P. Chingangbam, A. Deshamukhya and S. Panda,hep-th/0411210.

2. *Group Manifold Reduction of Dual N = 1 d = 10 Supergravity*, M. de Roo, M.G.C. Eenink, S. Panda and D.B. Westra,hep-th/0503059.


## Conference/Workshops Attended:

1. ISM04, Khajurao, India (2004).

2. Strings and Cosmology, IUCAA, Pune, India (2005).

## Visits to other Institutes:

1. University of Groningen, The Netherlands (2004).

2. Institute of Physics, Bhubaneswar (2004).

3. Jamia-Islamia Univ., Delhi (2005).

4. IUCAA, Pune (2005).

5. Harvard University, USA (2005).

## Invited Lectures/Seminars:

1. *"De Sitter Solution in four dimensional Supergravity"*; IOP, Bhubaneswar.

2. *"De Sitter Solution in N=4 supergravity in d=4"*; Invited Talk in Strings and Cosmology, IUCAA, Pune.

3. *"Unification of Interactions"*; Jamia-Islamia University, Delhi.

4. *"Tachyon Effective Action for BPS D-brane motion in the background of NS five-branes*; Groningen University, The Netherlands.

## Other Activities:

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

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# Tribhuvan Prasad Pareek

## Research Summary:

I have continued to explore the coupled spin and charge transport in mesoscopic systems. In particular I devoted last year on building computational codes using density matrix , which would allow to study the spin transport with nonmagnetic leads and would be able to give clear conceptual and quantitative answer to the question of spin coherence and dephasing as well the torque induced dues to spin orbit interaction. The density matrix formulation has its advantage compared to other formalism since it allows to study spin transport in fully nonmagnetic system and as well the question of entropy , i.e., Von Newman ,Shanon and other entropies associated with spin transport and spin based quantum computation can be addressed. These are important conceptual question which needs to be addressed qualitatively as well quantitatively and the codes developed using density matrix formulation will essentially answer these question. This SO induced torque is important from basic physics as well for the applied side since it will affect the operation any spintronics device based on SO interaction. The same computational codes written using density matrix would allow to study this question as well. This work is under progress. Using the above codes I have written two papers using above codes.

I have been looking at Full counting statistics of spin transport in multi-terminal geometries. Counting statistics is useful way to study cross correlation between current flows in multi-terminal geometries. For Charge transport it has been well studied. I with Dr. Vivek from Allahabad University have been looking at spin current cross correlation and counting statistics and have made initial progress.

I have also studied aspects on non integer ballistic conductance due to spin orbit interaction with Sumathi Rao. The work has been completed and we will soon write it up and submit for publication.

## Publications:

1. *Absolute spin valve effect: Charge transport in two dimensional hybrid system*. Phys. Rev. B70 033310 (2004)

## Preprints:

1. *Measuring Rashba Spin orbit interaction strength at Zero magnetic field*: cond-mat/0412115. Submitted to PRB Rapid communication for publication.

## Conference/Workshops Attended:

1. Third Indo Israeli meeting held at Puri , India from 17 - 21st April, 2005

## Invited Lectures/Seminars:

1. *"Pure spin currents and associated electrical voltage"*: Invited talk given at Third Indo-Israeli meeting held at Puri from 17th to 21st April 2005.

## Other Activities:

1. I have taught a full semester course to undergraduate students at HRI on 'Computational methods in Physics'.
2. I have worked as a member of three committees i.e., computer comm., Furniture comm. and Rajbhasa comm.
3. I have guided three summer students.
4. I have been member of interview comm. at Allahabad University for the selection of Research associates for DST projects.
5. I have refereed around 10 papers for PRL and PRB during last year. I have been referee for PRL and PRB since last 3 years.

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# Sumathi Rao

## Research Summary:

We have mainly been studying electronic transport in quantum wires and quantum dots, with the aim of computing conductances in these low-dimensional systems. We have concentrated on junctions of quantum wires and new geometries of quantum wires. The issue was to see how inter-electron interactions affect the transport through wires, which can be computed using the standard Landauer-Buttiker theory. We find that in the presence of interactions, the $S$-matrix for transport through junctions evolve under renormalisation group and thus the conductances become functions of the 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 have also studied the effect of interactions on the adiabatic charge pumping through coupled quantum dots. For non-interacting dots, the pumped charge through open quantum dots is small. Quantised charge pumping is only achieved for a periodic system. However, in the presence of interactions, the pumped charge increases and quantisation is achieved even for a single dot.

Finally, we have been studying the Kondo effect in junctions of quantum wires.

## Publications in refereed journals:

1. *Renormalisation group study of the conductances of interacting quantum wire systems with different geometries* (with Sourin Das and Diptiman Sen),Phys. Rev. B70,085318(2004).

2. *Transport through multiply connected quantum wires* (with Sourin Das),Phys. Rev. B70,155420(2004).

3. *Tunneling through two resonant levels : Fixed points and conductances* (with Diptiman Sen),Phys. Rev. B70 195115(2004).

## 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 Sourin Das and Diptiman Sen), to

be published in International Conference on Nanoscience and Technology, Kolkata, December 2003.

## Preprints:

1. *Effect of interactions on an adiabatic quantum electron pump* cond-mat/0410025 (with Sourin Das).

## Visits to other Institutes:

1. May 20-June 27, 2004, Dept of Physics, Boston University, Boston, U.S.A.
2. July 12 - July 17, Dept. of Physics, University of Geneva, Switzerland.
3. July 19 - August 12, Dept of Physics, University of Stockholm, Sweden.

## Invited Lectures/Seminars:

1. *"Transport through Quantum wires"* , June 11 2004, Dept of Physics, Boston University, Boston, U.S.A.
2. *"Transport through quantum dots"* , July 14th, Dept of Physics, University of Geneva, Switzerland
3. *"Transport through wires and dots"* , August 2nd, Dept of Physics, University of Stockholm, Sweden.

## Other Activities:

1. Taught condensed matter physics course, August 2004-December 2004
2. Member of National Organising Committee, Statphys 22, held in July 2004.
3. Member of the International Union of Pure and Applied Physics (IUPAP) working group on 'Women in physics'.
4. **Administrative duties:**
   - Convenor of Local works committee (LWC)
   - Member of budget committee

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# V. Ravindran

## Research Summary:

I have been working on next to-next to leading order QCD corrections to various leptonic and hadronic processes that are relevant for Higgs searches, searches for physics beyond Standard Model, studies of spin structure of the hadrons. We have computed the complete **two-loop vertex corrections**[2] to scalar and pseudo-scalar **Higgs boson production** for general colour factors for the gauge group $\mathrm{SU(N)}$ in the limit where the top quark mass gets infinite. We derive a general formula for the vertex correction which holds for conserved and non conserved operators. For the conserved operator we take the electromagnetic vertex correction as an example whereas for the non conserved operators we take the two vertex corrections above. We elucidate the origin of the second order single pole term which is equal to the second order singular part of the anomalous dimension plus a universal function which is the same for the quark and the gluon. Continuing along our earlier works[6,7] such as two loop QCD corrections to Higgs production, polarised Drell-Yan production, we have studied the mathematical structure of these corrections by working in Mellin space[4,5]. We find that these two loop results can be expressed in terms of few special functions called Nielsen polylogarithms.

**Models of extra dimensions** have dominated the recent theoretical literature on physics beyond the standard model. Existing collider studies of the effects of gravitons have been done at the Born level in QCD. It is important to compute **next-to-leading order QCD (NLO-QCD)** effects to these processes in order to quantify the size of the QCD correction and to see how robust the leading order estimate of the cross-section is with respect to the QCD correction. We have computed the NLO-QCD corrections to the process $e^+e^- \to$ **hadrons** via photon-, Z- and graviton-exchange in the context of TeV-scale gravity models. The quantitative impact of these QCD corrections for searches of extra dimensions at a Linear Collider[1] is briefly discussed. The first results on next-to-leading order QCD corrections to graviton-induced processes in hadron collisions in models of TeV-scale gravity are presented focusing on the case of **dilepton pair production**[3] in $\bar{p}p$ and $pp$ **collisions**. Distributions in the invariant mass $Q$, the longitudinal fraction $x_F$, the rapidity $Y$ and the forward-backward asymmetry of the lepton pair are studied. The quantitative impact of the QCD corrections for searches of extra dimensions at hadron colliders is investigated. It turns out that at the LHC ($\sqrt{S} = 14TeV$) the $K$-factor is rather large ($K = 1.6$) for large invariant mass $Q$ of the lepton pair, indicating the importance of accounting for these QCD corrections in the experimental search for TeV-scale gravity. At the Tevatron, the $K$-factor does not substantially deviate from the Standard Model value. How-

ever, its inclusion is necessitated to make the cross-section stable with respect to scale variations.

## Publications:

1. *NLO-QCD corrections to $e^+ e^- \to$ hadrons in model of TeV-scale gravity*, JHEP 0408:048 (2004), hep-ph/0405292, TIFR-TH-04-12, May 2004. 11pp. Prakash Mathews, V. Ravindran, K. Sridhar

2. *Two Loop Corrections to Higgs Production*
Nucl.Phys. B704:332-348,2005,hep-ph/0408315,
V. Ravindran, J. Smith, W.L. van Neerven,

3. *Next to leading order QCD corrections to the Drell-Yan cross section in models of TEV-Scale gravity*.
Nucl.Phys. B713 :333-377,2005, hep-ph/0411018, IPPP-04-70, Nov 2004.
Prakash Mathews, V. Ravindran, K. Sridhar, W.L. van Neerven.

4. *Mellin moments of the next-to-next-to leading order coefficient functions for the Drell-Yan process and hadronic Higgs-boson production*,
Nucl. Phys. B 716, 128 (2005), hep-ph/0501178.
J. Blumlein and V. Ravindran,

5. *NNLO coefficient functions of Higgs and Drell-Yan cross sections in Mellin space*,
Nucl. Phys. Proc. Suppl. 135, 24 (2004),hep-ph/0407045.
J. Blumlein and V. Ravindran,

6. *NNLO corrections to the Higgs production cross section*,
Nucl. Phys. Proc. Suppl. 135, 35 (2004) hep-ph/0405263.
V. Ravindran, J. Smith and W. L. van Neerven,

7. *NNLO corrections to the polarized Drell-Yan coefficient function*,
Nucl. Phys. Proc. Suppl. 135, 14 (2004) hep-ph/0405233.
V. Ravindran, J. Smith and W. L. van Neerven,

## Conference/Workshops Attended:

1. HERA and the LHC A workshop on the implications of HERA for LHC physics, Hamburg, Germany. 1-4, June, 2004

2. 7th DESY Workshop on Elementary Particle Theory: Loops and Legs in Quantum Field Theory, Zinnowitz, Germany, 25-30 Apr 2004.

3. HERA and the LHC A workshop on the implications of HERA for LHC physics, CERN, Geneva, Switzerland 11-13, October, 2004.

## Visits to other Institutes:

1. DESY, Zeuthen, Germany, 3rd March to 30th July 2004
2. CERN, Geneva, Switzerland, 1st August to 30th October 2004
3. University of Dortmund, Dortmund, 14-18, July 2004
4. ETH, Zurich, Switzerland, 17-20, October 2004
5. Workshop Series on Theoretical High Energy Physics, IIT, Roorkee, India, 16-20, March 2004

## Invited Lectures/Seminars:

1. *"Loops and Legs in Quantum Field Theory"*, Zinnowitz, Germany.
2. *"HERA-LHC Workshop"*, DESY, Hamburg, Germany.
3. CERN, Geneva, Switzerland.
4. University of Dortmund, Dortmund, Germany.
5. ETH, Zurich, Switzerland.
6. *"Workshop Series on Theoretical High Energy Physics*, IIT, Roorkee, India
7. *"Theoretical Physics Seminar Circuit*, IOP, Bhuvaneswar, India

## Other Activities:

1. Guided three second year Ph.D students of HRI for their projects.
2. Guided a Ph.D student from University of Hyderabad for three months.

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# Arnab Kumar Ray

## Research Summary:

The following is the summary of the research work done since the submission of the last annual report in 2004.

- The role of turbulence in a spherically symmetric accreting system has been studied on very large spatial scales of the system. This is also a highly subsonic flow region and here the accreting fluid has been treated as nearly incompressible. It has been shown here that the coupling of the mean flow and the turbulent fluctuations, gives rise to a scaling relation for an effective "turbulent viscosity". This in turn leads to a dynamic scaling for sound propagation in the accretion process. As a consequence of this scaling, the sonic horizon of the transonic inflow solution is shifted inwards, in comparison with the inviscid flow.

- In the presence of viscosity the hydraulic jump in one dimension is seen to be a first-order transition. A scaling relation for the position of the jump has been determined by applying an averaging technique on the stationary hydrodynamic equations. The importance of viscosity in the jump formation has been clearly established, and its physical basis has been understood by a time-dependent analysis of the flow equations. The height profile before the jump has been predicted, and our analysis also gives a dependence of the magnitude of the jump on the outer boundary condition.

- Deriving an equation for a dynamic perturbation about the steady shallow water solution, we use it to establish a physical basis for the formation of the circular hydraulic jump in the two-dimensional radial flow. In the process we indicate a closeness between the respective dynamic perturbation equations of the incompressible shallow water flow and the compressible spherically symmetric astrophysical accretion flow. We finally find an estimate of the critical volumetric flow rate, beyond which the jump position starts fluctuating.

- Modelling the flow in a thin accretion disc like a dynamical system, we analyse the nature of the critical points of the steady solutions of the flow. For the inviscid disc there are two critical points, with the outer one being a saddle point and the inner one a centre type point. For the weakly viscous disc, there are four critical points, of which the outermost is a saddle point, while the next inner one is a spiral. Coupling the nature of the critical points with the outer boundary condition of the flow, gives us a complete understanding of all the important physical features of the flow solutions.

A linearised time-dependent perturbation imposed on the steady solutions in the weakly viscous disc gives rise to instability, while for the inviscid disc, the physical realisability of the transonic solution passing through the saddle point, is addressed by considering a temporal evolution of the flow, which is a very likely non-perturbative mechanism for the selection of the transonic inflow solution.

## Publications:

1. *Large Scale Properties in Turbulent Spherically Symmetric Accretion*, Arnab K. Ray and J. K. Bhattacharjee, The Astrophysical Journal, 627, 368, July 1, 2005.

2. *Time-dependence in the Circular Hydraulic Jump*, Arnab K. Ray and J. K. Bhattacharjee, Proceedings of the Second National Conference on Nonlinear Systems and Dynamics (NCNSD 2005), 2005.

## Preprints:

1. *Hydraulic Jump in One-dimensional Flow*, Subhendu B. Singha, J. K. Bhattacharjee and Arnab K. Ray, 2005 (submitted).

2. *A Time-dependent Study in the Shallow Water Approach to the Circular Hydraulic Jump*, Arnab K. Ray and J. K. Bhattacharjee, 2005 (under revision).

3. *A Dynamical Systems Approach to a Thin Accretion Disc*, Arnab K. Ray and J. K. Bhattacharjee, 2005 (under revision).

## Conference/Workshops Attended:

1. Perspectives in Non-linear Dynamics, 2004, Institute of Mathematical Sciences, Chennai & Indian Institute of Technology, Madras, 12th. to 15th. July, 2004. Presented a poster on *"Dynamic Aspects of the Hydraulic Jump Problem"* on 12th. July, 2004

2. National Conference on Nonlinear Systems and Dynamics, Aligarh Muslim University, Aligarh, 24th. to 26th. February, 2005. Presented a talk on *"Time-dependence in the Circular Hydraulic Jump"* on 25th. February, 2005.

## Visits to other Institutes:

1. To Inter–University Centre for Astronomy and Astrophysics, Pune, for the period 17th. to 26th. July, 2004.

## Invited Lectures/Seminars:

1. Presented a seminar on *"Dynamic Aspects of the Hydraulic Jump Problem"* at the Department of Theoretical Physics, Indian Association for the Cultivation of Science, Kolkata, on 23rd. December, 2004.

## Other Activities:

1. Presented an astrophysics journal club talk at Harish–Chandra Research Institute on the paper titled *Of Atoms, Mountains and Stars : A Study in Qualitative Physics* (Reference : Victor F. Weisskopf, **Science**, 21 Feb. 1975, Vol. 187, No. 4177), on 5th. November, 2004.

2. Presented an astrophysics seminar at Harish–Chandra Research Institute on the topic of *Time-dependent Approach to the Shallow Water Hydraulic Jump*, on 3rd. January, 2005.

3. Presented an astrophysics journal club talk at Harish–Chandra Research Institute on the paper titled *Restrictions on the Physical Prescription for the Viscosity in Advection-dominated Accretion Discs* (Reference : Peter A. Becker & Prasad Subramanian, **ApJ**, 2005, Vol. 622, Pg. 520), on 4th. May, 2005.

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# Joseph Samuel

## Research Summary:

1. Inequivalence of ensembles in single molecule measurements: (Supurna Sinha and Joseph Samuel) This study concerns the importance of statistical ensembles in analysing single molecule experiments. It is shown that the interpretation of these experiments and the comparison with theory requires a proper understanding of the correct statistical ensemble. The role of fluctuations in single molecule experimental measurements of force-extension curves was studied. The Worm Like Chain (WLC) model was used to bring out the connection between the Helmholtz ensemble characterized by the Free Energy and the Gibbs ensemble characterized by the Free Energy . The rigid rod limit of the WLC model was considered as an instructive special case to bring out the issue of ensemble inequivalence. The need for taking into account the free energy of transition when one goes from one ensemble to another was pointed out. The "phase transition" noticed in an isometric setup for semiflexible polymers was commented on and a realization of its thermodynamic limit proposed. General arguments which rule out non-monotonic force-extension curves in some ensembles were presented and it was noted that these do not apply to the isometric ensemble.

2. Euler buckling in red blood cells: An optically driven biological micromotor (A. Ghosh, S. Sinha, J. A. Dharmadhikari, S. Roy, A. K. Dharmadhikari, J. Samuel, S. Sharma, D. Mathur) This work concerns the elasticity of red blood cells and the interaction of light with cellular matter. It is seen experimentally that a red blood cell folds in an optical trap and rotates if the trap radiation is circularly polarised.

The physics of an optically-driven micromotor of biological origin was investigated. A single red blood cell, when placed in an optical trap using circularly polarized light, first folds into a rod-like shape and then rotates. A model based on the concept of buckling instabilities captures the folding phenomenon; the rotation of the cell was modeled using the Poincare sphere. Predictions made by our model were successfully tested.

3. DNA elasticity: Topology of Self Avoidance (J. Samuel, Supurna Sinha and Abhijit Ghosh) (continued from the last year) This works studies the topological effects of self avoidance in DNA elasticity. It is shown that the topological effects of self avoidance can be captured by replacing it with the much simpler notion of south avoidance.

4. Ricci Flows (Work in Progress): (Sutirtha Roychowdhury, Javed Ahmad and Joseph Samuel) Work was begun on the use of the Ricci flow to address problems in general relativity like the Penrose inequality. This work is still in progress. Some preliminary findings, which recover known results using a new method have been obtained.

## Publications:

1. *Ensemble Inequivalence in Single Molecule measurements* Physical Review E71 021104 (2005).
2. *Connections and Fields -I*,Resonance April issue (2005)
3. *Connections and Fields-II*, Resonance May issue (2005)

## Preprints:

1. *DNA Elasticity: topology of self avoidance*, submitted for publication.
2. *Euler buckling in red blood cells: a biological micromotor*, submitted for publication.

## Conference/Workshops Attended:

None but my collaborator presented my work at ICTP in the form of a poster

| | Name of the conference | Place and date |
|---|---|---|
| 1. | International workshop on Biopolymers, | ICTP Trieste,30.5.05-3.6.05 |

Title of poster:Twisting Semiflexible polymers at low and high tensions

## Invited Lectures/Seminars:

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|---|---|---|
| 1. | *"Black Hole Entropy as Noether Charge* (two lectures) | March 8,9 2005 HRI Allahabad |
| 2. | *"Of Connections and Cats* (Colloquium) | 4th October, 2004, HRI Allahabad |
| 3. | *"Black Hole Thermodynamics"* (String Lunch Talk) | 7th March 2005, HRI Allahabad |

## Other Activities:

1. Spent a day at Devprayag School, Allahabad. Gave a set of lectures and physics demonstrations to school children at various levels: Class III,IV,VIII,VII
2. Gave some inputs to the HRI effort to build up some experimental physics activity drawing on similar experience at RRI.

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# Ashoke Sen

## Research Summary:

My research during 2004-05 has been focused on two distinct aspects on string theory, – the understanding of the dynamics of open string theory on unstable D-branes and the study of small black holes in string theory which describe elementary string states.

On the topic of open string tachyon dynamics, I developed a systematic procedure for constructing the conserved charge in open string theory associated with a given symmetry of the closed string theory. I applied this technique to study the conserved charges of the D0-brane in two dimensional string theory and showed that the results agree with the matrix model analysis of the same system.

It is an old idea that a very massive elementary string state should have sufficiently strong gravitational field so as to behave like a black hole. Earlier analysis of this problem had shown that the entropy of the black hole scales in the same way as the entropy associated with the elementary string state; recent analysis shows that even the overall numerical factor comes out correctly. I analyzed how the full solution interpolates between the near horizon geometry of the black hole and the asymptotically flat space-time. I also clarified the role of holomorphic anomaly in the non-leading contribution to the entropy of the black hole.

## Publications:


1. A. Sen, *Symmetries, conserved charges and (black) holes in two dimensional string theory* JHEP 0412, 053 (2004) [arXiv:hep-th/0408064].

2. A. Sen, *Tachyon dynamics in open string theory*, [arXiv:hep-th/0410103] (review article).

3. A. Sen, *How does a fundamental string stretch its horizon?*, JHEP 0505, 059 (2005) [arXiv:hep-th/0411255].

4. A. Sen, *Black holes, elementary strings and holomorphic anomaly*, [arXiv:hep-th/0502126].


## Academic recognition/Awards:

- Elected fellow of Third World Academy of Sciences
- Insa S.N. Bose Medal

## Invited Lectures/Seminars:

1. *"Open string tachyon dynamics"*, Nordic meeting, Groningen, May 13-15, 2004.
2. *"Symmetries and conservation laws in two dimensional string theory"*, Strings 2004, Paris, June 28 - July 2, 2004.
3. *"Tachyon dynamics in open string theory"*, Onassis Lecture, Crete, July 5-9, 2004
4. *"Aspects of tachyon condensation"*, ISM04, Khajuraho, December 15-23, 2004.
5. *"Black holes and elementary string states"*, IPM spring school, Qeshm island, Iran, Januray 5-14, 2005.
6. *"Black holes and elementary string states"*, ICTP spring school, Trieste, March 14-22 2005,

## Other Activities:

1. Search for a unified theory, Regional meeting of the Physics Academy of the North East, Shilchar, November 2004.
2. **Courses given:**
   - Spring, 2004: Quantum Field Theory 1
   - Fall, 2004: Quantum Field Theory 2
   - Spring, 2005: Quantum Field Theory 1

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# Prasenjit Sen

## Research Summary:

In this period my main research activity was to study adsorption of P on the Si(001) surface through first-principles calculations within density functional theory. Phosphine gas (chemical formula $PH_3$) is a commonly used *in situ* *n*-type dopant source in chemical vapor deposition (CVD) and gas-source molecular beam epitaxial growth of Si thin films used in ultra-large-scale integrated (ULSI) circuit technology. There are also recent proposals to use $PH_3$ gas to build atomic-scale devices by positioning the P atoms precisely on the Si surface using H lithography. Significantly, one such idea involves fabricating two-dimensional array of P atoms in Si for the realization of Si based quantum computers as proposed by Kane.

Hence, adsorption of P on the Si surfaces become of fundamental importance for these applications. There have been a number of experiments studying P adsorption on the Si(001) surface obtained by exposing it to phosphine gas at various temperatures. Most of these experiments observe similar features on the surface in their scanning tunneling microscopy (STM) images. However, interpretations of these have remained controversial and contradictory. I have done a detailed first principles calculation of P adsorption and incorporation on the Si(001) surface. These calculations have been able to resolve the controversy. These clearly point out that the controversial 'bright' features seen on the Si(001) surface at low P coverage is really Si-Si dimers, whereas at these low coverage P gets incorporated into the surface forming P-Si hetero-dimers. I have also found that at higher P coverages it becomes favourable for the P atoms to get adsorbed *on top of* the Si(001) surface and to form P-P hetero-dimers, rather than to get incorporated into the surface. I have also been able to obtain a rough estimate of the P-coverage at which this transition in behaviour of the P ad-atoms occur.

Another problem that I have been involved during this period is adsorption of In on the Si(211) surface. In/Si is a prototypical metal-semiconductor system, yet some of its properties, such as formation of its Schottky barrier is poorly understood. Recently there has been an experimental study by Gai *et al.* of this system using STM and low energy electron diffraction (LEED) methods. Based on their results these authors suggest a particular structure of In-adsorbed Si(211) surface. However, there is no theoretical justification for the model they propose. I am doing a calculation using first-principles calculation within DFT to compare their model with an alternative one proposed by Baski *et al.* to understand which one is more favourable and to understand the electronic structure of this system in more detail. This work is still going on.

## Preprints:

1. *Electronic Structure and Origin of Ferromagnetism in $CaB_6$: Hartree-Fock, Density Functional and Quantum Monte Carlo Study*, Z. Helms, P. Sen and L. Mitas.

2. *Growth of P on Si(001): Atomic Structure up to a Monolayer*, P. Sen, I. P. Batra, and B. Gupta.

## Conference/Workshops Attended:

1. School on Parallel Computing and Applications, IMSc, Chennai; January 7-14, 2005.

## Visits to other Institutes:

1. Visited S. N. Bose national Centre for Basic Sciences, Kolkata in July 2004.

## Invited Lectures/Seminars:

1. *"Electronic Structure Calculations"*, at the School on Parallel Computing and Applications, IMSc, Chennai; January 2005.

## Other Activities:

1. In August 2004 semester, I taught a course on Mathematical Methods to the first year graduate students.

2. During May-July 2005, and also December 2005, I advised a visiting student, Aditya Tiwari, from IIT-Bombay on some electronic structure related problems.

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# Supurna Sinha

## Research Summary:

- **Inequivalence Of Statistical Ensembles In Single Molecule Measurements:**

  Statistical mechanics of a single semiflexible polymer molecule is dominated by fluctuations because of the finite extent of the molecule. These fluctuations about the mean die out only in the thermodynamic limit of extremely long flexible polymers. The experimentally measured mean values of force or extension for a semiflexible polymer therefore depend on the choice of the ensemble. Thus, in general, experiments done in isometric and isotensional setups lead to distinct force-extension curves and their interpretation needs a proper theoretical treatment of these issues.

- **Euler buckling in red blood cells: An optically driven biological micromotor**

  We explore the physics of an optically-driven micromotor of biological origin. A single, disk-shaped red blood cell, when placed in an optical trap using circularly polarized light, first folds into a rod-like shape and then rotates. We also provide a simple picture for the rotation of the cell based on the Poincare sphere. A model based on the concept of Euler buckling instabilities captures the main observed features and makes predictions that are successfully tested. This cellular micromotor has potential applications in micromanipulation, possibly like an "optical screwdriver" to apply torques at the micron scale.

## Publications:

1. *Writhe distribution of stretched polymers*, Supurna Sinha, Physical Review E 70, 011801 (2004), has been selected for the July 15, 2004 issue of Virtual Journal of Biological Physics Research.

2. *Inequivalence Of Ensembles in Single Molecule Measurements* (Supurna Sinha and Joseph Samuel), Physical Review E 71, 021104 (2005). [Selected for the Virtual Journal Of Biological Physics Research].

## Preprints:

1. *DNA Elasticity: Topology Of Self-Avoidance* (with J. Samuel and A. Ghosh; Submitted to Physical Review E).

2. cond-mat/0410142: *Dynamics of Vibrated Grains* Abhishek Dhar and Supurna Sinha (A Technical Report).

3. physics/0501099: *Euler buckling in red blood cells: An optically driven biological micromotor* ( A. Ghosh, S. Sinha, J. A. Dharmadhikari, S. Roy, A. K. Dharmadhikari, J. Samuel, S. Sharma, D. Mathur)

## Conference/Workshops Attended:

1. Presented a Poster at *"StatPhys22"*, July 2004. Writhe distribution of Long Tense Molecules.

2. Third Indo-Israel Meeting in Condensed Matter Physics (Puri, April 2005) Presented a poster *"Ensemble Inequivalence In Single Molecule Measurements"*.

3. Presented a Talk at Einstein 1905 Symposium at HRI, Allahabad April 2005. *"Random Walks In Biology"*.

4. Presented a Poster at the ICTP Workshop On Biopolymers, May-June 2005. *"Twisting Semiflexible Polymers at Low and High Tensions"*.

## Visits to other Institutes:

1. Visited *Max Planck Institute for Polymer Physics Research, Mainz, Germany* and gave a talk **Writhe distribution at Low and High Tensions**.

2. Visited *ICTP, Trieste* and presented a poster **Twisting Semiflexible Polymers at Low and High Tensions**.

## Invited Lectures/Seminars:

1. A set of lectures on *"Introduction to Soft-Matter Physics: Equilibrium and Nonequilibrium Aspects"*. Condensed Matter Group Meeting, HRI, Allahabad (Sept-Oct 2004).

2. *"Phase Transitions In Small Systems"* (HRI, March 11, 2005).

## Other Activities:

1. Refereed a paper for PRL: Marco Frasca LT9311

2. Refereed a paper for PRL: A. Cebers LU9198

3. Refereed a paper for PRL: Cunha LW9160
4. Refereed a paper for PRE: Liu EJ8922
5. Refereed a paper for PRE: Baskal EB10028
6. Refereed a paper for Physics Letters A: wang 20050309/1
7. Refereed a paper for Physical Review Letters: LQ9541
8. Refereed a paper for Physical Review Letters : LD10059

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# L. Sriramkumar

## Research Summary:

My research work continues to be focused on understanding the effects of Planck scale physics on the inflationary density perturbation spectrum and the Cosmic Microwave Background (CMB). The measurement of the anisotropies in the CMB to a higher and higher precision has led to the hope that, may be, we are on the threshold of observing Planck scale effects in the CMB. In the absence of a workable quantum theory of gravity, the Planck scale effects on the perturbation spectrum have been studied by phenomenologically modifying the dynamics of the scalar field to take into account the quantum gravitational effects. The question then arises whether precise and accurate measurements of the CMB anisotropies can indeed help us to discriminate between the various high energy models that have been considered. We have been able to explicitly show that, given any modified spectrum (that is either, say, obtained from a high energy model or determined by observations), it can be reproduced with a suitably chosen squeezed state above the Bunch-Davies vacuum in the standard theory. Due to this degree of freedom available in choosing the initial state of the matter field, we have argued that the CMB observations can, at most, be useful in determining the initial state of the matter field in the standard theory, but it can not help us to discriminate between the different Planck scale models of matter fields.

Currently, we are examining the effects of non-vacuum initial states as well as dynamical, compact extra dimensions on the primordial spectrum. Being a closely related issue, I have also been studying the origins of entropy and the effects of very high energy modes on the 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.

## Publications:


1. S. Shankaranarayanan and L. Sriramkumar, *Trans-Planckian corrections to the primordial spectrum in the infra-red and the ultra-violet*, Phys. Rev. D **70**, 123520 (2004).

2. S. Shankaranarayanan and L. Sriramkumar, *Planck scale effects and the suppression of power on the large scales in the primordial spectrum*, To appear in the Proceedings of PASCOS '04 (World Scientific, 2004).


## Preprints:


1. L. Sriramkumar and T. Padmanabhan, *Initial state of matter fields and trans-Planckian physics: Can CMB observations disentangle the two?*, gr-qc/0408034.

## Visits to other Institutes:

1. Inter-University Centre for Astronomy and Astrophysics, Pune, July 18–26, 2004 and January 9–19, 2005.

## Invited Lectures/Seminars:

1. *"Does the primordial spectrum probe Planck scale physics"?*, Seminar at Raman Research Institute, Bangalore, January 25, 2005.

## Other Activities:

1. Along with Dr. Jasjeet Bagla, organized a *Summer School on Gravitation and Cosmology* at HRI during May 10–21, 2004. The School was open to final year bachelor's and master's students and the aim of the School was to introduce the students to the field of Cosmology.

2. Was involved in conducting (the Physics part of) the HRI Science Talent Test 2004.

3. Taught a course on Astrophysics to second year physics graduate students at HRI during August–December, 2004.

4. Guided the following M.Sc. Physics student on a project under the Visiting Students' Program: Aswani Kumar Unnam, Periyar University, Salem.

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# Ashok Sethia

## Research Summary:

We report for the first time a formulation for finding the path integral of many boson systems using hyperspherical harmonics. The accuracy of the method is established by comparison with analytical results of simple systems. The partition function, and hence several thermodynamic properties are also calculated using interactions that are relevent to Bose-Einstein condensation.

## Publications:

1. Chem. Phys. Lett. 404 192-198 (2005)

## Visits to other Institutes:

1. B.H.U., Varanasi

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# Arjun Bagchi

## Research Summary:

During the last year, I have spent some time looking at the alternative theories of gravitation. The work done in HRI was an extension of the Master's project I submitted in the Institute of Mathematical Sciences (IMSc) under the guidance of Dr. S. Kalyana Rama. We studied scalar-tensor theories of gravitation in D-dimensions laying stress on the cosmological and spherically symmetric solutions.

## Publications:

1. *Cosmology and Static Spherically Symmetric Solutions In D-Dimensional Scalar Tensors Theories: Some Novel Features.*
   Arjun Bagchi (IMSc, Chennai and Harish-Chandra Res. Inst.), S. Kalyana Rama (IMSc, Chennai).
   IMSC-2004-08-31, Aug 2004. 17pp.
   Published in Phys.Rev.D70:104030,2004
   e-Print Archive:gr-qc/0408030

## Other Activities:

*Courses Attended*

- Fall 2004: Classical Mechanics, Quantum Mechanics, Mathematical Methods, Electrodynamics, Quantum Field Theory 2.
- Spring 2005: Statistical Mechanics, Quantum Mechanics 2, Matematical Methods2, Quantum Field Theory 1, String Theory.

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# Pomita Ghoshal

## Research Summary:

In the last year, I have worked on studying earth matter effects in neutrino oscillations in the context of atmospheric neutrino experiments. The analysis of oscillations provides a window for the determination of fundamental neutrino parameters like mass squared differences and mixing matrix elements. The presence of matter effects at long baselines amplifies oscillation signals and enhances the sensitivity of oscillation probabilities to neutrino parameters, facilitating their measurement.

Most existing studies concentrate on a description of matter effects on the electron neutrino to muon neutrino oscillation probability. In a two-flavor analysis, matter effects in the muon neutrino to tau neutrino oscillation probability is negligible.

We have focused on muon neutrino survival and muon neutrino to tau neutrino oscillation probabilities as a probe for the determination of the neutrino mass hierarchy, and located a new resonance region where matter effects become prominent in the latter, which significantly modifies the muon neutrino survival probability. This is useful since the muon survival rate is the primary observable in iron calorimeter detectors like MINOS and the proposed MONOLITH and INO and a major constituent of the signal in SuperKamiokande (SK) and the megaton water Cerenkov detector HyperKamiokande. We have analysed how the different oscillation probabilities interact with and affect each other, particularly at very long baselines, to give rise to large matter effects and sensitivity of the muon survival probability to the sign of the atmospheric mass squared difference.

We have attempted to evaluate the observability and experimental viability of these theoretically predicted effects with the help of actual event rate calculations. Appreciable matter effects are observed in the muon survival events using atmospheric neutrinos as the source. We have examined the sensitivity offered by some future detectors to these effects and shown that one can determine the mass hierarchy and obtain a statistically significant result by a careful selection of energy and baseline ranges. This analysis has been performed for proposed atmospheric neutrino experiments using a large magnetized iron calorimeter detector like INO and a megaton Water Cerenkov detector like HyperKamiokande. Further applications of this analysis may include future experiments involving superbeams and neutrino factories.

## Publications:

1. R. Gandhi, P. Ghoshal, S. Goswami, P.Mehta, S. Uma Sankar, *Large Matter Effects in $\nu_\mu \to \nu_\tau$ Oscillations*, Phys. Rev. Lett. 94, 051801

## Preprints:

1. R. Gandhi, P. Ghoshal, S. Goswami, P.Mehta, S. Uma Sankar, *Earth Matter Effects at Very Long Baselines and the Neutrino Mass Hierarchy* ,hep-ph/0411252

2. R. Gandhi, P. Ghoshal, S. Goswami, P.Mehta, S. Uma Sankar, *Resolving the neutrino mass hierarchy from atmospheric neutrinos in a megaton Water Cerenkov detector*, work in progress

## Conference/Workshops Attended:

1. DAE High Energy Physics Symposium, Saha Institute of Nuclear Physics, Kolkata (29th November - 3rd December, 2004)

2. Summer School on Particle Physics, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy (13th - 24th June, 2005)

## Other Activities:

1. Worked as a tutor for the course taken by Raj Gandhi in Advanced Quantum Mechanics for first year students in H.R.I (January - May, 2005).

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# Sudhir Kumar Gupta

## Research Summary

Supersymmetry is an elegant extension of the presently well testified Standard Model. Besides being an important ingredient of 'theory of everything', it also addresses many important issues of the present day particle physics like, hierarchy problem, unification of couplings, neutrino masses etc. The idea lies in assigning each SM particle a superpartner with different spin-statistics (i.e. a bosonic field have a fermionic super-partner and vice versa.). Though it works very well for the above mentioned problems, some serious problems still survive, namely it is unable to explain the smallness of the cosmological constant (which is necessary to explain structure formation), excessive flavour and CP violation, fast dimension-5 proton decay, tight constraints on the Higgs mass.

Recently, Arkani-Hamed and Dimopolous proposed a scenario the so called 'split supersymmetry' to address few of the above mentioned problems. This is based on the landscape scenario of string theory which says that there exists a plathora of vacua (as many as $10^{200}$) out of which nature chooses a vacuum in which the cosmological constant is already fine-tuned. This guides us not to worry about the hierarchy problem as here the fine tuning is of even much smaller order. The essential feature of this model is that the masses of all the squarks and sleptons (superpartner of SM fermions) and the higgses, except one neutral higgs, lies on a much higher scale ($10^8 - 10^{12}$), whereas the gauginos and higgsinos remain light (within a TeV). Also, it maintains the successes of the supersymmetric SM, and account for the absence of problematic flavor and CP-violation, of fast proton decay, and of an excessively light Higgs, caused by the presence of light squarks and sleptons in the supersymmetric SM. The lightest neutralino (which is considered to be the lightest sparticle) remains still stable (a good dark matter candidate) unless we impose R-parity violation. Under a model independent calculation we investigated the implication of R-breaking on the neutralino. We showed that (depending upon the supersymmetry parameters), the lightest neutralino (which is unstable now and can decay in to SM particles) can be, (a) a good dark matter candidate, (b)invisible from the reach of the detector, or (c) visible with a displaced vertex unlike the usual supersymmetry case.

We also showed that the constraint on proton decay are also diluted as scalars (except one higgs) are ultra heavy now.

Presently I am working on signals which might show a possible distinction between the signals of split supersymmetry over standard model at future colliders like LHC, ILC and Photon-Photon collider. One of the project on similar ideas (distinguishing the SM and the split-susy higgs signals) is in progress since January.

## Publications:

1. *R-parity Violation in Split Supersymmetry* (Sudhir Kumar Gupta, Partha Konar and Biswarup Mukhopadhyaya)-Physics Letters B 606,384 (2005)

## Conference/Workshops Attended:

1. VI Indian Linear Collider Working Group meeting, IISC, Banglore, Oct'04.
2. XVI DAE symposium in High Energy Physics, SINP, Kolkata, Nov-Dec'04.
3. XX SERC School in Theoretical High Energy Physics, IIT, Kanpur, Dec'04.

## Invited Lectures/Seminars:

1. R-parity Violation in split supersymmetry and neutralino dark matter, SINP, Kolkata, Dec'04.
2. R-parity Violation in split supersymmetry, HRI, Allahabad, May'05

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# Jayanti Prasad

## Research Summary:

I have been working on aspects of non linear gravitational clustering in an expanding universe. Summary of my research work is as follows:

In a cold dark matter dominated universe galaxies, clusters of galaxies and other large scale structures in the universe form hierarchically i.e., small structures form first then they merge with each other and form large scale structures. This means that the collapse of large scale perturbations is always preceded by collapse of small scale perturbations. So it is important to understand how small scale perturbations or substructure affect the collapse of large scale perturbations. In order to understand the coupling of perturbations on various scales we have carried out a series of numerical experiments. In the first series of experiments we study the collapse of a large scale perturbation which is modeled as a plane in two cases: when there are no small scale perturbations or substructure and when there are small scale perturbations. Comparing the thickness of the pancake, which form when the plane wave collapse, density and velocity profile, we find that the relaxation of the plane wave is faster in presence of substructure. Results of this study have already been reported.

In the second series of experiments we study mode coupling for a generic case i.e., power law models. Our motivation has been the past simulation studies which have shown that at the level of second moments i.e., power spectrum, two point correlation function etc., there are significant effects of large scale perturbations on the growth of perturbations at small scales but not vice versa. In non linear gravitational clustering transfer of power mostly takes place from large to small scales. However, if there is no power at large scales or the initial power spectrum is stepper than $k^4$ then power can be transfered from small to large scale by formation of a $k^4$ tail in the initial power spectrum. Results of this study will be reported in a future publication.

## Publications:


1. Bagla, Prasad & Ray, 2005, MNRAS (in press),astro-ph/0408429


**Conference/Workshops Attended:**

1. XXIII Conference of the IAGRAG (7-10 December, 2004)
   Department of mathematics, University of Rajasthan, Jaipur, India.

2. School on Parallel Computing and Applications (7-14 January, 2005)
   Institute of Mathematical Sciences, Chennai, India.

3. XXIII meeting of Astronomical Society Of India (21-24 February, 2005) Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, India.

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# Raghavendra Srikanth

## Research Summary:

I started my research under Prof. Biswarup Mukhopadhyaya in Little Higgs models. This model comes under beyond standard models. We worked in neutrino mass issue in this model. Little Higgs model respects local gauge invariance of $[\mathrm{SU}(2) \times \mathrm{U}(1)]^2$ and it is valid upto a cutoff of 10 TeV. We introduced a $\Delta$L = 2, dimension-four operator in LH model, $\mathcal{L} = iY_{ij} L_i^T \, \phi \, C^{-1} L_j + \mathrm{h.c.}$ in which $\mathrm{SU}(2)$ doublet leptons($L$) have interactions with triplet Higgs($\phi$) of the model. We explained the smallness of neutrino masses by choosing small value for triplet VEV which results after electroweak symmetry breaking. The dimension-four operator which we introduced respects standard electroweak gauge invariance ($\mathrm{SU}(2)_\mathrm{L} \times \mathrm{U}(1)_\mathrm{Y}$) but does not respect full gauge invariance($[\mathrm{SU}(2) \times \mathrm{U}(1)]^2$) of LH model. We showed this kind of introduction of neutrino mass terms does not effect salient features of LH model. We also analysed loop induced dimension-five operators caused by our tree level dimension-four operator. We showed in our analysis that all these dimension-five operators give subleading contribution compared to tree level contribution. Neutrino mass model was already proposed by Kilian et al., J. Y. Lee in LH model which respects full gauge invariance of LH model. We compared our model with them. The advantage of ours is that we can take the coupling coefficient $Y$ to be order one as against to the unnaturally small coupling values in the models proposed by Kilian et al. and J. Y. Lee. Finally we studied decay branching ratios of doubly, singly and neutral charged triplet Higgs. Our model predicts decay of doubly charged triplet Higgs into same charge dileptons. Also there are decays into heavy top quark with a mass of $\sqrt{2}$ TeV which is a unique feature of LH model. Probing these decay channels in the allowed parameter range give testability of our model as well as LH model. This work is also done in collaboration with Tao Han and Heather Logan from University of Wisconsin, Madison.

## Conference/Workshops Attended:

I attended the following meetings.

1. Indian Linear Collider Working Group held at IISc, Bangalore during 13 - 15 Oct., 2004.

2. XVI DAE High Energy Physics Symposium held at SINP, Kolkata during 29 Nov. - 3 Dec., 2004.

3. XX SERC Main School in Theoritical High Energy Physics held at IIT, Kanpur during 4 - 24 Dec., 2004.

## Invited Lectures/Seminars:

1. I gave a talk *"Some aspects of Little Higgs model"* in the parallel session of XVI DAE High Energy Physics Symposium held at SINP, Kolkata.

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# LECTURES / TALKS / SEMINARS AT THE INSTITUTE

## MATHEMATICS

**By Academic Members :**

| | | |
|---|---|---|
| 1. | Dr. Kalyan Chakraborty | Elliptic Curves and Cryptography |
| 2. | Dr. R. Thangadurai | Point Counting Algorithms for Elliptic Curves over Finite Fields |
| 3. | Dr. Stephen Baier | The Large Sive with Sparse Sets of Moduli and Amplitudes |
| 4. | Dr. D. Surya Ramana | Number Theory: 2 Lectures in AFS-II<br>Complex Analysis: 2 Lectures in AFS-II |
| 5. | Prof. I.B.S. Passi | Algebra: 5 Lectures in AFS-II |
| 6. | Dr. Kalyan Chakraborty | Number Theory: 3 Lectures in AFS-II |
| 7. | Dr. N. Raghavendra | Complex Analysis: 6 Lectures in AFS-II |
| 8. | Dr. Punita Batra | Algebra: 2 Lectures in AFS-II |
| 9. | Prof. Ravi S. Kulkarni | Complex Analysis: 6 Lectures in AFS-II<br>Algebraic Topology: 4 Lectures in AFS-II |
| 10. | Dr. R. Thangadurai | Number Theory: 4 Lectures in AFS-II |
| 11. | Dr. Satya Deo | Algebraic Topology : 4 Lectures in AFS-II |
| 12. | Dr. S.D. Adhikari | Number Theory: 3 Lectures in AFS-II |
| 13. | Prof. B. Ramakrishnan | Number Theory : 3 Lectures in AFS-II |

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|---|---|---|
| 14. | Mr. Anupam Singh | Algebra Tutorial in AFS-II |
| 15. | Mr. Manoj Keshari | Algebra Tutorial in AFS-II |
| 16. | Mr. Shripad Garge | Algebra Tutorial in AFS-II |
| 17. | Dr. D. Surya Ramana | Complex Analysis Tutorial in AFS-II |
| 18. | Dr. P.K. Ratnakumar | Complex Analysis Tutorial in AFS-II |
| 19. | Mr. Siddhartha Sarkar | Complex Analysis Tutorial in AFS-II |
| 20. | Mr. Brundaban Sahu | Number Theory Tutorial in AFS-II |
| 21. | Mr. Purusottam Rath | Number Theory Tutorial in AFS-II |
| 22. | Ms. Sanoli Gun | Number Theory Tutorial in AFS-II |
| 23. | Mr. Ritumoni Sarma | Topology Tutorial in AFS-II |

**By Visitors :**

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|---|---|---|
| 1. | Prof. R. Sujatha | Iwasawa Algebras and Arithmetic |
| 2. | Prof. J.H. Coates | Iwasawa Algebras and Arithmetic |
| 3. | Prof. A.W. Hales | Jordan Decomposition |
| 4. | Prof. N. Saradha | Contributions Towards a Conjecture of Erdos on Perfect in Arithmetic Progressions |
| 5. | Dr. Tim Browning | Counting Rational Points on Threefolds and Problems in Analytic Number Theory |
| 6. | Dr. Tim Browning | On Manin's Conjecture for Del Pezzo Surfaces |
| 7. | Prof. Goutami Bhowmik | Analytic continuation of Several Variable Zeta Functions |

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|---|---|---|
| 8. | Prof. Marc Bourdon | Cayley Graphs and $l_p$ Cohomology |
| 9. | Mr. Rajeev Kumar | Composition Operators on Some h Banach Function Spaces |
| 10. | Dr. Neil Lambert | Revisiting Freund-Rubin |
| 11. | Mr. Gyan Prakash | Sum-Free Sets of a Finite Abelian Group |
| 12. | Dr. Rama Mishra | Polynomial Representations of Strongly Invertible and Strongly-Negative Ampicheiral Knots |
| 13. | Prof. Joseph Oesterle | Coverings of P1 Minus Three Points Series of 16 Lectures in AFS-II |
| 14. | Prof. Frederik P. Gardiner | A Short Course on Teichmuller's Theorem |
| 15. | Prof. Pavlov Dmitry | Number, Time and Relativity |
| 16. | Prof. Roman Mikhailov | Some Obstructions to Whitehead Asphericity Conjecture |
| 17. | Prof. Clifford J. Earle | 7 Lectures on Teichmuller Theory |
| 18. | Prof. Frederik P. Gardiner | A Short Course on Teichmuller's Theorem |
| 19. | Prof. Olivier Ramare | The Large Sieve |
| 20. | Prof. A.W. Hales | Jordan Decomposition in Integral Group Rings |
| 21. | Prof. Alessandro Zaccagnini | Introduction to Circle Method |
| 22. | Prof. M.S. Narasimhan | Moduli Spaces of Vector Bundles |
| 23. | Dr. Christopher R. Vinroot | Character Degree Sums of Finite Group of Lie Type |

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| 24. | Prof. William J. Harvey | gave 6 Lectures on<br>Mapping Class Groups |
| 25. | Prof. Rama Rawat | Approximation by K-Finite Functions<br>on Lp Spaces |
| 26. | Prof. J. K. Verma | Algebra : 4 Lecture |
| 27. | Prof. A. R. Shastri | Algebraic Topology : 10 Lectures in AFS-II |
| 28. | Prof. Amit Roy | Algebra : 4 Lectures in AFS-II |
| 29. | Prof. R. R. Simha | Complex Analysis : 6 Lectures in AFS-II |
| 30. | Prof. Dipendra Prasad | Number Theory: 2 Lectures in AFS-II |
| 31. | Prof. G. Mukherjee | Algeraic Topology: 4 Lectures in AFS-II |

# LECTURES / TALKS / SEMINARS AT THE INSTITUTE

## PHYSICS

**By Academic Members :**

| | | |
|---|---|---|
| 1. | Dr. J.S. Bagla | The VIMOS VLT Deep Survey: Evolution of Galax Clustering |
| 2. | Dr. S.G. Manickam | Numerical Simulation of Accretion Phenomena onto Schwarzschild Black Hole |
| 3. | Dr. Pinaki Majumdar | Correlated Electron Systems: Experimental Motivation Numerical Tools and Open Problems |
| 4. | Sanjeev Kumar | The Monte Carlo Approach to Disordered Interacting Systems |
| 5. | Dr. Pinaki Majumdar | Self Consistent Monte Carlo for Double Exchange Magnets |
| 6. | Sanjeev Kumar | The Travelling Cluster Approximation: Implementation and Results on the Lattice Polaron Problem |
| 7. | Dr. J.S. Bagla | Introduction to Cluster Computing on Cluster Computing at HRI |
| 8. | Dr. J.S. Bagla | Introduction to Parallel Computing |
| 9. | Dr. J.S. Bagla | Key Problems in Computational Cosmology |
| 10. | Suryadeep Ray | Parallel N-Body Simulations |
| 11. | Jayanti Prasad | Coupling of Modes and Gravitational Clustering |
| 12. | Suryadeep Ray | Non-Linear Scaling Relations in Gravitational Clustering |
| 13. | Dr. H.K. Jassal | Constraining Cosmological Parameters Using Cosmic Microwave Background Radiation and other Observation |
| 14. | Suryadeep Ray | Bias in Clustering of Galaxies |
| 15. | Dr. K.P. Yogendran | D-Brane Dynamics in NS5 Background |

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| 16. | Jayanti Prasad | Old Galaxies in the Young Universe |
| 17. | Prof. Ashoke Sen | Symmetries, Conserved Charges and (Black) Holes in Two Dimensional String Theory |
| 18. | Dr. Suprna Sinha | Intorduction to Soft-Matter Physics: Equilibrium and Non Equilibrium Aspects |
| 19. | Dr. Namit Mahajan | Big Bang Nucleosynthesis Limits on Physics Beyond the Standard Model |
| 20. | Prof. Rajesh Gopakumar | Free Field Theory as a String Theory |
| 21. | Prof. Satchitananda Naik | Perturbative Yang-Mills Amplitude as a String Theory in Twistor space |
| 22. | Dr. Somdatta Bhattacharya | Open Closed Duality and the (2,1) Minimal Model |
| 23. | Dr. Pravabati Chingangbam | Dynamics of Rolling Massive Scalar Field Cosmology |
| 24. | Dr. K. Furuuchi | Generally Covariant Actions for Multiple D-Branes |
| 25. | Dr. Arnab Kumar Ray | Of Atoms, Mountains and Stars A Study in Qualitative Physics |
| 26. | Dr. L. Sriramkumar | Varying a - Theory and Observations |
| 27. | Prof. Ashoke Sen | TBA |
| 28. | Dr. K.P. Yogendran | D-Branes in Coset Models |
| 29. | Dr. H.K. Jassal | Perturbations in Dark Energy and Their Effect on CMB Angular Power Spectrum |
| 30. | Suryadeep Ray | Gravitational Clustering and Large Scale Structuresc in the Universe |
| 31. | Dr. Arnab Kumar Ray | Time-Dependent Approach to the Shallow Water Hydraulic Jump |
| 32. | Swapan Kumar Majhi | On Higher Order Effects in Electroweak Physics |
| 33. | Dr. Alok Chandra Gupta | Optical Variability of Blazars |
| 34. | Dr. Dumitru Astefanesei | Boundary Black Holes in AdS/CFT |
| 35. | Dr. Namit Mahajan | B- p from Factors in PQCD |
| 36. | Jayanti Prasad | On the Environmental Dependence of Halo Formation |
| 37. | Prof. Debashis Ghoshal | Topological Landau-Ginzburg Model on a Disc |

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| 38. | Dr. L. Sriramkumar | Does the Primordial Spectrum Probe Planck Scale Physics? |
| 39. | Dr. J.S. Bagla | Earth-Mass Dark-Matter Haloes as the First Structures in the Early Universe |
| 40. | Prof. Ashoke Sen | Black Holes, Elementary String and Holomorphic Anomaly |
| 41. | Prof. Dileep Jatkar | One Dimensional Intersection of M-Branes |
| 42. | Dr. H.K. Jassal | Observational Constraints on Dark Energy Evolution |
| 43. | Dr. Pravabati Chingangbam | Randall-Sundrum Models - Lecture 1 |
| 44. | Prof. P. Majumdar | Acoustic Black Hole Analogues |
| 45. | Dr. Shrirang Deshigkar | Computational Relativistic Astrophysics with Adaptive Mesh Refinement |
| 46. | Dr. Sukanta Panda | Garvipartons |

**By Visitors :**

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|---|---|---|
| 1. | Dr. Sudhir Vempati | Lepton Flavour Violation from SUSY GUT's and its Consequences |
| 2. | Dr. A.V. Thampan | Differentially Rotating Magnetised Neutron Stars: Production of Toroidal Magnetic Fields |
| 3. | Dr. Jatush V. Sheth | Studying Morphology of the Supercluster-Void Network using SURFGEN |
| 4. | Prof. H.S. Mani | Quest for Dirac/Majorna Nature of the Neutrino by Multi OWL |
| 5. | Prof. Nirvikar Prasad | Strange Stars with a Density-Dependent Bag Parameter |
| 6. | Prof. Pankaj Jain | Is There a Prefered Direction in the Universe? |
| 7. | Prof. S. Sen | The Casimir Effect Between Non-Parallel Plates by Geometric Optics |
| 8. | Dr. Prasanta Tripathi | Flux Compactifications in String Theory |
| 9. | Dr. Manoj Gopalakrishnan | Co-Operative Effects in Ligand-Receptor Binding Kinetics |
| 10. | Dr. Saumen Datta | Charmonia in a Deconfined Gluonic Plasma |

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|---|---|---|
| 11. | Prof. Amitava Raychaudhuri | Lecture Series on Gand Unified Theories |
| 12. | Prof. U.C. Joshi | Infrared View of the Inner Milky Way Galaxy |
| 13. | Dr. Ajay Patwardhan | Some Geometric Effects in Quantum Theory and Field Theory |
| 14. | Dr. Abhishek Dhar | Fourier's Law: A Theorist's Challenge |
| 15. | Dr. Tom Theuns | The Intergalactic Medium at Redshifts 2-4 |
| 16. | Prof. Andreas Nyffeler | The Muon g-2 in the Standard Model and Beyond |
| 17. | Prof. B.S. Nara Singh | Nuclear Astrophysics at Weizmann Institute: S34, S17 - Factors Relevant to Solar Neutrino Problem |
| 18. | Dr. Justin David | N=4 SYM Correlators at Weak Coupling and String Bits |
| 19. | Dr. Malt Headdrick | TBA |
| 20. | Prof. Probir Roy | Neutrinos from Extra Dimensions |
| 21. | Prof. Mathew Headrick | TBA |
| 22. | Dr. Shrirang Deshingkar | New Approach to Calculating the News |
| 23. | Prof. Bikas Chakraborty | Dynamics of Fracture and the Fibre Bundle Models |
| 24. | Prof. Prasad Subramanian | Angular Momentum Trasport in Black Hole Accretion disks |
| 25. | Dr. Sourov Roy | Infared Fixed Point of the Top Quark Yukawa Coupling in Split Supersymmetry |
| 26. | Dr. Sanjay Jhingan | Listening to Black Holes |
| 27. | Dr. Sanjay Jhingan | KRenormalisation Group Approach to Cosmology |
| 29. | Prof. Sunil Mukhi | Non-Critcal String Theory |
| 30. | Dr. Pushan Majumdar | Dynamical Fermions on Lattice |
| 31. | Prof. A.K. Kembhavi | Fundamental Correlations in Galaxies |
| 32. | Dr. Ghanashyam Date | Implications of Loop Quantum Cosomoloy for the Early Isotropic Universe |
| 33. | Prof. Atish Dabholkar | Small Black Holes in String Theory |
| 34. | Dr. Joseph Samuel | Black Hole Entropy as Nother Charge |
| 35. | Prof. Jayant V. Narlikar | Cosmology from Sidelines |
| 36. | Swarnendu Sarkar | Aspects of Open-Closed Duality in a Background B-Field |

# COLLOQUIUM

# JOINTLY ORGANISED BY MATHS & PHYSICS

| | | |
|---|---|---|
| 1. | Dr. Somendra M. Bhattacharjee | DNA Unzipping by Force |
| 2. | Prof. Ashoke Sen | Search for a Unified Theory |
| 3. | Prof. N. Sthanumoorthy | Hirota Bilinear Equations, Boson-Fermion Correspondence and Vertex Operators |
| 4. | Dr. Joseph Samuel | Of Connections and Cats |
| 5. | Dr. Avinash Khare | A Kind of Linear Superposition for Nonlinear Equations and New Identities for Jacobi Elliptic Functions |
| 6. | Prof. Amitava Raychaudhuri | The pentaquark Theta |
| 7. | Dr. Ram Sagar | Optical Observations of Afterglows of Gamma Ray Bursts (GRB) |
| 8. | Prof. Pankaj S. Joshi | The Black Hole Conundrum |
| 9. | Prof. Rajaram Nityananda | High Ambitions at Low Frequencies: GMRT and Beyond |
| 10. | Prof. Bikas Chakraborty | A Physical History of Economics and a Kinetic Model of National Wealth Distribution |
| 11. | Prof. Clifford J. Earle | Isothermal Co Ordinates, Local and Global |
| 12. | Prof. Sunil Mukhi | Nobel for a Minus Sign |
| 13. | Prof. A.K. Kembhavi | Virtual Observatories |
| 14. | Prof. Atish Dabholkar | Going beyond Bekenstein-Hawking Black Hole Entropy in String Theory |
| 15. | Prof. Ghanashyam Date | Quantum Resolution of Cosomology Singularities |
| 16. | Prof. P. Majumdar | Quantum Black Hole Thermodynamics |
| 17. | Prof. Denis Whaite | Meromorphic Continuation of the Scattering Matrix |

# PUBLICATIONS AND PREPRINTS IN MATHEMATICS

## PUBLICATIONS :

### Sukumar Das Adhikari

1. *Monochromatic configurations for finite colourings of the plane*
(Jointly with Purusottam Rath)
Note di Matematica 22, no. 1, 59 –63 (2003/04).

2. *On the sets of uniqueness of the distribution function of* $\{\xi(p/q)^n\}$
(Jointly with P. Rath and N. Saradha)
Acta Arithmetica, to appear.

### Kalyan Chakraborty

1. *Exponent of the class group of real quadratic function fields II*, (jointly with A. Mukhopadhayay), to appear in Proc.of the AMS.

2. *On the divisibility of class numbers of real quadratic fields* , to appear in RIMS (Kyoto University) Conf. Proceedings, 2004.

3. *On the number of Fourier coefficients that determine a form*, to appear in Waseda University Number Theory Conf. Proceedings, 2005.

### Chandan Singh Dalawat

1. *Le groupe de Chow d'une surface rationnelle sur un corps local,* Compositio Mathematica 141 (2) 2005, pp. 344–358. `math.AG/0302157`.

2. *The Chow group of a del Pezzo surface over a local field,* Japanese Journal of Mathematics, to appear. `math.AG/0302260`.

### Satya Deo

1. *Spline modules from a divided domain to a subdivided domain* (with J. K. Maitra) Indian J. Pure Appl. Math 35(2004)1033-1041.

2. *Strongly contractible polyhedra which are not simply contractible at $n$ points for any $n \geq 2$* (with V. V. Awasthi), J. Indian Math Soc (to appear)

3. *Branched coverings, labelled coverings, and transitive permutation groups* (jointly with R.S.Kulkarni), in preparation.

4. *Freeness of homogenized spline module from a divided domain to a subdivided domain* (with J. K. Maitra), submitted.

5. Algebraic Topology, a Primer; Hindustan Book Agency, TRIM series Number 27, New Delhi, 2003.

## Rukmini Dey

1. *Deformation quantization of a dimensionally reduced Seiberg-Witten moduli space*, accepted for publication in Reports on Mathematical Physics, as an addendum to a previous paper.

2. *Quantization of a dimensionally reduced Seiberg-Witten moduli spaces*, Mathematical Physics Electronic Journal, vol 10, 2004, paper no.9,

   `http://www.maia.ub.es/mpej/`

3. *A complete conformal metric of preassigned negative Gaussian curvature for a punctured hyperbolic Riemann surfaces*, Proceedings of Indian Academy of Sciences – Math Sci. Vol.114,No.2, May 2004, pg. 141-151

## Manoj Kumar Keshari

1. *Stability results for projective modules over blowup rings*. To appear in J. Algebra.

## I.B.S. Passi

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2. *A contribution to Bass' conjecture*, J. Group Theory, 7 (2004), 409-420 (jointly with I. Emmanouil).

3. *Hyperbolic unit groups*, Proc. Amer. Math. Soc., 133 (2005), 415-423 (jointly with S. O. Juriaans and D. Prasad).

4. *Augmentation powers and group homology*,J. Pure Appl. Algebra, 192 (2004), 225–238 (jointly with R. Mikhailov).

5. *Higher traces on group rings*,Comm. Algebra, 33 (2005), 987-997 (jointly with R. Mikhailov).

6. *A transfinite filtration of Schur multiplicator*,International J. Algebra and Computation [to appear] (jointly with R. Mikhailov).

7. *Faithfulness of certain modules and residual nilpotence of groups*,International J. Algebra and Computation [to appear] (jointly with R. Mikhailov).

## B. Ramakrishnan

1. *An estimate for a certain average of the special values of character twists of modular L-functions* (with M. Manickam), Proc. Amer. Math. Soc. 133 (2005), 2515-2517.

2. *On the representation of integers as sums of an odd number of squares* (with Sanoli Gun), To appear in The Ramanujan Journal.

3. *On special values of certain Dirichlet L-functions* (with Sanoli Gun), To appear in The Ramanujan Journal.

4. *Distribution of Quadratic non-residues which are not primitive roots* (with Sanoli Gun, Brundaban Sahu and R. Thangadurai), Accepeted for publication in Math. Bohemica.

## Ratnakumar P.K.

1. *Schrödinger equation and the oscillatory semigroup for the Hermite operator*, jointly with A.K. Nandakumaran, Journal of Functional Analysis, (to appear).

## R. Thangadurai

1. *On Steinhaus sets*, (with S. M. Srivastava),Expositiones Mathematicae, No 2 **23** (2005), 171-178.

2. *On the structure of p-zero-sum free sequences and its application to a variant of Erdös-Ginzburg-Ziv theorem* (with W D Gao and A Panigrahi), Proceedings of the Indian Academy of Sciences (Mathematical Sciences), VOL. 115, NO. 1, FEBRUARY 2005, 67-77.

3. *On the structure of sequence with forbidden zero-sum problems* (with W. D. Gao), To appear in Aequisitiones Mathematicae.

4. *Irreducibility Criterion over* $\mathbb{Z}$, To appear in Elemente Mathematicae.

## Manoj K. Yadav

1. (Jointly with Everett C. Dade)*Finite groups with many product conjugacy classes*. to appear in Israel Journal of Mathematics.

## Sanoli Gun

1. *On the representation of integers as sums of an odd number of squares* (with B. Ramakrishnan), To appear in The Ramanujan Journal.

2. *On special values of certain Dirichlet L-functions* (with B. Ramakrishnan), To appear in The Ramanujan Journal.

3. *Distribution of Quadratic non-residues which are not primitive roots* (with Brundaban Sahu, R. Thangadurai and B. Ramakrishnan), Accepeted for publication in Math. Bohemica.

## Purusottam Rath

1. *Monochromatic configurations for finite colourings of the plane*
(Jointly with S.D.Adhikari)
Note di Matematica 22, no. 1, 59 –63 (2003/04).

2. *On the sets of uniqueness of the distribution function of* $\{\xi(p/q)^n\}$
(Jointly with S.D.Adhikari and N. Saradha)
Acta Arithmetica, to appear.

## Brundaban Sahu

1. *Distribution of Quadratic non-residues which are not primitive roots* (with Sanoli Gun, R. Thangadurai and B. Ramakrishnan), Accepeted for publication in Math. Bohemica.

## Anupam Kumar Singh

1. *Reality properties of conjugacy classes in* $G_2$ (with M. Thakur, appeared in Israel Journal of mathematics, vol. 145).

## PREPRINTS :

## Sukumar Das Adhikari

- *Contributions to zero–sum problems*
(Jointly with J. Friedlander, S. Konyagin and F. Pappalardi)

## Punita Batra

- (With S. Eswara Rao)*Classification of Irreducible Integrable modules for Twisted Toroidal Lie algebras with finite dimensional weight spaces.*

## Kalyan Chakraborty

- *Exponents of class groups of a family of cyclic cubic fields.*

## Chandan Singh Dalawat

- (with Dipendra Prasad) *Bad varieties with good motives.* In preparation.
- *Restriction and corestriction on the Chow group of a rational surface.*
- (with Bas Edixhoven) *Regular proper integral models of ruled surfaces ; applications.* In preparation.

## Satya Deo

- *Spline modules from a divided domain to a subdivided domain* (with J. K. Maitra) Indian J. Pure Appl. Math 35(2004)1033-1041.
- *Strongly contractible polyhedra which are not simply contractible at $n$ points for any $n \geq 2$.* (with V. V. Awasthi), J. Indian Math Soc (to appear)
- *Freeness of homogenized spline module from a divided domain to a subdivided domain* (with J. K. Maitra), submitted.

## Manoj Kumar Keshari

- *Stability results for projective modules over blowup rings*.

## I.B.S. Passi

- *Group homology and Connes' periodicity in the cyclic homology of group algebras* (jointly with I. Emmanouil).

## N. Raghavendra

- Indranil Biswas, and N. Raghavendra, *On transversely holomorphic principal bundles*, Submitted for publication.

## B. Ramakrishnan

- *Eichler-Zagier map for Jacobi forms of half-integral weight* (with M. Manickam).
- *On the Lacunarity of Two-Eta-Products* (with Sanoli Gun).

## D. Surya Ramana

- D.S.Ramana, *A Method of Vinogradov for Sums of Fractional Parts*.

## Ratnakumar P.K.

- *Schrödinger propagator for the special Hermite operator, a regularity result*.

## Ritumoni Sarma

- Ritumoni Sarma, *$S$-Arithmetic Subgroups of $SL_2$* (under preparation).

## R. Thangadurai

- *On Davenport's Constant*.

## Manoj K. Yadav

- *Class preserving automorphisms of finite $p$-groups* (in preparation).

## Sanoli Gun

- *On the Lacunarity of Two-Eta-Products* (with Shaun Cooper and B. Ramakrishnan).

## Krishnendu Gongopadhyay

- (with Ravi Kulkarni)*The spaces of $n$-planes and $n$-spheres*.

## Siddhartha Sarkar

- *Genus Spectrum for $p$-groups of exponent $p$ and order upto $p^6$.*

## Anupam Kumar Singh

- *Conjugacy classes in anisotropic $G_2$.*
- *Reality properties of conjugacy classes in Linear Algebraic Groups* (with M. Thakur, in preparation).

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## PUBLICATIONS :

## Jasjeet Singh Bagla

1. Jassal H. K., Bagla J. S. and Padmanabhan T. 2005, MNRAS Letters 356, L11 (doi: 10.1111/j.1745-3933.2005.08577.x) : *WMAP constraints on low redshift evolution of dark energy.*

2. Bagla J. S. 2004,Current Science 88, 1088 (Special section on cosmology, Guest editor T.Padmanabhan) : *Cosmological N-Body simulation: Techniques, Scope and Status.* (astro-ph/0411043)

3. Bagla J. S. 2004, Resource Summary, Khagol 59, 5 : *Cluster computing in Astronomy.*

## Pravabati Chingangbam

1. *Non-minimally coupled tachyonic inflation in warped string background*, Pravabati Chingangbam, Sudhakar Panda and Atri Deshamukhya,JHEP 02 (2005) 052.

2. *Dynamics of rolling massive scalar field cosmology*, P.Chingangbam and T. Qureshi, Accepted in IJMPA, hep-th/0409015.

## Tapas K. Das

1. Das, T. K., 2004, *Behaviour of matter close to the event horizon*.Monthly Notices of the Royal Astronomical Society. (349, 375)

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4. Das, T. K., 2004, *Transonic Black Hole Accretion as Analogue System*. Proceedings of 'Dynamics and Thermodynamics of Black Holes and Naked Singularities', Milan, May 2004 (gr-qc/0411006).

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## Raj Gandhi

1. R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar, *Large matter effects in nu/mu → nu/tau oscillations* Phys. Rev. Lett. 94, 051801 (2005) [arXiv:hep-ph/0408361].

2. A. Datta, R. Gandhi, P. Mehta and S. Uma Sankar, *Atmospheric neutrinos as a probe of CPT and Lorentz violation*, Phys. Lett. B 597, 356 (2004) [arXiv:hep-ph/0312027].

## Debashish Ghoshal

1. D. Ghoshal,
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2. D. Ghoshal, S. Mukhi and S. Murthy,
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3. D. Ghoshal,
*Exact noncommutative solitons in p-adic strings and BSFT*,
JHEP 0409, 041 (2004) [hep-th/0406259].

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*Towards p-adic string in constant B-field*,
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5. D. Ghoshal (Editor)
Current Perspectives in High Energy Physics: Lectures from SERC Schools
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## Rajesh Gopakumar

1. R. Gopakumar, *From free fields to AdS*, Phys. Rev. D 70, 025009 (2004).

2. R. Gopakumar, *From free fields to AdS. II*, Phys. Rev. D 70, 025010 (2004).

3. R. Gopakumar, *Free field theory as a string theory?*, Comptes Rendus Physique 5, 1111 (2004).

4. R. Gopakumar, *Large N and Topological Strings*, Encyclopedia of Mathematical Physics, Elsevier (to appear).

## Srubabati Goswami

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   R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S Uma Sankar Phys. Rev. Lett. 94, 051801 (2005), arXiv:hep-ph/0408361, (2004).

2. *Update of the solar neutrino oscillation analysis with the 766-Ty KamLAND spectrum*
   A. Bandyopadhyay, S. Choubey, S. Goswami, S. T. Petcov and D. P. Roy Phys. Lett. B 608, 115 (2005)' arXiv:hep-ph/0406328.

3. *Global Analysis of Neutrino Oscillation*
   S. Goswami, A. Bandyopadhyay, S. Choubey,
   Nucl. Phys. Proc. Suppl. 143, 121 (2005), e-Print Archive:hep-ph/0409224.

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## Harvinder Kaur Jassal

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## Dileep Jatkar

1. *ONE DIMENSIONAL M5-BRANE INTERSECTIONS*.
   with Ansar Fayyazuddin and Tasneem Zehra Husain
   Published in Phys.Rev.D71:106003,2005
   e-Print Archive:hep-th/0407129

## Namit Mahajan

1. *$B_d - \bar{B}_d$ mass difference in Little Higgs model*, S. R. Choudhury, N. Gaur, A. Goyal and Namit Mahajan, Phys. Lett. B601, 164 (2004).

## Pinaki Majumdar

1. *Singular Effect of Disorder on Electronic Transport in Strong Coupling Electron-Phonon Systems*, Sanjeev Kumar and Pinaki Majumdar,
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2. *The Many Electron Ground State of the Adiabatic Holstein Model in Two and Three Dimensions*, B. Poornachandra Sekhar, Sanjeev Kumar and Pinaki Majumdar,
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3. *Structural Disorder Induced Polaron Formation and Magnetic Scattering in the Disordered Holstein-Double Exchange Model*, Pinaki Majumdar and Sanjeev Kumar,
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## Poonam Mehta

1. *Large matter effects in $\nu_\mu \to \nu_\tau$ oscillatons*,
R. Gandhi, P. Ghoshal, S. Goswami, P. Mehta and S. Uma Sankar,
Phys. Rev. Lett. 94, 051801 (2005).

## Biswarup Mukhopadhyaya

1. *BULK KALB-RAMOND FIELD IN RANDALL-SUNDRUM SCENARIO*
By Biswarup Mukhopadhyaya, Siddhartha Sen, Somasri Sen, Soumitra Sen-Gupta
Published in Phys.Rev.D70:066009,2004

2. *INVISIBLE HIGGS IN THEORIES OF LARGE EXTRA DIMENSIONS*
By Anindya Datta, Katri Huitu, Jari Laamanen, Biswarup Mukhopadhyaya
Published in Phys.Rev.D70:075003,2004

3. *SPARTICLE SPECTRUM AND PHENOMENOLOGY IN SPLIT SUPERSYMMETRY: SOME POSSIBILITIES*
By Biswarup Mukhopadhyaya, Soumitra SenGupta
Published in Phys.Rev.D71:035004,2005

4. *R-PARITY VIOLATION IN SPLIT SUPERSYMMETRY AND NEUTRALINO DARK MATTER: TO BE OR NOT TO BE*
   By Sudhir Kumar Gupta, Partha Konar, Biswarup Mukhopadhyaya
   Published in Phys.Lett.B606:384-390,2005

5. *SPLIT SUPERSYMMETRY FROM ANOMALOUS U(1)*
   By K.S. Babu, Ts. Enkhbat, Biswarup Mukhopadhyaya, (Appeared in Nuclear Physics B)

## Sudhakar Panda

1. Chingangbam P., Deshamukhya A. and Panda S.,*Non-minimally Coupled Tachyonic Inflation in Warped String Background*,JHEP 02 (2005) 052.

2. de Roo M., Eenink M.G.C., Panda S., and Westra D.B.,*Group Manifold Reduction of Dual N=1 d=10 Supergravity*,JHEP 06 (2005) 077.

## Tribhuvan P. Pareek

1. *Absolute spin valve effect: Charge transport in two dimensional hybrid system*. Phys. Rev. B70 033310 (2004)

## Sumathi Rao

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 Sourin Das and Diptiman Sen), to be published in International Conference on Nanoscience and Technology, Kolkata, December 2003.

## V. Ravindran

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## Arnab Kumar Ray

1. *Large Scale Properties in Turbulent Spherically Symmetric Accretion*, Arnab K. Ray and J. K. Bhattacharjee, The Astrophysical Journal, 627, 368, July 1, 2005.

2. *Time-dependence in the Circular Hydraulic Jump*, Arnab K. Ray and J. K. Bhattacharjee, Proceedings of the Second National Conference on Nonlinear Systems and Dynamics (NCNSD 2005), 2005.

## Joseph Samuel

1. *Ensemble Inequivalence in Single Molecule measurements* Physical Review E71 021104 (2005).

2. *Connections and Fields -I*,Resonance April issue (2005)

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## Ashoke Sen

1. A. Sen, *Symmetries, conserved charges and (black) holes in two dimensional string theory* JHEP 0412, 053 (2004) [arXiv:hep-th/0408064].

2. A. Sen, *Tachyon dynamics in open string theory*, [arXiv:hep-th/0410103] (review article).

3. A. Sen, *How does a fundamental string stretch its horizon?*, JHEP 0505, 059 (2005) [arXiv:hep-th/0411255].

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## Ashok Sethia

1. Chem. Phys. Lett. 404 192-198 (2005)

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# ABOUT THE LIBRARY

The Institute's library is one of the best equipped libraries in the region. Being a research oriented institute, it provides 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 1729 number of volumes in its fold which includes 641 books received as gifts and 1050 bound volumes of the journals during the period from 1st April 2004 to 31st March 2005. The library had subscribed to 219 journals during this period including 119 as online journals.

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 (Due to the possibility of use in the computers and need not to arrange for other accessories such as VCRs and TVs) for viewing the lectures. The emphasis was also given to procure maximum number of journals on line. We have been providing on line access of the periodical to our users 119 (One hundred nineteen) journals through ip address. We provide some other search engines to our users such as Sciencedirect and Mathscinet for their precise searches.

We have provided the Web Enabled library catalogue to our users on the Internet with a proper link with our Institute's site. 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 Document Delivery Services on request through post, at a very nominal cost (postage), but requests had also been honoured through e-mail through pdf/scanned versions as attachment. We have encouraged the use of the library consultation facilities by the research scholars from the neighbouring institutes.

We have Bar Coded the complete library collection and the Library Membership Database last year with the implemented library software LibSys. Now the Circulation (Issue and Return of books) section has been completely automated and the work is being done with the help of the hand held scanners to reduce the time and enhance the accuracy.

We are planning to introduce the latest Library Security System with the help of Electro Magnetic Detection Systems through the Tattle Tapes, which will provide the security checks during library working hours.

# ABOUT COMPUTER SECTION

1. Campus Networking: Campus networking to connect all the buildings in the institute to computer center and main institute network was completed and made operational. 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. Shifting of all 20 KVA UPS systems which are providing the power supply to computers and related devices in the main institute building was completed.

4. Newer versions of SuSe, Redhat and Openbsd operating systems were purchased. Operating systems of users' desktop and other systems were upgraded.

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

6. Seismic station was upgraded by BARC, Bombay. The seismic related data is being transferred via the ANUNET VSAT facility.

7. Secure channel installation in the ANUNET was implemented.

8. HP scanner was upgraded.

9. 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.

10. New Pentuim machines were purchased and installed in conference computer room.

11. Computing related to conferences were held in the conference computer room.

12. About 50 Pentium based desktops were purchased and installed with latest versions of linux operating system in students' offices.

13. One high end Compaq Alpha Server DS25 was purchased and installed under the cryptography project.

14. Procurement and installation of the Crystal software under cryptography project was completed.

15. Broadband Internet connectivity with 1 Mbps, full duplex, 1:1, assured bandwidth was procured and made operational from Sify Limited.

## 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 being planned.
4. Upgradation of faculty and administrative staff computers is also being planned.
5. Expansion of the local area network in the cubicles of the first floor library building is in process.

# CONSTRUCTION WORK AT THE CAMPUS

- Construction of additional bedroom in Type IV/D quarters, extension of Gym area, Toilet for Store Purchase Office were completed and are in use.
- Construction of 6 Nos. New Type V/E quarters work is in progress.
- Renovaton of class room and discussion room of Main Institute Building were completed and made fully functional and are in use.