Academic Report 2008–09

Harish-Chandra Research Institute

Chhatnag Road, Jhunsi, Allahabad 211019

Contents

About the Institute

Early Years

The Harish-Chandra Research Institute is one of the premier research institutes in the country. It is an autonomous institute fully funded by the Department of Atomic Energy, Government of India. Till October 10, 2000 the Institute was known as Mehta Research Institute of Mathematics and Mathematical Physics (MRI) after which it was renamed as Harish-Chandra Research Institute (HRI) after the internationally acclaimed mathematician, late Prof Harish-Chandra.

The Institute started with efforts of Dr. B. N. Prasad, a mathematician at the University of Allahabad with initial support from the B. S. Mehta Trust, Kolkata. Dr. Prasad was succeeded in January 1966 by Dr. S. R. Sinha, also of Allahabad University. He was followed by Prof. P. L. Bhatnagar as the first formal Director. On Prof. Bhatnagar's demise in October 1976, reponsibilities 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 Department of Atomic Energy (DAE) entered into decisive stage and a review committee was constituted by the DAE to examine the Institute's future. In 1985 N. D. Tiwari, 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 1990, about 66 acres of land was acquired in Jhunsi, Allahabad and the Institute came up at this site.

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 Institute's activities picked up pace. This phase of rapid growth still continues.

New Phase

After a distinguished tenure of about nine years Prof. Mani retired in August 2001 and the charge was taken over by Prof. R. S. Kulkarni. After Prof. Kulka-

rni's tenure, Prof. Amitava Raychaudhuri has taken over as Director from July 19, 2005. The Institute continues to be devoted to fundamental research in diverse areas of mathematics and theoretical physics. Research is carried out by faculty members, visiting members, post-doctoral fellows and Ph. D. students. Since 1992 the Institute has attracted worldwide attention, as is evident from the recognition received by many of its members. Among them are Prof. Ashoke Sen, Prof. A. Rajchaudhuri, Prof. B. Mukhopadhyaya and Prof. Pinaki Majumdar, all winners of the prestigious S. S. Bhatnagar award. Prof. Ashoke Sen was also awarded the Padmashri, the Fellowship of the Royal Society, S. N. Bose Medal of the Indian National Science Academy (INSA) and the J. C. Bose fellowship of the Department of Science and Technology. Prof. Rajesh Gopakumar won the Swarnajayanti fellowship of Department of Science and Technology and the International Centre for Theoretical Physics (ICTP) prize for 2006.

Research in Mathematics

The mathematics group at HRI carries out research in several areas. In algebra, work is done on algebraic groups and related structures, the theory of groups and group rings, representation theory, and infinite-dimensional Lie algebras. Work in analysis is in the field of harmonic analysis of Lie groups. Activity in geometry includes discontinuous groups and Riemann surfaces, algebraic topology, variational problems on manifolds, Chow groups of rational surfaces, and moduli of vector bundles. The number theory group works on algebraic, analytic and combinatorial number theory, automorphic forms and cryptography.

Research in Physics

Research in Physics at HRI is carried out in the fields on astrophysics, condensed matter physics, high energy phenomenology and string theory. In astrophysics, work is done on the cosmic microwave background, large scale structure formation and galaxy evolution. Main areas of activity in condensed matter physics are strongly correlated electron systems, mesoscopic systems, quantum Hall effect and superconductivity. In string theory, perturbative and non-perturbative aspects of string theory and quantum field theory are being actively investigated. Research in neutrino physics, strong interactions, lattice gauge theory, supersymmetry and various aspects of physics beyond the standard model is done in high energy phenomenology. The Institute is a member of the India-based Neutrino Observatory (INO) collaboration.

The Institute has a residential campus in Jhunsi, Allahabad with a library, state of the art computational facility and fast Internet link to the outside world. There is an active graduate program and a large traffic of visiting scientists and students.

Director's Report

2008-09 has been a busy year at the Harish-Chandra Research Institute (HRI). The Institute, situated just outside the city of Allahabad, is known nationally and internationally for its innovative research in the fields of mathematics and theoretical physics. The Institute has taken the initiative to expand into the area of Quantum Information which straddles areas of physics as diverse as quantum optics and condensed matter physics as well as mathematics. It is expected that the group in this area will add a novel dimension to HRI's oeuvre.

The research activities as well as the pre-Ph. D. teaching programme at HRI have continued to be at the highest level. This has been possible through the sustained efforts of our scientists, post-doctoral fellows, students, and visitors to continuously upgrade themselves to remain at the frontiers of international research. They were assisted in no small measure by the steadfast administrative support from the entire Institute staff. All members of HRI carry a deep sense of belonging and are willing to walk the extra mile to ensure that the Institute steadily progresses towards further national and international recognition.

As a prominent member of the Department of Atomic Energy (DAE, Government of India) fraternity, the Institute is a participant in the Department's R&D programme through research and education endeavours. The Ph. D. students of HRI register with the Homi Bhabha National Institute (HBNI), the deemed university under DAE. It also maintains close linkages with a number of the other DAE institutes and units through teaching and research avenues.

Under the XIth Five-year Plan, HRI has set up a high performance computer cluster which provides the major computational backbone for the Institute. Through other Plan projects it is envisaged to expand the library and office space, to create a much needed new hostel, to add some space to the community centre, etc. The structural drawings for these are being finalised now. The number and scope of collaboration meetings, workshops, training school programmes, outreach activities, have all been significantly enhanced through the projects associated with Scientific Human Resources Training, Special Years in Mathematics, and the Regional Centre for Accelerator-Based Particle Physics. The recommendations of the 6th CPC have been approved for autonomous in-

stitutes by the DAE and these have been implemented effective January 2006. 40% of the arrears have already been disbursed and the rest will be completed in 2009-10.

HRI admits students at both the post-B. Sc. and the post-M. Sc. stage. The post-B. Sc. integrated Ph. D. students in physics receive their laboratory training at sister HBNI Constituent Institutes – e.g., RRCAT, Indore and SINP, Kolkata. In this year more than half a dozen students have completed their Ph. D.s. It is a cause of no small satisfaction that all of them have been picked up by good institutions in India and abroad as post-doctoral fellows. In mathematics, in 2008-09 one student joined the Ph. D. programme through the HRI selection procedure. This is partly a reflection of the very limited number of quality students in mathematics wishing to pursue an academic career. Nine students (post-B. Sc. and post-M. Sc.) joined the Ph. D. programme in physics. The post-B. Sc. students register for an integrated Ph. D. programme and attend an extra year of course work also undertaking laboratory training.

Among intending Ph. D. students in physics HRI holds a very high stature as is borne out from the preferences of the toppers in the JEST examination. There are also many applications from inside as well as outside the country for post-doctoral positions at the Institute. We are working to enhance the number of Ph.D. students in both physics and mathematics and hope to double the intake in the 2009-10 academic year.

The power situation in Allahabad is far from satisfactory with frequent outages. HRI is in the process of obtaining a dedicated 33kV connection from UPPCL. The work is nearing the end and it is our estimate that within the middle of this year the connection will be energised. The number of national and international conferences, workshops, and meetings at HRI have seen a steady increase. Indeed, in almost every area, be it in mathematics or in theoretical physics, there is usually at least one (and often more) scheduled activity every year.

Tirthankar Roy Choudhury is the newest faculty member to join the Institute. His area of expertise is Astrophysics. He is the fourth member of this group. During the past year two HRI faculty — Srubabati Goswami and Manoj Gopalakrishnan — were granted lien to accept positions elsewhere.

In the 3rd HRI Triveni Lecture, Professor C.S. Seshadri, Chennai Mathematical Institute, spoke about 'Algebraic Geometry and its development in India'. This lecture was held on December 26, 2008.

The 6th HRI Girdharilal Mehta Lecture was delivered on February 06, 2009 by Professor Roger Howe, Yale University. His lecture was entitled 'Symmetry: More than pretty pictures'.

The Institute's faculty are recognised by their peers for their innovative research every year. Some of these for the past year are:

- Professor Pinaki Majumdar was selected for the DAE-SRC Outstanding Research Investigator Award.
- Dr. Srubabati Goswami was selected for the Ramanujan Fellowship of DST.

- The Indian Academy of Sciences elected Professor Rajesh Gopakumar as a Fellow.

The year ahead looks promising for the Harish-Chandra Research Institute.

A. Raychaudhuri
Director

Governing Council

1.	Prof. M. S. Raghunathan (Chairman)	School of Mathematics Tata Institute of Fundamental Research Homi Bhabha Road Mumbai 400005
2.	Prof. R. Balasubramanian	Institute of Mathematical Sciences CIT Campus, Taramani Chennai 600113
3.	Dr. J. N. De	BH-135, Sector II Salt Lake Kolkata 700091
4.	Prof. Narendra Kumar	Raman Research Institute Sadashivnagar Bengaluru 560080
5.	Prof. H. S. Mani	2 Fourth Cross Street Durga Colony, Sembakkam Chennai 600073
6.	Mr. S. L. Mehta	4 Clive Row Kolkata 700001
7.	Mr. Avnish Mehta	4 Penn Road Kolkata 700027
8.	Mr. R. K. Mishra	23/1E P. C. Banerjee Road

		Allen Ganj Allahabad 211001
9.	Dr. Mian Jan	Civil Lines Allahabad 211001
10.	Prof. A. Raychaudhuri	Harish-Chandra Research Institute Chhatnag Road, Jhunsi Allahabad 211019
11.	Mr. V. R. Sadasivan	Joint Secretary (F) Govt. of India, DAE Ch. Shivaji Maharaj Marg Mumbai 400001
12.	Dr. P. Mukherjee	Joint Secretary (R& D) Govt. of India, DAE Ch. Shivaji Maharaj Marg Mumbai 400001

Academic Staff

Mathematics Faculty

1. Prof. Sukumar Das Adhikari
2. Prof. B. Ramakrishnan
3. Dr. Kalyan Chakraborty
4. Dr. Rukmini Dey
5. Dr. Punita Batra
6. Dr. D. Surya Ramana
7. Dr. R. Thangadurai
8. Dr. N. Ranghavendra
9. Dr. C. S. Dalawat
10. Dr. P. K. Ratnakumar
11. Dr. Manoj Kumar

Physics Faculty

1. Prof. Amitava Raychaudhuri
2. Prof. B. Mukhopadhyaya
3. Prof. S. Naik
4. Prof. Sudhakar Panda
5. Prof. Raj Gandhi
6. Prof. Ashoke Sen
7. Prof. Sumathi Rao
8. Prof. Dileep Jatkar
9. Prof. Debashis Ghoshal
10. Prof. Pinaki Majumdar
11. Prof. V. Ravindran
12. Prof. Jasjeet Singh Bagla
13. Prof. Rajesh Gopakumar
14. Dr. Srubabati Goswami

15. Dr. L. Sriramkumar
16. Dr. T. P. Pareek
17. Dr. Prasenjit Sen
18. Dr. Tapas Kumar Das
19. Dr. Justin Raj David
20. Dr. Aseshkrishna Datta
21. Dr. Manoj Gopalakrishnan
22. Dr. Sandhya Choubey
23. Dr. Tirthankar Roy Choudhury

Mathematics Research Scholars

1. Mr. Vijay Kumar Sohani
2. Ms. Supriya Pisolkar
3. Ms. Tanusree Pal
4. Mr. Karam Deo Shankhadhar
5. Ms. Archana Morye
6. Mr. Soumya Das
7. Mr. Mahender Singh
8. Mr. Sanjay Amrutiya
9. Mr. Mohan Chintamani
10. Mr. Jaban Meher
11. Mr. Bhavin Moriya

Physics Research Scholars

1. Mr. Rajeev Kumar Jain
2. Ms. Nabamita Banerjee
3. Mr. Kalpataru Pradhan
4. Mr. Anamitra Mukherjee
5. Mr. Arijit Saha
6. Mr. Nishikanta Khandai
7. Mr. Anurag Tripathi
8. Mr. Rajesh Kumar Gupta
9. Mr. Arjun Bagchi
10. Mr. Ayan Mukhopadhyay
11. Mr. Turbasu Biswas
12. Mr. Girish Kulkarni
13. Mr. Priyotosh Bandyopadhyay
14. Mr. Subhaditya Bhattacharya
15. Ms. Ipsita Mandal
16. Ms. Manimala Mitra

17. Mr. Vivekananda Singh
18. Mr. Rajarshi Tiwari
19. Mr. Shamik Banerjee
20. Mr. Shailesh Lal
21. Mr. Dhiraj Kumar Hazra
22. Mr. Satyanarayan Mukhopadhyay
23. Mr. Sanjoy Biswas
24. Mr. Joydeep Chakrabortty
25. Ms. Nishita Desai
26. Mr. Ram Lal Awasthi
27. Mr. Manoj Kumar Mandal
28. Mr. Arijit Kundu
29. Mr. Atri Bhattacharya
30. Mr. Saurabh Niyogi
31. Mr. Arunabha Saha
32. Mr. Ujjal Kumar Dey
33. Mr. Saurabh Pradhan
34. Mr. Vikas Chauhan
35. Mr. Sourav Mitra
36. Mr. Sabyasachi Tarat

Mathematics Visiting Fellow

1. Mr. Pavinder Singh

Physics Visiting Fellows

1. Dr. Yogesh Kumar Srivastava
2. Dr. Sudipta Das
3. Dr. Abhijit Samanta
4. Dr. Sashideep Gutti
5. Dr. Suvrat Raju
6. Dr. Akitsugu Miwa
7. Dr. Bobby Ezhuthachan
8. Dr. Jaswant Kumar
9. Dr. Subrat Kumar Das

Visiting Scientists

1. Dr. Paramita Dey
2. Dr. Ioulia Baoulina
3. Dr. Harvinder Kaur Jassal

4. Dr. Andreas Nyffeler
5. Dr. Sushan Konar

Visiting Professor

1. Prof. Satya Deo

Administrative Staff

1.	Mr. P. B. Chakraborty	Registrar
2.	Mr. Raaj Kumar Gulati	Accounts Officer
3.	Dr. Vijay Raghav Tiwari	Librarian
4.	Mr. Manish Sharma	Scientific Officer C
5.	Mr. Amit Roy	Internal Audit and Administrative Officer
6.	Mr. Sanjai Verma	Systems Manager
7.	Mr. Prabhat Kumar	Senior Private Secretary
8.	Mr. K. S. Shukla	Professional Assistant
9.	Mr. A. K. Srivastava	Jr. Engineer (Electrical)
10.	Mr. V. K. Srivastava	Jr. Engineer (Civil)
11.	Mr. Jagannath Yadav	Accountant
12.	Mr. R. P. Sharma	Manager Guest House
13.	Ms. Archana Tandon	Office Superintendent
14.	Mr. Deepak Srivastava	Store Purchase Officer
15.	Ms. Anju Verma	Scientific Assistant
16.	Mr. U. K. Dwivedi	Cashier
17.	Mr. D. Malhotra	Upper Division Clerk
18.	Mr. K. K. Srivastava	Upper Division Clerk
19.	Mr. Yashpal Singh	Stenographer
20.	Ms. Sumitra	Upper Division Clerk
21.	Mr. P. N. Mishra	Jr. Library Assistant
22.	Mr. D. P. Sharma	Jr. Library Assistant
23.	Ms. Seema Agarwal	Receptionist
24.	Mr. Kashi Prasad	Driver
25.	Mr. D. N. Dubey	Bearer
26.	Mr. Lalloo Ram	Bearer
27.	Mr. Kamlesh Thakur	Bearer
28.	Mr. R. K. Dixit	Peon

29.	Mr. Kamta Prasad	Peon
30.	Mr. Rajesh Kumar	Sweeper
31.	Mr. Munna Lal	Gardener

Academic Report — Mathematics

Sukumar Das Adhikari

Work has been continued in some problems related to weighted generalizations of some combinatorial group invariants. In a joint work with Andrew Granville, some general results on visibility of integer lattice points have been obtained, which in particular give the size of the smallest subset of the set of integer lattice points such that every element of a given rectangular grid is visible from our subset, answering a question of Paul Erdős et al.

Publications

1. S. D. Adhikari, R. Balasubramanian, F. Pappalardi and P. Rath, *Some zero-sum constants with weights*, Proc. Indian Acad. Sci. (Math. Sci.) **118** 2 (2008), 183–188.
2. Sukumar Das Adhikari, Stephan Baier and Purusottam Rath, *An extremal problem in lattice point combinatorics*, Diophantine Equations, (Ed. N. Saradha, Tata Institute of Fundamental Research, 2008), New Delhi: Narosa, 19–32.
3. Sukumar Das Adhikari, Chantal David and Jorge Jiménez Urroz, *Generalizations of some zero-sum theorems*, Integers **8** (2008), A52.
4. S. D. Adhikari and P. Rath, *A problem on the fractional parts of the powers of* $3/2$ *and related questions*, Number Theory and Discrete Geometry, Proceedings of the International Conference on Number Theory & Discrete Geometry held in honour of Professor R. P. Bambah, held at Department of Mathematics, Punjab University (Chandigarh, November 30-December 3, 2005, Eds. R. Balasubramanian, S. G. Dani, P. M. Gruber and R. J. Hans-Gill) Ramanujan Mathematical Society Lecture Notes Series 6 (2008), 1–12.
5. S. D. Adhikari, Mohan N. Chintamani, Bhavin K. Moriya and Prabal Paul, *Weighted sums in finite abelian groups*, Uniform Distribution Theory **3** No. 1 (2008), 105–110.
6. S. D. Adhikari, Sanoli Gun and Purusottam Rath, *Remarks on some zero-sum theorems*, To appear in Proc. Indian Acad. Sci. (Math. Sci.).
7. S. D. Adhikari and Andrew Granville, *Visibility in the plane*, In preparation.

Conference/Workshops Attended

1. Attended one day meeting on additive number theory at University of Saint-Etienne, France; September 9, 2008.
2. Attended Indian Mathematical Society Conference held at University of Allahabad; December 27–30, 2008.
3. Attended International conference at Jamia Millia Islamia, New Delhi; March 30–31, 2009.

Visits to other Institutes

1. Department of Mathematics, Queen's University Kingston, Canada; April 2008.
2. CRM, Université de Montréal; May, 2008.
3. Institute of Mathematical Sciences, Chennai; July 2008.
4. Chennai Mathematical Institute; July 2008.
5. Department of Mathematics, University of Saint-Etienne, France under ARCUS-INDE Programme; September 2008.
6. Department of Mathematics, Punjab University; November, 2008.
7. Department of Mathematics, Ramakrishna Mission Vivekananda University, Belur; July and November 2008.

Invited Lectures/Seminars

1. Summer number theory seminar at Department of Mathematics of Queen's University, Kingston, Canada; April 21, 2008.
2. Talk in one day meeting on additive number theory at University of Saint-Etienne, France; September 9, 2008.
3. Course of lectures in Commutative Algebra in the Department of Mathematics, Ramakrishna Mission Vivekananda University, Belur; November 2008.
4. Talk at Department of Mathematics, Punjab University; November, 2008.
5. Invited talk at International conference at Jamia Millia Islamia, New Delhi; March 30-31, 2009.

Academic recognitions

Delivered the 19th 'Hansraj Gupta Memorial Award Lecture' of Indian Mathematical Society at the IMS Conference held at the University of Allahabad; December 27-30, 2008.

Other Activities

1. Member of Board of Studies of Homi Bhabha National Institute for Mathematical Sciences.

2. Member of the editorial board of the periodical 'Mathematics Newsletter' published by Ramanujan Mathematical Society.

B. Ramakrishnan

1. Non-vanishing of L-functions of half-integral weight (with M. Manickam and V. Kumar Murty): Our joint work on twisted averages of L-functions of half-integral weight is revised. In the new revised version some of our results are improved and as a consequence we show that given a half-integral weight form f of weight λ, for sufficiently large primes ℓ, a positive proportion of twists $L(f, \chi, \lambda/2)$ by characters χ mod ℓ are non-zero.
2. Divisors of modular forms (with S. Gun): J. H. Bruinier, W. Kohnen and K. Ono proved a deep connection between the values of a certain sequence of modular functions (which are derived from the classical j-function) and the arithmetic of the coefficients of modular forms on SL_2-($\mathbf{Z}$). They also give an explicit description of the action of differential operators on modular forms, universal recurrences for the coefficients of certain meromorphic modular forms and an identity for the exponents in Borcherds' infinite product expansions. In his book K. Ono posed the problem of proving similar results for other types of modular forms. In this direction, the above work has been extended to certain class of genus zero subgroups of $SL_2(\mathbf{Z})$ by several authors. In this work we investigate analogue of these results for the genus zero congruence subgroups.
3. Pseudo-eigenvalues of the W-operators (with J. Meher): In their work, Atkin and Li studied the pseudo-eigenvalues of the Atkin-Lehner W-operator on newforms of integer weight and obtained the relation between these eigenvalues and the Fourier coefficients of the newforms. We study analogue of their work for the newforms of half-integral weight. The work is in progress.

Publications

1. S. Gun and B. Ramakrishnan, *On the representation of integers as sums of an odd number of squares,* The Ramanujan Journal **15** (2008), 367–376.

Preprints

1. M. Manickam, V. Kumar Murty and B. Ramakrishnan, *Non-vanishing of L-functions of half-integral weight* (revised version).
2. S. Gun and B. Ramakrishnan, *Divisors of modular forms for* $\Gamma_0(N)$ (in preparation).
3. J. Meher and B. Ramakrishnan, Pseudo-eigenvalues of the W-operators on modular forms of half-integral weight, (in preparation).

Visits to other Institutes

1. University of Toronto, Toronto, Canada; April 16–May 31, 2008,

2. University of Siegen, Siegen, Germany; June 1–8, 2008,
3. Institut Mathematiques de Jussieu (under Indo-French exchange programme), Paris, France; September 15–30, 2008,
4. Max-Planck Institute for Mathematics, Bonn, Germany; October 1–4, 2008.
5. The Institute of Mathematical Sciences, Chennai, India; January 2009.

Invited Lectures/Seminars

1. *A characterization of the space of new forms of half-integral weight*, Number Theory Seminar, University of Siegen, Siegen; June 2008.
2. *Non-vanishing of L-functions of half-integral weight*, Zum Mathematischen Kolloquium, RWTH Aachen; June 2008.
3. *Non-vanishing of L-functions of half-integral weight*, Chevaleret Number Theory seminar, Institut Mathematiques de Jussieu, Paris; September 2008.
4. *A characterization of the space of new forms of half-integral weight and a conjecture of Zagier*, Number Theory seminar, Max-Planck Institute for Mathematics, Bonn; October 2008.

Other Activities

1. Supervising three students for their Ph. D. Supervised the thesis work of Brundaban Sahu, who submitted his thesis in April 2008 and defended it in October 2008.
2. Organized a symposium on "Modular Forms and L-functions" as part of the 74th Annual conference of the Indian Mathematical Society held at the University of Allahabad during December 2008.
3. Organized a Discussion Meeting on Modular Forms at HRI February 21–March 6, 2009 under the SYM project.
4. One of the organizers of the International Conference in Mathematics held at HRI during the period March 7, 8 & 16–20, 2009 as part of the SYM project.
5. Dean of Administration (since October 2005).
6. Advisory committee member of the UGC-SAP DRS-1 programme (Mathematics) of the Lucknow University.
7. Member of the National Library Committee of NBHM (North Central Zone)

Kalyan Chakraborty

In a joint work with S. Kanemitsu and H. -L. Li we have studied relations between values at rational arguments of functions of a class of zeta functions. In another joint work with S. Kanemitsu and T. Kuzumaki we have studied equivalence of the finite expression for the derivative of Deninger R function at the rational argument and the Kronecker limit formula.

In a joint work with S. Kanemitsu and Y. Tanigawa we consider the zeta functions satisfying the functional equation with multiple gamma factors and prove an intermediate modular relation that gives rise to many arithmetical Fourier series as a consequence of the functional equation. Work is in progress with Loic Merel in developing modular symbols for number fields and using these symbols to study special values of twisted L functions associated to automorphic forms.

In another note the Fourier expansion for non-holomorphic Eisenstein series was proved by using Maass' original method with slight modification, which enables one to derive as a bonus two integral representations for the modified Bessel function of the third kind. Writing a book together with S. Kanemitsu and Y. Tanigawa on special functions. The title will be "Vistas of special functions II" and it will be published by World Scientific.

Publications

1. K. Chakraborty, F. Luca *Perfect powers in solutions to Pell equations*, Revista Colombiana de matematicas, To appear.
2. K. Chakraborty, Florian Luca and Anirban Mukhopadhyay *Exponents of class groups of real quadratic fields,* Int. J. Number Theory **4** 4 (2008), 597–611.
3. K. Chakraborty, Florian Luca and Anirban Mukhopadhyay *Class numbers with many prime factors*, J. Number Theory **128** 9 (2008), 2559–2572.
4. K. Chakraborty, S. Kanemitsu and T. Kuzumaki *Finite expressions for higher derivatives of the Dirichlet L function and the Deninger R function*, Hardy-Ramanujan Journal, To appear.

Preprints

1. K. Chakraborty *On the Chowla-Selberg integral formula for non-holomorphic Eisenstein series,* Preprint
2. K. Chakraborty, S. Kanemitsu and Y. Tanigawa *Arithmetical Fourier series and the modular relation* Preprint
3. K. Chakraborty, S. Kanemitsu and H. -L. Li *On the values of a class of Dirichlet series at rational arguments,* Preprint
4. K. Chakraborty, S. Kanemitsu and Y. Tanigawa *Vistas of Special functions II*, To be published by World Scientific.

Conference/Workshops Attended

1. *National seminar on emerging areas in mathematics and applications (*NSEAMA *2009)*, Dept. of Mathematics, University of Burdwan, Burdwan; February, 2009.
2. *Fifth North-West number theory conference*, Sangluo, China; March 2009.

Visits to other Institutes

1. Tribhuvan University, Kathmandu, Nepal; August 2008.
2. Kathmandu University, Kathmandu, Nepal; August 2008.
3. North-West University, Xi'an, China; March 2009.
4. Weinan Teacher's University, Weinan, China; March 2009.

Invited Lectures/Seminars

1. *Manifestations of the Parseval Identity*, National seminar on emerging areas in mathematics and applications, Burdwan University, Burdwan; February 2009.
2. *Introduction to* ECC, Tribhuvan University, Kathmandu, Nepal; August 2008.
3. *On the* ABC *conjecture*, Fifth North-West number theory conference, Sangluo, China; March 2008.

Other Activities

1. Organising Committee member of Summer Programme In Mathematics (SPIM); June 2009.
2. Coordinator of NBHM Examinations, Co-ordinated M. A./M. Sc. and JRF written tests and interviews; 2008–09.

Rukmini Dey

I had been doing research on geometric prequantization of various moduli spaces. Previously, I had prequantized the vortex moduli space, the Hitchin system and a dimensionally reduced and modified Seiberg-Witten moduli space using Quillen's determinant line bundles. This year, after discussing with Professor J. Andersen of CTQM, Denmark, I successfully managed to relate my quantization of the vortex moduli space to the quantization of the stable triple products of Indranil Biswas and N. Raghavendra. I am also studying $SL(2,R)$ Chern-Simons theory in the context of vortex quantization as there is a connection between a certain flat $SL(2,R)$ connection and the vortex equation. I am also working on making more rigourous my prequantization of moduli space of the dimensionally reduced Seiberg-Witten moduli space.

In collaboration with Tapas Das and Shilpi Agarwal, I did work on transonicity in black hole accretion. Using Strum chains to find the number of roots of polynomials in certain real domains, we found the number of sonic surfaces in certain cases when we get polynomial equations for the locations. In certain cases, we were able to calculate the locations exactly.

Publications

1. Rukmini Dey *Geometric prequantization of the modified Seiberg-Witten equations in* 2*-dimensions,* Adv. Theor. Math. Phys. **13.5**, (2009)

Preprints

1. Shilpi Agarwal, Tapas Das, Rukmini Dey *Transonicity in black hole accretion — a mathematical study using generalized Strum chains* (in preparation)
2. Rukmini Dey, *Addendum: Geometric prequantization of the moduli space of the vortex equations on a Riemann surface ,* (in preparation)

Conference/Workshops Attended

1. HRI-ICM, India, March 2009.

Visits to other Institutes

1. CTQM, Aarhus University, Denmark, March-April 2009,
2. S. N. Bose Center, Kolkata, India, May 2008.
3. NISER, Bhubaneswar, Feb 2009.

Invited Lectures/Seminars

1. *Geometric Prequantization of various moduli spaces*, Topology Seminar, CTQM, Aarhus, Denmark, March–April, 2009.

2. *Geometric Prequantization of various moduli spaces* , HRI-ICM , March, 2009.
3. *Geometric Quantization*, NISER, Bhuvaneswar, February, 2009.

Other Activities

1. Teaching: Topology I, HRI, August–November, 2008.

Punita Batra

Let $\mathbb{C}_q$ be the quantum tori associated to the $n \times n$ matrix q of non-zero complex numbers, where $q = (q_{ij})$ satisfy $q_{ii} = 1, {q_{ij}}^{-1} = q_{ji}$ for all $1 \leq i, j \leq n$. $\mathbb{C}_q$ is said to be cyclotomic if q_{ij} are roots of unity for all $1 \leq i, j \leq n$. In a joint work with Tanusree Pal, we finished the classification of the finite dimensional irreducible integrable representations of the Lie Tori $sl_{l+1}(\mathbb{C}_q)$.

Publications

1. Tanusree Pal and Punita Batra, *Representations of Graded Multiloop Lie algebras,* Communications in Algebra, (to appear).

Preprints

1. Tanusree Khandai and Punita Batra, *Representations of Lie Tori of type A_l coordinated by Cyclotomic Quantum Tori.*

Conference/Workshops Attended

1. 23^{rd} *Annual Conference of the Ramanujan Mathematical Society,* IIT, 19-21 May, 2008.
2. 19^{th} *Annual Conference of the Jammu Mathematical Society,* University of Jammu, 27-28 February, 2009.

Visits to other Institutes

1. Aligarh Muslim University, 5-7 February, 2009.

Invited Lectures/Seminars

1. Gave an invited talk *"A Realization of twisted toroidal Lie algebras and its representations"*, in "Symposium in Algebra" in the 23^{rd} Annual Conference of the Ramanujan Mathematical Society held at IIT Kanpur on 20 May, 2008.
2. Gave two lectures on *"Field Theory"* in the refresher course on the theme of "Some recent trends in Mathematics" held at Aligarh Muslim University on 5 and 7 February, 2009.
3. Gave two seminars on *"Infinite Dimensional Lie algebras and Representation Theory"* in UGC-DRS programme at Aligarh Muslim University on 5 and 6 February, 2009.
4. Gave an invited talk *"Modules over Pre exp-polynomial Lie algebras"*, in the 19^{th} Annual Conference of the Jammu Mathematical Society held at University of Jammu on 27 February, 2009.

Other Activities

1. Evaluated Ph. D. thesis of A. Nazeer Basha of University of Madras titled "Various classes of root systems and root multiplicities for Borcherds Kac-Moody Lie superalgebras" during June 2008.
2. Gave six lectures on "Galois Theory" in Summer Programme in Mathematics (SPIM) at HRI in June, 2008.
3. Gave two lectures in the Rajbhasha scientific workshop at HRI in July, 2008.
4. Organised an ATM (Advanced training in Mathematics) workshop on "Compact Lie Groups and their Representations" at HRI during 17–29, November 2008. I was the Convener of this workshop.
5. Gave five lectures and one tutorial in the ATM workshop on "Compact Lie Groups and their Representations" at HRI in November 2008.
6. Was one of the coordinators of the Organising Committee of "HRI International Conference in Mathematics" held at HRI during March 7–8 and March 16-a-20, 2009.
7. Supervised Ph. D. work of Ms. Tanusree Pal, who will be submitting her Ph. D. thesis in July 2009.
8. Convener of Mathematics Visitor's Committee of HRI. Also serving as a member in the Rajbhasha Committee, the Office and Furniture Committee and the SYM (Special Years in Mathematics) Committee.

D. Surya Ramana

When A and B are intervals in the integers in $[1, X]$ and $[1, Y]$ respectively, satisfying $|A| \geq \alpha X$ and $|B| \geq \beta Y$, where X, Y real numbers ≥ 1, α, β are real numbers in $(0, 1]$, a standard application of the Möbius inversion formula shows that the number of rational numbers a/b with (a, b) in $A \times B$ is $\gg \alpha\beta XY$. In a preprint titled *The number of rational numbers determined by large sets of integers* and authored with J. Cilleruelo and O. Ramaré, we investigate what might be deduced when in place of intervals we consider arbitrary but large subsets A and B of the integers in $[1, X]$ and $[1, Y]$.

Our principal conclusion is that when A and B are subsets of the integers in $[1, X]$ and $[1, Y]$ respectively, with $|A| \geq \alpha X$ and $|B| \geq \beta Y$, the number of rational numbers expressible as a/b with (a, b) in $A \times B$ is $\gg (\alpha\beta)^{1+\epsilon} XY$ for any $\epsilon > 0$, where the implied constant depends on ϵ alone. We then construct examples that show that this bound cannot in general be improved to $\gg \alpha\beta XY$. We also resolve the natural generalisation of our problem to arbitrary subsets C of the integer points in $[1, X] \times [1, Y]$. Finally, we apply our results to answer a question of Sárközy concerning the differences of consecutive terms of the product sequence of a given integer sequence. These results are of interest in the area of additive combinatorics and number theory.

Publications

1. Gyan Prakash and D. S. Ramana, *The large sieve inequality for real quadratic polynomial amplitudes*, Journal of the Ramanujan Math. Soc. **24** 2 (2009), 127-142.

Preprints

1. J. Cilleruelo, D. S. Ramana and O. Ramaré, *The number of rational numbers determined by large sets of integers*, arXiv:0903.2714v1.

Conference/Workshops Attended

1. *Workshop on Elliptic Curves and Cryptography*, I.M.Sc., Chennai; July 2008 (Organiser along with R. Balasubramaian).

Visits to other Institutes

1. Institute of Mathematical Sciences, Chennai; May, 2008.

Invited Lectures/Seminars

1. *The Large Sieve*, Mathematics Colloquium, I.M.Sc., Chennai; May 2008.

Other Activities

1. Organised the Discussion Meeting on Additive Combinatorics, February, 2009 together with S. D. Adhikari and R. Thangadurai.
2. Gave a course on Analysis in the first semester and a course on Analytic Number Theory in the second semester of the academic year 2008-2009 in the HRI Graduate Programme.

R. Thangadurai

Let $S = \{a_1, a_2, \cdots, a_n\}$ be subset of integers. Then we found a necessary and sufficient condition that every element of S is a quadratic non-residue modulo p for infinitely many primes p. As an application of this result, we explicitly computed the degree of the extension field $\mathbb{Q}(\sqrt{a_1}, \sqrt{a_2}, \cdots, \sqrt{a_n})$ over $\mathbb{Q}$. Apart from this result, we also gave an upper bound for Davenport's Constant for any finite abelian group. A study of transcedental numbers and normal numbers in progress.

Publications

1. F. Luca and R. Thangadurai, *On an arithmetic function considered by Pillai,* Journal de theorie des nombres de Bordeaux, (To appear)
2. R. Balasubramanian, S. Laishram, T. N. Shorey and R. Thangadurai, *The number of prime divisors of the product of consecutive integers,* Journal of Combinatorics and Number Theory, (To appear)
3. N. Saradha, R. Thangadurai, *Pillai's problem on consecutive integers,* Conference proceedings of Number Theory and Applications, Hindustan Book Agency, India (2009), 175-188.

Preprints

1. F. Luca and R. Thangadurai, *Distribution of residues modulo p – II,* (2008).
2. B. K. Moriya, M. N. Chintamani, W. D. Gao, P. Paul and R. Thangadurai, *On Davenport's Constant* (2009).
3. R. Balasubramanian, F. Luca, and R. Thangadurai, *Degree of $\mathbb{Q}(\sqrt{a_1}, \sqrt{a_2}, \cdots, \sqrt{a_n})$ over $\mathbb{Q}$* (2009).
4. R. Thangadurai, *A variant of Champernowne number which is transcendental and simply normal in any base b* (2009).

Conference/Workshops Attended

1. *Additive Number Theory*, France; September 2008.
2. *Indian Mathamatical Society Conference*; December 2008.
3. *Additive Combinatorics - Discussion Meeting*; January 2009.
4. *Modular Forms - Discussion Meeting*; February-March 2009.
5. *HRI - International Conference in Mathematics*; March 2009.

Visits to other Institutes

1. University of Saint-Etienne, Saint-Etienne, France; September 2008.
2. Institute of Mathematical Sciences, Chennai; January 2009.

Invited Lectures/Seminars

1. *Factorization*, MTTS 2008, NBHM sponsored programme, Mysore; May-June 2008.
2. *Complexity Theory*, AIS Programme, Institute of Mathematical Sciences, Chennai; July 2008.
3. *Additive Combinatorics*, Discussion Meeting, HRI, Allahabad; January 2009.
4. *Irrationality of* $\zeta(3)$, Discussion Meeting, HRI, Allahabad; February-March 2009.

Other Activities

1. One of the Organizers of the Discussion Meeting on Additive Combinatorics held at HRI; January 2009.
2. One of the Organizers of the (HRI-ICM) International Conference in Mathematics held at HRI; March 2009.
3. Member of (1) Graduate Committee (2) Ph. D. selection Committee (3) Library Committee.

N. Raghavendra

Have been working on alternative approaches to the determinant bundle on the moduli space of parabolic bundles on a curve.

Other Activities

1. Taught a second year graduate course *Riemann Surfaces*, second semester; 2008–09.
2. Was the convener of the Mathematics Graduate Studies Committee, and a member of the SYM (Special Years in Mathematics) Coordination Committee.
3. Was a member of the Board of Studies in Mathematics, Homi Bhabha National Institute (HBNI).

Chandan Singh Dalawat

My investigations this year were focussed on local kummerian extensions of exponent equal to the residual characteristic, their upper and lower ramification breaks, the existence of such extensions with given ramification breaks, their possible degrees when there is just one break, and the valuation of the discriminant in all these cases.

Supriya Pisolkar has completed her doctoral work under my supervision, resulting in two papers which have been accepted for publication. In the first one (14 pp.), to appear in *Indagationes mathematicae*, she computes the Chow group of a smooth projective surface over a local field K given by $y^2 - dz^2 = f(x)$, where f is a cubic polynomial which is either irreducible or has an irreducible quadratic factor, in almost all cases. (When f is a product of three linear factors, this had been done by me in all possible cases.)

In the second paper (9 pp.), to appear in the *Journal de Théorie des nombres de Bordeaux*, she proves a result about p-primary numbers of which the case $p = 2$ implies Martinet's generalisation of Stickelberger's congruence for the absolute discriminant of a number field. More precisely, she shows that if a finite extension K of $\mathbf{Q}_p$ (p being a prime number) contains a primitive p^m-th root of 1 for some $m > 0$, then the absolute norm of any p-primary unit in K is $\equiv 1$ modulo p^{m+1}.

Publications

1. Chandan Singh Dalawat, *Wilson's theorem*, *Journal de Théorie des nombres de Bordeaux*; to appear.
2. C. S. Dalawat, *Ribet's modular construction of unramified p-extensions of $\mathbf{Q}(_p\mu)$*, *Proceedings of the Gauhati workshop*, to appear.

Preprints

1. Chandan Singh Dalawat, *Further remarks on local discriminants*.
2. Chandan Singh Dalawat, *A first course in Local arithmetic*, Lecture notes; arXiv:0903.2615.

Conferences/Workshops Attended

1. *Workshop on Arithmetic Geometry*, IIT Gauhati; September 22–30, 2008.

Visits to other Institutes

1. ISI Kolkata, September 15–21, 2008.
2. TIFR Mumbai, November 17–December 5, 2008, March 22–28, 2009.
3. IISER Pune, February 10–12, 2009.

Invited Lectures/Seminars

1. *An introduction to p-adic numbers*, six lectures, HRI summer programme in mathematics, June 23–28, 2008; two lectures, Refresher course, Allahabad University, February 20, 2009.
2. *Congruent numbers*, Colloquium, ISI Kolkata, September 16, 2008; Refresher course, Allahabad University, February 19, 2009.
3. *Primary numbers*, ISI Kolkata, September 17, 2008.
4. *Kummer–Herbrand–Ribet*, ISI Kolkata, September 19, 2008; TIFR Mumbai, November 27, 2008.
5. *Ribet's results*, three lectures, *Workshop on Arithmetic Geometry*, IIT Gauhati, September 22–30, 2008.
6. *The ramification filtration in local kummerian extensions*, IIT Bombay, November 25, 2008.
7. *The theorem of the century*, Colloquium, JNU Delhi, February 9, 2009 ; Colloquium, IISER Pune, February 11, 2009.

Academic recognition/Awards

Awarded, along with A. Saikia of IIT, Gauhati, and R. Sujatha of TIFR, Mumbai, a grant of Rs. 1 million for organising a satellite conference on Galois representations at Goa, before the International Congress of Mathematicians in August 2010.

Other Activities

1. Supervised a student from ISI Bangalore for two months and a student from Purdue University for a week.
2. One of the organisers of the *Workshop on Arithmetic Geometry*, IIT Gauhati.
3. Gave a one-semester course on *Local arithmetic*.
4. Interviewed candidates for the talent search (KVPY) conducted by IISc, Bangalore.

P. K. Ratnakumar

I worked mainly on two problems for the last few months. The first one is on an uncertainty principle on the Heisenberg group, in collaboration with Dr. E. K. Narayanan, from IISc. Bangalore. The result is in spirit of the classical Benedick's theorem, which says in essence that a nontrivial function and its fourier transform cannot both be supported on a set of finite measure. From a general view point, an uncertainty principle essentially says that a function and its fourier transform cannot both be higly localised. In our theorem for the Heisenberg group, we measure the size of the Heisenberg fourier transform $\hat{f}(\lambda)$ (which is an operator) by its rank. Our result essentially says that if $f \in L^2(\mathbb{H}^n)$ is compactly supported and the Heisenberg fourier transform $\hat{f}(\lambda)$ is a finite rank operator for $\lambda \in \mathbb{R}_+$ then f has to be identically zero. Interestingly analogous results (in terms of rank) do not hold on other lie groups, say for instance, in the Euclidean space, or say rank one semi-simple lie groups etc. This work is submitted for publication.

The second problem that I worked on concerns with analyticity for solutions of the Schrödinger equation on Heisenberg group. This is a joint work with Prof. S. Thangavelu and Sanjay Parui, where we also consider Schrödinger equations for certain operators, generalising the Heisenberg sublaplacian. This work is also completed and submitted for publication.

I also worked on improving an old unpublished work regarding the L^p mapping property of fractional spherical maximal operator on n dimensional Euclidean space. This is a joint work with Ron Kerman and is recently submitted for publication.

Apart from this I am working on two more projects. One is a geometric result, concerning a distance formula for the geometry of the rank one symmetric space arising from exceptional Lie groups. Such a formula is crucial in establishing the endpoint weak type estimate for the spherical maximal operator on exceptional symmetric spaces. For the case of constant curvature spaces, we have proved such an estimate (joint work with Amso Nevo) and later I have proved that the result holds for more general rank one symmetric spaces. The symmetric space for the exceptional group now considered, was left open in my earlier work. This is jointly with Dr. Ritumoni Sarma, IIT Delhi and is in progress.

The second concerns the Schrödinger equation for a general class of differential operators with discrete spectrum. I could establish a Strichartz type inequality for the Schrödinger equation for such a class of operators. This generalises my previous work in this direction concerning Schrödinger equation for the Hermite and special Hermite operator. (The Schrödinger equation in these cases corresponds to a Schrödinger equation on $\mathbb{R}^n$, with the scalar potential $V(x) = |x|^2$, and a Schrödinger equation on $\mathbb{C}^n$, with the magnetic vector potential $A(x, y) = (-y, x)$ and the scalar potential $V(x) = 0$ respectively). I am presently trying to use this estimate to study the well posedness of the nonlinear Schrödinger equation with nonlinearity of the form $F(u) = |u|^\alpha u$.

Publications

1. P. K. Ratnakumar, *On Schrödinger propagator for the special Hermite operator*, J. Fourier Anal. and Appl., **14** 2 (2008), 286–300.

Preprints

1. S. Parui, P. K. Ratnakumar, S. Thangavelu, *Analyticity of the Schrödinger propagator on the Heisenberg group.*
2. E. K. Narayanan and P. K. Ratnakumar, *Benedick's theorem for the Heisenberg Group.*

Conference/Workshops Attended

1. *Twenty-third Annual Conference of the Ramanujan Mathematical Society*, Indian Institute of Technology Kanpur; May 2008.
2. *Workshop in Harmonic Analysis and Partial Differential Equations*, Indian Institute of Science Bangalore; December, 2008.
3. *16th Ramanujan Symposium on Fourier analysis and its Applications*, Ramanujan Institute of Advanced Study in Mathematics, Madras; February 2009.

Visits to other Institutes

1. Indian Institute of Science, Bangalore; July 2008 and March 2009.

Invited Lectures/Seminars

1. *Schödinger propagator for the special hermite operator, Strichartz estimate and analyticity*, Indian Institute of Technology, Kanpur; May 2008.
2. *On Schrödinger propagator for differential operators with discrete spectrum*, Indian Institute of Science, Bangalore; December 2008.
3. *Schrödinger equation, a survey on regularity*, 16th Ramanujan Symposium on Fourier analysis and its Applications, Ramanujan Institute of Advanced Study in Mathematics, Madras; February 2009.

Other Activities

1. Organised Summer Programme in Mathematics; June 2008.
2. Gave a set of 10 lectures in Fourier Analysis in SPIM 2008.
3. Taught advanced course in Harmonic Analysis, for the 3rd semester Ph. D. students for the year 2007–2008.
4. Served in the sports and entertainment committee of HRI.

Manoj Kumar

I have been studying various aspects of automorphisms of finite groups. In particular I studied central automorphisms of finite p-groups G. Central automorphisms are those automorphisms of G which centralize the group of all inner automorphisms of G. I gave necessary and sufficient conditions on a finite p-group G such that all the central automorphisms of G fixing its center elementwise are inner automorphisms. An automorphism α of a group G is called class preserving if $\alpha(x) \in x^G$ for all $x \in G$, where $x^G = \{g^{-1}xg | g \in G\}$. I started working on the following problems: (1) Classify all finite p-groups G of nilpotency class 2 such that each automorphism of G is class preserving. (2) Classify all finite p-groups G such that G has maximum number of class preserving automorphisms.

Let G be a finite group, N be an abelian group which is isomorphic to a subgroup N' of G and H be a group which is isomorphic to G/N'. In this situation, G is said to be an abelian extension of N by H. I (jointly with Mahender Singh and I. B. S. Passi) started working on the conditions on the group G under which an automorphism of H can be lifted to an automorphism of G.

Publications

1. Manoj K. Yadav, *On central automorphisms fixing the center elementwise,* Comm. Algebra (2009), in press.

Preprints

1. Manoj K. Yadav, *Automorphisms of finite p-groups of class 2*, in preparation.
2. Manoj K. Yadav, Mahender Singh and I. B. S. Passi, *Automorphisms of abelian extensions*, in preparation.

Conference/Workshops Attended

1. *Annual Conference of Ramanujan Mathematical Society*; May 2008.
2. *Annual Conference of Indian Mathematical Society*; December 2008.
3. *Internation Conference in Mathematics*; March 2009.

Visits to other Institutes

1. Indian Institute of Science Education and Research, Mohali; May–June 2008.

Invited Lectures/Seminars

1. *On central automorphisms fixing the center elementwise*, Contributory Talk, Annual Conf. of RMS, IIT Kanpur, Kanpur; May 2008.

2. *On some open problems in automorphisms of finite p-groups*, Indian Institute of Science Education and Research, Mohali; June 2008.
3. *On finite p-groups whose all automorphisms are class preserving*, Algebra Symposium, Annual Conf. of IMS, Department of Mathematics, University of Allahabad, Allahabad; December 2009.

Other Activities

1. Gave two lectures in Rajbhasha programme; May 2008.
2. I was a member of various committees constituted in HRI; 2008–2009.

Satya Deo

During this academic year, I have continued mostly with the research problems in the field of nonmetrizable manifolds. Besides these, I have also worked out some problems of cohomological dimension with respect to compactification of spaces. In the first case, the question has been to determine the groups of homeomorphisms of the powers of the long ray or long line. In addition, we have also determined the mapping class groups of these spaces. We have settled the two important cases mentioned above, but the same problems with respect to other nonmetriable manifolds, which are so many, still remain to be worked out. This has been done jointly with M. Ballif and David Gauld. Along with David Gauld, I introduced the notion of eventually constant spaces, which is a far reaching generalization of finite dimensional manifolds. In this connection, we have obtained an interesting generalization of a result of M. Baillif: *Any eventually constant space, which has the ordinal space* $\omega_1 = [0, \omega_1)$ *as a subspace, cannot be contractible*. Concerning the second topic on cohomological dimension, it has been proved by Dranishnikov that the cohomological dimension does not behave well with respect to Cech compactification. This is in contrast with the classical covering dimension. There is, however, an interesting positive result proved by L. Rubin which asserts that *if the space is finitistic, then the cohomological dimension of X and its Stone-Cech compactification* βX *are same*. We are investigating whether or not the converse of Rubin's theorem is also true. There seems to be some positive evidences for such a possibility.

Publications

1. Satya Deo, *Why do we call them projective spaces?*, Mathematics Newsletter, Ramanujan Mathematical Society, **18** (2008), 1-6.
2. Satya Deo, *Cohomology theories best suited for the cohomological dimension theory* , Mathematics Student, Special Centenary Volume-2007, published in 2008 (2007), 121-134.
3. Satya Deo and David Gauld, *Eventually constant spaces and nonmetrizable homology spheres*, Journal of Indian Mathematical Society, Special Centenary Volume (2007), 165-175.

Preprints

1. Mathiew Baillif, Satya Deo and David Gauld, *Mapping class groups of the powers of the long ray*.
2. Satya Deo, *Cohomological dimension and finitistic spaces*, (in preparation)

Conference/Workshops Attended

1. *International Conference on surfaces-2008*, NEHU, Shillong; June 2008.
2. *Annual Conference of Ramanujan Mathematical Society*, IIT Kanpur; May 2008

3. *74th Annual Conference of the Indian Mathematical Society*, University of Allahabad, Allahabad; Dec 2008.

Visits to other Institutes

1. University of Pune, Pune, April 2008.
2. Center for Advanced Studies in Mathematics, Punjab University, Chandigarh; Dec 2008.
3. Department of Mathematics, University of Delhi, Delhi; Feb 2009.

Invited Lectures/Seminars

1. *Six lectures on division algebras*, Refresher Course in Mathematics, University of Pune, Pune; April 2008.
2. *Five lectures on algebraic topology*, to the participants of SPIM at HRI, Allahabad; Summer 2008.
3. *On history and proof of the Poincare conjecture* , DST Center of Linear algebra and Analysis, BHU, Varanasi; Sep 2008.
4. *Eight Lectures on Differential Topology* , ATM programme in Mathematics of NBHM, Punjab University, Chandigarh, Dec 2008.
5. *Mapping class groups and nonmetrizable manifolds*, Special lecture, University of Delhi, South Campus, Delhi; Dec 2008.
6. *Dimension of general topological spaces*, Refresher Course in Mathematics, University of Allahabad, Allahabad; Feb 2009.
7. *Four lectures on dimension of a topological space*, Refresher Course in Mathematics, University of Delhi, Delhi; Feb 2009.
8. *Cohomological dimension and compactifications* , International conference on mathematics, HRI, Allahabad; March 2009.
9. *Dimension theory- from Lebesgue to Dranishnikov*, International conference on recent trends in analysis and applications, Jamia Milia Islamia, New Delhi; March 2009.

Academic recognition/Awards

- Delivered the keynote address during the national conference on linear algebra and analysis, BHU, Varanasi, March 2009.
- Continue to work as the Academic Secretary of the Indian Mathematical Society during the year 08-09.
- Gave the Valedictory address of the Refresher Course in Mathematics, Department of Mathematics, University of Allahabad, Allahabad; March 2009.
- Gave the valedictory address of the refresher course in Mathematics, ILLL, University of Delhi, Delhi; Feb 2009.

Other Activities

1. One student, named V. V. Awasthi, got his Ph. D. degree from Rani Durgawati University, Jabalpur, under my supervision in 2008. The other student, named Mahender Singh, has completed his Ph. D. work at HRI and is submitting the thesis to HBNI, Mumbai, March 2009.

2. As the Academic Secretary, I planned and organized the complete academic programme of the 74th annual conference of the Indian Mathematical Society held at the University of Allahabad, Allahabad; Dec 2008.

3. Taught a course on Topology-II to the first year students of HRI during the first half of the year 2008.

Ioulia Baoulina

Some special equations over finite fields were studied. Explicit formulas for the number of solutions were obtained.

Publications

1. I. Baoulina, *On the number of solutions to the equation* $(x_1 + \cdots + x_n)^2 = ax_1 \cdots x_n$ *in a finite field,* Int. J. Number Theory **4** (2008), 797-817.
2. I. Baoulina and F. Luca, *On positive integers with a certain nondivisibility property,* Ann. Math. Inform. **35** (2008), 11–19.

Preprints

1. I. Baoulina, *On the number of solutions of the equation* $(x_1 + \ldots + x_n)^m = ax_1 \cdots x_n$ *over the finite field* $\mathbf{F}_q$ *for* $\gcd(m-n, q-1) = 7$ *and* $\gcd(m-n, q-1) = 14$ (to appear in HRI Proceedings)
2. I. Baoulina, *On the number of solutions to certain diagonal equations over finite fields* (to appear in Int. J. Number Theory)

Conference/Workshops Attended

1. *ATM Workshop on "Elliptic Curves and Cryptology"*, IMSc, Chennai; July-August, 2008.
2. *ATM Workshop on "Arithmetic Geometry"*, IIT, Guwahati; September, 2008.
3. *Indo-French Conference in Mathematics*, IMSc, Chennai; December, 2008.
4. *International Conference on "Number Theory and Modular Forms"*, Sastra University, Kumbakonam; December, 2008.
5. *Discussion Meeting on "Additive Combinatorics"*, HRI, Allahabad; January, 2009.
6. *International Conference in Mathematics*, HRI, Allahabad; March, 2009.

Visits to other Institutes

1. Tribhuvan University, Kathmandu, Nepal, April, 2008.
2. Kathmandu University, Dhulikhel, Nepal, April, 2008.

Invited Lectures/Seminars

1. *On diagonal equations over finite fields*, Tribhuvan University, Kathmandu, Nepal; April, 2008.
2. *On integer solutions of Markoff-Hurwitz equations*, Kathmandu University, Dhulikhel, Nepal; April, 2008.

Other Activities

1. Reviewer in Mathematical Reviews; April 2008–March, 2009.
2. Referee in Finite Fields and Their Applications; April–May, 2008.

Pavinder Singh

During last seven months, I have read a portion of book entitled "Combinatorics and Commutative algebra" by R. P. Stanley. I understood the Stanley's proof of Anand, Dumir and Gupta conjecture and worked upon a counting problem on generalized magic squares. We obtained a counting formula in a particular case and trying to find out the nature of the polynomial in general case.

Apart from working over the combinatorial problem, I have studied the Hilbert functions of finite modules over a local ring, associated to the stable filterations. The Hilbert function of a local ring (**A**,**m**) is a polynomial like function whose leading coefficient gives a deep information about the corresponding singularity. The Hilbert function of a standard graded k-algebra is well understood in case **A** is Cohen-Macaulay, but a very little is known in the local case. One doesn't even have a guess of the shape of the Hilbert function in one dimensional Cohen-Macaulay local domain. In the case of Cohen-Macaulay local ring, starting from the work of Northcott in the 60's, several results have been proved which describe some relationship between Hilbert coefficients and other numerical invariants, thus implying some constrains on the Hilbert function. We are trying to understand the combinatorial interpretation of the second Hilbert coefficient of Stanley-Reisner ring in terms of system of parameters.

Conference/Workshops Attended

1. *Annual Conference of Indian Mathematical Society*; December 2008.
2. *Harish-Chandra Research Institute, International Conference of Mathematics*; March 2009.

Bhavin K. Moriya

We have proved the weighted generalization of Bollabás and Leader Theorem (Journal of Number Theory **78** 1 (1999), 27-35) which is published in Uniform Distribution Theory in 2008. In this paper we have studied number of weighted k-sums ($k \in \mathbb{N}$) of given sequence of length $(k + r)$ in a group G which doesn't have zero as a weighted k-sum. Here $r \in \mathbb{N},\ 1 \leq r \leq |G| - 1$, weights are integers co-prime to $|G|$ and zero is the most repeated element in this sequence. Currently I am working on Finite Fields, Coding Theory and Additive Number Theory.

Publications

1. S. D. Adhikari, M. N. Chintamani, B. K. Moriya, P. Paul, *Weighted sums in finite abelian groups.* Uniform Distribution Theory **3** 1 (2008), 105-110.

Conferences/Workshops Attended

1. Attended a workshop on "Codes over rings" at Middle East Technical University, Ankara, Turkey; August 18–29, 2008.

Jaban Meher

In their work, Atkin and Li studied the pseudo-eigenvalues of the Atkin-Lehner W-operator on newforms of integer weight and obtained the relation between these eigenvalues and the Fourier coefficients of the newforms. We study analogue of their work for the newforms of half-integral weight. The work is in progress.

Preprints

1. J. Meher and B. Ramakrishnan, *Pseudo-eigenvalues of the W-operators on modular forms of half-integral weight* (in preparation).

Conference/Workshops Attended

1. *Workshop on Elliptic curves and their Applications*, IMSc, Chennai; 21 July–2 August, 2008.
2. *Workshop on Compact Liegroups and their Representations*, HRI, Allahabad; 17–29 November, 2008.
3. *Discussion Meeting on Modular Forms*, HRI, Allahabad; 21 February – 6 March, 2009.
4. HRI *International Conference in Mathematics*, HRI, Allahabad; 7–8 and 16–20 March, 2009.

Mohan Namdev Chintamani

The idea of Hong Bing Yu (while he gave a proof of a theorem of Bollobas and Leader) is generalized. In this context, one would like to mention that this idea of weighted sum was introduced by Prof. S. D. Adhikari, Prof. Y. G. Chen, Prof. J. B. Friedlander, Prof. S. V. Konyagin and Prof. F. Pappalardi in 2005. In a particular case, by taking all the weights equals to one, the famous EGZ (Erdős, Ginzburg and Ziv) theorem is generalized.

Let $G \cong Z_{n_1} \oplus Z_{n_2} \oplus \cdots \oplus Z_{n_r}$, $(1 < n_1 \mid n_2 \mid \cdots \mid n_r)$ be a finite abelian group. Let $M(G) = 1 + \sum_{i=1}^{r}(n_i - 1)$. J. E. Olson has proved that the Davenport constant $D(G) = M(G)$ for all finite groups G with $r \leq 2$ or G is any p group. W. Gao conjectured that $D(G) = M(G)$ for all groups of rank ≤ 3. W. Narkiewich and J. Sliwa (1982) conjectured that $D(G) \leq \sum_{i=1}^{r} n_i$. Towards this conjecture, we have some results. This result gives better bound for $D(G)$ than that due to Alford, Granville and Pomerance but for the groups with higher exponents. It is also an extension of the results proved by Dimitrov and Balasubramanian and Bhowmik.

Publications

1. S. D. Adhikari, M. N. Chintamani, B. K. Moriya and P. Paul *Weighted sums in finite abelian groups*, Uniform Distribution Theory, **3** 1 (2008), 105-110.

Preprints

1. W. D. Gao, M. N. Chintamani, B. K. Moriya, P. Paul, And R. Thangadurai, *On Davenport's Constant*, (in preparation).

Conference/Workshops Attended

1. CIMPA *Sumer School On Codes Over Rings*, Ankara, Turkey; August 2008.
2. IMS *Conference*, Allahabad University, Allahabad; 2008.
3. *Discussion Meeting on Additive Combinatorics*, HRI, January 16–31 2009.
4. *Discussion Meeting on Modular Forms*, HRI, February 21–March 6, 2009
5. *International Conference in Mathematics*, HRI; March 2009.

Sanjay Hansraj Amrutiya

I have been working on a problem related to the neutral Tannakian category and affine group-scheme. Let k be an algebraically closed field of characteristic $p > 0$. Let X be a smooth projective vatiety over k. Let $F_X : X \to X$ denote the absolute Frobenius morphism. For any polynomial f with non-negative integer coefficients and for any vector bundle E over X, we define $\tilde{f}(E)$ as follows:

$$\tilde{f}(E) := a_0\mathcal{O}_X + a_1(F_X^1)^*(E) + \cdots + a_n(F_X^n)^*(E)$$

where $f(x) = a_0 + a_1x + \cdots a_nx^n$ with $a_i \geq 0 \; \forall \; i$. Let S_X denote the set of all vector bundle E on X for which there exists two distinct polynomial f and g with non-negative integer coefficients such that $\tilde{f}(E)$ is isomorphic to $\tilde{g}(E)$. Fix k-rational point $x_0 \in X$. Consider the tensor abelian k-category generated by S_X and denote it by $\mathcal{C}_F(X)$. The category $\mathcal{C}_F(X)$ together with the fibre functor $T_{x_0} : \mathcal{C}_F(X) \to k - \mathrm{mod}$ becomes a neutral Tannakian category over a field k, where $k-$mod denote the category of finite dimensional vector spaces over k.

It is well known theorem that any neutral Tannakian category is equivalent to the category of finite dimensional representations of some affine group-scheme. So there is an affine group scheme corresponding to the neutral Tannakian category $\mathcal{C}_F(X)$ which we denote by $\mathcal{G}(X, x_0)$. I am studying the properties of the affine group scheme $\mathcal{G}(X, x_0)$.

Visits to other Institutes

1. Chennai Mathematical Institute, Chennai; April 24–May 28, 2008.

Mahender Singh

During the academic year 2008–2009, I have been working mainly on compact transformation groups. Particularly, I have been investigating the structure of cohomology algebra of orbit spaces of certain compact transformation groups on finitistic spaces using techniques of spectral sequences.

I investigated free involutions on lens spaces and determined the possible mod 2 cohomology algebra of orbit space of any free involution on a finitistic mod 2 cohomology lens space X of dimension $2m-1$ where $4 \nmid m$, using the Leray spectral sequence associated to the Borel fibration $X \hookrightarrow X_{\mathbb{Z}_2} \longrightarrow B_{\mathbb{Z}_2}$. As an application, it was shown that if X is a finitistic mod 2 cohomology lens space of dimension $2m-1$ where $4 \nmid m$, then there does not exist any $\mathbb{Z}_2$-equivariant map from $\mathbb{S}^n \to X$ for $n \geq 2$, where $\mathbb{S}^n$ is equipped with the antipodal involution.

I also worked on the parametrized Borsuk-Ulam problem and proved some parametrized Borsuk-Ulam results for bundles whose fibers are finitistic mod 2 cohomology real or complex projective spaces with free involutions. The size of the $\mathbb{Z}_2$-coincidence sets was also estimated.

Recently, I got interested in the problem of lifting of automorphisms in group extensions. If $1 \to N \to G \to H \to 1$ is a group extension, then it is an interesting problem to find the conditions under which an automorphism of H can be lifted to an automorphism of G centralizing N. Along with Manoj K. Yadav and I. B. S. Passi, I am investigating this problem using cohomological methods.

Publications

1. Mahender Singh, *$\mathbb{Z}_2$ actions on complexes with three non-trivial cells,* Topology and its Applications **155** (2008), 965-971.
2. Mahender Singh, *Fixed points of circle actions on spaces with rational cohomology of $S^n \vee S^{2n} \vee S^{3n}$ or $P^2(n) \vee S^{3n}$*, Archiv der Mathematik **92** (2009), 174-183.
3. Mahender Singh, *A note on the commutativity of inverse limit and orbit map,* Mathematica Slovaca, (2009) (to appear).

Preprints

1. Mahender Singh, *Cohomology algebra of orbit spaces of free involutions on lens spaces,* arXiv:0805.2865.
2. Mahender Singh, *Parametrized Borsuk-Ulam problem for projective space bundles,* arXiv:0810.4669.
3. I. B. S. Passi, Manoj K. Yadav and Mahender Singh, *Lifting automorphisms in group extensions* (in preparation).

Conference/Workshops Attended

1. *International Conference in Mathematics*, Harish-Chandra Research Institute; March, 2009.
2. *The Second East Asia Conference on Algebraic Topology*, National University of Singapore, Singapore; December, 2008.
3. *Workshop on Algebraic Topology, Braids and Mapping Class Groups*, National University of Singapore, Singapore; 2008.
4. *Workshop and conference in Surface Mapping Class Groups and Related Topics*, North Eastern Hill University; July, 2008.

Invited Lectures/Seminars

1. *Cohomology algebra of orbit spaces of free involutions on lens spaces*, International Conference in Mathematics, Harish-Chandra Research Institute, India, March, 2009.
2. *Parametrized Borsuk-Ulam problem for projective space bundles*, The Second East Asia Conference on Algebraic Topology, National University of Singapore, Singapore, December, 2008.

Other Activities

1. Tutor in Algebraic Topology course, August-September 2008.
2. Reviewed papers for Zentralblatt MATH, October 2008, March 2009.

Soumya Das

It is well known that the Jacobi Poinacaré series defined for the full Jacobi group of degree g span the space of Jacobi cusp forms. The question is to decide which of the Poincaré series do not vanish identically. In the elliptic case R. A. Rankin has given upper bound on n (roughly $n \sim O(k^2)$), for which the Poincaré series $P_{k,n}$ of weight k doesnot vanish identically. We prove that under suitable conditions, the Jacobi Poincaré series of exponential type of integer weight and matrix index does not vanish identically. Also, a result on the non-vanishing of Jacobi Poincaré series is obtained when an odd prime divides the index.

In the theory of Jacobi forms, one of the use of differential operators has been to produce new Jacobi forms from old or to construct other classes of modular forms, eg. elliptic modular forms. In this paper we introduce a certain differential operator $D_\nu, \nu \in N$ on the space of Hermitian Jacobi forms of weight k and index m (denoted $J_{k,m}(O_K)$) of degree 1 for the Hermitian Jacobi group over the ring of integers of the imaginary quadratic field $Q(i)$ to construct modular forms for $SL(2, Z)$. This is the analogue for the heat operator defined and studied for classical Jacobi forms by M. Eichler and D. Zagier. We show that the operators D_ν commute with certain Hecke operators and use them to construct a lift of elliptic cusp forms to Hermitian Jacobi cusp forms. We determine the number of Fourier coefficients that determine a Hermitian Jacobi form and use it to embed a certain subspace of Hermitian Jacobi forms into a direct sum of modular forms for the full modular group.

Hermitian Jacobi forms of integer weight and index are defined for the Jacobi group over the ring of integers O_K of an imaginary quadratic field K. Such a form $\phi(\tau, z_1, z_2)$ gives rise to classical Jacobi forms for the Jacobi group defined over Z by the restriction π_ρ: $J_{k,m}(O_K) \to J_{k,N(\rho)m}$ defined by $\pi_\rho\phi(\tau, z_1,$- $z_2) = \phi(\tau, \rho z, \bar{\rho} z)$. We study the restriction maps from Hermitian Jacobi forms (HJF) of weight k and indices $1, 2$ to classical Jacobi forms (JF) of weight k and indices $1, 2, 4$. As a Corollary of the Theorems we also get a description of the kernels of the restriction maps; using description of the kernel of the restriction map D_0 from classical Jacobi forms of index 1 to elliptic modular forms, that has been studied By S. Bocherer and T. Arakawa. Depending on $k \pmod 4$ these maps either give an isomorphism (resp. embedding) of HJF with (resp. into) JF or an exact sequence connecting them with eliptic modular forms (EMF). As a corrolary for each $k \pmod 4$ we get either an isomorphism or an embedding of HJF of indices $1, 2$ into direct sum of spaces of EMF. Also, using the embedding into JF, upper bounds for the order of vanishing of HJF at the origin is obtained.

Continuation of the work on estimation of Fourier coefficients of Hermitian modular forms is in progress.

Preprints

1. Soumya Das, *Non vanishing of Jacobi Poincaré series.*

2. Soumya Das, *On Hermitian Jacobi forms.*
3. Soumya Das, *Restriction maps on Hermitian Jacobi forms of small index,* Submitted.
4. Soumya Das, *Estimation of Fourier coefficients of Hermitian modular forms* In preparation.

Conference/Workshops Attended

1. *Discussion Meeting on Modular forms*; February 21– March 6, 2009.

Invited Lectures/Seminars

1. *Non vanishing of Jacobi Poincaré series*, HRI International Conference in Mathematics (HRI ICM), Harish-Chandra Research Institute, Allahabad; March 7-8, 16-20, 2009.

Archana Subhash Morye

I have been working with Prof. N. Raghavendra on a problem related to vector bundles on locally ringed spaces. We determine a class of ringed spaces, $(X, \mathcal{O}_X)$ for which the category of locally free sheaves of bounded rank over X (i.e., vector bundles) is equivalent to the category of finitely generated projective $\Gamma(X, \mathcal{O}_X)$-modules. The well-known Serre-Swan theorems for affine schemes, differentiable manifolds, Stein spaces, etc., are then derived.

I have been also working on a problem related to connections on principal bundles over real abelian varieties.

Publications

1. Archana S. Morye, *Note on the Serre-Swan Theorem,* accepted for publication in Mathematische Nachrichten.

Conference/Workshops Attended

1. HRI *International Conference in Mathematics*, HRI, Allahabad, 7-8 and 16-20 March, 2009.

Visits to other Institutes

1. Chennai Mathematical Institute, Chennai, 28 April to 28 May, 2008 (Attended a short course on Geometric Invariant Theory given by Prof. C. S. Seshadri).

Other Activities

1. Tutor for Topology course taught in SPIM; June 2008.
2. Helped in organizing HRI Science talent test, 2008 (Mathematics).

Tanusree Pal

During the academic year 2008-2009 I have been working on two projects.

In collaboration with Vyjayanthi Chari and Ghislain Fourier, I have been studying the Weyl modules for the Lie algebra $\mathfrak{g} \otimes A$, where $\mathfrak{g}$ is any simple finite-dimensional Lie algebra over the complex field $\mathbb{C}$ and A is a finitely generated commutative algebra over $\mathbb{C}$. The global and local Weyl Modules were introduced via generators and relations in the context of affine Lie algebras in a work by Chari and Pressley and were motivated by representations of quantum affine algebras. The case when these modules are associated to the coordinate ring of an affine variety was considered by Feigin and Loktev. We show that there is a natural definition of the local and global modules via homological properties. This characterization allows us to define the Weyl functor from the category of left modules of a commutative algebra to the category of modules for a simple Lie algebra. As an application we are able to understand the relationships of these functors to tensor products, generalizing previous results. Finally an analysis of the fundamental Weyl modules proves that the functors are not left exact in general, even for coordinate rings of affine varieties.

In collaboration with Punita Batra, I have also studied the representations of a Lie tori of type A_ℓ coordinated by a cyclotomic quantum tori $\mathbb{C}_q$. Let $\mathfrak{sl}_{\ell+1}(\mathbb{C}_q)$ be a Lie tori of type A_ℓ coordinated by the quantum tori $\mathbb{C}_q$ of rank greater than equal to two. Using the representation theory of finite-dimensional modules for the multiloop Lie algebras, we classify the finite-dimensional irreducible $\mathfrak{sl}_{\ell+1}(\mathbb{C}_q)$-modules. In addition we prove that given any finite–dimensional irreducible $\mathfrak{sl}_{\ell+1}(\mathbb{C}_q)$-module V, there exists a subalgebra $S(q)$ of $\mathfrak{sl}_{\ell+1}(\mathbb{C}_q)$, which is isomorphic to a multiloop Lie algebra of type A_ℓ, and V is completely reducible as a $S(q)$-module. Hence an understanding the $\mathfrak{sl}_{\ell+1}(\mathbb{C})$-decomposition of the finite-dimensional modules for multiloop Lie algebras also gives a $\mathfrak{sl}_{\ell+1}(\mathbb{C})$-decomposition of any finite-dimensional irreducible $\mathfrak{sl}_{\ell+1}(\mathbb{C}_q)$-module.

Publications

1. Tanusree Pal, *Vogan diagrams of twisted affine KacMoody Lie algebras*, Pacific Journal of Mathematics **239** (2009), 65-88.
2. Tanusree Pal and Punita Batra, *Representations of graded multiloop Lie algebras*, Communications in Algebra, to appear.

Preprints

1. Vyjayanthi Chari, Ghislain Fourier, and Tanusree Khandai, *A Categorical Approach to Weyl Modules*, arXiv:0906.2014
2. Tanusree Khandai and Punita Batra, *Representations of Lie tori of type A_ℓ coordinated by a cyclotomic quantum tori*, (in preparation)

Conference/Workshops Attended

1. *Advanced Training in Mathematics Schools Workshop on Compact Lie Groups and their Representations*; November 2008.
2. HRI *International Conference in Mathematics*; March 2009.

Visits to other Institutes

1. University of California, Riverside, California, USA; 31 March–14 June, 2008.

Invited Lectures/Seminars

1. *Integrable Representations of Graded Multi-loop Lie Algebras* , Lie Theory Seminar, Department of Mathematics, University of California, Riverside, California; May 2008.
2. *Vogan diagrams of twisted affine KacMoody Lie algebras*, HRI International Conference in Mathematics, Harish-Chandra Research Institute, Allahabad; March 2009.

Other Activities

1. Teaching assistant for Algebra in SPIM, June, 2008.
2. Teaching assistant for the Advanced Training in Mathematics Schools Workshop on Compact Lie Groups and their Representations; November, 2008.

Academic Report — Physics

Amitava Raychaudhuri

In the past year research has been carried out on aspects of neutrino physics, in part associated with the India-based Neutrino Observatory (INO), and grand unified theories.

In continuing work on the prospects of the proposed Iron Calorimeter detector at INO as an end-detector for a very long baseline experiment in conjunction with a beta-beam source in Europe, it has been shown that this set-up has unmatched sensitivity for probing many of the remaining unknowns of the neutrino mass matrix. Related work on long baseline experiments with a beta-beam have explored the rich benefits of using two different baselines with complementary sensitivities to the CP-violating phase and the mass hierarchy.

In addition, grand unified theories have been investigated with special focus on leptogenesis and the impact of dimension-5 operators.

Publications

1. Sanjib Kumar Agarwalla, Sandhya Choubey, and Amitava Raychaudhuri, *Unraveling neutrino parameters with a magical beta-beam experiment at* INO, Nucl. Phys. **B798**, 124 (2008)*.
2. Sanjib Kumar Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, and Walter Winter, *Optimizing the greenfield Beta-beam experiment at* INO, J. of High Energy Physics **06** 090 (2008)*.
3. Sanjib Kumar Agarwalla, Sandhya Choubey, and Amitava Raychaudhuri, *Exceptional Sensitivity to Neutrino Parameters with a Two-Baseline Beta-Beam Set-up,* Nucl. Phys. **B805,** 305 (2008).
4. Swarup Kumar Majee, Mina K. Parida, and Amitava Raychaudhuri, *Neutrino mass and low-scale leptogenesis in a testable SUSY SO(10) model,* Phys. Lett. **B668,** 299-302 (2008).
5. Joydeep Chakrabortty and Amitava Raychaudhuri, *A note on dimension-5 operators in GUTs and theit impact,* Phys. Lett. **B673**, 57-62 (2009).
6. Amitava Raychaudhuri, *Getting to know the India-based Neutrino Observatory (*INO*)*, Physics News. **38,** 38-45 (2008). *(Popular article)*

* These articles were listed last year as preprints.

Conference/Workshops Attended

1. *Indian Physics and Mega-projects: Research on the frontiers*, Miranda House, Delhi; February 2009.
2. *Beyond the Standard Model Physics at the* LHC, IACS, Kolkata; January 2009.
3. *10th International Workshop on Neutrino Factories, Super beams and Beta beams*, Valencia, Spain; June 2008.

Invited Lectures/Seminars

1. *Neutrino Novelties*, Indian Physics and Mega-projects: Research on the frontiers, Miranda House, Delhi; February 2009.
2. *Neutrino mass and leptogenesis in a* GUT*-Model testable at the* LHC, Beyond the Standard Model Physics at the LHC, IACS, Kolkata; January 2009.
3. *Conference Summary*, NuHorizons09, HRI, Allahabad; January 2009.
4. *The Large Hadron Collider: Why, What and When?*, Special Evening Lecture, 53rd DAE Solid State Physics Symposium, BARC, Mumbai; December 2008.
5. *The status of* INO, 10th International Workshop on Neutrino Factories, Super beams and Beta beams, Valencia, Spain; June-July 2008.
6. *A Passage to India: Exploring Neutrinos at* INO, Bose Colloquium, S. N. Bose National Centre for Basic Sciences, Kolkata; May 2008.

Other Activities

1. Chancellor's Nominee, Executive Council, Allahabad University.
2. Vice President, National Academy of Sciences, India.

Biswarup Mukhopadhyaya

An extensive investigation on the phenomenological consequences of high-scale gaugino and scalar non-universality in supersymmetry (SUSY) was carried out, and interesting links between high-scale boundary conditions and LHC signals were established. In particular, a new way of benchmarking non-universality was proposed, in terms of the non-availability of hadronic signals, when the hadroniocally quiet ones are the only option (with Subhaditya Bhattacharya and Aseshkrishna Datta).

A novel way testing universality in boundary conditions in SUSY was proposed, in terms of the relative production rates of charged and neutral Higgs bosons at the LHC (with Priyotosh Bandyopadhyay and Aseshkrishna Datta). The generation of neutrino masses at the two-loop level in R-parity violating SUSY was investigated, for situations where one-loop contributions are disallowed. The correlation between the SUSY parameter space and the neutrino sector in such conditions was studied (with Paramita Dey, Anirban Kundu and Soumitra Nandi).

Little Higgs theories with T-parity were investigated for cases where the Lightest T-odd particle could be a heavy neutrino. It was demonstrated that this possibility was disallowed by direct dark matter search experiments (with Paramita Dey and Sudhir K. Gupta). The viability of SUSY signals for cases where only the third family sfermions are accessible at the LHC experiments was studied. In particular, important search criteria were devised for situation where extremely energetic top-and bottom quarks had a poor identification efficiency at the LHC (with Nishita Desai).

As a follow-up of a series of earlier studies on SUSY signals with a right-sneutrino LSP and a quasi-stable charged NLSP, the possiblity of reconstructing neutralinos was investigated. Several useful techniques of reconstruction were formulated (with Sanjoy Biswas). The idea of bulk torsion and bulk dilatons at the same time in a Randall-Sundrum model was explored. It was found that not only are the earlier found features of a bulk torsion scenario preserved with addition of a dilaton, but one can also think of phenomenological consequences due to the presence of the dilaton states (with Somasri Sen and Soumitra Sen-Gupta).

Publications

1. Paramita Dey, Sudhir Kumar Gupta and Biswarup Mukhopadhyaya, *The Impossibility of heavy neutrino dark matter in the Littlest Higgs Model with T-parity: Constraints from direct search*, Phys. Lett. B **674** (2009), 188-191.
2. Subhaditya Bhattacharya, Aseshkrishna Datta and Biswarup Mukhopadhyaya, *Non-universal gaugino and scalar masses, hadronically quiet trileptons and the Large Hadron Collider*, Phys. Rev. D **78** (2008), 115018.
3. Paramita Dey, Anirban Kundu, Biswarup Mukhopadhyaya and Soumitra Nandi, *Two-loop neutrino masses with large R-parity violating interactions in supersymmetry* JHEP 0812:100 (2008).

4. Priyotosh Bandyopadhyay, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Signatures of gaugino mass non-universality in cascade Higgs production at the LHC*, Phys. Lett. B **670** (2008) 5–11.
5. Subhaditya Bhattacharya, Aseshkrishna Datta, Biswarup Mukhopadhyaya *Non-universal scalar masses: A Signal-based analysis for the Large Hadron Collider*, Phys. Rev. D **78** (2008) 035011.
6. Debajyoti Choudhury, Sudhir Kumar Gupta and Biswarup Mukhopadhyaya, *Right sneutrinos in a supergravity model and the signals of a stable stop at the Large Hadron Collider*, Phys. Rev. D **78** (2008), 015023.
7. S. Gabriel, Biswarup Mukhopadhyaya, S. Nandi and Santosh Kumar Rai, *Inverted neutrino mass hierarchy and new signals of a chromophobic charged Higgs at the Large Hadron Collider* Phys. Lett. B **669** (2008), 180–185.
8. Paramita Dey, Anirban Kundu and Biswarup Mukhopadhyaya, textit-Some consequences of a Higgs triplet, J. Phys. G **36** (2009) 025002.

Preprints

1. Paramita Dey, Biswarup Mukhopadhyaya and Soumitra SenGupta, *Neutrino masses, the cosmological constant and a stable universe in a Randall-Sundrum scenario*, e-Print: arXiv: 0904.1970 [hep-ph]
2. Biswarup Mukhopadhyaya, Somasri Sen, Soumitra SenGupta, *A Randall-Sundrum scenario with bulk dilaton and torsion*, e-Print: arXiv: 0903.0722 [hep-th] (To appear in Phys. Rev. D)
3. Sanjoy Biswas, Biswarup Mukhopadhyaya, *Neutralino reconstruction in supersymmetry with long-lived staus*, e-Print: arXiv: 0902.4349 [hep-ph] (To appear in Phy. Rev. D)
4. Nishita Desai, Biswarup Mukhopadhyaya, *Signals of supersymmetry with inaccessible first two families at the Large Hadron Collider*, e-Print: arXiv: 0901.4883 [hep-ph]

Conference/Workshops Attended

1. *Nordita Worksop on Physics Beyond the Standard Model*, Stockholm, Sweden; July, 2008.
2. *Recent Trends in Quantum Field Theories*, Banaras Hindu University; November, 2008.
3. *Instructional School on Physics at the* LHC, IISER, Kolkata; December, 2008.
4. *Physics Beyond the Standard Model and the* LHC, IACS, Kolkata; January, 2009.

Visits to other Institutes

1. Nordita, Stockholm, Sweden; July, 2009.
2. IISER, Kolkata; September, 2008 and December, 2008.
3. IACS, Kolkata; January, 2009 and February, 2009.

4. Institute of Physics, Bhubaneswar; February, 2009.
5. IIT, Roorkee; March, 2009
6. Jamia Milia Islamia University, Delhi; March, 2009.

Invited Lectures/Seminars

1. *Supersymmetry and right-handed neutrinos*, Nordita Workshop, Sweden; July, 2009
2. *The Large Hadron Collider*, Colloquium at IISER, Kolkata September, 2008.
3. *The Large Hadron Collider: new challenges in a new era*, Public Lecture at Conference on Recent Trends in Quantum Field Theories, Banaras Hindu University; November, 2009.
4. *Some basic issues in collider physics*, Instructional School on Physics at the LHC, IISER, Kolkata; December, 2008.
5. *New Physics at the LHC: prejudice and prospects*, keynote address at Conference on Physics Beyond the Standard Model at the LHC, IACS Kolkata; January, 2009.
6. The Large hadron Collider: some reflections on the visible and the invisible, Institute of Physics, Bhubaneswar; February, 2009.
7. *The Large Hadron Collider*, Public Lecture at Techfest, IIT, Roorkee; March, 2009.
8. *New Physics at the* LHC, Jamia Milia Islamia University, Delhi; March, 2009.

Other Activities

1. Acted as co-ordinator, Regional Centre for Accelerator-based Particle Physics, Harish-Chandra Research Institute.
2. Served as Dean (academic), Harish-Chandra Research Institute.

Satchidananda Naik

Self-Dual $\mathcal{N}$ = 8 Supergravity as a Closed String Field Theory in Twistor Space: A closed string field theory action is formulated for the $\mathcal{N}$ = 8 self-dual supergravity which is off-shell and Lorentz covariant. The bosonic truncation in the quantum field theory limit gives the Plebanski action in the super space. three point function is calculated and the method can be extended to calculate n-point function at least in the tree level.

Preprints

1. Satchidananda Naik, *Self-Dual $\mathcal{N}$=8 Supergravity as a Closed String Field Theory in Twistor Space,* hep-th: 0903.2872

Conference/Workshops Attended

1. *International Confernce on String theory*, Pondicherry; December 6-13, 2008.

Sudhakar Panda

The motion of a Dp-brane in the background of a stack of NS5-branes is studied as the motion of a relativistic point particle in the transverse space of the five-branes. In this system the particle experiences a proper acceleration orthogonal to its proper velocity due to the background dilaton field which changes the dynamics from that of a simple geodesic motion. In particular we found that in the vicinity of the five-branes, it is this acceleration which is responsible for modifying the motion of the radial mode to that of an inverted simple harmonic oscillator leading to the tachyonic instability.

Further, we showed that when a fundamental string, described by the Nambu-Goto action, is moving in the background of a stack of coincident Dp-branes, the geometric tachyon mode can also appear since the overall conformal mode of the induced metric for the string can act as a source for proper acceleration. We qualitatively argue that the condensation of the geometric tachyon is responsible for the (F-Dp) bound state formation. We studied brane inflation in a warped deformed conifold background that includes general possible corrections to the throat geometry sourced by coupling to the bulk of a compact Calabi-Yau space. Focusing on the perturbation by a chiral operator of dimension 3/2 in the dual conformal field theory, we found that the effective potential can give rise to required number of e-foldings and spectral index n_s consistent with observation. The tensor to scalar ratio of perturbations is found to be very low which is a very good feature of the model. The COBE normalization could be achieved only if the model parameters are properly fine tuned.

We investigated the horizon structure for Born-Infeld black holes, in the context of Einstein-Born-Infeld gravity. We showed that the entropy function formalism agrees with a direct calculation of the entropy. We also estimated the entropy when an axion-dilaton system as well as gravitational derivative corrections are included. We showed that the warm tachyonic inflation predicts the density perturbations consistent with the experimental bound given by WMAP 5 years data. However, for the validity of the four dimensional string effective action, we need the string coupling constant to be $g \ll 1$ and the compact space volume to be $v \gg 1$.This could be acheived only by warped compactification. The number of background branes necessary to produce the required warped background is found to be only order of ten. This can be contrasted with 10^{14} branes required in the cold inflationary scenario.

Publications

1. *Origin of the geometric tachyon* (with A. Das and S. Roy), Phys. Rev. D **78** (2008) 061901(R).
2. *Thermodynamics of Born-Infeld Black Holes*, (with W. A. Chemissany and M. de Roo), Class. Quant. Grav. **25** (2008) 225009.
3. *Proper acceleration, geometric tachyon and dynamics of a fundamental string near Dp-branes*, (with A. Das and S. Roy), Class. Quant. Grav. **26** (2009) 055004.

4. *Prospects of inflation with perturbed throat geometry*, (with A. Ali, R. Chingangbam and M. Sami), Phys. Lett. B **674** (2009), 131.

Preprints

1. *Warm tachyonic inflation in warped background*, (with A. Deshamukhya), arXiv: 0901.0471 [hep-th].

Conference/Workshops Attended

1. *Monsoon Workshop on String Theory*, TIFR; 2008.
2. FTAG-*VII (Field theoretic aspects of gravity)*, Shimla; 2008.
3. ISM-*08 (International String Meeting, Pondicherry*, India, 2008.

Visits to other Institutes

1. TIFR, Mumbail 2008.
2. Univ. of Groningen, Groningen, The Netherlands; 2008.
3. University of Rochester, NY, USA; 2008.
4. Centre for Theoretical Physics, Jamia Milia Univ, Delhi; 2009.
5. Institute of Physics, Bhubaneswar; 2009.

Invited Lectures/Seminars

1. *D-brane dynamics near NS5-branes and Origin of the Geometric tachyon* in Monsoon workshop at TIFR, Mumbai; 2008.
2. *Geometric Tachyons* in FTAG VII held at IAS, Shimla; 2008.
3. *Origin of Geometric Tachyon* in Centre for Theoretical Physics, Jamia Milia Islamia, Delhi; 2009.
4. *Brane inflation and Moduli Stabilization* in IOP, Bhubaneswar; 2009.
5. *Brane Inflation and Reheating* in Centre for High Energy Physics, Bangalore; 2009.

Other Activities

1. Member, Local Works Committee; 2008–09.
2. Member, Library Committee; 2008–09.
3. Member, Board of Studies, CTP, Jamia Milia Islamia, Delhi.
4. External Member, Ph. D. Defence Board, Groningen university, 2008.
5. Convenor, Horticulture Committee, 2008–09.
6. Taught a course on General Theory of Relativity under HRI Ph. D. course program; July–December, 2008.
7. Taught a course on Advanced Quantum Mechanics under HRI Ph. D. course program, January–May, 2009.

Raj Gandhi

It is well known that the lepton mixing angle θ_{13} is small, unlike the other two leptonic mixing angles. Its smallness, along with the observed fact that $\theta_(23)$ is close to $\pi/4$ could be indicative of a symmetry of nature that treats the μ and τ flavours on an equal footing. Under these circumstances, the determination of the mass hierarchy becomes very challenging. With my collaborators (S. Goswami, P. Ghoshal and Uma Sankar, arXiv:0905.2382), we have studied this in detail, and delineated the stringent requirements that a future experiment, either singly or in combination with another must meet for the hierarchy to be determined.

Ultra-high energy neutrinos present an exciting frontier where physics beyond the Standard Model (BSM) may be observable. In order to do so, it is however necessary to understand the fluxes of these very high energy in the absence of BSM physics. An important issue is the charm contribution to the fluxes in highly energetic astrophysical objects. With A. Watanabe and A. Samanta (arXiv: 0905.2483) we have studied the observable consequences of charm meson production and decay for UHE fluxes. our studies points out the ramifications for observations of important BSM physics, like the Glashow resonance and flavour ratios of neutrinos.

With my student, Atri Bhattacharya and S. Choubey and A. Watanabe, we are currently studying the consequences of important new physics (Lorentz Violation, pseudo-Dirac neutrino states, decay and CP violation) on the UHE neutrino fluxes whose observation is imminent in detectors like ICECUBE.

Publications

1. R. Gandhi, P. Ghoshal, S. Goswami and U. Sankar , *Resolving the Mass Hierarchy with Atmospheric Neutrinos using a Liquid Argon Detector ,* Phys. Rev. **D78** (2008), 073001.

Visits to other Institutes

1. CERN Theory Group, Geneva, Switzerland; May 2008,
2. Institute for Particle Phenomenology, University of Wisconsin at Madison, USA; June 2008.

Invited Lectures/Seminars

1. *Mass Hierarchy Determination for $\theta_{13} = 0$*, Theory Seminar, CERN, Geneva; May 2008.
2. *Mass Hierarchy Determination for $\theta_{13} = 0$*, Theory Seminar, Institute for Particle Phenomenology, University of Wisconsin Madison; June 2008.

Other Activities

1. Atri Bhattacharya has joined me as Ph. D. student.
2. Three visiting students, Avijit Mishra, Ushak Rahman and Chandan Gupta did study projects with me in September and October 08.
3. I taught the Particle Physics Course in the Fall Semester of 2008.
4. I guided three second year graduate students, Atri Bhattacharya, Satyanarayan Mukhopadhya and Ramlal Awasthi for their projects as part of their academic requirements in Spring 2009. Also, in Spring 2009, I guided 2 first year students Arunabha Saha and Sourabh Niyogi in their study projects.
5. As a member of the Project Management Committee of the Indian Neutrino Observatory (INO), I continue to be actively involved in this national effort.
6. I am a member of the UKIERI project, which is a research project involving Indian and UK scientists

Ashoke Sen

My research during the period April 2008 - March 2009 focussed mainly on understanding black hole entropy in string theory. The leading order contribution to the black hole entropy is given by the Bekenstein-Hawking formula. In string theory this formula receives correction due to two effects: stringy effects and quantum effects. Of these stringy effects are well understood, – and are captured by a generalization of the Bekenstein-Hawking formula due to Wald. My main goal was to understand the effect of quantum corrections. I proposed a quantum generalization of Wald's formula in the limit when the black holes are extremal, i.e. have zero temperature. Ths formula – called the quantum entropy function – reduces to Wald's formula in the classical limit and can also be understood as a realization of the AdS_2/CFT_1 correspondence. I carried out various other consistency tests of this proposal in various collaborations.

Besides this I also worked on the theory of membranes in M-theory and understanding of the spectrum of dyons in $N = 4$ and $N = 8$ supersymmetric string theories.

Publications

1. A. Sen, *U-duality Invariant Dyon Spectrum in type II on T^6*, JHEP **0808** 037 (2008) arXiv:0804.0651 [hep-th].
2. A. Sen, *Entropy Function and AdS(2)/CFT(1) Correspondence*, JHEP **0811**, 075 (2008) [arXiv:0805.0095 [hep-th]].
3. S. Banerjee and A. Sen, *Interpreting the M2-brane Action* arXiv:0805.3930 [hep-th].
4. R. K. Gupta and A. Sen, *Ads(3)/CFT(2) to Ads(2)/CFT(1)*, JHEP **0904** 034 (2009) [arXiv:0806.0053 [hep-th]].
5. S. Cecotti and A. Sen, *Coulomb Branch of the Lorentzian Three Algebra Theory* arXiv:0806.1990 [hep-th].
6. S. Banerjee, A. Sen and Y. K. Srivastava, *Genus Two Surface and Quarter BPS Dyons: The Contour Prescription* JHEP **0903**, 151 (2009) arXiv: 0808.17-46 [hep-th].
7. A. Sen, *Quantum Entropy Function from AdS(2)/CFT(1) Correspondence*, arXiv : 0809.3304 [hep-th].
8. N. Banerjee, D. P. Jatkar and A. Sen, *Asymptotic Expansion of the N=4 Dyon Degeneracy*, arXiv:0810.3472 [hep-th].
9. N. Banerjee, I. Mandal and A. Sen, *Black Hole Hair Removal*, arXiv: 0901.0359 [hep-th].
10. A. Sen, *Arithmetic of Quantum Entropy Function* arXiv:0903.1477 [hep-th].

Invited Lectures/Seminars at Schools/Conferences

1. Spring School On Superstring Theory And Related Topics, Trieste, Italy; March 27– April 4, 2008.

2. ISS 2008, Isfahan Iran; April 9–17, 2008.
3. Cargese Summer School, Cargese France; June 16–June 28, 2008.
4. Eurostrings 2008, June 30–July 4, 2008.
5. Prestrings 2008, Zurich; August 11–15, 2008.
6. Strings 2008, CERN, Geneva; August 18–23, 2008.
7. Indian Strings Meeting, Pondicherry, India; December 6–13, 2008,
8. IISc Centenary Conference, Bangalore; December 13–16.

Courses given

1. Statistical Mechanics; January–May, 2008.
2. Classical Mechanics; August–December, 2008.
3. Statistical Mechanics; January–May, 2008.

Sumathi Rao

We continued our investigations of superconducting junctions of quantum wires, with new phenomena like Andreev reflection and crossed Andreev reflection in the wires due to the proximity of the superconductor in different geometries. We also studied a junction (point contact) of two line junctions in a $\nu = 5/2$ quantum Hall system.

We established the existence of $g \leftrightarrow 1/g$ duality (where g is the Luttinger Liquid parameter) between the charge conserving (normal) junction and the charge non-conserving (superconducting) junction by evaluating and comparing the scaling dimensions of various operators around the fixed points in both the normal and superconducting sectors of the theory. We showed that the fixed points in the dual theory can be stabilized for $g < 1$ (repulsive electrons) within the superconducting sector of the theory which makes them experimentally relevant.

We studied the renormalization group flows of the two terminal conductance of a superconducting junction of two Luttinger liquid wires and computed the power laws associated with the renormalization group flow around the various fixed points of this system and then performed a comprehensive stability analysis. In particular, for the non-trivial fixed point which has intermediate values of transmission, reflection, Andreev reflection and crossed Andreev reflection, we showed that there are eleven independent directions in which the system can be perturbed, which are relevant or irrelevant, and five directions which are marginal.

We studied transport across a point contact separating two line junctions in a $\nu = 5/2$ quantum Hall system. We analyzed the effect of inter-edge Coulomb interactions between the chiral bosonic edge modes of the half-filled Landau level (assuming a Pfaffian wave function for the half-filled state) and of the two fully filled Landau levels. In the presence of inter-edge Coulomb interactions between all the six edges participating in the line junction, we showed that the stable fixed point corresponds to a point contact which is neither fully opaque nor fully transparent. This fixed point represents a situation where the half-filled level is fully transmitting, while the two filled levels are completely backscattered; hence the fixed point Hall conductance is given by $G_H = \frac{1}{2}e^2/h$.

We studied the tunneling density of states (TDOS) for a junction of three Tomonaga-Luttinger liquid wires. For a three-wire junction, we showed that there are fixed points which allow for the *enhancement* of the TDOS which is unusual for Luttinger liquids. We studied transport through a single channel T-stub geometry strongly coupled to a superconducting reservoir. Due to the proximity effect, and transport also through holes, this geometry has a non-unimodular resonance at $T = 1/4$, where charge transport vanishes while the spin transport is perfect.

Publications

1. Sourin Das and Sumathi Rao, *Duality between normal and superconducting junctions of multiple quantum wires*, cond-mat/0807.0804, Phys. Rev. B **78** (2008), 205421.
2. Sourin Das, Sumathi Rao and Arijit Saha, *A systematic stability analysis of the renormalisation group flow for the normal-superconductor-normal junction of Luttinger liquid wires*, cond-mat/0901.0126, Phys. Rev. B **79** (2009), 155416.
3. Sourin Das, Sumathi Rao and Diptiman Sen, *Effect of inter-edge Coulomb interactions on transport through a point contact in a $\nu = 5/2$ quantum Hall state*, cond-mat/0808.2249, Europhys. Lett. **81** (2009), 37010.

Preprints

1. Amit Agarwal, Sourin Das, Sumathi Rao and Diptiman Sen, *Enhancement of tunneling density of states at a junction of three Luttinger liquid wires* cond-mat/0810.3513, to be published in Phys. Rev. Lett.
2. Sourin Das, Sumathi Rao and Arijit Saha, *Resonant transmission of pure spin current through a t-stub coupled to a superconductor* cond-mat/0811.06-60, submitted to Europhys. Lett.
3. Arijit Kundu, Sumathi Rao and Arijit Saha, *Resonant spin transport through a superconducting double barrier structure*, in preparation.

Conferences/Workshops attended

1. *Quantum Phases and excitations in quantum Hall systems*, Max Planck Institute, Dresden, Germany; June 16–21, 2008.
2. *Third IUPAP conference on women in physics*, Seoul, Korea; Oct 10-12, 2008.
3. *New Trends in Field theory*, Physics Department, Banaras Hindu University, Varanasi; Nov 1–2, 2008.
4. *K.S. Krishnan Discussion meeting on 'Quantum matter and quantum information*, IMSc, Chennai; Dec 1–2 (2008).
5. *'Indian condensed matter workshop'*, Centre for Theoretical Sciences, Tata Institute of Fundamental Research, held at Mahableshwar; Dec 9–23, 2008.
6. *Women in Science and Technology programme at PAN-IIT 2008*, Indian Institute of Technology, Chennai; Dec 19–21, 2008.
7. *Recent trends in condensed matter physics*, Saha Institute of Nuclear physics, Kolkata, India; March 27–29, 2009.

Visits to other Institutes

1. Centre for High Energy Physics, Indian Institute of Science, Bangalore, April 2008.

2. Department of Condensed Matter Physics, University of Karlsruhe, Karlsruhe, Germany, June 1-15, 2008.
3. Dept of Physics, University of Paris, Jussieu, June 24-July 1, 2008
4. Theoretical physics, Tata Institute of Fundamental Research, Mumbai, July, 2008.
5. Centre for high energy physics,Indian Institute of Science,Bangalore, July, 2008.
6. Indian Institute of Science Education and Research, Pune, July, 2008.
7. Korea Institute of Advanced Study, Seoul, Korea, October, 2008.
8. Centre for high energy physics,Indian Institute of Science,Bangalore, December, 2009.
9. Institute of Physics, Sachivalaya Marg, Bhubaneswar, February, 2009.

Invited Lectures/Seminars

1. *Duality between charge conserving and superconducting sectors of junctions of quantum wires*, Colloquium, Dept. of Physics, Karlsruhe, Germany; June 5, 2008.
2. *Transport through superconducting junctions*, Dept. of Physics, Karlsruhe, Germany, June 9, 2008.
3. *Inter-edge interactions and novel fixed points at a junction of quantum Hall line junctions*, Dresden, Germany; June 16, 2008.
4. *Duality between charge conserving and superconducting sectors of junctions of quantum wires*, TIFR, Mumbai; July 8, 2008.
5. *Transport through junctions of quantum wires*, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; July 23, 2008.
6. *Novel phenomena in mesoscopic physics or There's room at the bottom*, IISER; Pune, July 29, 2008.
7. *Transport through junctions of quantum wires*, Dept. of Physics, Jawaharlal Nehru University, New Delhi; September 10, 2008.
8. *Summary of session on Personal Professional Development*, Third IUPAP International conference on Women in Physics, Seoul, Korea; October 10, 2008.
9. *Transport through junctions of quantum wires*, KIAS, Seoul, Korea; October 13, 2008.
10. *Transport through junctions of quantum wires : Application of quantum field theory methods in low dimensional condensed matter systems*, Dept. of Physics, Banaras Hindu University; November 1, 2008.
11. *Transport through junctions of quantum wires*, IMSc, Chennai; Dec 1, 2008.
12. *Duality between charge conserving and superconducting sectors of junctions of quantum wires*, Mahableswhar; December 12, 2008.
13. *Report on the International conferences on women in physics*, Women in Science and Technology programme, PANIIT, Chennai; December 20, 2008.
14. *How to attract girls and women to physics*, Panel discussion on women in science and technology, PANIIT, Chennai; December 20, 2008.

15. *There's room at the bottom*, Physicist's retreat, Dept. of Physics, IIT Chennai; Dec 21, 2008.
16. *Transport through junctions of quantum wires : Application of quantum field theory methods in low dimensional condensed matter systems*, Institute of Physics, Bhubaneswar; March 3, 2009.
17. *Novel phenomena in mesoscopic physics* in *Recent trends in condensed matter physics*, Saha Institute, Kolkata; March 28, 2009.
18. *Transport through quantum wires* in *Recent trends in condensed matter physics*, Saha Institute, Kolkata; March 29, 2009.

Other Activities

1. Organised a session on Personal and Professional development in the third International conference on women in Physics in Seoul, Korea.
2. Taught *quantum field theory I*; Jan–May 2009.
3. Convenor, Local works committee, HRI.
4. Convenor, Women's grievance cell, HRI.
5. Member, Faculty Advisory committee and Budget committee.
6. Member, Working group of women in physics, International Union of Pure and Applied Physics.
7. Member, Board of Studies, School of Physics, Jawaharlal Nehru University, New Delhi.

Dileep Jatkar

In last one year, I have continued studying the dyon degeneracy formula in more detail. In particular we looked as the asymptotic behaviour of it, which included studying power suppressed terms as well as exponentially supressed corrections.

Preprints

1. *Asymptotic Expansion of the $N = 4$ dyon degeneracy*, Nabamita Banerjee, Dileep P. Jatkar, Ashoke Sen, [arXiv:0810:3472].

Conference/Workshops Attended

1. Indian String Meeting at Pondicherry, December 6-13 2008.
2. String Theory Meeting, Kanha, February 11-18, 2009

Invited Lectures/Seminars

1. Lectured at SERC School on Theoretical High-Energy Physics, Guwahati, March 12-21, 2009.

V. Ravindran

Models of extra dimensions and scale invariant sector have dominated the recent theoretical literature on physics beyond the standard model. Existing collider studies of the effects of gravitons in the case of extra-dimension models and unparticles in the scale invariant theories have been done at the Born level in QCD. It is important to incorporate NLO QCD corrections to these processes in order to quantify the size of the effects and to see how robust the leading order estimate of the cross-section is with respect to these corrections. We have investigated the quantitative impact of the QCD corrections for searches of extra dimensions at hadron colliders and found that at the LHC ($\sqrt{S} = 14TeV$) the K-factor is rather large ($K = 1.6$) for the lepton and diphoton productions, indicating the importance of accounting for these QCD corrections in the experimental search for TeV-scale gravity and unparticles.

We have checked against exact three-loop results for the non-singlet F_2 and F_3 structure functions the validity of a class of ansatz for threshold resummation at the next-to-leading order in $1 - x$. We find that the ansatz do not work exactly, pointing towards an obstruction to threshold resummation at this order, but still yield correct results at the leading logarithmic level for each color structures, as well as at the next-to-next-to-leading logarithmic level for the specific color factor. A universality of the leading logarithm contributions to the physical evolution kernels of F_2 and F_3 at the next-to-leading order in $1-x$ is observed.

Publications

1. M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Unparticles in diphoton production to NLO in QCD at the LHC, Phys. Rev. D **79** (2009), 075012.
2. M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Diphoton signals in theories with large extra dimensions to NLO QCD at hadron colliders, Phys. Lett. B **672** (2009), 45–50.
3. M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Direct photon pair production at the LHC to $O(\alpha_s)$ in TeV scale gravity models, Nucl. Phys. B **818** (2009), 28–51.

Preprints

1. Neelima Agarwal, M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Di-jet production at the LHC through unparticles. arXiv: 0903.0202
2. G. Grunberg, V. Ravindran, On threshold resummation beyond leading 1-x order, arXiv: 0902.2702

Conference/Workshops Attended

1. RECAPP Meeting 2008, Harish-Chandra Research Institute, Allahabad, September 21 - October 4, 2008.
2. Renormalization Group-2008-Conference dedicated to 80th Anniversary of Professor Shirkov, Dubna, Russia, September 1-5, 2008.

Visits to other Institutes

1. Theory group, DESY-Zeuthen, Germany, April-June, 2008,
2. Centre de Physique Theorique,Ecole Polytechnique, Paris, France June-July, 2008

Invited Lectures/Seminars

1. Theory Seminar, Theory group, DESY-Zeuthen, Germany, May 2008.
2. Theory Seminar, Centre de Physique Theorique, Ecole Polytechnique, Paris, France July, 2008.
3. Theory Seminar, Center for High Energy Physics, IISc, Bangalore, October 2008.
4. Renormalization Group-2008-Conference dedicated to 80th Anniversary of Professor Shirkov, Dubna, Russia, September 1-5, 2008.

Other Activities

1. Organised a international meeting on Getting Ready for Physics at the LHC, Harish-Chandra Research Institute, Feb 16–20, 2009.

Pinaki Majumdar

We have completed our work on the field induced melting of charge order in the manganites. We are also nearly done with our study of B site doping in various manganite phases. Most of our recent focus is on the double perovskites. We have also started work on cellular DMFT for correlated electron systems.

Publications

1. Anamitra Mukherjee, Kalpataru Pradhan and Pinaki Majumdar, *Conductance Switching and Inhomogeneous Field Melting in the Charge Ordered Manganites,* Europhys. Lett. **86**, 27003 (2009).
2. Kalpataru Pradhan and Pinaki Majumdar, *Magnetic Order Beyond* RKKY *in the Classical Kondo Lattice,* Europhys. Lett. **85**, 37007 (2009).
3. Kalpataru Pradhan, Anamitra Mukherjee and Pinaki Majumdar, *Exploiting B Site Disorder for Phase Control in the Manganites,* Europhys. Lett. **84**, 37007 (2008).
4. Prabuddha Sanyal, Sabyasachi Tarat and Pinaki Majumdar, *Structural Ordering and Antisite Defect Formation in Double Perovskites,* Eur. Phys. J. **B65**, 39, (2008).

Preprints

1. Anamitra Mukherjee and Pinaki Majumdar, *A Real Space Description of Field Induced Melting in the Charge Ordered Manganites: I. The Clean Limit,* arXiv: 0811.3563.
2. Anamitra Mukherjee and Pinaki Majumdar, *A Real Space Description of Field Induced Melting in the Charge Ordered Manganites: II. The Disordered Case,* arXiv: 0811.3746.
3. Prabuddha Sanyal and Pinaki Majumdar, *A Magnetic Model for the Ordered Double Perovskites*, arXiv: 0812.1182.

Conference/Workshops Attended

1. *Advanced Research Workshop, Univ of Goa*, India, December 2008.
2. *Meeting on Oxides,* SNBNCBS, India, February 2009.
3. SPS *Symposium, Jawaharlal Nehru University*, India, March 2009.

Invited Lectures/Seminars

1. *The interplay of phase competition and disorder in the manganites* , Indo-Brazil Meeting, Brazilian Academy of Sciences, Rio de Janeiro, April 2008.
2. *Nanoscale textures in correlated electron systems*, Annual Lecture of IPS, Indian Physical Society, IACS Kolkata, May 2008.

3. *Metallising insulators with disorder*, Colloquium, IIT Kanpur, Kanput; Sep 2008.

Academic recognition/Awards

- DAE-SRC Outstanding Research Investigator Award (2008).
- Global Indus Technovator Award (GITA), MIT (2008).

Other Activities

1. Professional refereeing and thesis examination.
2. KVPY interviews in Jan 2009.

Jasjeet Singh Bagla

Observations of temperature and polarization anisotropies in the cosmic microwave background radiation (CMBR) along with observations of large scale structure in the universe and other extra-galactic observations have been used to put strong constraints on parameters of the concordant cosmological model. The same constraints also put strong restrictions on the spectrum of density perturbations in matter and the rate of growth of these perturbations. Galaxies are believed to form when density perturbations becomes sufficiently large to lead to rapid cooling of infalling gas and hence formation of stars. Radiation from stars and other objects that form in galaxies in turn emit radiation that is believed to ionize the inter galactic medium (IGM). CMBR observations also provide a constraint on the epoch when the IGM became ionized, and hence one can attempt to make a self consistent model of early galaxy formation. Several such attempts have been made in the last few years. We find that by adding observational constraints arising from chemical enrichment of the IGM, we are able to make statements about the kind of stars that may have been responsible for producing the ionizing radiation (Bagla, Kulkarni & Padmanabhan, 2009).

N-Body simulations, vital tools as they are for the study of galaxy formation, make several approximations in order to make computation tractable. We had developed an analytical technique for estimating the effect of using a finite simulation box. During the last year, we developed the model further for estimating the effect on a number of physical quantities. We also carried out tests using N-Body simulations that tested the predictions of our model. We find that a true representation of large scale structure so as to capture at least the first few moments of the density distribution requires use of a much larger simulation box than was deduced using the second moment alone (Bagla, Prasad & Khandai, 2008).

Publications

1. Bagla J. S., Yadav Jaswant and Seshadri T. R., *Fractal Dimension of a Weakly Clustered Distribution and the Scale of Homogeneity,* MNRAS **390** (2008), 829.
2. Bagla J. S. and Prasad Jayanti, *Gravitational collapse in an expanding background and the role of substructure II: Excess power at small scales and its effect of collapse of structures at larger scales*, MNRAS **393** (2009), 607.
3. Bagla J. S., *Hubble, Hubble's law and the expanding universe*, Resonance **14** (2009), 216.

Preprints

1. Bagla J. S., Prasad Jayanti and Khandai Nishikanta, *Effects of the size of cosmological N-Body simulations on physical quantities — III: Skewness*, 0804.1197
2. Bagla J. S. and Khandai Nishikanta, *The Adaptive TreePM: An Adaptive Resolution Code for Cosmological N-body Simulations*, 0811.4228

3. Bagla J. S., Kulkarni Girish and Padmanabhan T., *Metal Enrichment and Reionization Constraints on Early Star Formation*, 0902.0853

Conference/Workshops Attended

1. *Cosmology with the textsccmb and* LSS, Pune; July–August, 2008.
2. *National Frontiers of Science Symposium*; January, 2009.
3. *Indo-US Frontiers of Science Symposium*, Agra; March, 2009.
4. *Reionization@Ringberg: The Cosmic Evolution of Helium and Hydrogen*, Germany; March, 2009.

Visits to other Institutes

1. University of Delhi, Delhi; March 2009.
2. Max-Planck Institute for Astrophysics, Garching, Germany; March 2009.

Invited Lectures/Seminars

1. *Hyperfine transitions: The view from Helium*, Reionization@Ringberg, Max-Planck Institute for Astrophysics, Ringberg; March 2009.

Other Activities

1. I am a member of the Editorial board for the journal Research in Astronomy and Astrophysics. The Chinese Journal of Astronomy and Astrophysics has been relaunched in this form in Jan.2009 with the view of giving it an international flavor.
2. An outreach programme at the institute that was initiated last year has become more popular. This programme, funded by INSA, involves inviting batches of about 50 school students for a lecture and an interactive session. Three sessions were held in the period from April 1, 2008 to March 31, 2009.
3. I am the principal investigator for the high performance scientific computing XI-plan project. We completed remodeling of an area in the institute for housing the cluster facilities. Old facilities were either retired or shifted to the new housing. Two new clusters as well as several other useful features have been added to the high performance scientific computing facilities at the institute.
4. As a member of the Rajbhasha committee at the institute, i coordinated lectures in a week long school that we organize every year for students from schools in Allahabad and Jhusi.

Rajesh Gopakumar

As in previous years I have continued with the development of methods to try and reconstruct the worldsheet duals to the QFT duals of string theories in the AdS/CFT correspondence. In this context, with Justin David and Matthias Gaberdiel we have been developing a new approach to reconstruct the one loop worldsheet partition function of the string theory on AdS_3 which is dual to the orbifold CFT. To this end we have been developing the technical tool of computing the heat kernel on thermal AdS_3 for fields of arbitrary spin. We have also applied this to computing the one loop quantum fluctuations in $N = 1$ supergravity to check that it does give a super Virasoro character.

Another direction of research has been to consider nonrelativistic limits in the AdS/CFT conjecture. Together with Arjun Bagchi we have been considering a systematic nonrelativistic limit of the relativistic AdS/CFT conjecture. This involves taking a group contraction of the original conformal symmetry which gives rise to a symmetry algebra which admits an infinite dimensional extension. The latter algebra is in fact the natural set of conformal isometries of nonrelativistic galilean spacetime. This Galilean conformal algebra contains a Virasoro-Kac-Moody symmetry and presumably should lead to more powerful constraints than those following from the finite dimensional relativistic group. On the gravity side the nonrelativistic limit leads to a Newton-Cartan like theory with an AdS_2 base. Some of the consequences of this new limit and its generalisations have been further developed by Arjun Bagchi and Ipsita Mandal.

Publications

1. J. David, R. Gopakumar and A. Mukhopadhyay, *Worldsheet Properties of Extremal Correlators in AdS/CFT* HEP **0810**, 029, (2008)
2. Arjun Bagchi and R. Gopakumar, *Galilean Conformal Algebras and AdS/CFT,* JHEP (to appear)

Preprints

1. J. R. David, M. Gaberdiel and R. Gopakumar, *The Heat Kernel on AdS_3 and its Applications* (in preparation)

Conference/Workshops Attended

1. *ICTS Monsoon Workshop in String Theory*, (co-organizer) TIFR Mumbai, Jun- Aug., 2008.
2. *Indian Strings Meeting (ISM) 08*, Pondicherry, India, Dec. 2008.
3. *Pan-IIT Physics Retreat*, IIT-Madras, Dec. 2008
4. *3rd National Frontiers of Science*, INSA, New Delhi, Jan. 2009.
5. *String Theory and Fundamental Physics*, Kanha, Feb. 2009.

6. *Physics of Turbulence*, SN Bose Centre, Feb. 2009.
7. *3rd Indo-US Frontiers of Science*, Agra, Mar. 2009.

Visits to other Institutes

1. ETH, Zurich, Switzerland; May 2008.
2. TIFR, Mumbai; June–August 2008.
3. IACS, Kolkata; December 2008.
4. CMI, Chennai; December 2008.
5. IMSc, Chennai; January 2008.
6. IOP, Bhubaneshwar; February2009.
7. Delhi University, Dept. of Physics; March 2009.
8. IISER, Pune; March 2009.

Invited Lectures/Seminars

1. *Free Fermions and Thermal AdS/CFT*, String Theory Seminar, ETH, Zurich; May, 2008.
2. *On the Non-relativistic Limit of the AdS/CFT Correspondence*, ISM08, Pondicherry; December 2008.
3. *Non-Relativistic Gauge-Gravity Dualities* Pan-IIT Meet, IIT Madras; December 2008
4. *Non-Relativistic Gauge-Gravity Dualities*, HEP Seminar, IACS, Kolkata, December 2008.
5. *From Fields to Strings* S. L. Sircar Memorial Lecture, IACS, Kolkata; December 2008.
6. *String Theory and Spacetime*, Popular Talk, RKM Vidyamandir, Belur; March 2009.
7. *Open-closed String Dualities* Maths-Physics Colloquium, CMI, Chennai; December 2008.
8. *What on earth is String Theory?*, Nag Memorial Lectures, IMSc, Chennai; January 2009.
9. *String Theory and Geometry* 3rd National Frontiers of Science – Session chair talk, INSA, New Delhi; January 2009.
10. *Black Holes and Fluid Mechanics*, Lectures at school on Physics of Turbulence, SN Bose Centre Kolkata; February 2009.
11. *From AdS to Free Fields?* String Theory and Fundamental Physics, Kanha, February 2009.
12. *Non-Relativistic Gauge-Gravity Dualities* HEP Seminar, IOP Bhubaneshwar; February 2009.
13. *String Theory and Spacetime* Colloquium, NISER, Bhubaneshwar, February 2009.
14. *From Fields to Strings* Colloquium, DU, Deptartment of Physics, New Delhi; March 2009.
15. *String Theory and Spacetime* Colloquium, IISER, Pune; March 2009.

16. *Spacetime and String Theory*, Session Chair Talk, 3rd Indo-US FOS, Agra; March 2009.

Academic recognition/Awards

- Elected Fellow of Indian Academy of Sciences, Bangalore; January 2009.
- Delivered S. Nag Memorial Lectures, IMSc, Chennai January 2009.
- Delviered S. L. Sircar Memorial Lecture, IACS, Kolkata; December 2008.

Other Activities

1. Co-Organiser (with S. Minwalla) of ICTS Monsoon workshop on String Theory, TIFR, Mumbai, June–August, 2008.
2. Member, Program Committee, International Centre for Theoretical Sciences (ICTS).
3. Member of various academic and administrative committees at HRI.

L. Sriramkumar

During the last year, my research work was essentially focused on investigating the following problems in inflationary cosmology:

- Deviations from slow roll inflation and features in the primordial spectrum
- Reheating and its effects on the evolution of perturbations

I have been studying these issues along with my graduate student Rajeev Kumar Jain. Brief description of the problems we have been considering in this context can be found in his report.

Publications

1. S. Sarkar, S. Shankaranarayanan and L. Sriramkumar, *Sub-leading contributions to the black hole entropy in the brick wall approach*, Phys. Rev. D **78** (2008), 024003.
2. D. A. Kothawala, S. Shankaranarayanan and L. Sriramkumar, *Quantum gravitational corrections to the stress-energy tensor around the BTZ black hole*, JHEP **0809** (2008), 095.
3. R. K. Jain, P. Chingangbam, J. -O. Gong, L. Sriramkumar and T. Souradeep, *Punctuated inflation and the low* CMB *multipoles*, JCAP **0901** (2009), 009.

Preprints

1. S. Sarkar, S. Shankaranarayanan and L. Sriramkumar, *Corrections to the Bekenstein-Hawking entropy in the brick wall approach*, To appear in the Proceedings of the Meeting on Black Holes in General Relativity and String Theory, August 24–30, 2008, Veli Losinj, Croatia.
2. R. K. Jain, P. Chingangbam and L. Sriramkumar, *Reheating in tachyonic inflationary models: Effects on the large scale curvature perturbations*, arXiv:0902.1067.

Conferences/Workshops Attended

1. *Cosmology with the* CMB *and* LSS, Inter-University Centre for Astronomy and Astrophysics, Pune, July 21–31 and August 18–31, 2008.
2. *The Second Indo-Brazilian Workshop on Gravitation and Cosmology*, Universidade Federal do Rio Grande do Norte, Natal, Brazil, October 13–17, 2008.
3. *The 18th* DAE-BRNS *High Energy Physics Symposium*, Banaras Hindu University, Varanasi, December 14–18, 2008.
4. *XXV Meeting of the Indian Association of General Relativity and Gravitation*, Saha Institute of Nuclear Physics, Kolkata, India, January 28–31, 2009.

Visits to other Institutes

1. Inter-University Centre for Astronomy and Astrophysics, Pune, June 1–4, 2008.
2. Institute of Physics, University of Sao Paulo, Sao Paulo, Brazil, October 5–12, 2008.
3. Saha Institute of Nuclear Physics, Kolkata, India, October 20–24, 2008.
4. Inter-University Centre for Astronomy and Astrophysics, Pune, February 7–21, 2009.
5. Tata Institute of Fundamental Research, March 25–27, 2009.

Invited Lectures/Seminars

1. *Black holes* (2 lectures), Introductory Summer School on Astronomy and Astrophysics, Inter-University Centre for Astronomy and Astrophysics, Pune, India, June 2–3, 2008.
2. *Probing Planckian scales through inflation*, Invited lecture in the Link to Early Universe session at Cosmology with the CMB and LSS, Inter-University Centre for Astronomy and Astrophysics, Pune, India, August 18–31, 2008.
3. *Reheating in tachyonic inflationary models and effects on large scale curvature perturbations*, Invited presentation in the Link to Early Universe session at Cosmology with the CMB and LSS, Inter-University Centre for Astronomy and Astrophysics, Pune, India, August 18–31, 2008.
4. *Sub-leading contributions to the black hole entropy in the brick wall approach*, Seminar at the Institute of Physics, University of Sao Paulo, Sao Paulo, Brazil, October 6, 2008.
5. *Double inflation and the low* CMB *multipoles*, Invited plenary talk in The Second Indo-Brazilian Workshop on Gravitation and Cosmology, Universidade Federal do Rio Grande do Norte, Natal, Brazil, October 13–17, 2008.
6. *Cosmology* (9 lectures), The Fourth Amal Kumar Raychaudhuri School on General Relativity, Saha Institute of Nuclear Physics, Kolkata, India, October 21–24, 2008.
7. *Inflation—A cosmological magnifying glass for Planck scale physics*, Invited plenary review talk at *The 18th* DAE-BRNS *High Energy Physics Symposium*, Banaras Hindu University, Varanasi, December 14–18, 2008.
8. *Inflation and reheating*, Invited plenary talk at the *XXV Meeting of the Indian Association of General Relativity and Gravitation*, Saha Institute of Nuclear Physics, Kolkata, India, January 28–31, 2009.
9. *Origin and evolution of perturbations during inflation and reheating* (11 lectures), Topical course at Inter-University Centre for Astronomy and Astrophysics, Pune, India, February 9–20, 2009.
10. *Can reheating affect large scale curvature perturbations?*, Seminar at Inter-University Centre for Astronomy and Astrophysics, Pune, India, Febru-

ary 19, 2009.

11. *Punctuated inflation and the low* CMB *multipoles*, Seminar at Tata Institute of Fundamental Research, March 27, 2009.

Other Activities

1. I organized the *Summer School on Gravitation and Cosmology* at HRI during May 12–24, 2008.
2. I was the tutor (7 tutorials) for the courses titled *The smooth universe* and *The perturbed universe* taught by Profs. Shiv Sethi and Somnath Bharadwaj at the Summer School on Gravitation and Cosmology held at HRI during May 12–24, 2008.
3. I taught a full-semester course on *Quantum Mechanics* to physics graduate students at HRI during August–December, 2008.
4. I was incharge of conducting (the Physics part of) the HRI Science Talent Test 2008.
5. I supervised the following HRI graduate student on a project: Dhiraj Kumar Hazra, January–May 2009, Topic: *Deviations from slow roll inflation and features in the primordial spectrum*.

Tribhuvan Prasad Pareek

My research have mainly focused on the spin transport in mesoscopic and nano-system. In particular we have been trying to develop a transport theory for system with broken spin rotation symmetry. This is particularly important since in presence of spin orbit interaction or other spin flip mechanism spin is not a conserved quantity hence a continuity equation for spin current does not exist as is for charge currents due to charge conservation. Moreover in an electrical circuit where an external voltage is applied the thermodynamically conjugate variable to electrical field is charge current and not the spin currents. Therefore the spin currents concepts is inherently is ill defined. These conceptual problems and it consequence for spin transport have been studied and further studies are going on.

Further we are developing an Non equilibrium Green function method to study different aspect of spin transport. For this we are using quaternion algebra which is necessary to deal with the broken SU(2) symmetry in spin space. This would eventually allow us to develop analytical methods to study spin transport and related effects.

Publications

1. T. P. Pareek and A. M. Jayannavar, *Generation and measurement of non-equilibrium spin currents in two-terminal systems,* PRB **77**, 153307, (2008).

Preprints

1. T. P. Pareek, *Multi-terminal Spin Transport: Non applicability of linear response and Equilibrium spin currents,* 0809.5119 (submitted for publication)
2. T. P. Pareek *Spin Dephasing in system with broken spin rotation symmetry: an analytical approach,* (in preparation)

Conference/Workshops Attended

1. *Entanglement in Quantum Condensed Matter Systems*; November 2008.
2. *"Homi Bhabha Centenary DAE-BRNS National conference and School on Spintronic and Magneto electronic Materials and Devices"*; January 2009.

Visits to other Institutes

1. IOP, Bhubaneswar; January 2009.

Invited Lectures/Seminars

1. *Spin transport in nano-systems*, "Homi Bhabha Centenary DAE-BRNS National conference and School on Spintronic and Magneto electronic Materials and Devices", HRI-IACS-IOP, Puri; January 2009.

Other Activities

1. Myself in collaboration with Prof. G. P. Das (IACS, Kolkata) and Dr. S. M. Yusuf (BARC) have organized , "Homi Bhabha Centenary DAE-BRNS National conference and School on Spintronic and Magneto electronic Materials and Devices" from January 5–10, 2009. The venue of the conference cum school was Toshali sand, Puri. The school preceded the conference and around 40 students participated in the school cum conference. The school was aimed at introducing the youngster to the emerging field of spintronics and magneto-electronic.
2. Three visiting students did their summer project with me during last year. I have participated in the administrative committees of the institute.

Prasenjit Sen

My major research effort this year has been focussed on theoretical designing of new materials, using TM-doped alkali metal clusters as building blocks. It has been found that atomic clusters of appropriate size and composition mimic certain chemical properties of elemental atoms. But they may also posses additional properties by virtue of being aggregates of a number of atoms, which the elemental atoms do not have. This freedom may be viewed as adding a third dimension to the periodic table. For example, an Al_{13} cluster has been found to behave as a better halogen than an iodine, and has been termed a *superhalogen*. K_3O is an example of a super-alkali. All known superatom behavior so far is related to the tendency of clusters to achieve a filled shell electronic configuration. This precludes possibility of having superatoms that are magnetic, since a filled electronic shell is necessarily non-magnetic. In course of our work we found that a VCs_8 cluster resembles a Mn atom in the following sense. The V atom at the center of a Cs_8 square prism is in a half-filled $3d^5$ electronic configuration, having a moment of 5 μ_B, while 8 s electrons lead to a filled electronic shell of the delocalized valence electrons. Mn atoms has a half-filles $3d^5$ and filled $4s^2$ electronic configuration. This makes VCs_8 cluster most stable in the series VCs_n ($n = 1 - 12$). We then explored if VCs_8 behaves like a Mn atom in chemical bonding. Indeed, we found that a $(VCs_8)_2$ dimer is similar to a Mn_2 dimer in that in DFT calculations it has a ferromagnetic (FM) ground state that is lower in energy than an anti-ferromagnetic (AFM) state by 0.1 eV. A $(VCs_8)_2^+$ dimer also has a FM ground state like a Mn_2^+ dimer. A $(VCs_8)_3$ trimer has a triangular geometry with FM and frustrated AFM states within 0.08 eV of each other. Mn_3 also has a similar geometry, and FM and AFM states within 0.014 eV of each other. Based on these calculations we make the following general proposal. Atomic clusters having appropriate numbers of both localized and delocalized electrons in their valence space may be able to sustain magnetic moment (due to the localized electrons) while achieving enhanced stability due to an electron shell filling (due to the delocalized electrons). This gives rise to the possibility of designing hitherto unknown magnetic superatoms. We also propose VCs_8 cluster as the superatom analog of a Mn atom.

While VCs_8 behaves analogous to a Mn atom due to a filled shell configuration, VNa_9, VCs_9 etc. have a single electron in a new shell. This is similar to alkali atoms. Because the lone electron in a new shell is loosely bound to the nucleus, alkali atoms have low ionization potential (IP). By analogy, VNa_9 and VCs_9 clusters should also have low IP. This, indeed, turn out to be true in our DFT calculations. We also found that these clusters make strong ionic bonds with halogen atoms Cl, Br and I, forming alkali halide-like molecules that have an inherent magnetic moment (on the central V atom). VNa_9 and VCs_9 clusters, thus, behave like magnetic super-alkali, a completely new species of superatoms. We are now exploring if it is possible to combine these magnetic super-alkali clusters with halogen atoms to form magnetic super-alkali halide solids.

I am studying electronic and structural properties of small Au clusters de-

posited on the Si(001) surface, in collaboration with Dr. Bikash C Gupta of the Viswabharati University, Shantiniketan. In this project we have studied adsorption of Au, Au_2, Au_3 and Au_4 on the Si(001) surface. Most importantly, we discovered that a regular array of Au_3 clusters can drive the Si(001) surface from semiconducting to metallic. This have important implications of the electronics industry.

I am studying electronic, structural and magnetic properties of $3d$ TM-doped Ge clusters in collaboration with Dr. Debashis Bandyopadhyay of BITS, Pilani.

Publications

1. K. Pradhan, P. Sen, J. U. Reveles, and S. N. Khanna, *First Principles Study of TMNa_n Clusters (TM=Cr, Mn, Fe, Co, Ni; $n = 4 - 7$) clusters*, J. Phys. Cond. Mat. **20**, 255243, (2008).
2. S. Barman, P. Sen and G. P. Das, *Ti decorated doped silicon fullerene: a possible hydrogen storage material*, Ti decorated doped silicon fullerene: a possible hydrogen storage material **112**, 19963, (2008).

Preprints

1. J. U. Reveles, P. A. Clayborne, A. C. Reber, S. N. Khanna, K. Pradhan, P. Sen and M. R. Pederson, *Designer magnetic superatoms*, (submitted).
2. R. P. Bose, P. Sen and B. C. Gupta, *A density functional study of Au clusters adsorbed on Si(001): Formation of cluster lattice and a transition from non-metallicity to metallicity*, (in preparation).
3. D. Bandyopadhyay and P. Sen, *Study of structural and electronic properties of Ni-doped germanium clusters: A density functional investigation*, (in preparation).

Conference/Workshops Attended

1. *Asianano 2008*, Singapore; November 2008.
2. *Condensed Matter Workshop at IIT Kanpur*; February 2009.

Visits to other Institutes

1. Virginia Commonwealth University, Richmond VA, USA; July 2008.
2. North Carolina State University, Raleigh NC, USA; July 2008.
3. Viswabharati University, Shantiniketan; November 2008.
4. Indian Institute of Technology Kanpur, Kanpur; February 2009.

Invited Lectures/Seminars

1. *Tuning magnetic properties of atomic clusters through size and composition*,

Department of Physics, NC State University, Raleigh NC; July 2008.
2. *Unusual magnetism in two classes of materials: TM-alkali clusters and bulk alkali oxides*, Physics Colloquium, Department of Physics, Virginia Commonwealth University, Richmond VA; July 2008.
3. *Designing Materials Bottom-up: A recipe for Magnetic Superatoms*, Condensed Matter Workshop, IIT Kanpur, Kanpur; February 2009.

Other Activities

1. Organized a training workshop for local Garuda Grid users at HRI; April 2008.
2. Organized *International Symposium on Clusters, Cluster Assemblies and Nano-scale Materials*, February, 2009.
3. Acted as the nodal person at HRI for the Garuda Grid throughout the year.
4. Reviewed manuscripts for the journals *Physical Review B*, *Physical Review Letters* and *Applied Physics Letters*.
5. Was thesis examiner for Ms. Jayita Paul of JNCASR, Bangalore.

Tapas Kumar Das

I have been working on analytical aspects of black hole astrophysics, analogue gravity phenomena, dynamical systems and topological Hamiltonian dynamics.

Preprints

1. Bhattacharjee, J. K., Bhattacharya, A., Das, T. K., & Ray, A. K., *Quasi-viscous accretion flow – I: Equilibrium conditions and asymptotic behaviour*, Monthly Notices of the Royal Astronomical Society (To Appear).
2. Das, T. K., & Czerny, B., *Hysteresis effects and diagnostics of the shock formation in low angular momentum axisymmetric accretion in the Kerr metric*, Monthly Notices of the Royal Astronomical Society (Submitted).
3. Agarwal, S., Das, T. K., & Dey, R., *Transonicity in black hole accretion - A mathematical study using generalized Sturm chains*, Monthly Notices of the Royal Astronomical Society (Submitted).
4. Chakraborti, I., Barai, P., Das, T. K., & Wiita, P. J., *Behaviour of relativistic accretion close to the event horizon*, arXiv:0902.4093v1 [astro-ph.HE].

Visits to other Institutes

1. Theoretical Institute of Advanced Research in Astrophysics (TIARA), Hsinchu, Taiwan; March–May 2008.
2. Institute of Astronomy, Academia Sinica, Taipei, Taiwan; April, 2008.
3. National Central University, Chungli, Taiwan; April 2008.
4. National Chiao Tung University, Hsinchu, Taiwan; April, 2008.
5. Chulalongkorn University, Bangkok, Thailand; May, 2008.
6. Indian Institute of Astrophysics, Bangalore; October, 2008.
7. Vidyasgara College, Calcutta; December, 2009.
8. Indian Institute of Science, Bangalore; January, 2009.
9. National College, Bangalore; January, 2009.
10. Institute of Mathematical Sciences, Chennai; March, 2009.
11. Chennai Mathematical Institute, Chennai; March, 2009.

Invited Lectures/Seminars

1. Colloquium at Institute of Mathematical Sciences, Chennai, on 'Black Hole at your Bathtub'; March, 2009.
2. Seminar at Institute of Mathematical Sciences, Chennai, on 'Astrophysical accretion as an analogue gravity phenomena'; March, 2009.
3. Colloquium at Chennai Mathematical Institute, Chennai, on 'Black Hole at your Bathtub'; March, 2009.
4. Seminar at Institute of Mathematical Sciences, Chennai, on 'Accreting black hole as an analogue gravity model'; March, 2009.

5. Public Lecture organized by Navakarnataka Publications, at National College Bangalore, on 'Astrophysical Black Hole, a Current Perspective'; January, 2009.
6. Seminar at Indian Institute of Science, Bangalore, on 'Simulating Astrophysical and Cosmological Spacetime in Classical and Quantum Fluid'; January, 2009.
7. Invited lecture on the occasion to celebrate 100 years of Physics Department of Vidyasgara College on 'Astrophysical Black Holes: Laboratory to Test the Theory of Relativity'; December, 2008.
8. Seminar Indian Institute of Astrophysics, Bangalore, on 'Astrophysical Accretion as Analogue Gravity Phenomena'; October, 2008.
9. Special lecture at Indian Institute of Astrophysics, Bangalore, on 'Back Holes in Your Bathtub'; October, 2008.
10. Public lecture at SSGC (Summer School on Gravitation & Cosmology, held at HRI) on 'Emergent Spacetime in Classical & Quantum Flow'; May, 2008.
11. Lecture course at Department of Physics, Faculty of Science, Chulalongkorn University, Bangkok, Thailand, on 'Analogue gravity in classical and quantum fluid'; May, 2008.
12. Colloquium at the Astronomy Department, National Central University, Taiwan, on 'Black Hole Analogue in Astrophysics & Cosmology'; April, 2008.
13. Seminar at the Physics Department, National Central University, Taiwan, on 'Acoustic Black Holes'; April, 2008.
14. Seminar at the Physics Department, National Chiao Tung University, Taiwan, on 'Analogue Hawking Radiation'; April, 2008.
15. Seminar at Institute of Astronomy, Academia Sinica, Taipei, Taiwan, on 'Analogue Black Hole'; April, 2008.

Other Activities

1. Taught Graduate Course titled Astrophysical Processes (40 lectures) at HRI, August–December 2008.
2. Tutored course on General Relativity at *Summer School on Gravitation and Cosmology*, held at HRI during May 12–24, 2008.
3. Mentored three visiting students, Hardepinder Singhm, Ipsita Chakraborty, and Shilpi Agarwal (jointly with Rukmini Dey).

AseshKrishna Datta

During 2007–2008, I have been working mainly on the following areas:

- Systematic signal-based studies at the Large Hadron Collider (LHC) of physics beyond the Standard Model like Supersymmetry (SUSY), different extra-dimensional scenarios, scenarios of alternate electroweak symmetry breaking etc. These involve careful and precise studies of the distinctive features of various such scenarios that might help understand the nature of the new physics when some signal is observed at the LHC.
- Studies on techniques to determine the mass and the spin of the new particles that can be seen at the LHC.
- Streamlining the usage of the Monte Carlo event generators along with other software tools that are indispensable for LHC studies.

Publications

1. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Non-universal gaugino and scalar masses, hadronically quiet trileptons and the Large Hadron Collider,* Phys. Rev. D **78** (2008), 115018.
2. Priyotosh Bandyopadhyay, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Signatures of gaugino mass non-universality in cascade Higgs production at the LHC,* Phys. Lett. B **670** (2008), 5.
3. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Non-universal scalar masses: A Signal-based analysis for the Large Hadron Collider,* Phys. Rev. D **78** (2008), 035011.

Conference/Workshops Attended

1. *Instructional Workshop on the Large Hadron Collider (LHC) and Related Physics*; December, 2008.
2. Repeated invitations to attend the workshop "Physics of the Large Hadron Collider" held at KITP, Santa Barbara, USA during February–June, 2008. Could not attend due to a serious mistake made by the Regional Passport Office, Lucknow in my re-issued passport.

Visits to other Institutes

1. Visited the Theoretical Physics Group, Indian Association for the Cultivation of Science, Kolkata; June–July, 2008.

Invited Lectures/Seminars

1. Invited as a speaker to the International meeting on charged Higgs search at LHC (*Charged-2008*), held at University of Uppsala, Sweden in Septem-

ber, 2008. *Could not attend the same due to a serious mistake made by the Regional Passport Office, Lucknow in my re-issued passport*.
2. Invited as a speaker in the parallel session of "SUSY08" held in Seoul, Korea in June, 2008. *Could not attend the same for the reason mentioned above*.
3. Invited to visit the Theory Group, CERN during summer 2008 and *asked to speak* on my recent research interests. *Could not visit the same for the reason mentioned above*.
4. Invited to write a contributory article for the special volume on *Physics at the Large Hadron Collider*, to be published in commemoration of the Platinum Jubilee of the Indian National Science Academy (INSA). Invitation initially accepted but could not deliver.

Other Activities

1. Organising (along with my colleagues at HRI) a pedagogical school on the physics of the LHC held at IISER, Kolkata (jointly organised by Regional Centre for Accelerator-based Particle Physics (RECAPP), HRI and IISER, Kolkata; December, 2008.
2. Organising (along with my colleagues at HRI) a two-week long held at HRI under the auspices of RECAPP; September–October, 2008.
3. Gave a semester-long course on Classical Electrodynamics to the first-year graduate students; August-December, 2008.
4. As the Technical Coordinator of RECAPP, carried out works related to RECAPP's computational infra-structure.
5. Served as a referee for peer-reviewed national and international journals.

Manoj Gopalakrishnan

Bacterial chemotaxis: The common bacterium *E. Coli* is a motile organism, and moves in a series of straight runs and tumbles. The tumble frequency is tuned in response to chemo-attractant/repellant gradients in the environment, and the resulting biased motion is referred to as *chemotaxis*. In weak gradients, this motion can be described to a good approximation as a biased random walk, with a drift velocity proportional to the chemical concentration gradient. We studied chemotaxis in E. Coli using a reduced version of the famous Barkai-Leibler model of the signal transduction network, which reproduces the "perfect adaptation" property observed in E. Coli. Analytical forms were obtained for the adaptation-induced negative feedback and the chemotactic response function, and the latter was related to the drift velocity, in the limit of low background concentrations. Efforts are presently in progress to extend this study to arbitrary background concentrations and gradients.

Microtubules and motor proteins: In recent times, many motor proteins have been discovered which also act as depolymerizing agents for *microtubules*, an important class of dynamic sub-cellular filaments. Two such proteins are (a) MCAK belonging to kinesin-13 family and (b) Kip3p belonging to kinesin-8 family. While MCAK is a weakly binding, diffusing motor on the microtubule, Kip3p is a strongly binding "walking" motor, targeting the plus end of the filament. However, both motors use ATP hydrolysis to destabilize and depolymerize microtubules from the tip(s). We studied a model of surface binding, transport and depolymerization of microtubules by these motor proteins, and concluded that such motors may be selectively used by the cell to regulate microtubule lengths.

Chromosome search by microtubules in mitosis: The mitotic spindle is an important intermediate structure in eucaryotic cell division, in which each of a pair of duplicated chromosomes is attached through microtubules to centrosomal bodies located close to the two poles of the dividing cell. It is widely believed that the spindle starts forming by the 'capture' of chromosome pairs, held together by kinetochores, by randomly searching microtubules. We presented a complete analytical formulation of this problem, in the case of a single fixed target and for arbitrary cell size. A set of Green's functions for the microtubule dynamics and an associated set of first passage quantities were obtained from the theory. We extracted the conditions of optimized search from our formalism, and found that the cell size is an important factor in the optimization process. For small cell sizes, the search time is minimized when both catastrophe and rescue frequencies are small, while for large cells, the rescue frequency need to be close to zero, while the catastrophe frequency need to be around a certain optimal value. These conclusions are found to be in agreement with available experimental results for various cell types and existing theoretical results where applicable.

Publications

1. B. S. Govindan, M. Gopalakrishnan and D. Chowdhury *Length control of microtubules by depolymerizing motor proteins,* Europhys. Lett. **83** (2008), 40006-p1.

Preprints

1. M. Reneaux and M. Gopalakrishnan, *From random to directed motion: Understanding chemotaxis in E.Coli within a simplified model,* arXiv:0812.4583
2. M. Gopalakrishnan and B. S. Govindan, *Optimization strategies of chromosome search-and-capture by microtubules: exact analytical results for a single fixed target,* arXiv: 0904.0111

Conference/Workshops Attended

1. *Integrating Physics, Chemistry, Mathematics and Biology*, Bose Institute, Kolkata; December 2008.
2. *Disorder, Complexity and Biology*, Department of Physics, BHU, Varanasi; January 2009.

Visits to other Institutes

1. Tata Institute of Fundamental Research, Mumbai, India, May 2008.

Invited Lectures/Seminars

1. *Lectures on "Physics in Biology"*, Department of Biological Sciences, TIFR, Mumbai; May 2008.
2. *Olfactory signal transduction: how feedback controls noise*, Department of Theoretical Physics, TIFR, Mumbai; May 2008.
3. *From random to directed motion: Understanding chemotaxis in E. Coli*, IPCMB 2008, Bose Institute, Kolkata; December 2008.

Other Activities

1. Co-organized HRI Summer School on Biological Physics, June 2008.

Sandhya Choubey

Neutrinos are at the forefront of research in high energy physics today. Outstanding results over the last few years from the neutrino have provided the most undisputed signal of physics beyond the standard model (BSM). With the evidence of new physics established, the next frontier in neutrino physics involves better knowledge of neutrino parameters. This can then be used as requirement on the BSM and help to constrain and define it. Along with my collaborators, I have been actively involved in both the phenomenology of determining the low energy neutrino mass matrix from experimental observations, as well as looking for a consistent theory beyond the standard model.

Two very important sets of solar neutrino data were released last year. One was by the SNO experiment and the other by Borexino. We did a re-analysis to asses the impact of these solar results experiment and the recent 2.8 KTy KamLAND data on the solar neutrino oscillation parameters. The current Borexino results were found to have no impact on the allowed solar neutrino parameter space. The new KamLAND data causes a significant reduction of the allowed range of Δm^2_{21}, determining it with an unprecedented precision of 8.3% at 3σ. The precision of Δm^2_{21} is controlled practically by the KamLAND data alone. Inclusion of new KamLAND results also improves the upper bound on $\sin^2\theta_{12}$, but the precision of this parameter continues to be controlled by the solar data. The third mixing angle is constrained to be $\sin^2\theta_{13} < 0.063$ at 3σ from a combined fit to the solar, KamLAND, atmospheric and CHOOZ results. We also address the issue of how much further reduction of allowed range of Δm^2_{21} and $\sin^2\theta_{12}$ is possible with increased statistics from KamLAND. We find that there is a sharp reduction of the 3σ "spread" with enhanced statistics till about 10 KTy after which the spread tends to flatten out reaching to less than 4% with 15 KTy data. For $\sin^2\theta_{12}$ however, the spread is more than 25% even after 20 KTy exposure and assuming $\theta_{12} < \pi/4$, as dictated by the solar data. We show that with a KamLAND like reactor "SPMIN" experiment at a distance of ~ 60 km, the spread of $\sin^2\theta_{12}$ could be reduced to about 5% at 3σ level while Δm^2_{21} could be determined to within 4%, with just 3 KTy exposure.

The most important missing links in the program for the understanding the neutrino mass matrix include the third mixing angle θ_{13}, the CP phase δ_{CP} and the ordering of the neutrino mass spectrum, which will be known through measuring the $sgn(\Delta m^2_{31})$. In earlier papers along with Sanjib Agarwalla and Amitava Raychaudhuri, we had proposed an experimental set-up where a pure electron flavor neutrino beam could be sent from CERN to the detector at the India-based Neutrino Observatory (INO). The CERN-INO distance being the so-called "magic" baseline, ensures unprecedented sensitivity to two of the parameters mentioned above – θ_{13} and δ_{CP}. In a paper concluded last April, we examine the reach of a Beta-beam experiment with two detectors at carefully chosen baselines for exploring all three neutrino mass parameters, including δ_{CP}. Locating the source at CERN, the two detectors and baselines are: (a) a 50 kton iron calorimeter (ICAL) at a baseline of around 7150 km which is roughly the magic baseline, e.g., ICAL@INO, and (b) a 50

kton Totally Active Scintillator Detector at a distance of 730 km, e.g., at Gran Sasso. We choose 8B/8Li source ions with a boost factor γ of 650 for the magic baseline while for the closer detector we consider 18Ne/6He ions with a range of Lorentz boosts. We find that the locations of the two detectors complement each other leading to an exceptional high sensitivity. With $\gamma = 650$ for 8B/8Li and $\gamma = 575$ for 18Ne/6He and total luminosity corresponding to $5\times(1.1\times10^{18})$ and $5\times(2.9\times10^{18})$ useful ion decays in neutrino and antineutrino modes respectively, we find that our two detector set-up can probe maximal CP violation and establish the neutrino mass ordering if $\sin^2 2\theta_{13}$ is 1.4×10^{-4} and2.7×10^{-4}, respectively, or more. The sensitivity reach for $\sin^2 2\theta_{13}$ itself is 5.5×10^{-4}. With a factor of 10 higher luminosity, the corresponding $\sin^2 2\theta_{13}$ reach of this set-up would be 1.8×10^{-5}, 4.6×10^{-5} and 5.3×10^{-5} respectively for the above three performance indicators. CP violation can be discovered for 64% of the possible δ_{CP} values for $\sin^2 2\theta_{13} \geq 10^{-3}(\geq 8 \times 10^{-5})$, for the standard luminosity (10 times enhanced luminosity).

Collective flavor oscillations driven by neutrino-neutrino self interaction inside core-collapse supernovae have now been shown to bring drastic changes in the resultant neutrino fluxes. This would in turn significantly affect the diffuse supernova neutrino background (DSNB), created by all core-collapse supernovae that have exploded in the past. In view of these collective effects, we re-analyzed the potential of detecting the DSNB in currently running and planned large-scale detectors meant for detecting both electron neutrinos and antineutrinos. The next generation detectors should be able to observe DSNB fluxes. Under certain conducive conditions, one could learn about neutrino parameters. For instance, it might be possible to determine the neutrino mass hierarchy, even if θ_{13} is almost zero.

The final challenge is to understand the theory which generates the correct neutrino mass and mixing parameters. This challenge is two-fold. The first issue is to understand the smallness of the neutrino masses compared to the charged leptons and quarks. The next problem is to explain the peculiar mixing pattern of the neutrinos, which demand one mixing angle to be close to maximal, another close to zero and a third close to 35°. In a paper with my student Manimala Mitra, we showed that viable neutrino and charged lepton masses and mixings are obtained by imposing a $S_3\times Z_4\times Z_3$ flavor symmetry in a model with a few additional Higgs. We used two $SU(2)_L$ triplet Higgs which are arranged as a doublet of S_3, and standard model singlet Higgs which are also put as doublets of S_3. We break the S_3 symmetry in this minimal model by giving vacuum expectation values (VEV) to the additional Higgs fields. Dictated by the minimum condition for the scalar potential, we obtain certain VEV alignments which allow us to maintain $\mu - \tau$ symmetry in the neutrino sector, while breaking it maximally for the charged leptons. This helps us to simultaneously explain the hierarchical charged lepton masses, and the neutrino masses and mixings. In particular, we obtain maximal θ_{23} and zero θ_{13}. We allow for a mild breaking of the $\mu - \tau$ symmetry for the neutrinos and study the phenomenology. We give predictions for θ_{13} and the CP violating Jarlskog invariant J_{CP}, as a function of the $\mu - \tau$ symmetry breaking parameter. We

also discuss possible collider signatures and phenomenology associated with lepton flavor violating processes.

The most well accepted theory for naturally understanding the smallness of neutrino masses is the Seesaw mechanism. In the so-called Type-I variant of this scheme, the neutrino masses at low energy are generated by dimension five operators which appear when the heavy right-handed neutrino fields are integrated out from the Lagrangian. The neutrino mass term is hence suppressed by the heavy right-handed neutrino mass scale, and is therefore naturally light. For type I seesaw and in the basis where the charged lepton and heavy right-handed neutrino mass matrices are real and diagonal, four has been shown to be the maximum number of zeros allowed in the neutrino Yukawa coupling matrix Y_ν. These four zero textures have been classified into two distinct categories. We investigated the phenomenological consequences of these textures within a supersymmetric framework. This is done by using conditions implied on elements of the neutrino Majorana mass matrix for textures of each category in Y_ν. These conditions turn out to be stable under radiative corrections. Including the effective mass, which appears in neutrinoless double beta decay, along with the usual neutrino masses, mixing angles and phases, it is shown analytically and through scatter plots how restricted regions in the seesaw parameter space are selected by these conditions. We also make consequential statements on the yet unobserved radiative lepton flavor violating decays such as $\mu \to e\gamma$. All these decay amplitudes are proportional to the moduli of entries of the neutrino Majorana mass matrix. We also show under which conditions the low energy CP violation, showing up in neutrino oscillations, is directly linked to the CP violation required for producing successful flavor dependent and flavor independent lepton asymmetries during leptogenesis.

Publications

1. Sandhya Choubey, Werner Rodejohann, Probir Roy, *Phenomenological consequences of four zero neutrino Yukawa textures*, Nucl. Phys. B **808** (2009), 272.
2. Manimala Mitra, Sandhya Choubey, *Lepton Masses in a Minimal Model with Triplet Higgs and S(3) x Z(4) Flavor Symmetry*, Phys. Rev. D **78** (2008), 115014.
3. Sovan Chakraborty, Sandhya Choubey Basudeb Dasgupta, Kamales Kar, *Effect of Collective Flavor Oscillations on the Diffuse Supernova Neutrino Background*, JCAP **0809** (2008), 013.
4. Sanjib K. Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, *Exceptional Sensitivity to Neutrino Parameters with a Two Baseline Beta-Beam Setup*, Nucl. Phys. **B805**, 305, (2008).
5. Sandhya Choubey, Viviana Niro, Werner Rodejohann, *On Probing $\theta(23)$ in Neutrino Telescopes*, Phys. Rev. D **77** 2008, 113006.
6. Sandhya Choubey and D. Indumathi, *Working group report: Neutrino phy-*

sics, Pramana **72** (2009), 269.

Preprints

1. Abhijit Bandyopadhyay, Sandhya Choubey, Srubabati Goswami, S. T. Petcov, D. P. Roy, *Neutrino Oscillation Parameters After High Statistics KamLAND*, arXiv: 0804.4857
2. Sanjib K. Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, *Probing neutrino parameters with a Two-Baseline Beta-beam set-up*, arXiv: 0811.1828 [hep-ph].
3. Sanjib K. Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, CERN-INO *magical Beta-beam experiment: A high precision probe for neutrino parameters*, arXiv: 0811.1822 [hep-ph].

Conference/Workshops Attended

1. *Joint* UKNF, INO, UKIERI *meeting 2008*, Warwick, United Kingdom; April 2008.
2. *Neutrino and Beams*, Darjeeling, India, May 2008. *The XXIII International Conference on Neutrino Physics and Astrophysics*, New Zealand; May 2008.
3. *10th International Workshop on Neutrino Factories, Superbeams and Betabeams, NuFact08*, Valencia, Spain, July 2008.
4. *The 18th* DAE-BRNS *High Energy Physics Symposium*, BHU, Varanasi; December 2008.

Visits to other Institutes

1. University of Southampton, Southampton, United Kingdom; April 2008.
2. Saha Institute of Nuclear Physics, Kolkata; May 2008.

Invited Lectures/Seminars

1. *Long Baseline Neutrinos and* INO, Joint UKNF, INO, UKIERI meeting 2008, University of Warwick; April 2008.
2. *Neutrino Phenomenology: An Outlook*, Seminar, University of Southampton, Southampton, United Kingdom; April 2008.
3. *Neutrino Beams and* INO, Invited talk at "Neutrinos and Beams", Darjeeling; May 5-7, 2008.
4. *Working Group I: Theory*, 10th International Workshop on Neutrino Factories, Superbeams and Betabeams, NuFact08, Valencia, Spain; July 2008.
5. *Physics with the India-based Neutrino Observatory*, Invited plenary talk at "The 18th DAE-BRNS High Energy Physics Symposium", BHU, Varanasi; December 2008.
6. *Neutrino Oscillations: Status and Outlook*, Talk at NuHoRIzons09, HRI, Allahabad; January 2009.

7. *The India-based Neutrino Observatory*, seminar, MPI-K Heidelberg, Germany; May 2009.

Other Activities

1. Member of the organizing committee of "NuHoRIzons, Neutrinos in Physics, Astrophysics and Cosmology", held at HRI, Allahabad, January 2008.
2. Member of the National Organizing Committee, The 18th DAE-BRNS High Energy Physics Symposium, BHU, Varanasi, December 2008.
3. Convernor of the Neutrino Oscillation Physics (WG1) of the International Workshop on Neutrino Factories, Superbeams and Betabeams, NuFact08, Valencia, Spain, June, 2008.
4. Member of the Scientific Program Committee (SPC) and convenor of the "Current and Future Experiments" session at the "Sixth International Workshop on Neutrino-Nucleus Interactions in the Few-GeV Region", NUINT09, Sitges, Barcelona, Spain, May 2009.
5. Taught third semester course on "Computational Methods" in HRI.
6. Currently mentoring Ph. D. Students Manimala Mitra and Ram Lal Awasthi.
7. Mentored Project Students Kaushik Subramanian, University of Mysore and Shankha Banerjee, IIT Kharagpur.
8. Refereed papers for Physical Review D, Journal of High Energy Physics, Physica Scripta and New Journal of Physics.
9. Gave talk at HRI on Non-Standard Interaction Effects at Reactor Neutrino Experiments during pheno-lunch on October 21, 2008.
10. Served on HRI committees: Office and Furniture Committee (Convenor), Pantry (Convenor), HRIRA (Chair-person until August, member since then).

Tirthankar Roy Choudhury

My main research interests lie in the field of Cosmological reionization and the Intergalactic Medium. In recent times, I have been working on (i) constraining theoretical models of cosmological reionization by comparing them with a variety of observational data, (ii) understanding the topology of reionization at high redshifts $z > 6$ using semi-analytical methods and numerical simulations, (iii) models for detecting the signal from cosmological neutral hydrogen at $z > 6$ using maps of 21cm hyperfine transition, (iv) studying the intergalactic medium through Lyα forest at redshifts $z \sim 3$.

Publications

1. Tirthankar Roy Choudhury, Martin G. Haehnelt, John Regan, *Inside-out or outside-in: the topology of reionization in the photon-starved regime suggested by Lyα forest data*, Monthly Notices of the Royal Astronomical Society **394** (2009) 960.

Preprints

1. Tirthankar Roy Choudhury, *Analytical Models of the Intergalactic Medium and Reionization*, arXiv:0904.4596

Conference/Workshops Attended

1. *Cosmological evolution in diffuse baryons: Reionization epoch to the present day*, Orange County, Coorg, India, December 2008.
2. *From Black Holes to the Universe: Gravity at Work*, 25th IAGRG meeting, Saha Institute of Nuclear Physics, Kolkata, India, January 2009.

Invited Lectures/Seminars

1. *Probing the topology of reionization with 21 cm emission in the "photon-starved" scenario*, Invited talk in workshop on cosmological reionization, Coorg; December 2008.
2. *Cosmological Reionization*, Invited plenary talk in the 25th Meeting of the Indian Association for General Relativity & Gravitation, Saha Institute of Nuclear Physics, Kolkata; January 2009.

Other Activities

1. I guided HRI graduate student Sourav Mitra through a reading course on *Cosmological Large-scale Structure Formation* during January-May 2009.
2. I guided HRI graduate student Dhiraj Hazra for a project on *Constraints in matter power spectra from Lyman-α forest* during January–May 2009.

Sudipta Das

Cosmological observations suggest that about 70% of the total energy density of the universe is made up of an exotic form of matter, dubbed as 'dark energy', which generates some effective negative pressure and drives the late surge of accelerated expansion. Naturally a host of candidates have appeared in the literature which can provide this anti gravity effect. Recently a well-known sector of matter, namely the neutrino distribution, has also been proposed as a dark energy candidate. However, neutrinoes are normally considered to be the sector which *'feels'* the existence of dark energy and cannot really solve the problem by itself. In the present work, the neutrinoes have been treated completely classically and possibilities have been explored whether bulk viscous stresses in the neutrino distribution can generate sufficient effective negative pressure and drive the late time cosmic acceleration. The advantage of neutrinoes is that they are real objects and the method of detection is quite well conceived. The neutrinoes were decoupled from the background radiation quite early in the evolution when the temperature was as high as 3×10^{10} K. So the interaction of the neutrinos with other forms of matter can be neglected. In the first work a two component non-interacting matter sector has been employed, one being the normal cold dark matter and the other being a neutrino distribution endowed with bulk viscosity which produces a negative stress. It has been shown that neutrino bulk viscous stresses can indeed do the trick and can serve as a potential dark energy candidate. It has been found that a number of spatially flat FRW models with a negative deceleration parameter can be constructed using neutrino viscosity and one of them mimics a ΛCDM model. The model may appear to be a bit contrived, as the contribution of neutrino to the net density is quite low, but the amount of bulk viscous stress has to be quite high to drive the acceleration. But the model is able to produce a lot of features and can show the transition from decelerated to accelerated phase at present as well as gives a transition from a radiation to a matter dominated universe which took place in a distant past.

Also, the ratio of pressure to density for the dark energy component, referred to as the equation of state parameter ω_{de}, is given by $\omega_{de} = \frac{p_{de}}{\rho_{de}}$. Recent observations suggest that ω_{de} is close to -1. With future observational data, if ω_{de} continues to be around -1, then the most reasonable choice for dark energy will be a cosmological constant. However, if the observations predict a value close to -1, but not exactly equal to -1, dynamical dark energy models, like those which are driven by a scalar field can be an interesting option to look for. Such models usually depict the evolution of ω_{de} over time. This fact has recently been explored by many authors which examined the quintessence models as well as phantom dark energy models where the scalar field potentials satisfy the slow-roll conditions : $\left(\frac{1}{V}\frac{dV}{d\phi}\right)^2 << 1$ and $\frac{1}{V}\frac{d^2V}{d\phi^2} << 1$. The advantage of these models is that they provide a natural mechanism to produce an equation of state parameter ω_{de} slightly less than -1 at present. However the disadvantage of most of these scalar field models is that the quintessence

potentials do not have any sound field theoretic background explaining their genesis. So, it might appear more appealing to employ a scalar field which is already there in the realm of the theory. This is where non-minimally coupled scalar field models become crucial where the scalar field is not put in by hand, but is already there in the purview of the theory. In the second work we try to investigate dark energy models in non-minimally coupled theory of gravity, more precisely in BD theory. We write the equations in the conformally transformed version of the theory (so called Einstein frame) and try to obtain a general form of the equation of state parameter $\omega_\phi (\equiv \omega_{de})$ such that the scalar field potential satisfies the slow-roll conditions. To study this model, we have assumed that the coupling parameter between the matter and dark energy (which is related with BD parameter ω) is small. This ensures that our model does not deviate much from the standard Einstein gravity. In such a scenario, we show that all of them converge to a universal behaviour. We have also tested our model with the observational data from Sn Ia and BAO peak. Although to get strong bound on the equation of state, one needs to have strong independent observational constraint on $\Omega_{\phi 0}$, still inclusion of BAO data put a strong upper bound on $\omega_{\phi 0}$ irrespective of the value of the coupling parameter.

Preprints

1. Sudipta Das and Narayan Banerjee, *Can neutrino viscosity drive the late time cosmic acceleration?*, arXiv:0806.3666 [gr-qc]
2. Anjan A Sen, Gaveshna Gupta and Sudipta Das, *Non-Minimal Quintessence with Nearly Flat Potential*, arXiv:0901.0173 [gr-qc]

Conference/Workshops Attended

1. *Summer school in Cosmology,* ICTP, Trieste, Italy; July 21 – August 2 2008.
2. *Cosmology with CMB and LSS,* IUCAA, Pune; August 18 – 31 August 2008.
3. *4th Amal Kumar Raychaudhuri School on General Relativity,* SINP, Kolkata; October 15 – 25 2008. (Conducted tutorial classes for the cosmology course)
4. *The 25th* IAGRG *meeting - From Black Holes to the Universe:Gravity at Work*, SINP, Kolkata; January 28 – 31 2009.

Visits to other Institutes

1. IUCAA Reference Centre, Department of Physics, Jadavpur University, Kolkata; May 26 – June 23 2008.
2. Jamia Milia Islamia, New Delhi; June 24 – 27 2008.

Invited Lectures/Seminars

1. *Aspects of Quintessence Matter - The Driver of the Late Time Acceleration of*

the Universe , 25th IAGRG meeting, Saha Institute of Nuclear Physics, Kolkata; January 2008.

Academic recognition/Awards

1. Won the V. V. Narlikar Best Thesis Award competition held during the 25th IAGRG meeting (2009).

Abhijit Samanta

We have studied the prospects of the Iron CALorimeter (ICAL) detector at India-based Neutrino Observatory (INO) by simulation. We have generated neutrino events by neutrino event generator Nuance and then studied the detector response through detector simulation package GEANT-4. We have studied the recent important issues of neutrino physics at this detector like mass hierarchy determination, precision of oscillation parameters and the possibility to observe CP violation in leptonic sector.

We have also studied the role and detectability of the charm contribution to ultra high energy neutrino fluxes at ICECUBE detector.

Publications

1. A. Samanta *"A comparison of the sensitivities of the parameters with atmospheric neutrinos for different analysis methods"*, Phys. Rev. D **79** 053011 (2009).
2. A. Samanta *"The mass hierarchy with atmospheric neutrinos at INO"*, Phys. Lett. B **673** 37 (2009)

Preprints

1. R. Gandhi, A. Samanta and A. Watanabe *"The Role and Detectability of the Charm Contribution to Ultra High Energy Neutrino Fluxes"*, arXiv:0905.2483 [hep-ph]
2. A. Samanta *"Exceptional sensitivities of neutrino mixing parameters with atmospheric neutrinos"*, arXiv:0812.4639 [hep-ph]

Conference/Workshops Attended

1. INO simulation meeting, IMSc; August 27–30 2008.
2. INO-KEK meeting, TIFR; January 28–29 2009.
3. "Aspects of Neutrinos", Goa; April 8–15 2009.

Invited Lectures/Seminars

1. *Sensitivity to neutrino mixing parameters with atmospheric neutrinos at* INO, "Aspects of Neutrinos", International Center for Theoretical Sciences, TIFR, Goa; April 2009.

Other Activities

1. We set up a new cluster computational facility with 16 nodes under neutrino physics project.

Sashideep Gutti

Work is in progress on the topic "Quantum Gravitational Collapse in the Lemaitre-Tolman-Bondi (LTB) model with a positive cosmological constant". Previous re-search work dealt with quantization of LTB models in the context of the cosmologi- cal constant being zero and negative. We extend the study to the case of a positive cosmological constant. Our goal is to arrive at the Wheeler-deWitt equation and present the explicit solution. We make use of the solutions to give an interpretation to the Hawking radiation in the context of the canonical quantization approach fol- lowed by us. We derive the Hawking radiation from both the cosmological horizon and the black hole horizon that occur in the Schwarzschild-deSitter spacetime. The work is done in collaboration with Ms. Anne Franzen, Prof. Claus Kiefer (University of Cologne, Germany).

Work is being done in collaboration with Dr. L. Sriramkumar and Dr. Raghavan Rangarajan (PRL). The work involves deriving the renormalized Green's function for the massless minimally coupled scalar field propagating in the background of deSitter spacetime expressed in flat coordinate system. We use the method of Adiabatic Subtraction to arrive at the renormalized Green's function. The Green's function for the case discussed above has been calculated using different renormalization methods in the existing literature. There is an ambiguity with regard to the correct expressions for the Green's function derived using various approaches. We re-derive the expression using the method of Adiabatic Subtraction in order to arrive at the correct expression for the Green's function.

Preprints

1. Anne Franzen, Sashideep Gutti, Claus Kiefer,*Quantum Gravitational Collapse in the Lemaitre-Tolman-Bondi (LTB) model with a positive cosmological constant*, (in preparation).

Conference/Workshops Attended

1. *Indian Association For General Relativity and Gravitation-25*; January 2009.

Invited Lectures/Seminars:

1. *Quantum Gravitational Collapse and Hawking Radiation in the presence of a positive cosmological constant*, IAGRG-25, SINP; January 2009.

Suvrat Raju

My research in this academic year, focused on on-shell methods in quantum field theory. It has recently been discovered that perturbative gauge-theory amplitudes satisfy remarkable properties. This has led to the development of new on-shell techniques for calculating the S-matrix in quantum field theory. One part of my work focused on extending these techniques to a simple example of non-local theories – non-commutative quantum field theories. The S-matrix for this theory has very different analytic properties from that of ordinary quantum field theories but I showed that it is still possible to use on-shell techniques to calculate amplitudes in this theory.

With Shailesh Lal, I also worked on a study of the analytic properties of gauge theories with $\mathcal{N} = 1$ and $\mathcal{N} = 2$ supersymmetry. The S-matrix of the $\mathcal{N} = 4$ Yang-Mills theory, has very distinctive analytic properties. However, we found that the analytic properties of $\mathcal{N} = 1, 2$ theories (with or without matter) resembled those of non-supersymmetric Yang-Mills theory rather than the $\mathcal{N} = 4$ theory.

Publications

1. Suvrat Raju, *The Noncommutative S-Matrix*, JHEP **06** 5 (2009)

Preprints

1. Shailesh Lal and Suvrat Raju, *The Next-to-Simplest Quantum Field Theories?*, HRI/ST/0911, TIFR/TH/09-08

Conference/Workshops Attended

1. Indian Strings Meeting, Pondicherry; December 2008.
2. Cargese Summer School and Workshop, France; June 2008.

Visits to other Institutes

1. Tata Institute of Fundamental Research, Mumbai; December 2008.
2. Tata Institute of Fundamental Research, Mumbai; March 2009.

Invited Lectures/Seminars

1. *The Non-Commutative S-matrix*, Indian Strings Meeting, Pondicherry; December 2008.
2. *On-shell methods for Quantum Field Theory*, Tata Institute of Fundamental Research, Mumbai; December 2008.
3. *Black-Hole Entropy and AdS/CFT*, Jawaharlal Nehru University, Delhi; August 2008.

Akitsugu Miwa

We studied the gauge/gravity correspondence by focusing on the relation between the Wilson loop operator and it's gravity dual in two different systems. The first system was the four-dimensional supersymmetric Yang-Mills theory, in which the expectation value of the circular Wilson loop is calculable by means of a Gaussian matrix model. We derived the resolvent of the matrix model to the next leading order with respect to $1/N$. Then, based on the gauge/gravity correspondence, we succeeded in finding the gravity dual of an eigenvalue of the matrix model. The second system is the one-dimensional supersymmetric Yang-Mills theory, which is related to the first system through a dimensional reduction. We studied the system in finite temperature cases. In such cases, because of the less symmetry, the analytical computation of the expectation value of the Wilson loop in strong coupling regime becomes difficult. So, we used the Monte Carlo calculation method which was proposed recently. In the method, we first fix the gauge symmetry non-perturbatively and then introduce a Fourier mode cutoff. By computing the expectation value of the Wilson loop, we found that it beautifully agrees with the semi-classical propagator of a string world sheet in the curved spacetime background. Physically, our observation suggests that the black hole horizon is produced around the length scale of the open string fluctuation.

Preprints

1. Masanori Hanada, Akitsugu Miwa, Jun Nishimura, Shingo Takeuchi, *Schwarzschild radius from Monte Carlo calculation of the Wilson loop in supersymmetric matrix quantum mechanics,* arXiv:0811.2081.
2. Shoichi Kawamoto, Tsunehide Kuroki, Akitsugu Miwa, *Boundary condition for D-brane from Wilson loop, and gravitational interpretation of eigenvalue in matrix model in AdS/CFT correspondence,* arXiv:0812.4229.

Conference/Workshops Attended

1. *Indian Strings Meeting* ; December 2008
2. *JPS annual meeting* , Japan; March 2009.

Visits to other Institutes

1. Kyoto University, Kyoto, Japan; March 2009,
2. Tokyo University, Tokyo, Japan; March 2009.

Bobby Ezhuthachan

During this period, I was mostly involved in computing higher derivative corrections to the Bagger-Lambert-Gustavsson (BLG) theory. At the two derivative level, BLG had already shown that $\mathcal{N} = 8$ supersymmetry and $SO(8)$ R-Symmetry was equivalent to having a 3-algebra structure in the action, which basically meant that the action is built out of certain building block terms. Our procedure was to assume that this result holds at the higher order as well, and then write down the most general action consistent with $SO(8)$ R-Symmetry, $\mathcal{N} = 8$ Supersymmetry as well as the three algebra structure. The various coefficients appearing in front of the various terms are then fixed by demanding that this action reduces to the known correction to the D-brane action, in the appropriate limit. We showed that this procedure uniquely fixes the action.

Publications

1. Bobby Ezhuthachan, *The Power of the Higgs Mechanism: Higher-Derivative BLG Theories*, JHEP **0904** 101 (2009)

Conference/Workshops Attended

1. *Indian Strings Meeting (ISM08)*; December 2008.
2. *Kanha workshop on String theory and Fundamental Physics*; February 2009.

Visits to other Institutes

1. Institute Of Physics, Bhubhaneswar; March 2009.

Invited Lectures/Seminars

1. *The Four derivative BLG action*, String Theory and Fundamental Physics, TIFR, Kanha National Park, February 2009.
2. *The Power Of the Higgs Mechanism: Higher Derivative BLG Theories* IOP Internal Seminar, IOP, Bhubhaneswar; March 2009.

Jaswant Kumar

I joined Harish Chandra Research Institute on December 15, 2008 as a Post Doctoral Fellow in Physics. Since then I have been working in the areas of *Galaxy Formation and Evolution* as well as *Fractal Analysis of Distribution of Large Scale Structures*. In this regard, I, along with Girish Kulkarni and Jasjeet Singh Bagla, have written a computer code that constructs a Halo Merger Tree and then helps in the identification of galaxy positions in the Halo. For this purpose we have used the outputs of large cosmological N-Body Simulations performed by Nishikant Khandai and Jasjeet. We are now in the process of performing a semi analytic prescription of the processes governing galaxy formation.

On the fractal analysis side we have performed a fractal analysis of the new data release of the Sloan Digital Sky Survey. We have performed this analysis to verify our earlier similar work with the smaller data set. Here we have used data from the data release 6 of the SDSS and found that the distribution of galaxies in the Universe is homogeneous on the scales bigger than about $70\,h^{-1}Mpc$. We have also compared our results of fractal analysis of SDSS data with a similar analysis of the data from dissipationless N-Body Simulations as well as data from semi analytic models of galaxy distribution.

I, along with Nishikant and Jasjeet, have also performed a fractal analysis of large volume simulation to study the behavior of fractal dimension over a range of scales. Here we have calculated the contribution to fractal dimension due to small number density as well as clustering present in the distribution of points. We have also reported expected error in the deviation of fractal dimension from the dimension of the ambient space in which particles are distributed.

Preprints

1. Jaswant Yadav, Nishikant Khandai and J. S. Bagla, *"On the fractal Dimension and Scale of Homogeneity"*, (In Preparation)
2. Prakash Sarkar, Jaswant Yadav, B. Pandey & S. Bharadwaj, *"An examination of large scale clustering in SDSS DR6"*, (In Preparation)

Paramita Dey

In a recent collaboration with A. Kundu and B. Mukhopadhyaya, we consider an extension of the scalar sector of the Standard Model with a single complex Higgs triplet X. Such extensions are the most economic, model-independent ways of generating neutrino masses through triplet interactions. We show that a term like $a_0 \Phi\Phi X^\dagger$ must be included in the most general potential of such a scenario in order to avoid a massless neutral physical scalar. We also demonstrate that a_0 must be real. As a result, any additional source of CP-violation is ruled out. We then examine the implications of this term in the mass matrices of the singly-and doubly-charged scalar, neutral scalar and pseudoscalar fields. We find that for small values of a_0/v_2, where v_2 is the triplet VEV, the spectrum allows the decay of heavier scalars into lighter ones via gauge interactions. For large a_0/v_2, the doubly-charged, singly-charged and neutral pseudoscalar bosons become practically degenerate, while the even-parity neutral scalars remain considerably lighter, thus emphasizing the possibility of decay of the singly-charged or neutral pseudoscalar states into the neutral scalars. We also study the couplings of the various physical states in this scenario. For small values of $|a_0|/v_2$, we find the lightest neutral scalar field to be triplet-dominated, and thus having extremely suppressed interactions with fermion as well as gauge boson pairs.

In a collaboration with A. Kundu, B. Mukhopadhyaya and S. Nandi, our attempt has been to reconcile large trilinear R-parity violating interactions in a supersymmetric (SUSY) theory with the observed pattern of neutrino masses and mixing. We show that, with a restricted number of such interaction terms with the λ'-type couplings in the range $0.1 - 1.0$, it is possible to forbid one-loop contributions to the neutrino mass matrix. We computed the two-loop contributions in such cases, and found that they generate the neutrino masses in the requisite order. In addition, they also lead us to specific allowed regions of the parameter space. In particular, the minimal choice of free parameters, motivated by recent results on D_s decay, appears to favour the normal hierarchy scenario over the ones with inverted hierarchy and degenerate neutrino masses. Thus the rich phenomenology associated with large R-parity violating couplings does not pose a contradiction to the mechanism of neutrino mass generation.

In a collaboration with S. K. Gupta and B. Mukhopadhyaya, we explored the possibility of heavy neutrino dark matter in the Littlest Higgs Model with T-parity (LHT). In the LHT model there is a region in the parameter space where a heavy neutrino is the lightest T-odd particle LTP. This territory of the LHT model has not been probed in detail before, and the extant studies generally address the more "common" possibility of the T-odd photon to be the LTP. In our study, having emphasized that the heavy neutrino LTP corresponds to a sizable region in the parameter space of the theory, we show that both the Cryogenic Dark Matter Search (CDMS) and Xenon10 experiments disallow the entire region where LHT can have some relevance in stabilising the electroweak scale. Therefore, any observation of the signals of a heavy neutrino LTP is likely

to seriously reopen the issue of cold dark matter in the universe.

The Randall-Sundrum model of warped geometry in a five-dimensional scenario, aimed at explaining the hierarchy between the Planck and electroweak scales, is intrinsically unstable in its minimal form due to negative tension of the visible brane. A proposed solution to the problem yields a negative cosmological constant in four dimensions. In a collaboration with B. Mukhopadhyaya and S. Sengupta, we show that this wrong-sign cosmological constant is restricted to small values, therefore requiring less cancellation from hitherto unknown physics, if bulk neutrinos are postulated to explain the observed neutrino mass pattern. Thus neutrino masses, a stable TeV-brane configuration and new physics in the context of the cosmological constant get rather suggestively connected by the same thread.

In a collaboration with S. Bhattacharya and B. Mukhopadhyaya, we investigate the possibility of unitarity violation in the sequential neutrino mixing matrix in a scenario with extra compact spacelike dimensions. Gauge singlet neutrinos are assumed to propagate in one extra dimension, giving rise to an infinite tower of states in the effective four-dimensional theory. It is shown that this leads to small lepton-number violating entries in the neutrino mass matrix, which can violate unitarity on the order of one per cent.

Publications

1. P. Dey, A. Kundu and B. Mukhopadhyaya, *Some consequences of a Higgs triplet*, J. Phys. **G36** (2009) 025002
2. P. Dey, A. Kundu, B. Mukhopadhyaya and S. Nandi, *Two-loop neutrino masses with large R-parity violating interactions in supersymmetry*, JHEP **0812** (2008) 100
3. P. Dey, S. K. Gupta and B. Mukhopadhyaya, *The impossibility of heavy neutrino dark matter in the Littlest Higgs Model with T-parity: constraints from direct search*, Phys. Lett. **B674** (2009) 188

Preprints

1. P. Dey, B. Mukhopadhyaya and S. Sengupta, *Neutrino masses, the cosmological constant and a stable universe in a Randall-Sundrum scenario*, arXiv: 0904.1970
2. S. Bhattacharya, P. Dey, B. Mukhopadhyaya, *Unitarity violation in sequential neutrino mixing in a model of extra dimensions*, arXiv: 0907.0099
3. P. Dey, P. Ghosh, B. Mukhopadhyaya and S. Roy, *One-loop corrected neutrino mass in certain extensions of the minimal supersymmetric standard model*, (in preparation)

Conference/Workshops Attended

1. *Neutrinos in Physics, Astrophysics and Cosmology (*NuHoRIzons*)*; Febru-

ary 2008
2. *Workshop on the* LHC *and Related Physics*; September – October 2008
3. *Instructional Workshop on* LHC *Physics*; December 2008
4. *Neutrinos in Physics, Astrophysics and Cosmology (NuHoRIzons)*; January 2009
5. *Topical Meeting on Beyond the Standard Model Physics at the LHC (*BSMLHC-2009*)*; January 2009
6. *Getting Ready for Physics at the* LHC; February 2009.

Visits to other Institutes

1. Calcutta University, Kolkata; May–June 2008
2. Calcutta University, Kolakata; October 2008,
3. Institut für Theoretische Physik E (RWTH), Aachen, Germany; October 2008
4. Institut für Theoretiche Physik und Astronomie (Universität Wuerzburg), Wuerzburg, Germany; October 2008
5. Theoretical Physics Department Fermilab, Illinois, USA; November 2008
6. Michigan State University, Michigan, USA; November 2008
7. University of Maryland, Maryland, USA; November 2008
8. Bartol Research Institute, Delaware, USA; November 2008
9. University of Florida (Gainesville), Florida, USA; November 2008
10. Oklahoma State University, Stillwater, USA, November–December 2008
11. Indian Association for the Cultivation of Science, Kolkata; January–February 2009

Invited Lectures/Seminars

1. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Workshop on the LHC and Related Physics, Regional Centre for Accelerator-based Particle Physics (RECAPP), Harish-Chandra Research Institute, Allahabad; September 2008.
2. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Institut für Theoretische Physik E, RWTH, Aachen, Germany; October 2008.
3. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Institut für Theoretiche Physik und Astronomie (Universitaet Wuerzburg), Wuerzburg, Germany; October 2008.
4. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Fermilab, Illinois, USA; November 2008.
5. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Michigan State University, Michigan, USA; November 2008.
6. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, University of Maryland, Maryland, USA; November 2008.

7. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Bartol Research Institute (University of Delaware), Delaware, USA; November 2008.
8. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, University of Florida (Gainesville), Florida, USA; November 2008.
9. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Oklahoma State University, USA; November–December 2008.
10. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Neutrinos in Physics, Astrophysics and Cosmology (NuHoRIzons), Harish-Chandra Research Institute, Allahabad; January 2009.
11. *Two-loop Neutrino Masses with Large R-parity Violating Interactions in Supersymmetry*, Indian Association for the Cultivation of Science, Kolkata; February 2009.
12. *Neutrino masses, the cosmological constant and a stable universe in a Randall-Sundrum scenario*, Indian Institute of Science, Bangalore; April 2009.

Academic recognition/Awards

1. The paper, *Some consequences of a Higgs triplet*, P. Dey, A. Kundu and B. Mukhopadhyaya J. Phys. **G36** (2009) 025002 has been selected for inclusion in IOP Select (`http://select.iop.org`).

Harvinder Kaur Jassal

Accelerated expansion of the universe requires either a cosmological constant or some form of dark energy to drive the acceleration. Although a cosmological constant is a simpler solution from a phenomenological point of view, there is no natural explanation of the small observed value. This has inspired theorists to develop toy models where a field, typically a scalar field provides the source of dark energy. All such models require fine tuning in order to ensure transition to a dark energy dominated universe at $z \sim 0.5$. A distinctive feature of these models as compared to the cosmological constant is that the equation of state changes with time and it is in general different from -1. In absence of significant spatial variations in these fields, this is the only difference between cosmological constant and other models of dark energy. Current observations do not rule out $w = -1$, thus observational evidence for a varying equation of state will be of great significance.

The assumption that the distribution of dark energy with equation of state parameter not equal to -1 is homogeneous at all length scales is inconsistent with the observational fact that dark matter is distributed inhomogeneously. Therefore, one needs to consider perturbations in dark energy. We find that on length scales comparable to or greater than the Hubble radius, the perturbation in dark energy can become comparable to perturbations in matter. For this study, we have chosen parameters which are allowed by measurements of distance, namely supernova data and CMB data. Given this range, the evolution of perturbations differs significantly. For smaller scales, i.e. scales less than $1000\,\mathrm{Mpc}$, the perturbation in dark energy can be neglected in comparison with the perturbation in matter at least in the linear regime. In other words, at these scales we can consider dark energy component to be homogeneous. We have demonstrated this using an exponential potential for the quintessence field. We have further demonstrated that quintessence dark energy results in suppression of matter power spectrum relative to the cosmological constant model.

Dark energy perturbations in fluid models suppress matter perturbations as compared to the corresponding smooth dark energy model. Matter perturbations are suppressed as compared to the cosmological constant model. As long as the sound speed is positive the evolution of matter perturbations is indistinguishable from a smooth dark energy model. This is true for scales smaller then the Hubble radius. Dark energy perturbations in the fluid model emulate perturbations in the scalar field model at scales smaller than the Hubble radius, however there are differences at larger scales. In order to make predictions for observations at these scales, the fluid model is inadequate and exact calculations are required.

Extending an earlier work on constraining dark energy parameters using supernova data and WMAP first year data, we did a detailed analysis using the updated WMAP five year data. We show theoretically that the main constraint from CMB data arises from the size of the Hubble radius at the last scattering surface and not from the angular diameter distance. Using a modified version

of the Markov chain Monte Carlo method, we show that CMB data constrains dark energy parameters better than the Supernova data.

Publications

1. S. Unnikrishnan, H. K. Jassal and T. .R. Seshadri, *Scalar field dark energy perturbations and their scale dependence*, Phys. Rev. **78** (2008) 123504 (2008)

Preprints

1. H. K. Jassal, *A comparison of perturbations in fluid and scalar field models of dark energy*, arXiv:0903.5370 [astro-ph.CO].

Conference/Workshops Attended

1. Cosmology with CMB and LSS, Inter-University Centre for Astronomy and Astrophysics, Pune; August 2008.
2. SERC school on THEP, S.G.T.B. Khalsa College, University of Delhi, Delhi; September 2008.
3. Workshop on radiation matter interaction under extreme conditions, Benaras Hindu University, Varanasi; December 2008.

Invited Lectures/Seminars

1. Guest faculty at SERC school on THEP, S.G.T.B. Khalsa College, University of Delhi, Delhi; September 2008.

Andreas Nyffeler

My field of research is phenomenological particle physics. I work on precision tests of the Standard Model and on new physics models in the TeV region. I am particularly interested in the analysis of the electroweak symmetry breaking sector in the Standard Model and its extensions and in the low-energy structure of the strong interactions.

I have been mostly working, together with Fred Jegerlehner (Humboldt University and DESY Zeuthen, Germany), on a review article on the anomalous magnetic moment of the muon (to appear in Physics Reports). We reviewed in detail the theory of the anomalous moments of the electron and the muon which are likely the most precisely measured quantities in particle physics. After a brief description of the principle of the Brookhaven muon $g-2$ experiment, we presented a review of the status of the theoretical prediction for a_μ and in particular discussed the role of the hadronic vacuum polarization effects and the hadronic light-by-light scattering correction, including a new evaluation of the dominant pion-exchange contribution. In the end, we found a 3.2 standard deviation discrepancy between experiment and Standard Model prediction. This is the largest "established" deviation from the Standard Model seen in a "clean" electroweak observable and thus could be a hint for New Physics to be around the corner. We also presented a number of examples of how extensions of the Standard Model (like Supersymmetry, Extra Dimensions or Little Higgs models) would change the theoretical prediction of the muon $g-2$. Perspectives for future developments in experiment and theory were briefly discussed and critically assessed.

Recently it was pointed out that for the evaluation of the numerically dominant pion-exchange contribution to the hadronic light-by-light scattering correction in the muon $g-2$, a fully off-shell pion-photon-photon form factor should be used. Following this proposal, I derived a new short-distance constraint on the off-shell form factor which enters at the external vertex for the muon $g-2$ and showed that it is related to the quark condensate magnetic susceptibility in QCD. I then evaluated the pion-exchange contribution in the framework of large-N_C QCD using an off-shell form factor which fulfills all short-distance constraints. With a value for the magnetic susceptibility as estimated in the same large-N_C framework, I obtained the result $a_\mu^{\mathrm{LbyL};\pi^0} = (72 \pm 12) \times 10^{-11}$. Updating my earlier results for the contributions from the exchanges of the η and η' using simple VMD form factors, I obtained $a_\mu^{\mathrm{LbyL;PS}} = (99 \pm 16) \times 10^{-11}$ for the sum of all light pseudoscalars. Combined with available evaluations for the other contributions to hadronic light-by-light scattering this leads to the new estimate $a_\mu^{\mathrm{LbyL;had}} = (116 \pm 40) \times 10^{-11}$.

Publications

1. A. Belyaev, I. A. Christidi, A. De Roeck, R. M. Godbole, B. Mellado, A. Nyffeler, C. Petridou, D. P. Roy, *Dictionary of LHC Signatures*, Pramana **72**

229 (2009)
2. A. Nyffeler, *Hadronic light-by-light scattering in the muon $g-2$: a new short-distance constraint on pion-exchange,* Phys. Rev. D **79** 073012 (2009)

Preprints

1. F. Jegerlehner and A. Nyffeler, *The Muon $g-2$,* arXiv:0902.3360 [hep-ph] (to appear in Physics Reports)

Conference/Workshops Attended

1. *Little Higgs at the LHC* and *Electroweak Fit without a light Higgs boson: The Electroweak Chiral Lagrangian*, RECAPP Workshop, Allahabad; September–October 2008
2. *The Hadronic Light-by-Light Scattering Contribution to the Muon $g-2$*, Strong Frontier 2009, Bangalore; January 2009
3. *International Workshop Getting Ready for Physics at the LHC*, Allahabad; February 2009

Visits to other Institutes

1. DESY, Zeuthen, Germany; June 2008.
2. ETH, Zürich, Switzerland; June 2008.
3. University of Bern, Switzerland; June 2008.

Invited Lectures/Seminars

1. *Little Higgs at the LHC*, DESY, Zeuthen, Germany; June 2008.

Other Activities

1. Pheno lunch talk *UV Completions of Little Higgs models with T-parity* (based on arXiv:0803.4202 [hep-ph] and 0804.0622 [hep-ph]), April 2008.
2. I helped in the organization of the RECAPP Workshop on "LHC and Related Physics", held at HRI in September-October 2008.
3. I was heavily involved in the organization of the RECAPP Workshop "Getting Ready for Physics at the LHC", HRI; February 2009.
4. I supervised three Visiting Students on an "Introduction in Quantum Mechanics"; October – November 2008.
5. I supervised two Graduate Students Projects; January – March 2009.
   (a) Little Hierarchy Problem and Decoupling Theorem
   (b) Electroweak Precision Tests
6. Pheno lunch talk *Search for the Higgs boson at the Tevatron* (based on arXiv: 0903.4312 [hep-ex], 0903.4312 [hep-ph] and 0901.2427 [hep-ph]); March 2009.

Konar Sushan

The single glitch observed in *PSR B1821-24*, a millisecond pulsar in *M28*, is unusual on two counts. First, the magnitude of this glitch is at least an order of magnitude smaller ($\Delta\nu/\nu \sim 10^{-11}$) than the smallest glitch observed to date. Secondly, all other glitching pulsars have strong magnetic fields with $B < 10^{11}\ G$ and are young, whereas *PSR B1821-24* is an old recycled pulsar with a field strength of $2.25 \times 10^9\ G$. In an earlier work we have proposed that some of the recycled pulsars could actually be strange quark stars. Now we show that the crustal properties of such strange recycled pulsars are just right to give rise to a glitch like that in *B1821-24*.

Millisecond pulsars are more numerous in globular clusters than in the galactic disc, due to the prevalence of binaries in the globular clusters. Recent observations indicate that the millisecond pulsars in the globular cluster may have somewhat different evolutionary history than those in the galactic disc, as the two populations differ in many characteristic properties. We investigate the nature of this difference by looking at the binary evolution scenarios in the globular clusters. Work in progress.

Publications

1. Manjari Bagchi, Jishnu Dey, Sushan Konar, Gour Bhattacharya and Mira Dey, *Members of the double pulsar system PSR J0737-3039 : neutron stars or strange stars*, New Astron. **14** 37 (2009).
2. Zdenek Stuchlik, Sushan Konar, John C. Miller, Stanislav Hledik, *Gravitational excitation of high frequency QPOs*, Astron. & Astrophys. **489** 963 (2008).

Preprints

1. Raka Dona Ray Mandal, Sushan Konar, Mira Dey, Jishnu Dey, *The microglitch in PSR B1821-24 : A case for a strange pulsar?*, arXiv:0904.2559.
2. Sushan Konar, *Trends in pulsar current : Millisecond pulsars in galactic disc and globular clusters* (in preparation)

Rajeev Kumar Jain

During the last year, my research work has been focused on investigating the following two issues in inflationary cosmology and reheating:

1. Reheating and its effects on the large scale curvature perturbations
2. The tensor-to-scalar ratio in 'punctuated inflationary scenarios'

I have briefly described these issues below.

Reheating and its effects on the large scale curvature perturbations: We investigate the problem of perturbative reheating and its effects on the evolution of the curvature perturbations in tachyonic inflationary models. We derive the equations governing the evolution of the scalar perturbations for a system consisting of a tachyon and a perfect fluid. Assuming the perfect fluid to be radiation, we solve the coupled equations for the system numerically and study the evolution of the perturbations from the sub-Hubble to the super-Hubble scales. In particular, we analyze the effects of the transition from tachyon driven inflation to the radiation dominated epoch on the evolution of the large scale curvature and non-adiabatic pressure perturbations. We consider two different potentials to describe the tachyon and study the effects of two possible types of decay of the tachyon into radiation. We plot the spectrum of curvature perturbations at the end of inflation as well as at the early stages of the radiation dominated epoch. We find that reheating does not affect the amplitude of the curvature perturbations in any of these cases. These results corroborate similar conclusions that have been arrived at earlier based on the study of the evolution of the perturbations in the super-Hubble limit. We illustrate that, before the transition to the radiation dominated epoch, the relative non-adiabatic pressure perturbation between the tachyon and radiation decays in a fashion very similar to that of the intrinsic entropy perturbation associated with the tachyon. Moreover, we show that, after the transition, the relative non-adiabatic pressure perturbation dies down extremely rapidly during the early stages of the radiation dominated epoch. It is these behaviors which ensure that the amplitude of the curvature perturbations remain unaffected during reheating. We also discuss the corresponding results for the popular chaotic inflation model in the case of the canonical scalar field.

The tensor-to-scalar ratio in punctuated inflationary scenarios: Scalar spectra which exhibit a sharp drop in power at length scales corresponding to the Hubble radius today are known to lead to a better fit of the observed Cosmic Microwave Background (CMB) anisotropies, when compared to the conventional, featureless, power law spectrum. Recently, we have shown that scalar spectra with lower power on large scales naturally occur in *punctuated inflation*, i.e. the scenario wherein a brief period of rapid roll is sandwiched between two stages of slow roll inflation. In this work, we highlight a characteristic feature of the punctuated inflationary scenario that could lead to a potentially observable signature. With examples from the canonical scalar field as well as the tachyonic models, we illustrate that, in punctuated inflation, a drop in the scalar power on large scales is *always* accompanied by a rise in the tensor power

and, hence, even a more pronounced increase in the tensor-to-scalar ratio that actually *exceeds well beyond unity* over a small range of scales. This translates to a rapid increase in the angular power spectrum, $C_\ell^{\rm BB}$, of the B-mode polarization of the CMB at the low multipoles. Although, in the specific models of punctuated inflation that we study, the $C_\ell^{\rm BB}$ does not attain values that are observable, our work suggests that there could be models of punctuated inflation that fit the data well, and also predict observable levels of $C_\ell^{\rm BB}$.

Publications

1. Rajeev Kumar Jain, P. Chingangbam, J. O. Gong, L. Sriramkumar and T. Souradeep, *Punctuated inflation and the low CMB multipoles*, Journal of Cosmology and Astroparticle Physics **0901**, 009 (2009).

Preprints

1. Rajeev Kumar Jain, P. Chingangbam and L. Sriramkumar, *Reheating in tachyonic inflationary models: Effects on the large scale curvature perturbations*, arXiv:0902.1067 [astro-ph.CO].
2. Rajeev Kumar Jain, P. Chingangbam, L. Sriramkumar and T. Souradeep, *The tensor-to-scalar ratio in punctuated inflation*, arXiv: 0904.2518 [astro-ph.CO].

Conference/Workshops Attended

1. *Summer School in Cosmology*, The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy; July 21–August 1, 2008.
2. *Cosmology with* CMB *and* LSS*: Link to Early Universe*, Inter-University Centre for Astronomy and Astrophysics, Pune; August 18–31, 2008.

Visits to other Institutes

1. Korea Institute for Advanced Study, Seoul, Korea; May 23–June 19, 2008.
2. The Beecroft Institute of Particle Astrophysics and Cosmology, University of Oxford, Oxford, UK; December 1–3, 2008.
3. The Astronomy Centre, Department of Physics and Astronomy, University of Sussex, Sussex, UK; December 4–6, 2008.
4. Institute of Cosmology and Gravitation, University of Portsmouth, Portsmouth, UK; December 7–10, 2008.
5. Department of Theoretical Physics, University of Geneva, Geneva, Switzerland; December 11–15, 2008.

Invited Lectures/Seminarsx

1. *On the evolution of curvature perturbations at super-Hubble scales*, Korea Institute for Advanced Study, Seoul, Korea; June 17, 2008.
2. *Double inflation and the low* CMB *quadrupole*, in Cosmology with CMB and LSS, Inter-University Centre for Astronomy and Astrophysics, Pune, India, August 18–31, 2008.
3. *Punctuated inflation and the low* CMB *multipoles*, The Beecroft Institute of Particle Astrophysics and Cosmology, University of Oxford, Oxford, UK; December 2, 2008; The Astronomy Centre, Department of Physics and Astronomy, University of Sussex, Sussex, UK; December 4, 2008.
4. *Deviations from slow roll inflation and features in the primordial spectrum*, Institute of Cosmology and Gravitation, University of Portsmouth, Portsmouth, UK;x December 8, 2008; Department of Theoretical Physics, University of Geneva, Geneva, Switzerland; December 12, 2008.

Other Activities

1. *On the origin and evolution of perturbations in the early universe*, Synopsis seminar, March 5, 2009.
2. Helped in organizing and evaluating the papers (Physics) of HRI Science Talent Test 2008.

Kalpataru Pradhan

During the last year, my major work has been focused on studying the transport and magnetic properties of manganites (ABO_3) in the presence of B site impurities. Using a powerful Monte Carlo technique, we were able to provide a detailed description of the effects of B site dopants in manganites and clarify the spatial textures that arise in the process. I have also studied the Kondo lattice model to explore the wide window between the RKKY and double exchange limits and proposed an understanding of the $4f$ elements based on our results. We believe many interesting materials like the DMS ($Ga_{1-x}Mn_xAs$, say) and magnetic semiconductors like EuO belongs to intermediate coupling, and we have been investigating diluted (and 'concentrated') magnetic semiconductors recently. I have also been involved in the study of field melting and non-equilibrium response in the charge ordered manganites.Broadly, all these problems required numerical study using a combination of exact diagonalization (ED) and Monte Carlo (MC). We use a locally developed 'travelling cluster' (TCA) version of the standard algorithm, and can access huge system sizes (> 1000 sites) in the process.

We have also studied sodium metallic clusters in the presence of transition metals (TM). We use first principle calculation (employing VASP, deMon) and report that the magnetic moment of the TM in sodium clusters could be larger than the atomic moment. We have studied the cluster size (apart from Na we have taken K, Cs also) upto 12 (n=12) and we noticed that *spd* hybridization strongly depend on the coordination number of alkali atoms to the TM. In recent work, we propose a framework for magnetic superatoms by invoking systems marked by both localized and delocalized electron states, where localized electrons stabilize magnetic moments while filled nearly free electron shell leads to stable species.

Publications

1. Kalpataru Pradhan, Prasenjit Sen, J. U. Reveles, S. N. Khanna, *First-principles study of $TMNa_n$(TM= Cr, Mn, Fe, Co, Ni; n = 4-7) clusters,* J. Phys. Condens. Matter **20**, 255243 (2008)..
2. Kalpataru Pradhan, Anamitra Mukherjee and Pinaki Majumdar, *Exploiting B Site Disorder for Electronic Phase Control in the Manganites,* Europhys. Lett. **84**, 37007 (2008).
3. Kalpataru Pradhan, Pinaki Majumdar, *Magnetic order Beyond RKKY in the Classical Kondo Lattice* Europhys. Lett. **85**, 37007 (2009).
4. Anamitra Mukherjee, Kalpataru Pradhan, Pinaki Majumdar, *Conductance switching and inhomogeneous field melting in the charge ordered manganites,* Europhys. Lett. **86**, 27003 (2009).
5. J. U. Reveles, P. A. Clayborne, A. C. Reber, S. N. Khanna, K. Pradhan, P. Sen, and M. R. Pederson, *Designer Magnetic Superatoms,* Nature Chemistry, in press (2009).

Preprints

1. Kalpataru Pradhan and Pinaki Majumdar, *The Effects of B site Doping on the Manganites*

Conference/Workshops Attended

1. *Homi Bhabha Centenary DAE-BRNS National Conference and HRI School on 'Spintronic and Magnetoelectronic Materials and Devices'*, Puri; January 5–10, 2009.
2. *International Symposium on Clusters, Cluster Assemblies, and Nano-scale Materials*, HRI, Allahabad; February 9–11, 2009.

Visits to other Institutes

1. Computational Condensed Matter Physics Laboratory, RIKEN, Tokyo, Japan; March, 2009

Invited Lectures/Seminars

1. *The 'large S' Kondo lattice: 4f magnets to magnetic semiconductors*, Computational Condensed Matter Physics Laboratory, RIKEN, Tokyo, Japan; March, 2009.
2. *Electronic phase control via B site disorder in the manganites*, Cross-Correlated Materials Research Group, RIKEN, Tokyo, Japan; March, 2009.

Other Activities

1. Condensed Matter talk on *Electronic phase control in the manganites*
2. Condensed Matter talk on *Europium chalcogenides (electronic structure and magnetism)*

Arijit Saha

For the last one year I am working on the field of mesoscopic superconductivity especially the effect of electron electron (e-e) interaction on transport through superconducting hybrid junctions of one-dimensional quantum wires and analyze some of the applications and utilities of such junctions. Experimentally these systems are generally fabricated in GaAs/AlGaAs heterostructure junctions by gating the 2-dimensional electron gas or in Carbon nanotube systems. Also in these systems superconductivity can be induced by the proximity effect. In presence of superconductivity, apart from the electron channel, hole channel also takes part in transport giving interesting behaviour in the subgap ($E < \Delta$) Landauer-Buttiker conductance. I have also explored transport through such systems without any bias in the adiabatic limit which is known as quantum pumping in literature.

Another interesting aspect of these 1-Dimensional systems is the effect of electron electron (e-e) interaction which is very different from its higher dimensional counterparts. This is because, in 1-D, due to electron -electron interactions the Fermi liquid ground state is destroyed and the electrons form a non-Fermi liquid ground state knows as Luttinger Liquid. I have explored the effect of electron electron (e-e) interaction on transport through different geometries of mesoscopic superconducting hybrid junction of Luttinger liquid and analyze some of the applications of such junctions.

We demonstrate possible scenarios for production of pure spin current and large tunnelling magnetoresistance ratios from elastic co-tunnelling and crossed Andreev reflection across a superconducting junction comprising of normal metal-superconductor-normal metal (NSN), where, the normal metal is a one-dimensional interacting quantum wire (Luttinger liquid). We show that there are fixed points in the theory which correspond to the case of pure spin current. We analyze the influence of electron-electron interaction and see how it stabilizes or de-stabilizes the production of pure spin current. These fixed point can be of direct experimental relevance for spintronics application of normal metal-superconductor-normal metal junctions of one-dimensional quantum wires. We also calculate the power law temperature dependence of the crossed Andreev reflection enhanced tunnelling magnetoresistance ratio for the ferromagnet- superconductor- ferromagnet (FSF) junction. We show that the tunnelling magnetoresistance has a high value (magnitude of 2) compared to ferromagnet- normal metal- ferromagnet (FNF) junction which can have significant importance in device application.

We investigate transport properties of a superconducting junction of many ($N \geq 2$) one-dimensional quantum wires (Luttinger liquid). We include the effect of electron-electron interaction within the one-dimensional quantum wires using a weak interaction renormalization group (WIRG) procedure. In the presence of a superconductor, superconductivity is being induced inside the quantum wires by proximity effect. Due to the proximity effect, transport across the junction occurs via direct tunneling as well as via the crossed Andreev channel. We find that the fixed point structure of this system is far more

rich than the fixed point structure of a normal metal−superconductor junction ($N = 1$), where we only have two fixed points - the fully insulating fixed point ($r = 1$) which is stable under RG or the Andreev fixed point ($r_A = 1$) which is unstable under RG. Even a two wire ($N = 2$) system with a superconducting junction ie a normal metal−superconductor−normal metal structure, has nontrivial fixed points with intermediate transmissions and reflections ($r = 1/2$, $r_A = -1/2$, $t = 1/2$, $t_A = 1/2$). We also include electron-electron interaction induced back-scattering in the quantum wires in our study and hence obtain non-Luttinger liquid behaviour. It is interesting to note that *(a)* effects due to inclusion of electron-electron interaction induced back-scattering in the wire, and *(b)* competition between the charge transport via the electron and hole channels across the junction, give rise to a non-monotonic behavior of conductance as a function of temperature. We also find that transport across the junction depends on two independent interaction parameters. The first one is due to the usual correlations coming from the scattering of electron from Friedel oscillations for spin-full electrons giving rise to the well-known interaction parameter ($\alpha = (g_2 - 2g_1)/2\pi\hbar v_F$). The second one arises due to the scattering of electron into holes induced by the proximity of the superconductor and is given by ($\alpha' = (g_2 + g_1)/2\pi\hbar v_F$). The non-monotonic conductance and the identification of this new interaction parameter are two of our main results. In both the expressions $g_1 = V(2k_F)$, $g_2 = V(0)$, where $V(k)$ is the inter electron interaction potential.

We study the renormalization group flows of the two terminal conductance of a superconducting junction of two Luttinger liquid wires. We compute the power laws associated with the renormalization group flow around the various fixed points of this system using the generators of the $SU(4)$ group to generate the appropriate parametrization of an S matrix representing small deviations from a given fixed point S matrix and we then perform a comprehensive stability analysis. In particular, for the nontrivial fixed point which has intermediate values of transmission, reflection, Andreev reflection, and crossed Andreev reflection, we show that there are eleven independent directions in which the system can be perturbed, which are relevant or irrelevant, and five directions which are marginal. We obtain power laws associated with these relevant and irrelevant perturbations. Unlike the case of the two-wire charge-conserving junction, here we show that there are power laws which are nonlinear functions of $V(0)$ and $V(2k_F)$ [where V(k) represents the Fourier transform of the interelectron interaction potential at momentum k]. We also obtain the power law dependence of linear response conductance on voltage bias or temperature around this fixed point.

We consider quantum charge pumping of electrons across a superconducting double barrier structure in the adiabatic limit. The superconducting barriers are assumed to be reflection-less so that an incident electron on the barrier can either tunnel through it or Andreev reflect from it. In this structure, quantum charge pumping can be achieved *(a)* by modulating the amplitudes, Δ_1 and Δ_2, of the gaps associated with the two superconductors or alternatively, *(b)* by a periodic modulation of the order parameter phases, ϕ_1 and ϕ_2 of the

superconducting barriers. In the former case, we show that the superconducting gap gives rise to a very sharp resonance in the transmission resulting in quantization of pumped charge, when the pumping contour encloses the resonance. On the other hand, we find that quantization is hard to achieve in the latter case. We show that inclusion of weak electron-electron interaction in the quantum wire leads to renormalisation group evolution of the transmission amplitude towards the perfectly transmitting limit due to interplay of electron-electron interaction and proximity effects in the wire. Hence as we approach the zero temperature limit, due to renormalisation group flow of transmission amplitude we get destruction of quantized pumped charge. This is in sharp contrast to the case of charge pumping in a double barrier through a Luttinger liquid where quantized charge pumping is actually achieved in the zero temperature limit.

We study transport through a single channel T-stub strongly coupled to a superconducting reservoir. Due to the interplay of the proximity effect and the weak repulsive inter-electron interaction inside the quantum wires, we observe a cross-over in the renormalization group flow for the S-matrix describing the T -junction as a function of temperature. In the high temperature limit ($L_{th} < L_s$, incoherent limit), where L_{th} refers to the thermal length and L_s is the stub length) the S-matrix renormalization group flow is that of a normal three-wire junction, whereas in the low temperature limit ($L_{th} > L_s$, coherent limit), the renormalization group flow crosses over to that of a normalsuperconducting-normal junction. In sharp contrast to the standard stub geometry which has both transmission resonances and anti-resonances in the coherent limit, we find that the superconducting stub geometry shows neither a T = 1 resonance (T is the transmission probability for electrons incident on the T -stub) nor a T = 0 anti-resonance as we vary the energy of the incident electron. Instead, we find that there is only one value at T = $1/4$ which is analogous to the resonance or the anti-resonance. We also point out that the resonant value of T = $1/4$ coincides with the value of T corresponding to an unstable fixed point in the theory of normal-superconducting-normal junction.

Publications

1. Arijit Saha, Sourin Das and Sumathi Rao, *A systematic stability analysis of the renormalisation group flow for the normal-superconductor-normal junction of Luttinger liquid wires,* Phys. Rev. B **79**, 155416, (2009)
2. Arijit Saha and Sourin Das, *Quantized charge pumping in superconducting double barrier structure : Non-trivial correlations due to proximity effect,* Phys. Rev. B **78**, 075412, (2008)
3. Arijit Saha, Sourin Das and Sumathi Rao, *Renormalization group study of transport through a superconducting junction of multiple one-dimensional quantum wires,* Phys. Rev. B **77**, 155418, (2008)
4. Arijit Saha, Sourin Das and Sumathi Rao, *Spintronics with NSN Junction of one-dimensional quantum wires : A study of Pure Spin Current and Magne-*

toresistance, Europhys. Lett. **81**, 67001, (2008)

Preprints

1. Arijit Saha, Sourin Das and Sumathi Rao, *Resonant transmission through a T-stub coupled to a superconductor,* e-Print: arXiv:0811.0660 [cond-mat]

Visits to other Institutes

1. Saha Institute of Nuclear Physics, Kolkata; June 1–3, 2008.
2. Indian Institute of Science, Bangalore; July 10–31, 2008.
3. Jawaharlal Nehuru University, New Delhi; November 24, 2008.
4. Freie University of Berlin, Berlin, Germany; November 25–29, 2008.
5. Laboratoire de Physique des Solides, Paris (Orsay), France; November 30–December 2, 2008.
6. LPMMC (University of Joseph Fourier), Grenoble, France; December 3–4, 2008.
7. University of Geneva, Geneva, Switzerland; December 5–9, 2008.
8. ICTP, Trieste, Italy, December 10–13, 2008.
9. Scuola Normale Superiore, Pisa, Italy; December 14–17, 2008.
10. University of Konstanz, Konstanz, Germany; December 18-21, 2008.

Talks presented in India and Abroad

1. *Transport through superconducting junction of multiple one-dimensional quantum wires*, Saha Institute of Nuclear Physics, Kolkata; June, 2008.
2. *Transport through superconducting junction of multiple one-dimensional quantum wires*, Indian Institute of Science, Bangalore; July, 2008.
3. *Transport through superconducting junction of multiple one-dimensional quantum wires*, Jawaharlal Nehuru University, New Delhi; November, 2008.
4. *Transport through superconducting junction of multiple one-dimensional quantum wires*, Freie University of Berlin, Berlin, Germany; November, 2008.
5. *Transport through superconducting junction of multiple one-dimensional quantum wires*, Laboratoire de Physique des Solides, Paris, France; December, 2008.
6. *Transport through superconducting junction of multiple one-dimensional quantum wires*, LPMMC (University of Joseph Fourier), Grenoble, France; December, 2008.
7. *Transport through superconducting junction of multiple one-dimensional quantum wires*, University of Geneva, Geneva, Switzerland; December, 2008.
8. *Transport through superconducting junction of multiple one-dimensional quantum wires*, ICTP, Trieste, Italy; December, 2008.
9. *Transport through superconducting junction of multiple one-dimensional quantum wires*, Scuola Normale Superiore, Pisa, Italy; December, 2008.

10. *Transport through superconducting junction of multiple one-dimensional quantum wires*, University of Konstanz, Konstanz, Germany; December, 2008.

Other Activities

1. Extension talk: *Renormalization group study of charge and spin transport through a superconducting junction of multiple one-dimensional quantum wires*; April, 2008.
2. Pre Thesis talk: *Transport through superconducting junction of multiple one-dimensional quantum wires*; November 21, 2008.

Nishikanta Khandai

For the past year I have developed and used high resolution cosmological $N-$Body algorithms to study aspects of non-linear gravitional clustering in the Universe.

Publications

1. J. S. Bagla, Jayanti Prasad, Nishikanta Khandai *Effects of the size of cosmological N-Body simulations on physical quantities - III: Skewness,* MNRAS 395, 918, (2009)
2. J. S. Bagla & Nishikanta Khandai *The Adaptive TreePM: an adaptive resolution code for cosmological N-Body simulations,* MNRAS 396, 221 (2009)
3. Nishikanta Khandai & Bagla, J. S. *A Modified TreePM Code,* Research In Astronomy and Astrophysics 9, 861-873, (2009)

Conference/Workshops Attended

1. *Workshop on Using the Garuda Grid (India's National Grid Initiative)*, Harish-Chandra Research Institute; April, 2008
2. *Cosmology with the CMB and LSS*, IUCAA; August 2008
3. *Meeting on Cosmological Evolution in Diffuse Baryons: Reionization Epoch to the Present Day*, Raman Research Institute; November–December 2008.

Visits to other Institutes

1. Institut D'Astrophysique de Paris, Paris, France; February 2009.
2. Onsala Space Observatory, Onsala, Sweden; February 2009
3. University College London, London, UK; February 2009
4. Astrophysical Institute Potsdam, Potsdam, Germany; February 2009
5. Institute for Computational Cosmology, University of Durham, UK; February 2009

Invited Lectures/Seminars

1. *The Adaptive TreePM Code,* Workshop on Cosmology with CMB and LSS, IUCAA, Pune; August 2008.
2. *The Effect of Patchy UV Background on the Absorption Spectra of Quasars,* Meeting on Cosmological Evolution in Diffuse Baryons: Reionization Epoch to the Present Day, Raman Research Institute, Bangalore; December 2008.
3. *Adaptive TreePM: A Collisionless Code for Cosmological N-Body Simulations,* Institut D'Astrophysique de Paris, Paris, France; February 2009.
4. *Adaptive TreePM: A Collisionless Code for Cosmological N-Body Simulations*, Onsala Space Observatory, Onsala, Sweden; February 2009.

5. *Adaptive TreePM: A Collisionless Code for Cosmological N-Body Simulations*, University College London, London, UK; February 2009.
6. *Adaptive TreePM: A Collisionless Code for Cosmological N-Body Simulations*, Astrophysik Institute Potsdam, Potsdam, Germany, February 2009.
7. *Adaptive TreePM: A Collisionless Code for Cosmological N-Body Simulations*, Institute for Computational Cosmology, University of Durham, Durham, UK, February 2009.

Arjun Bagchi

With my advisor, Ashoke Sen, I have looked at areas of Tachyon Condensation. We formulated string theory on a separated brane-antibrane system using Level truncation methods of superstring field theory. We adopted analytical and numerical methods to answer some time independent and some time dependent questions. Though this project was finished before this academic year, the paper got published in May 2008.

With Turbasu Biswas and Debashis Ghoshal, I have worked on Logarithmic CFTs. We found integral representations for characters in LCFT minimal models. My next project was with Rajesh Gopakumar. We formulated the first systematic non-relativistic limit of the AdS/CFT conjecture. The boundary theory has a symmetry algebra called the Galilean conformal algebra (GCA) of which we found an infinite lift. We also proposed a novel Newton-Cartan like modification of the bulk theory.

With Ipsita Mandal, I have continued the work on GCA. In our first work, we found representations and correlation functions of the GCA. Later, we also found supersymmetric extensions of GCA in another piece of work. We are looking at other extensions in this direction.

With Bobby Ezuthachan and Ashoke Sen, I am also looking at a problem of tachyons on hairpin branes in Liouville theory with applications to AdS/CFT in mind.

Publications

1. Arjun Bagchi and Ashoke Sen, *Tachyon Condensation on Separated Brane-Antibrane System,* Journal of High Energy Physics **0805:010**, (2008)
2. Arjun Bagchi and Rajesh Gopakumar, *Galilean Conformal Algebras and AdS/CFT.* Accepted for publication in Journal of High Energy Physics. 0902.1385 (hep-th)
3. Arjun Bagchi and Ipsita Mandal, *On Representations and Correlation Functions of Galilean Conformal Algebras.* Physics Letters **B675**, 393-397.(2009)

Preprints

1. Arjun Bagchi, Turbasu Biswas and Debashis Ghoshal, *Contour Integral Representations for Characters in Logarithmic CFTs.* 0810.2374 (hep-th).

Conference/Workshops Attended

1. *Summer School on AdS/CFT*, ICTP, Trieste, Italy, May 2008.
2. *Monsoon Workshop in String Theory*, TIFR, Mumbai, India, July 2008.
3. *Indian Strings Meet*, Pondicherry, India, December 2008.
4. *Spring School on Superstring Theory*, ICTP, Trieste, Italy, March 2009.

Visits to other Institutes

1. Jawaharlal Nehru University, New Delhi, India, April 2008.
2. Kings' College, London, United Kingdom, May 2008.
3. Queen Mary, London, United Kingdom, May 2008.
4. LMU, Max-Plank Institute, Munich, Germany, June 2008.
5. ETH, Zurich, Switzerland, March 2009.

Invited Lectures/Seminars

1. *Tachyons on Separated Branes*, Queen Mary, University of London, UK, May 2008.
2. *Tachyons on Separated Branes*, Kings' College, University of London, UK, May 2008.
3. *Tachyon Condensation on Separated Branes*, LMU, Munich, Germany, June 2008.
4. *Galilean Conformal Algebras and AdS/CFT*, ETH, Zurich, Switzerland, March 2009.

Other Activities

1. Tutored a General Relativity course for second year graduate students.

Ayan Mukhopadhyay

My work, this academic year, done with R K Gupta, is related to understanding the universal sector in AdS_5/CFT_4 correspondence which is defined to be the consistent truncation of the AdS_5/CFT_4 correspondence at strong coupling and large N to pure five dimensional gravity. We showed that, when the CFT lives in flat space, all such states in this sector can be uniquely characterised by the vev of the (traceless) stress tensor and their dynamics also be completely determined by the conservation of the stress tensor, since any asymptotically AdS_5 solution of Einstein's equation with negative cosmological constant can be uniquely determined locally by the boundary stress tensor when the boundary metric is flat. We also showed that the solution when written in Fefferman-Graham coordinates always is a power series in the radial coordinate. We pointed out that there are two potential pathologies an arbitrary boundary stress tensor can have for the pure gravity solution, firstly it may destroy the AdS_5 asymptotics, secondly it may produce naked singularities. We showed that any hydrodynamic stress tensor will not produce the first pathology, though it may produce naked singularities. We also established that the procedure of finding solutions (by using a derivative expansion) for arbitrary hydrodynamic stress tensors in Fefferman-Graham coordinates is easier because the solution could be found in a manifestly covariant form and constraints simplify.

Publications

1. R. K. Gupta and A. Mukhopadhyay , *"On the universal hydrodynamics of strongly coupled CFTs with gravity duals"*, JHEP **0903**, 067 (2009) arXiv: 0810.4851 [hep-th].

Conference/Workshops Attended

1. *Indian String Meeting*, Pondicherry; December 2008

Girish Kulkarni

My research interest centres in astrophysical cosmology. I started work in this field in 2008. My current project deals with cosmic reionization, which is a period in the Universe's history in which much of the baryonic content of the Universe was ionized due to electromagnetic radiation produced by small-scale structure. Reionization is interesting firstly because it is caused by, and strongly influences, formation of gravitationally bound structure. Secondly, the epoch of reionization in the history of the Universe is now opening up to observations thanks to better telescopes. This demands better theoretical understanding.

Almost all theoretical work on reionization has been done in the last one decade. Much of it has focussed on modelling the process of reionization in various cosmological and structure formation scenarios. I am studying the inverse problem of how to *use* reionization to study structure formation. In a recently completed work (Bagla, Kulkarni and Padmanabhan 2009) we showed that reionization makes only weak demands on the small-scale structure. I am now improving on this by (1) considering more accurate analytical models and (2) using cosmological N-body simulations.

Preprints

1. Bagla J. S., Kulkarni Girish and Padmanabhan T., *Metal Enrichment and Reionization Constraints on Early Star Formation*, 0902.0853

Conference/Workshops Attended

1. *Cosmology with the* CMB *and* LSS, Pune; July–August, 2008.
2. *Cosmological Evolution in Diffuse Baryons: Reionization Epoch to the Present Day*, Coorg; December 2008.

Priyotosh Bandyopadhyay

In the last year we mainly worked in Supersymmetric phenomenology in the context of the impact of non-universal gaugino masses in the Higgs production in a supersymmetric cascade decay. We mainly tried to distinguish the non-universal scenarios from that of the universal one via these Higgs productions.

Apart from the above studies we also proposed a model with two Higgs doublet in type III case which can produce small neutrino mass and predicted its collider signature specially at the LHC.

We are also working in the model with universal extra dimension (UED) in the context of Higgs production from the cascade decay of the third generation level one KK quarks.

Publications

1. Priyotosh Bandyopadhyay, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Signatures of gaugino mass non-universality in cascade Higgs production at the LHC.,* Phys.Lett.B **670** (2008)
2. Priyotosh Bandyopadhyay, Amitava Datta, Aseshkrishna Datta, Biswarup Mukhopadhyaya, *Associated Higgs production in CP-violating supersymmetry: Probing the 'open hole' at the large hadron collider,* Phys.Rev.D **78** 015017 (2008)

Preprints

1. Priyotosh Bandyopadhyay, *Probing non-universal gaugino masses via Higgs boson production under SUSY cascades at the LHC: A Detailed study,* arXiv: 0811.2537

Conference/Workshops Attended

1. *3rd CERN-Fermilab Hadron Collider School*, USA; August 2008.
2. *LHC Workshop*; September 2008.
3. *International Workshop on LHC*; December 2008.
4. *Nu Horizons*, India, January 2009.
5. *BSMLHC*; January 2009.
6. *Getting Ready for Physics at the LHC*; February 2009.

Visits to other Institutes

1. Fermilab, Batavia, USA; August 2008.
2. SLAC, Melnopark, USA; August 2008.
3. Oklahama State University, Stillwater, USA; September 2008.
4. University of Florida, Gainseville, USA; September 2008.
5. University of Wisconsin, Madison, USA; September 2008.

6. Indian Association for the Cultivation of Science, Kolkata; December 2008.
7. TIFR, Mumbai; December 2008.

Invited Lectures/Seminars

1. *Associated Higgs production in CP-violating supersymmetry: Probing the 'open hole' at the large hadron collider*, Theory seminar, SLAC, Menlopark, USA; August 2008.
2. *Associated Higgs production in CP-violating supersymmetry: Probing the 'open hole' at the large hadron collider*, Theory seminar, Oklahama State University, Stillwater, USA; September 2008.
3. *Associated Higgs production in CP-violating supersymmetry: Probing the 'open hole' at the large hadron collider*, University of Florida, Gainseville, USA; September 2008.
4. *Associated Higgs production in CP-violating supersymmetry: Probing the 'open hole' at the large hadron collider*, University of Wisconsin, Madison, USA; September 2008.
5. *Aspects of Higgs searches in CP-violating & CP-conserving SUSY scenarios at Large Hadron Collider*, Free Meason semiinar, TIFR, Mumbai; December 2008.
6. *Higgs searches under supersymmetric cascades with non-universal gaugino masses*, BSM LHC seminar, Indian Association for the Cultivation of Science, Kolkata; January 2009.

Subhaditya Bhattacharya

I have been working in $\mathcal{N} = 1$ supersymmetry (SUSY) phenomenology, particularly in the Minimal Supersymmetric Extension of Standard Model (MSSM). My work is mostly related to the collider aspect of SUSY, particularly in context of the upcoming experiment at Large hadron Collider (LHC) in CERN, Switzerland.

In the most simplified framework of SUSY, namely minimal supergravity (mSUGRA), all low scale SUSY breaking parameters are generated from a common scalar mass m_0, common gaugino mass $m_{1/2}$, common trilinear coupling A_0, $\tan\beta$ (ratio of two higgs vacuum expectation values) and the sign of μ (higgsino mass parameter). My work is aimed at studying situation where gaugino and scalar masses at the high scale are non-universal. We have worked in multilepton channel analysis for non-universal high scale supersymmetric theories, namely non-universal gaugino and scalar mass scenarios, in context of the LHC using the event generator Pythia and shown that the ratios of two different channels, apart from minimizing various uncertainties coming from different choice of PDFSET, jet-energy scale etc., can be useful discriminators of the underlying non-universal spectra. We also proposed a benchmark region of MSSM parameter space motivated from high-scale gaugino and scalar non-universality, where the hadronically quiet trilepton channel will be more useful than the usual multilepton channels associated with hard jets, for the discovery of supersymmetry. We calculated non-universal gaugino mass ratios in context of different non-singlet representations in an underlying $SO(10)$ Grand-Unified Theory, and studied the low energy consistency of such high-scale breaking patterns. Also studied collider signature in multileptonic channels at some selected benchmark points allowed by the cold dark matter constraints provided by the WMAP data and indicated their distinguishability from the mSUGRA scenarios in this regard.

We have also been studying a non-universal scalar scenario, motivated from various low energy constraints like FCNC and CP violations, where the first two generation scalars need to be much heavier than the third generation, popularly called an 'inverted heirarchy', where we end up having a larger region of the parameter space satisfying the cold dark matter constraints. We study the collider signature in multileptonic channels at some selected benchmark points and also indicate their spectacular distinguishability from the mSUGRA ones.

Publications

1. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya *Non-universal scalar masses: A Signal-based analysis for the Large Hadron Collider,* Phys. Rev. **D78**:035011 (2008)
2. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya *Non-universal gaugino and scalar masses, hadronically quiet trileptons and the Large Hadron Collider,* Phys. Rev. **D78**:115018 (2008)

Preprints

1. Subhaditya Bhattacharya, Joydeep Chakraborty *Gaugino mass non-universality in an SO(10) supersymmetric Grand Unified Theory: Low-energy spectra and collider signals,* arXiv:0903.4196[hep-ph]
2. Subhaditya Bhattacharya *Signatures of non-universal gaugino and scalar masses at the Large Hadron Collider,* arXiv:0809.2451[hep-ph]

Conference/Workshops Attended

1. SUSY*08*, Seoul, Korea; June 16–21, 2008.
2. *Instructional Workshop on* LHC *Physics*, Indian Institute of Science Education and Research, Kolkata; December 19–24, 2008.
3. *NuHoRIzons*, Neutrinos in Physics, Astrophysics and Cosmology, Harish-Chandra Research Institute, Allahabad; January 7–9, 2009.
4. *BSMLHC*, Indian Association For the Cultivation Of Science, Kolkata; January 15–17, 2009.
5. *Getting Ready For The Physics at the* LHC, Regional Centre for Accelerator-based Particle Physics RECAPP, Harish-Chandra Research Institute, Allahabad; February 16–20, 2009.

Visits to other Institutes

1. Korean Institute For Advanced Study (KIAS), Seoul, June 2008.

Ipsita Mandal

I have been studying different aspects of string theory. I have surveyed the existing literature about the string phenomenology aspects dealing with flux compactifications. I have worked on fluid dynamics using ADS/CFT, various aspects of black hole physics and Galilean (super)conformal algebras.

Publications

1. Sayantani Bhattacharyya, R. Loganayagam, Ipsita Mandal, Shiraz Minwalla, Ankit Sharma, *Conformal Nonlinear Fluid Dynamics from Gravity in Arbitrary Dimensions* , JHEP **0812:116** (2008).
2. Nabamita Banerjee, Ipsita Mandal, Ashoke Sen, *Black Hole Hair Removal*, (To be published in JHEP).
3. Arjun Bagchi, Ipsita Mandal, *On Representations and Correlation Functions of Galilean Conformal Algebras,* Phys. Lett. B **675, Issues 3-4** (2009).

Preprints

1. Arjun Bagchi, Ipsita Mandal,, *Supersymmetric Extension of Galilean Conformal Algebras* , arXiv: 0905.0580
2. Nabamita Banerjee, Shamik Banerjee, Rajesh Gupta, Ipsita Mandal, Ashoke Sen, *Supersymmetry, Localization and Quantum Entropy Function* , arXiv: 0905.2686

Conference/Workshops Attended

1. *Monsoon workshop on String Theory*; June 2008.
2. *Indian Strings Meeting 2008*; December 2008.
3. *Particle Physics in the Age of LHC*, Israel; December 2008.
4. *Spring School on Superstring Theory and Related Topics*, Italy; March 2009.

Visits to other Institutes

1. University of Rome, Tor Vergata, Italy; March 2009.
2. Indian Association for the Cultivation of Science, Kolkata; May 2009.

Manimala Mitra

During April, 2008 to March, 2009 we have looked on the prospect of different models to explain the neutrino mass and mixing. Two of my works are based on flavor symmetry where I have concentrated on the two flavor symmetry group A_4 and S_3 to explain the neutrino mass and mixing and charged lepton mass hierarchy. The third one is Type-III Seesaw with 2HDM, in this work we have concentrated on the possibility of Seesaw with Fermionic Triplet and with two Higgs doublets and we have explored in detail its phenomenology and interesting collider signatures.

Publications

1. Biswajoy Brahmachari, Sandhya Choubey and Manimala Mitra, *The A(4) Flavor Symmetry and Neutrino Phenomenology*; Phys. Rev. D **77**, 073008, (2008)
2. Manimala Mitra and Sandhya Choubey, *Lepton Masses in a Minimal Model with Triplet Higgs Bosons and S_3 Flavor Symmetry*; Phys. Rev. D **78**, 115014, (2008)

Preprints

1. Biswajoy Brahmachari, Sandhya Choubey and Manimala Mitra, *The A(4) Flavor Symmetry and Neutrino Phenomenology*; arXiv: 0801.3554
2. Manimala Mitra and Sandhya Choubey, *Lepton Masses in a Minimal Model with Triplet Higgs Bosons and S_3 Flavor Symmetry*; arXiv: 0806.3254
3. Priyotosh Bandyopadhyay, Sandhya Choubey and Manimala Mitra, *Two Higgs Doublet Type-III Seesaw with $\mu-\tau$ Symmetry at LHC*; arXiv: 0906.5330

Conference/Workshops Attended

1. *NuHoRIzons 09*; January, 2009.
2. *NuGoa09*; April, 2009.
3. *Summer School on Particle Physics in the LHC era*; June, 2009.

Visits to other Institutes

1. Physical Research Laboratory, Ahmedabad; November, 2008.
2. J. Stefan Institute, Slovenia; June, 2009.
3. INFN, Padova, Italy; July 2009.

Lectures/Seminars

1. *Triplet Higgs Model with S_3 Symmetry and Lepton Masses*, NuHoRizons 09, HRI, Allahabad; January, 2009.

2. *Triplet Higgs Model with S_3 Symmetry and Lepton Masses*, NuGoa09, Tata Institute of Fundamental Research, Goa; April, 2009.
3. *Type-III Seesaw with 2HDM*, J. Stefan Institute, Ljubljana, Slovenia; July, 2009.

Viveka Nand Singh

1. I am looking at the effect of antisite disorder in double perovskite. Double perovskite materials, of the form $A_2BB'O_6$, are currently of great interest due to their magnetic and transport properties. Usually one of the B ions is magnetic and the other non-magnetic and a combination of strong local coupling and electron delocalisation promotes magnetic order. Most real materials have some extent of "antisite disorder" involving wrongly located B and B' ions. The magnetic order is primarily controlled by the choice of B, B' and electron density, but antisite disorder also play a crucial role. The problem is complicated because the antisite disorder arises from an annealing process, and is spatially correlated rather than random. One has to solve the electronic-magnetic problem in that nontrivally correlated background. Recent Lorentz microscopy measurements by T. Asaka et al. PRB 75, 184440 (2007) on Ba_2FeMoO_6 reveal that there are structural domains associated with the antisite disorder, and these also correspond to the magnetic domains in the material, with antiferromagnetic coupling across the domain boundary. The experiments also probed the evolution of the magnetic configuration with an applied magnetic field, observing a "pinning" effect at the crystallographic boundary. To model this system we have done a two stage calculation. (1) We generate the antisite disorder configuration from an effective lattice-gas model developed by Sanyal et al. EPJB (2008), and (2) use a real space, exact diagonalization based Monte Carlo (ED-MC) technique called "Travelling Cluster Approximation"(TCA) developed by S.Kumar et al., EPJB 50, 571-579 (2006), that allows one to handle fermions in the background of strong spatial fluctuations, to solve the magnetic problem in this "disordered" background. Our microscopic model has the usual couplings of the ordered double perovskite, and an additional antiferromagnetic coupling when two B ions are nearest neighbour. We find that for moderate antisite disorder (large domain size) the crystallographic and magnetic domains do coincide, but fail to do so for more fragmented domains. We also track the field induced switching of domain orientation in an applied field. We are working on the transport calculation to fully characterise this domain state and quantify the associated magnetoresistance.
2. We are also working on developing code for Cellular Dynamical Mean Field Theory(CDMFT). In CDMFT, the preffered sites are chosen as a cluster of n_c sites. Correlations within the cluster sites are kept intact, while approximating longer-ranged physics on the mean field level. The Green's function is chosen as a matrix within these sites. This method becomes exact when the cluster size diverges, and recovers corresponding mean field approximation when the cluster size become one. In CDMFT, we have been exploring the Lanczos based impurity solver. In order to attain large system sizes we applied Lanczos procedure to get ground state, and from there calculated Green's function using recursive rela-

tion. We have a working code for calculation of ground state and Green's function, on systems upto $n_s = 12$ (matrix size=853776,853776) and now working on setting up CDMFT. When the CDMFT implementation will be completed, we plan to study the quantum critical point and associated superconductivity in heavy fermions/ Kondo lattice models.

Conference/Workshops Attended

1. *Meeting on Physics and Chemistry of Oxide Materials*, S. N. Bose National Centre for Basic Sciences, Kolkata; February 23–25, 2009.
2. *Recent trends in Strongly Correlated Systems* IACS, Kolkata; March 2–4 2009.

Rajarshi Tiwari

I started working for my Ph. D. under supervision of Prof. Pinaki Majumdar from this academic year 2008-09 and onwards.

I started my work by studying the phenomenology of Double perovskites (chemical formula $A_2BB'O_6$, A = Alkali,rare earth metal, B, B' = transition metals, O = oxygen.) We model clean perovskites with two magnetic sites, which consists of a lattice model with electrons coupled to classical spins (which exist as a consequence of the localized electrons in the B, B' atoms).

The model has to solved in order to get the magnetic behavior of the system at low temperature, and to calculate the conduction properties. The model is impossible to solve for an arbitrary configuration of the classical spins in a straight forward way. We hence follow the method of real space Monte-Carlo based on exact diagonalization, to get the nature of the low temperature magnetic phases and their corresponding transition temperature T_c. Doing Monte-Carlo for a selected range of parameters and a number of electron density, show various interesting magnetic phases.(various magnetic ordering in real materials have interesting and useful technological applications.)

A phase diagram was generated in electron density N versus transition temperature T_c to see the trends and stability of various magnetic phases. The magnetic phases occurring were again analyzed separately using the variational calculation, in which they are diagonalized analytically and compared for the stability in various electron density window. A magnetic phase diagram was generated showing the stability of the magnetic phases for much bigger lattice sizes. Monte-Carlo results show that invoking electron spin coupling for the second magnetic site enhances the T_c in general and also widens the ferromagnetic window of stability.

Preprints

1. Rajarshi Tiwari and Pinaki Majumdar, *Modeling Double perovskite with two magnetic sites*. (in preparation)

Conference/Workshops Attended

1. *Homi-Bhabha Centenary DAE-BRNS National Conference and HRI school on Spintronic and Magnetoelectronic materials and devices*, Toshali Sands, Puri; January 4–10, 2009.
2. *Conference on Physics and Chemistry of Oxide materials*, S. N. Bose National Center of Basic Sciences, Kolkata; February 22–25 2009.
3. *Recent Trends in Strongly Correlated Systems*, Indian Association for the Cultivation of Sciences, Kolkata; March 2–4 2009.

Shamik Banerjee

I am working on black holes in string theory.

Publications

1. Shamik Banerjee, Ashoke Sen, *Interpreting The M2-Brane Action*, Modern Physics Letters A **24** 10 (2009).
2. Shamik Banerjee, Ashoke Sen, Yogesh K. Srivastava , *Genus Two Surface and Quarter BPS Dyons: The Contour Prescription* , JHEP 0903:151, 2009.

Conference Attended

1. *Indian Strings Meeting* ; December 2008.
2. *Monsoon Workshop on String Theory*; June 2008.

Invited Talks

1. *Spectrum of quarter BPS dyons in N=4 string theory*, Indian Strings Meeting, Jointly organized by the Indian string theory community, Pondicherry; December 2008.
2. *Classification of T-duality invariants for Heterotic string theory on T^6 and dyon spectrum.*, Monsoon Workshop on String Theory, Tata Institute of Fundumental Research, Mumbai; June 2008.

Shailesh Lal

In the past few years, it has been established that tree level scattering amplitudes of pure gauge theory are simple, in the sense that they are easily calculable through recursion relations. This can be shown to imply that using these recursion relations, any tree-level n-point amplitude in a pure gauge theory is completely determined from the non-zero three-point amplitudes of the theory. It is also known that this simplicity extends to maximally supersymmetric theories. It turns out that as a consequence, the one-loop scattering amplitudes of maximally supersymmetric theories have a remarkably simple singularity structure. In the past year, I and Suvrat Raju have shown that the scattering amplitudes of gauge theories with one or two supersymmetries are also calculable through this technique. We have also shown that the scattering amplitudes of these theories at one-loop do not have the simple structure that a maximally supersymmetric theory has. In this sense, we have found that these amplitudes are structurally more similar to gauge theory amplitudes than maximally supersymmetric field theory amplitudes. A preprint detailing these results is nearing completion.

Conference/Workshops Attended

1. *Field Theoretic Aspects of Gravitation-VII*, Shimla; November 2008,
2. *Indian Strings Meet*, Pondicherry; December 2008,
3. XXIV SERC *Main School on Theoretical High Energy Physics*, Guwahati; March 2009
4. IPM *String School and Workshop*, Iran; April 2009

Sanjoy Biswas

I am working on collider aspects of supersymmetric extension of the Standard Model Physics in context of the Large Hadron Collider, CERN. My recent work based on mass reconstruction of the supersymmetric particles, namely the neutralinos, in a scenario in which the lightest supersymmetric particle is the superpartner of a right handed neutrino. We studied the collider signature of such a scenario and prescribed some event selection criteria to make the signal practically background free. The neutralinos can then be reconstructed once the four-momenta of its decay products are known. We also showed that the faithful reconstruction of the neutralinos is possible over a large region of supersymmetric parameter space following our reconstruction strategy.

At present I am working on mass reconstruction of the "chargino" in the above mentioned scenario.

Publications

1. Sanjoy Biswas and Biswarup Mukhopadhyaya, *Neutralino reconstruction in supersymmetry with long-lived staus,* Physical Review D **79**, 115009, (2009)

Preprints

1. Sanjoy Biswas and Biswarup Mukhopadhyaya, *Chargiino reconstruction in supersymmetry with long-lived staus,* (in preparation)

Conference/Workshops Attended

1. *Instructional Workshop on* LHC *Physics*, Indian Institute of Science Education and Research, Kolkata, December 19–24, 2008.
2. *NuHoRIzons*, Neutrinos in Physics, Astrophysics and Cosmology, Harish-Chandra Research Institute, Allahabad; January 7–9, 2009.
3. *Getting Ready For The Physics at the* LHC, Regional Centre for Accelerator-based Particle Physics (RECAPP), Harish-Chandra Research Institute, Allahabad, February 16–20, 2009.
4. XXIV SERC THEP *Main School*, Indian Institute of Technology, Guwahati; March 2–21, 2009.

Other Activities

1. I have been the tutor of the Classical Mechanics course for the semester August–December, 2008.

Joydeep Chakrabortty

I am working on Grand Unified Theory (GUT) and Neutrino Physics. In context of GUT, we have propsed a simple mechanism to calculate the vacuum expectation values for any dimensional Higgs and it is applicable for any group. We have also shown the impact of dimension-5 operators in gauge coupling unification for non-supersymmetric and supersymmetric case. We have calculated the ratios of non-universal Gaugino masses at the high scale and did the low scale phenomenology.

Now we are trying to see the effect of non-renormalizable operators in presence of the intermediate scales. I am also working on the neutrino mass models. We have constructed the Renormalization Group Equations (RGEs) for the Yukawa and gauge couplings in Type-III seesaw models. In the context of neutrino physics few works are going on. Now I am working on Inverse seesaw mechanism, Leptogenesis.

Publications

1. Joydeep Chakrabortty and Amitava Raychaudhuri, *A note on dimension-5 operators in GUTs and their impact* , Physics Letters B **673**, 57-62, (2009)
2. Joydeep Chakrabortty, Amol Dighe, Srubabati Goswami, Shamayita Ray *Renormalization group evolution of neutrino masses and mixing in the Type-III seesaw mechanism* , Nuclear Physics B **820**, 116-147, (2009)

Preprints

1. Subhaditya Bhattacharya and Joydeep Chakrabortty, *Gaugino mass non-universality in an SO(10) supersymmetric Grand Unified Theory: low-energy spectra and collider signals* , hep-ph/0903.4196
2. Joydeep Chakrabortty, Anjan S. Joshipura, Poonam Mehta, Sudhir K. Vempati, Degenerate neutrinos and Maximal Mixing (in preparation)

Conference/Workshops Attended

1. *Homi Bhabha Centenary* XVIII DAE-BRNS *Symposium on High Energy Physics*, Banaras Hindu University, Varanasi; December 14–18, 2008
2. *Instructional Workshop on LHC Physics*, Indian Institute of Science Education and Research, Kolkata; December 19–24, 2008.
3. *NuHoRIzons*, Neutrinos in Physics, Astrophysics and Cosmology, Harish-Chandra Research Institute, Allahabad; January 7–9, 2009.
4. *Getting Ready For The Physics at the LHC*, Regional Centre for Accelerator-based Particle Physics (RECAPP), Harish-Chandra Research Institute, Allahabad; February 16–20, 2009.

Visits to other Institutes

1. Center for High Energy Physics (CHEP-IISC), Bangalore; March 2009.

Invited Lectures/Seminars

1. *Impact of dimension-5 operators in GUTs*, DAE Symposium, Banaras Hindu University, Varanasi; December 2009.

Other Activities

1. I have been the tutor of the Quantum Field Theory I course for the semester January–March, 2009.

Nishita Desai

I have been working on identification of signals of beyond the standard model (BSM) physics at the LHC. I have recently completed a study on identification of supersymmetric signals when only the third family of squarks is accessible at the LHC and the first two families have such high masses as to be decoupled. We have looked at signatures for multi-top final states involving dileptons and various multiplicities of tagged b-jets. We also supplement our results by looking at higgs signatures arising out of cascades of neutralinos. I am further interested in studying various other models for BSM and comparison of the differences in their signals as would be visible at the LHC.

Preprints

1. Nishita Desai and Biswarup Mukhopadhyay, *Signals of supersymmetry with inaccessible first two families at the Large Hadron Collider,* arXiv: 0901.4-883

Conference/Workshops Attended

1. *Instructional Workshop on the Large Hadron Collider (*LHC*) and Related Physics*; December 2008.
2. *Getting Ready for Physics at the* LHC; February 2009.
3. XXIV SERC THEP *Main School*; March 2009.

Seminars and Colloquia

Mathematics Talks and Seminars

1. D. N. Verma: Study of Weyl groups, Coxeter groups, & Rootsystems: basic tools for Lie Theory and many related topics.
2. John Coates: The Arithmetic of elliptic curves with complex multiplication bottle with vertex-transitive group actions.
3. R. Sujatha: The Arithmetic of elliptic curves with complex multiplication
4. Loic Merel: The Galois properties of torsion points of elliptic curves
5. Ambris Pal: Unform bounds on the cardinality of preperiodic points of certain polynomials
6. Dipendra Prasad: Central critical L-values, and representations of p-groups.
7. Makoto Minamide: Zeros of the derivative of the Selberg zeta function for $PSL(2, Z)$.
8. Yoshio Tanigawa: Dirichlet series obtained from the error term in the Dirichlet divisor problem.
9. S. Kumaresan: Borel–Weil Theorems
10. Anupam Kumar Singh: Real and Strongly Real Clases in Finite Linear Groups
11. Shigeru Kanemitsu: Topics brief of his lectures: in the theory of zeta and allied functions
12. Shakir Ali: On *-derivations in *-algebras
13. Ram Murty: Logic, Number Theory, and the Limits of Human Reason
14. N. Raghavendra: A course on Riemann Surfaces and zero curves with n marked points.
15. D. S. Ramana: A course on Additive Number Theory
16. Clemens Fuchs: On a problem of Diophantus and its variants
17. N. P. Skoruppa: Computation of Modular Forms and Lie Groups.

Physics Talks and Seminars

1. Neil Lambert: M2 branes
2. S. Shankaranarayanan: Sub-leading corrections to black-hole entropy
3. S. Shankaranarayanan: Probing quantum gravitational physics via inflation.
4. Archana Pai: Optimal source tracking and beaming of LISA
5. Sudhir Kumar Gupta: Some Studies on Supersymmetry Search in Accelerators
6. Bindusar Sahoo: Black hole entropy and Higher derivative corrections
7. Tirthbir Biswas: Dark Energy vs. Local Void
8. B. Zwieback
9. Partha Konar: Graviton production with 2 jets at the LHC in Large extra Dimensions.
10. Sudipta Das: Brans-Dicke scalar field as a chameleon
11. Soumen Basak: Simulating weak lensing on CMB maps
12. Colin Benjamin: Effect of disorder on positive shot noise cross correlations in superconducting hybrids
13. K. Subramanian: Magnetic helicity conservation in galactic dynamos
14. Ratna Koley: Confinement of fermions in warped spacetime and the smallness of cosmological constant.
15. Girish Kulkarni: Bayesian analysis and Cosmology
16. Jasjeet Singh Bagla: GRB 080913 at redshift 6.7
17. Prasenjit Sen: Electron-electron interactions
18. Jerome Martin: DBI inflation: Theoretical predictions and comparison to CMB data
19. D. V. Ahluwalia: Local fermionic dark matter with mass dimension one.
20. Sudipta Das: Can Dark Matter decay in Dark Energy?
21. Raghavan Rangarajan: Gravitino Production in an Inflationary Universe and Implications for Leptogenesis.
22. Manoj Gopalkrishnan: Non-equilibrium Stat. Mech.
23. Bruce Mellado: A set of 4 lecture series on LHC experiment
24. Archana Sharma: The CMS experient: readiness for LHC physics
25. Bruce Mellado: Challenges of the LHC
26. Kanan K. Datta: Probing Cosmological Reionization through Radio-Interferometric Observations of Neutral Hydrogen
27. Pasquale Di Bari: Leptogenesis
28. Thomas Hambye: Leptogenesis Models
29. Alejandro Ibarra: Lepton Flavour Violation
30. Mary Hall-Reno: Ultrahigh Energy Neutrinos:Production and Detection (two lectures)
31. Indranil Chattopadhyay: How plasma composition affects relativistic fl-

ow?
32. Eric Bergshoeff: Three dimensional superconformal field theories
33. Giulia Ricciardi: Flavour and B Physics
34. Antonella Maselli: Radiative transfer and Cosmological Reionization (five lectures)
35. Ravi K. Sheth: The halo model of gravitational clustering
36. Pravabati Chingangbam: Signatures of primordial non-Gaussianity

Joint Colloquia

1. S. Shankaranarayanan: Probing quantum gravitational physics via inflation
2. Archana Pai: Fishing gravitational wave chirps with multi-detector network
3. Venketeswara Pai: Some recent developments in two dimensional electron systems
4. Tirthabir Biwas: Non-singular Universes
5. H. Kushwaha: Safe and Green Nuclear Energy
6. Colin Benjamin: Effect of disorder on positive shot noise cross-correlations in superconducting hybrids
7. Aditi Sen (De): What is Quantum Correlation?
8. Arun Pati: What is Quantum Information
9. Jerome martin: Inflationary Cosmology
10. Yashwant Gupta: The Giant Metrewave Radio Telescope: An Overview, Some Results & Future Plans
11. Pinaki Sengupta : Bose-Einstein condensation of magnons
12. Shrihari Gopalakrishna: New Physics Expectation at the Large Hadron Collider
13. Eric Bergshoeff: What is Gravity
14. Paul Wiita: Active Galactic Nuclei and Blazars: Conical Jet Effects
15. Ravi K. Sheth: Through a Glass Darkly: Searches for Dark Matter and Energy in the Universe

Workshops and Conferences

Mathmatics

1. ATM Workshop on Compact Lie Groups; November 17–29, 2008
2. Discussion Meeting on Additive Combinatorics; January 16–31, 2009
3. Discussion Meeting on Modular Forms; February 21–March 8, 2009
4. International Conference in Mathematics; March 16–20, 2009

Physics

1. Summer School on Gravitation and Cosmology; May 12–24, 2008
2. Summer School in Biological Physics; May 26–June 7, 2008
3. RECAPP Workshop; September 21–October 4, 2008
4. Instructional Workshop on LHC physics; December 19–24, 2008
5. NuHoRIzons 09; January 7–9, 2009
6. International Symposium on Clusters and Cluster Assemblies and Nanoscale Materials; February 9–11, 2009
7. Getting Ready for physics at LHC; February 16–20, 2009
8. School on Spintronic and Magnetoelectronic Materials and Devices; January 8–10, 2009
9. Homi Bhabha Centernary DAE-BRNS National Conference; January 5–7, 2009

Recent Graduates

1. **Raghavendra Srikant H.**, *Some studies in physics Beyond the Standard Model,* Allahabad University; August 8, 2008.
2. **Pomita Ghoshal**, *A Study of Matter Effects in Neutrino Oscillations*, Allahabad University; September 7, 2008.
3. **Suvankar Datta**, *Aspects if the Thermal AdS/CFT Correspondence,* Homi Bhabha National Institute; February 17, 2009.
4. **Bindusar Sahoo**, *Black Hole Entropy and Higher Derivative Corrections,* Homi Bhabha National Institute; February 17, 2009.
5. **Sanjib Kumar Agarwala**, *Some Aspects of Neutrino Mixing and Oscillations,* Calcutta University (submitted).
6. **Swarup Majee**, *Some Explorations of New Physics Beyond the Standard Model,* Calcutta University; (submitted).
7. **Jayanti Prasad**, *Aspects of Gravtational clustering,* Allahabad University; (submitted).
8. **Anupama Panigrahi**, *Some problems in Combinatorial and Algebraic Number Theory,* Allahabad University; August 20, 2008.
9. **Brindaban Sahoo**, *Some problems in Number Theory,* Allahabad University; November 6, 2008.

Publications

Sukumar Das Adhikari

1. S. D. Adhikari, R. Balasubramanian, F. Pappalardi and P. Rath, *Some zero-sum constants with weights*, Proc. Indian Acad. Sci. (Math. Sci.) **118** 2 (2008), 183–188.
2. Sukumar Das Adhikari, Stephan Baier and Purusottam Rath, *An extremal problem in lattice point combinatorics*, Diophantine Equations, (Ed. N. Saradha, Tata Institute of Fundamental Research, 2008), New Delhi: Narosa, 19–32.
3. Sukumar Das Adhikari, Chantal David and Jorge Jiménez Urroz, *Generalizations of some zero-sum theorems*, Integers **8** (2008), A52.
4. S. D. Adhikari and P. Rath, *A problem on the fractional parts of the powers of* $3/2$ *and related questions*, Number Theory and Discrete Geometry, Proceedings of the International Conference on Number Theory & Discrete Geometry held in honour of Professor R. P. Bambah, held at Department of Mathematics, Punjab University (Chandigarh, November 30-December 3, 2005, Eds. R. Balasubramanian, S. G. Dani, P. M. Gruber and R. J. Hans-Gill) Ramanujan Mathematical Society Lecture Notes Series 6 (2008), 1–12.
5. S. D. Adhikari, Mohan N. Chintamani, Bhavin K. Moriya and Prabal Paul, *Weighted sums in finite abelian groups*, Uniform Distribution Theory **3** No. 1 (2008), 105–110.
6. S. D. Adhikari, Sanoli Gun and Purusottam Rath, *Remarks on some zero-sum theorems*, To appear in Proc. Indian Acad. Sci. (Math. Sci.).
7. S. D. Adhikari and Andrew Granville, *Visibility in the plane*, In preparation.

Andreas Nyffeler

1. A. Belyaev, I. A. Christidi, A. De Roeck, R. M. Godbole, B. Mellado, A. Nyffeler, C. Petridou, D. P. Roy, *Dictionary of LHC Signatures,* Pramana **72** 229 (2009)
2. A. Nyffeler, *Hadronic light-by-light scattering in the muon* $g-2$*: a new short-distance constraint on pion-exchange,* Phys. Rev. D **79** 073012 (2009)

Archana Subhash Morye

1. Archana S. Morye, *Note on the Serre-Swan Theorem,* accepted for publication in Mathematische Nachrichten.

Amitava Raychaudhuri

1. Sanjib Kumar Agarwalla, Sandhya Choubey, and Amitava Raychaudhuri, *Unraveling neutrino parameters with a magical beta-beam experiment at* INO, Nucl. Phys. **B798**, 124 (2008)*.
2. Sanjib Kumar Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, and Walter Winter, *Optimizing the greenfield Beta-beam experiment at* INO, J. of High Energy Physics **06** 090 (2008)*.
3. Sanjib Kumar Agarwalla, Sandhya Choubey, and Amitava Raychaudhuri, *Exceptional Sensitivity to Neutrino Parameters with a Two-Baseline Beta-Beam Set-up,* Nucl. Phys. **B805,** 305 (2008).
4. Swarup Kumar Majee, Mina K. Parida, and Amitava Raychaudhuri, *Neutrino mass and low-scale leptogenesis in a testable SUSY SO(10) model,* Phys. Lett. **B668,** 299-302 (2008).
5. Joydeep Chakrabortty and Amitava Raychaudhuri, *A note on dimension-5 operators in GUTs and theit impact,* Phys. Lett. **B673**, 57-62 (2009).
6. Amitava Raychaudhuri, *Getting to know the India-based Neutrino Observatory (*INO*)*, Physics News. **38,** 38-45 (2008). *(Popular article)*

Arijit Saha

1. Arijit Saha, Sourin Das and Sumathi Rao, *A systematic stability analysis of the renormalisation group flow for the normal-superconductor-normal junction of Luttinger liquid wires,* Phys. Rev. B **79**, 155416, (2009)
2. Arijit Saha and Sourin Das, *Quantized charge pumping in superconducting double barrier structure : Non-trivial correlations due to proximity effect,* Phys. Rev. B **78**, 075412, (2008)
3. Arijit Saha, Sourin Das and Sumathi Rao, *Renormalization group study of transport through a superconducting junction of multiple one-dimensional quantum wires,* Phys. Rev. B **77**, 155418, (2008)
4. Arijit Saha, Sourin Das and Sumathi Rao, *Spintronics with NSN Junction of one-dimensional quantum wires : A study of Pure Spin Current and Magnetoresistance,* Europhys. Lett. **81**, 67001, (2008)

Arjun Bagchi

1. Arjun Bagchi and Ashoke Sen, *Tachyon Condensation on Separated Brane-Antibrane System,* Journal of High Energy Physics **0805:010**, (2008)
2. Arjun Bagchi and Rajesh Gopakumar, *Galilean Conformal Algebras and AdS/CFT.* Accepted for publication in Journal of High Energy Physics. 0902.1385 (hep-th)

3. Arjun Bagchi and Ipsita Mandal, *On Representations and Correlation Functions of Galilean Conformal Algebras.* Physics Letters **B675**, 393-397.(2009)

AseshKrishna Datta

1. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Non-universal gaugino and scalar masses, hadronically quiet trileptons and the Large Hadron Collider,* Phys. Rev. D **78** (2008), 115018.
2. Priyotosh Bandyopadhyay, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Signatures of gaugino mass non-universality in cascade Higgs production at the LHC,* Phys. Lett. B **670** (2008), 5.
3. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Non-universal scalar masses: A Signal-based analysis for the Large Hadron Collider,* Phys. Rev. D **78** (2008), 035011.

Ashoke Sen

1. A. Sen, *U-duality Invariant Dyon Spectrum in type II on T^6,* JHEP **0808** 037 (2008) arXiv:0804.0651 [hep-th].
2. A. Sen, *Entropy Function and AdS(2)/CFT(1) Correspondence*, JHEP **0811**, 075 (2008) [arXiv:0805.0095 [hep-th]].
3. S. Banerjee and A. Sen, *Interpreting the M2-brane Action* arXiv:0805.3930 [hep-th].
4. R. K. Gupta and A. Sen, *Ads(3)/CFT(2) to Ads(2)/CFT(1)*, JHEP **0904** 034 (2009) [arXiv:0806.0053 [hep-th]].
5. S. Cecotti and A. Sen, *Coulomb Branch of the Lorentzian Three Algebra Theory* arXiv:0806.1990 [hep-th].
6. S. Banerjee, A. Sen and Y. K. Srivastava, *Genus Two Surface and Quarter BPS Dyons: The Contour Prescription* JHEP **0903**, 151 (2009) arXiv: 0808.17-46 [hep-th].
7. A. Sen, *Quantum Entropy Function from AdS(2)/CFT(1) Correspondence*, arXiv : 0809.3304 [hep-th].
8. N. Banerjee, D. P. Jatkar and A. Sen, *Asymptotic Expansion of the N=4 Dyon Degeneracy*, arXiv:0810.3472 [hep-th].
9. N. Banerjee, I. Mandal and A. Sen, *Black Hole Hair Removal*, arXiv: 0901.0359 [hep-th].
10. A. Sen, *Arithmetic of Quantum Entropy Function* arXiv:0903.1477 [hep-th].

Ayan Mukhopadhyay

1. R. K. Gupta and A. Mukhopadhyay , *"On the universal hydrodynamics of strongly coupled CFTs with gravity duals"*, JHEP **0903**, 067 (2009) arXiv: 0810.4851 [hep-th].

Bhavin K. Moriya

1. S. D. Adhikari, M. N. Chintamani, B. K. Moriya, P. Paul, *Weighted sums in finite abelian groups.* Uniform Distribution Theory **3** 1 (2008), 105-110.

Biswarup Mukhopadhyaya

1. Paramita Dey, Sudhir Kumar Gupta and Biswarup Mukhopadhyaya, *The Impossibility of heavy neutrino dark matter in the Littlest Higgs Model with T-parity: Constraints from direct search*, Phys. Lett. B **674** (2009), 188-191.
2. Subhaditya Bhattacharya, Aseshkrishna Datta and Biswarup Mukhopadhyaya, *Non-universal gaugino and scalar masses, hadronically quiet trileptons and the Large Hadron Collider*, Phys. Rev. D **78** (2008), 115018.
3. Paramita Dey, Anirban Kundu, Biswarup Mukhopadhyaya and Soumitra Nandi, *Two-loop neutrino masses with large R-parity violating interactions in supersymmetry* JHEP 0812:100 (2008).
4. Priyotosh Bandyopadhyay, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Signatures of gaugino mass non-universality in cascade Higgs production at the LHC*, Phys. Lett. B **670** (2008) 5–11.
5. Subhaditya Bhattacharya, Aseshkrishna Datta, Biswarup Mukhopadhyaya *Non-universal scalar masses: A Signal-based analysis for the Large Hadron Collider*, Phys. Rev. D **78** (2008) 035011.
6. Debajyoti Choudhury, Sudhir Kumar Gupta and Biswarup Mukhopadhyaya, *Right sneutrinos in a supergravity model and the signals of a stable stop at the Large Hadron Collider*, Phys. Rev. D **78** (2008), 015023.
7. S. Gabriel, Biswarup Mukhopadhyaya, S. Nandi and Santosh Kumar Rai, *Inverted neutrino mass hierarchy and new signals of a chromophobic charged Higgs at the Large Hadron Collider* Phys. Lett. B **669** (2008), 180–185.
8. Paramita Dey, Anirban Kundu and Biswarup Mukhopadhyaya, textit-Some consequences of a Higgs triplet, J. Phys. G **36** (2009) 025002.

Bobby Ezhuthachan

1. Bobby Ezhuthachan, *The Power of the Higgs Mechanism: Higher-Derivative BLG Theories,* JHEP **0904** 101 (2009)

Chandan Singh Dalawat

1. Chandan Singh Dalawat, *Wilson's theorem*, *Journal de Théorie des nombres de Bordeaux*; to appear.
2. C. S. Dalawat, *Ribet's modular construction of unramified p-extensions of $\mathbf{Q}(_p\mu)$*, *Proceedings of the Gauhati workshop*, to appear.

Rajesh Gopakumar

1. J. David, R. Gopakumar and A. Mukhopadhyay, *Worldsheet Properties of Extremal Correlators in AdS/CFT* HEP **0810**, 029, (2008)
2. Arjun Bagchi and R. Gopakumar, *Galilean Conformal Algebras and AdS/CFT,* JHEP (to appear)

Harvinder Kaur Jassal

1. S. Unnikrishnan, H. K. Jassal and T. .R. Seshadri, *Scalar field dark energy perturbations and their scale dependence*, Phys. Rev. **78** (2008) 123504 (2008)

Ioulia Baoulina

1. I. Baoulina, *On the number of solutions to the equation* $(x_1 + \cdots + x_n)^2 = ax_1 \cdots x_n$ *in a finite field,* Int. J. Number Theory **4** (2008), 797-817.
2. I. Baoulina and F. Luca, *On positive integers with a certain nondivisibility property,* Ann. Math. Inform. **35** (2008), 11–19.

Ipsita Mandal

1. Sayantani Bhattacharyya, R. Loganayagam, Ipsita Mandal, Shiraz Minwalla, Ankit Sharma, *Conformal Nonlinear Fluid Dynamics from Gravity in Arbitrary Dimensions* , JHEP **0812:116** (2008).
2. Nabamita Banerjee, Ipsita Mandal, Ashoke Sen, *Black Hole Hair Removal,* (To be published in JHEP).
3. Arjun Bagchi, Ipsita Mandal, *On Representations and Correlation Functions of Galilean Conformal Algebras,* Phys. Lett. B **675, Issues 3-4** (2009).

Jasjeet Singh Bagla

1. Bagla J. S., Yadav Jaswant and Seshadri T. R., *Fractal Dimension of a Weakly Clustered Distribution and the Scale of Homogeneity,* MNRAS **390** (2008), 829.
2. Bagla J. S. and Prasad Jayanti, *Gravitational collapse in an expanding background and the role of substructure II: Excess power at small scales and its effect of collapse of structures at larger scales*, MNRAS **393** (2009), 607.
3. Bagla J. S., *Hubble, Hubble's law and the expanding universe*, Resonance **14** (2009), 216.

Joydeep Chakrabortty

1. Joydeep Chakrabortty and Amitava Raychaudhuri, *A note on dimension-5 operators in GUTs and their impact* , Physics Letters B **673**, 57-62, (2009)
2. Joydeep Chakrabortty, Amol Dighe, Srubabati Goswami, Shamayita Ray *Renormalization group evolution of neutrino masses and mixing in the Type-III seesaw mechanism* , Nuclear Physics B **820**, 116-147, (2009)

Kalpataru Pradhan

1. Kalpataru Pradhan, Prasenjit Sen, J. U. Reveles, S. N. Khanna, *First-principles study of TMNa$_n$(TM= Cr, Mn, Fe, Co, Ni; n = 4-7) clusters,* J. Phys. Condens. Matter **20**, 255243 (2008)..
2. Kalpataru Pradhan, Anamitra Mukherjee and Pinaki Majumdar, *Exploiting B Site Disorder for Electronic Phase Control in the Manganites,* Europhys. Lett. **84**, 37007 (2008).
3. Kalpataru Pradhan, Pinaki Majumdar, *Magnetic order Beyond RKKY in the Classical Kondo Lattice* Europhys. Lett. **85**, 37007 (2009).
4. Anamitra Mukherjee, Kalpataru Pradhan, Pinaki Majumdar, *Conductance switching and inhomogeneous field melting in the charge ordered manganites,* Europhys. Lett. **86**, 27003 (2009).
5. J. U. Reveles, P. A. Clayborne, A. C. Reber, S. N. Khanna, K. Pradhan, P. Sen, and M. R. Pederson, *Designer Magnetic Superatoms,* Nature Chemistry, in press (2009).

Kalyan Chakraborty

1. K. Chakraborty, F. Luca *Perfect powers in solutions to Pell equations*, Revista Colombiana de matematicas, To appear.
2. K. Chakraborty, Florian Luca and Anirban Mukhopadhyay *Exponents of class groups of real quadratic fields,* Int. J. Number Theory **4** 4 (2008), 597–611.
3. K. Chakraborty, Florian Luca and Anirban Mukhopadhyay *Class numbers with many prime factors*, J. Number Theory **128** 9 (2008), 2559–2572.
4. K. Chakraborty, S. Kanemitsu and T. Kuzumaki *Finite expressions for higher derivatives of the Dirichlet L function and the Deninger R function*, Hardy-Ramanujan Journal, To appear.

Manoj Gopalakrishnan

1. B. S. Govindan, M. Gopalakrishnan and D. Chowdhury *Length control of microtubules by depolymerizing motor proteins,* Europhys. Lett. **83** (2008), 40006-p1.

Mahender Singh

1. Mahender Singh, *$\mathbb{Z}_2$ actions on complexes with three non-trivial cells,* Topology and its Applications **155** (2008), 965-971.
2. Mahender Singh, *Fixed points of circle actions on spaces with rational cohomology of $S^n \vee S^{2n} \vee S^{3n}$ or $P^2(n) \vee S^{3n}$,* Archiv der Mathematik **92** (2009), 174-183.
3. Mahender Singh, *A note on the commutativity of inverse limit and orbit map,* Mathematica Slovaca, (2009) (to appear).

Manimala Mitra

1. Biswajoy Brahmachari, Sandhya Choubey and Manimala Mitra, *The A(4) Flavor Symmetry and Neutrino Phenomenology*; Phys. Rev. D **77**, 073008, (2008)
2. Manimala Mitra and Sandhya Choubey, *Lepton Masses in a Minimal Model with Triplet Higgs Bosons and S_3 Flavor Symmetry*; Phys. Rev. D **78**, 115014, (2008)

Mohan Namdev Chintamani

1. S. D. Adhikari, M. N. Chintamani, B. K. Moriya and P. Paul *Weighted sums in finite abelian groups*, Uniform Distribution Theory, **3** 1 (2008), 105-110.

Manoj Kumar

1. Manoj K. Yadav, *On central automorphisms fixing the center elementwise,* Comm. Algebra (2009), in press.

Nishikanta Khandai

1. J. S. Bagla, Jayanti Prasad, Nishikanta Khandai *Effects of the size of cosmological N-Body simulations on physical quantities - III: Skewness,* MNRAS 395, 918, (2009)
2. J. S. Bagla & Nishikanta Khandai *The Adaptive TreePM: an adaptive resolution code for cosmological N-Body simulations,* MNRAS 396, 221 (2009)
3. Nishikanta Khandai & Bagla, J. S. *A Modified TreePM Code,* Research In Astronomy and Astrophysics 9, 861-873, (2009)

Sudhakar Panda

1. *Origin of the geometric tachyon* (with A. Das and S. Roy), Phys. Rev. D **78** (2008) 061901(R).
2. *Thermodynamics of Born-Infeld Black Holes*, (with W. A. Chemissany and M. de Roo), Class. Quant. Grav. **25** (2008) 225009.
3. *Proper acceleration, geometric tachyon and dynamics of a fundamental string near Dp-branes*, (with A. Das and S. Roy), Class. Quant. Grav. **26** (2009) 055004.
4. *Prospects of inflation with perturbed throat geometry*, (with A. Ali, R. Chingangbam and M. Sami), Phys. Lett. B **674** (2009), 131.

Paramita Dey

1. P. Dey, A. Kundu and B. Mukhopadhyaya, *Some consequences of a Higgs triplet,* J. Phys. **G36** (2009) 025002

2. P. Dey, A. Kundu, B. Mukhopadhyaya and S. Nandi, *Two-loop neutrino masses with large R-parity violating interactions in supersymmetry,* JHEP **0812** (2008) 100
3. P. Dey, S. K. Gupta and B. Mukhopadhyaya, *The impossibility of heavy neutrino dark matter in the Littlest Higgs Model with T-parity: constraints from direct search,* Phys. Lett. **B674** (2009) 188

Tribhuvan Prasad Pareek

1. T. P. Pareek and A. M. Jayannavar, *Generation and measurement of non-equilibrium spin currents in two-terminal systems,* PRB **77**, 153307, (2008).

Pinaki Majumdar

1. Anamitra Mukherjee, Kalpataru Pradhan and Pinaki Majumdar, *Conductance Switching and Inhomogeneous Field Melting in the Charge Ordered Manganites,* Europhys. Lett. **86**, 27003 (2009).
2. Kalpataru Pradhan and Pinaki Majumdar, *Magnetic Order Beyond* RKKY *in the Classical Kondo Lattice,* Europhys. Lett. **85**, 37007 (2009).
3. Kalpataru Pradhan, Anamitra Mukherjee and Pinaki Majumdar, *Exploiting B Site Disorder for Phase Control in the Manganites,* Europhys. Lett. **84**, 37007 (2008).
4. Prabuddha Sanyal, Sabyasachi Tarat and Pinaki Majumdar, *Structural Ordering and Antisite Defect Formation in Double Perovskites,* Eur. Phys. J. **B65**, 39, (2008).

Prasenjit Sen

1. K. Pradhan, P. Sen, J. U. Reveles, and S. N. Khanna, *First Principles Study of $TMNa_n$ Clusters (TM=Cr, Mn, Fe, Co, Ni; $n = 4 - 7$) clusters,* J. Phys. Cond. Mat. **20**, 255243, (2008).
2. S. Barman, P. Sen and G. P. Das, *Ti decorated doped silicon fullerene: a possible hydrogen storage material,* Ti decorated doped silicon fullerene: a possible hydrogen storage material **112**, 19963, (2008).

Priyotosh Bandyopadhyay

1. Priyotosh Bandyopadhyay, AseshKrishna Datta, Biswarup Mukhopadhyaya, *Signatures of gaugino mass non-universality in cascade Higgs production at the LHC.,* Phys.Lett.B **670** (2008)
2. Priyotosh Bandyopadhyay, Amitava Datta, Aseshkrishna Datta, Biswarup Mukhopadhyaya, *Associated Higgs production in CP-violating supersymmetry: Probing the 'open hole' at the large hadron collider,* Phys.Rev.D **78** 015017 (2008)

Punita Batra

1. Tanusree Pal and Punita Batra, *Representations of Graded Multiloop Lie algebras,* Communications in Algebra, (to appear).

Rajeev Kumar Jain

1. Rajeev Kumar Jain, P. Chingangbam, J. O. Gong, L. Sriramkumar and T. Souradeep, *Punctuated inflation and the low CMB multipoles*, Journal of Cosmology and Astroparticle Physics **0901**, 009 (2009).

Raj Gandhi

1. R. Gandhi, P. Ghoshal, S. Goswami and U. Sankar , *Resolving the Mass Hierarchy with Atmospheric Neutrinos using a Liquid Argon Detector ,* Phys. Rev. **D78** (2008), 073001.

B. Ramakrishnan

1. S. Gun and B. Ramakrishnan, *On the representation of integers as sums of an odd number of squares,* The Ramanujan Journal **15** (2008), 367–376.

P. K. Ratnakumar

1. P. K. Ratnakumar, *On Schrödinger propagator for the special Hermite operator*, J. Fourier Anal. and Appl., **14** 2 (2008), 286–300.

V. Ravindran

1. M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Unparticles in diphoton production to NLO in QCD at the LHC, Phys. Rev. D **79** (2009), 075012.
2. M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Diphoton signals in theories with large extra dimensions to NLO QCD at hadron colliders, Phys. Lett. B **672** (2009), 45–50.
3. M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Direct photon pair production at the LHC to $O(\alpha_s)$ in TeV scale gravity models, Nucl. Phys. B **818** (2009), 28–51.

Rukmini Dey

1. Rukmini Dey *Geometric prequantization of the modified Seiberg-Witten equations in* 2*-dimensions,* Adv. Theor. Math. Phys. **13.5**, (2009)

Abhijit Samanta

1. A. Samanta *"A comparison of the sensitivities of the parameters with atmospheric neutrinos for different analysis methods"*, Phys. Rev. D **79** 053011 (2009).
2. A. Samanta *"The mass hierarchy with atmospheric neutrinos at INO"*, Phys. Lett. B **673** 37 (2009)

Sandhya Choubey

1. Sandhya Choubey, Werner Rodejohann, Probir Roy, *Phenomenological consequences of four zero neutrino Yukawa textures*, Nucl. Phys. B **808** (2009), 272.
2. Manimala Mitra, Sandhya Choubey, *Lepton Masses in a Minimal Model with Triplet Higgs and S(3) x Z(4) Flavor Symmetry*, Phys. Rev. D **78** (2008), 115014.
3. Sovan Chakraborty, Sandhya Choubey Basudeb Dasgupta, Kamales Kar, *Effect of Collective Flavor Oscillations on the Diffuse Supernova Neutrino Background*, JCAP **0809** (2008), 013.
4. Sanjib K. Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, *Exceptional Sensitivity to Neutrino Parameters with a Two Baseline Beta-Beam Setup*, Nucl. Phys. **B805**, 305, (2008).
5. Sandhya Choubey, Viviana Niro, Werner Rodejohann, *On Probing $\theta(23)$ in Neutrino Telescopes*, Phys. Rev. D **77** 2008, 113006.
6. Sandhya Choubey and D. Indumathi, *Working group report: Neutrino physics*, Pramana **72** (2009), 269.

Sanjoy Biswas

1. Sanjoy Biswas and Biswarup Mukhopadhyaya, *Neutralino reconstruction in supersymmetry with long-lived staus,* Physical Review D **79**, 115009, (2009)

Satya Deo

1. Satya Deo, *Why do we call them projective spaces?*, Mathematics Newsletter, Ramanujan Mathematical Society, **18** (2008), 1-6.
2. Satya Deo, *Cohomology theories best suited for the cohomological dimension theory* , Mathematics Student, Special Centenary Volume-2007, published in 2008 (2007), 121-134.
3. Satya Deo and David Gauld, *Eventually constant spaces and nonmetrizable homology spheres*, Journal of Indian Mathematical Society, Special Centenary Volume (2007), 165-175.

Shamik Banerjee

1. Shamik Banerjee, Ashoke Sen, *Interpreting The M2-Brane Action*, Modern Physics Letters A **24** 10 (2009).
2. Shamik Banerjee, Ashoke Sen, Yogesh K. Srivastava , *Genus Two Surface and Quarter BPS Dyons: The Contour Prescription* , JHEP 0903:151, 2009.

L. Sriramkumar

1. S. Sarkar, S. Shankaranarayanan and L. Sriramkumar, *Sub-leading contributions to the black hole entropy in the brick wall approach*, Phys. Rev. D **78** (2008), 024003.
2. D. A. Kothawala, S. Shankaranarayanan and L. Sriramkumar, *Quantum gravitational corrections to the stress-energy tensor around the BTZ black hole*, JHEP **0809** (2008), 095.
3. R. K. Jain, P. Chingangbam, J. -O. Gong, L. Sriramkumar and T. Souradeep, *Punctuated inflation and the low* CMB *multipoles*, JCAP **0901** (2009), 009.

Subhaditya Bhattacharya

1. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya *Non-universal scalar masses: A Signal-based analysis for the Large Hadron Collider,* Phys. Rev. **D78**:035011 (2008)
2. Subhaditya Bhattacharya, AseshKrishna Datta, Biswarup Mukhopadhyaya *Non-universal gaugino and scalar masses, hadronically quiet trileptons and the Large Hadron Collider,* Phys. Rev. **D78**:115018 (2008)

Sumathi Rao

1. Sourin Das and Sumathi Rao, *Duality between normal and superconducting junctions of multiple quantum wires*, cond-mat/0807.0804, Phys. Rev. B **78** (2008), 205421.
2. Sourin Das, Sumathi Rao and Arijit Saha, *A systematic stability analysis of the renormalisation group flow for the normal-superconductor-normal junction of Luttinger liquid wires*, cond-mat/0901.0126, Phys. Rev. B **79** (2009), 155416.
3. Sourin Das, Sumathi Rao and Diptiman Sen, *Effect of inter-edge Coulomb interactions on transport through a point contact in a $\nu = 5/2$ quantum Hall state*, cond-mat/0808.2249, Europhys. Lett. **81** (2009), 37010.

D. Surya Ramana

1. Gyan Prakash and D. S. Ramana, *The large sieve inequality for real quadratic polynomial amplitudes,* Journal of the Ramanujan Math. Soc. **24** 2 (2009), 127-142.

Konar Sushan

1. Manjari Bagchi, Jishnu Dey, Sushan Konar, Gour Bhattacharya and Mira Dey, *Members of the double pulsar system PSR J0737-3039 : neutron stars or strange stars*, New Astron. **14** 37 (2009).
2. Zdenek Stuchlik, Sushan Konar, John C. Miller, Stanislav Hledik, *Gravitational excitation of high frequency QPOs*, Astron. & Astrophys. **489** 963 (2008).

Suvrat Raju

1. Suvrat Raju, *The Noncommutative S-Matrix,* JHEP **06** 5 (2009)

Tanusree Pal

1. Tanusree Pal, *Vogan diagrams of twisted affine KacMoody Lie algebras,* Pacific Journal of Mathematics **239** (2009), 65-88.
2. Tanusree Pal and Punita Batra, *Representations of graded multiloop Lie algebras,* Communications in Algebra, to appear.

R. Thangadurai

1. F. Luca and R. Thangadurai, *On an arithmetic function considered by Pillai,* Journal de theorie des nombres de Bordeaux, (To appear)
2. R. Balasubramanian, S. Laishram, T. N. Shorey and R. Thangadurai, *The number of prime divisors of the product of consecutive integers,* Journal of Combinatorics and Number Theory, (To appear)
3. N. Saradha, R. Thangadurai, *Pillai's problem on consecutive integers,* Conference proceedings of Number Theory and Applications, Hindustan Book Agency, India (2009), 175-188.

Tirthankar Roy Choudhury

1. Tirthankar Roy Choudhury, Martin G. Haehnelt, John Regan, *Inside-out or outside-in: the topology of reionization in the photon-starved regime suggested by Lyα forest data,* Monthly Notices of the Royal Astronomical Society **394** (2009) 960.

Preprints

Andreas Nyffeler

1. F. Jegerlehner and A. Nyffeler, *The Muon $g-2$,* arXiv:0902.3360 [hep-ph] (to appear in Physics Reports)

Arijit Saha

1. Arijit Saha, Sourin Das and Sumathi Rao, *Resonant transmission through a T-stub coupled to a superconductor,* e-Print: arXiv:0811.0660 [cond-mat]

Arjun Bagchi

1. Arjun Bagchi, Turbasu Biswas and Debashis Ghoshal, *Contour Integral Representations for Characters in Logarithmic CFTs.* 0810.2374 (hep-th).

Biswarup Mukhopadhyaya

1. Paramita Dey, Biswarup Mukhopadhyaya and Soumitra SenGupta, *Neutrino masses, the cosmological constant and a stable universe in a Randall-Sundrum scenario*, e-Print: arXiv: 0904.1970 [hep-ph]
2. Biswarup Mukhopadhyaya, Somasri Sen, Soumitra SenGupta, *A Randall-Sundrum scenario with bulk dilaton and torsion*, e-Print: arXiv: 0903.0722 [hep-th] (To appear in Phys. Rev. D)
3. Sanjoy Biswas, Biswarup Mukhopadhyaya, *Neutralino reconstruction in supersymmetry with long-lived staus*, e-Print: arXiv: 0902.4349 [hep-ph] (To appear in Phy. Rev. D)
4. Nishita Desai, Biswarup Mukhopadhyaya, *Signals of supersymmetry with inaccessible first two families at the Large Hadron Collider*, e-Print: arXiv: 0901.4883 [hep-ph]

Chandan Singh Dalawat

1. Chandan Singh Dalawat, *Further remarks on local discriminants*.
2. Chandan Singh Dalawat, *A first course in Local arithmetic*, Lecture notes; arXiv:0903.2615.

Dileep Jatkar

1. *Asymptotic Expansion of the $N = 4$ dyon degeneracy*, Nabamita Banerjee, Dileep P. Jatkar, Ashoke Sen, [arXiv:0810:3472].

Girish Kulkarni

1. Bagla J. S., Kulkarni Girish and Padmanabhan T., *Metal Enrichment and Reionization Constraints on Early Star Formation*, 0902.0853

Rajesh Gopakumar

1. J. R. David, M. Gaberdiel and R. Gopakumar, *The Heat Kernel on AdS_3 and its Applications* (in preparation)

Harvinder Kaur Jassal

1. H. K. Jassal, *A comparison of perturbations in fluid and scalar field models of dark energy*, arXiv:0903.5370 [astro-ph.CO].

Ioulia Baoulina

1. I. Baoulina, *On the number of solutions of the equation* $(x_1 + \ldots + x_n)^m = ax_1 \cdots x_n$ *over the finite field* $\mathbf{F}_q$ *for* $\gcd(m-n, q-1) = 7$ *and* $\gcd(m-n, q-1) = 14$ (to appear in HRI Proceedings)
2. I. Baoulina, *On the number of solutions to certain diagonal equations over finite fields* (to appear in Int. J. Number Theory)

Ipsita Mandal

1. Arjun Bagchi, Ipsita Mandal,, *Supersymmetric Extension of Galilean Conformal Algebras* , arXiv: 0905.0580
2. Nabamita Banerjee, Shamik Banerjee, Rajesh Gupta, Ipsita Mandal, Ashoke Sen, *Supersymmetry, Localization and Quantum Entropy Function* , arXiv: 0905.2686

Jaban Meher

1. J. Meher and B. Ramakrishnan, *Pseudo-eigenvalues of the W-operators on modular forms of half-integral weight* (in preparation).

Jasjeet Singh Bagla

1. Bagla J. S., Prasad Jayanti and Khandai Nishikanta, *Effects of the size of cosmological N-Body simulations on physical quantities — III: Skewness*, 0804.1197

2. Bagla J. S. and Khandai Nishikanta, *The Adaptive TreePM: An Adaptive Resolution Code for Cosmological N-body Simulations*, 0811.4228
3. Bagla J. S., Kulkarni Girish and Padmanabhan T., *Metal Enrichment and Reionization Constraints on Early Star Formation*, 0902.0853

Jaswant Kumar

1. Jaswant Yadav, Nishikant Khandai and J. S. Bagla, *"On the fractal Dimension and Scale of Homogeneity"*, (In Preparation)
2. Prakash Sarkar, Jaswant Yadav, B. Pandey & S. Bharadwaj, *"An examination of large scale clustering in SDSS DR6"*, (In Preparation)

Joydeep Chakrabortty

1. Subhaditya Bhattacharya and Joydeep Chakrabortty, *Gaugino mass non-universality in an SO(10) supersymmetric Grand Unified Theory: low-energy spectra and collider signals* , hep-ph/0903.4196
2. Joydeep Chakrabortty, Anjan S. Joshipura, Poonam Mehta, Sudhir K. Vempati, Degenerate neutrinos and Maximal Mixing (in preparation)

Kalpataru Pradhan

1. Kalpataru Pradhan and Pinaki Majumdar, *The Effects of B site Doping on the Manganites*

Kalyan Chakraborty

1. K. Chakraborty *On the Chowla-Selberg integral formula for non-holomorphic Eisenstein series,* Preprint
2. K. Chakraborty, S. Kanemitsu and Y. Tanigawa *Arithmetical Fourier series and the modular relation* Preprint
3. K. Chakraborty, S. Kanemitsu and H. -L. Li *On the values of a class of Dirichlet series at rational arguments,* Preprint
4. K. Chakraborty, S. Kanemitsu and Y. Tanigawa *Vistas of Special functions II*, To be published by World Scientific.

Manoj Gopalakrishnan

1. M. Reneaux and M. Gopalakrishnan, *From random to directed motion: Understanding chemotaxis in E.Coli within a simplified model,* arXiv:0812.4583
2. M. Gopalakrishnan and B. S. Govindan, *Optimization strategies of chromosome search-and-capture by microtubules: exact analytical results for a single fixed target,* arXiv: 0904.0111

Mahender Singh

1. Mahender Singh, *Cohomology algebra of orbit spaces of free involutions on lens spaces,* arXiv:0805.2865.
2. Mahender Singh, *Parametrized Borsuk-Ulam problem for projective space bundles,* arXiv:0810.4669.
3. I. B. S. Passi, Manoj K. Yadav and Mahender Singh, *Lifting automorphisms in group extensions* (in preparation).

Manimala Mitra

1. Biswajoy Brahmachari, Sandhya Choubey and Manimala Mitra, *The A(4) Flavor Symmetry and Neutrino Phenomenology*; arXiv: 0801.3554
2. Manimala Mitra and Sandhya Choubey, *Lepton Masses in a Minimal Model with Triplet Higgs Bosons and S_3 Flavor Symmetry*; arXiv: 0806.3254
3. Priyotosh Bandyopadhyay, Sandhya Choubey and Manimala Mitra, *Two Higgs Doublet Type-III Seesaw with $\mu-\tau$ Symmetry at LHC*; arXiv: 0906.5330

Akitsugu Miwa

1. Masanori Hanada, Akitsugu Miwa, Jun Nishimura, Shingo Takeuchi, *Schwarzschild radius from Monte Carlo calculation of the Wilson loop in supersymmetric matrix quantum mechanics,* arXiv:0811.2081.
2. Shoichi Kawamoto, Tsunehide Kuroki, Akitsugu Miwa, *Boundary condition for D-brane from Wilson loop, and gravitational interpretation of eigenvalue in matrix model in AdS/CFT correspondence,* arXiv:0812.4229.

Mohan Namdev Chintamani

1. W. D. Gao, M. N. Chintamani, B. K. Moriya, P. Paul, And R. Thangadurai, *On Davenport's Constant,* (in preparation).

Manoj Kumar

1. Manoj K. Yadav, *Automorphisms of finite p-groups of class 2*, in preparation.
2. Manoj K. Yadav, Mahender Singh and I. B. S. Passi, *Automorphisms of abelian extensions*, in preparation.

Nishita Desai

1. Nishita Desai and Biswarup Mukhopadhyay, *Signals of supersymmetry with inaccessible first two families at the Large Hadron Collider,* arXiv: 0901.4-883

Sudhakar Panda

1. *Warm tachyonic inflation in warped background*, (with A. Deshamukhya), arXiv: 0901.0471 [hep-th].

Paramita Dey

1. P. Dey, B. Mukhopadhyaya and S. Sengupta, *Neutrino masses, the cosmological constant and a stable universe in a Randall-Sundrum scenario,* arXiv: 0904.1970
2. S. Bhattacharya, P. Dey, B. Mukhopadhyaya, *Unitarity violation in sequential neutrino mixing in a model of extra dimensions,* arXiv: 0907.0099
3. P. Dey, P. Ghosh, B. Mukhopadhyaya and S. Roy, *One-loop corrected neutrino mass in certain extensions of the minimal supersymmetric standard model,* (in preparation)

Tribhuvan Prasad Pareek

1. T. P. Pareek, *Multi-terminal Spin Transport: Non applicability of linear response and Equilibrium spin currents,* 0809.5119 (submitted for publication)
2. T. P. Pareek *Spin Dephasing in system with broken spin rotation symmetry: an analytical approach,* (in preparation)

Pinaki Majumdar

1. Anamitra Mukherjee and Pinaki Majumdar, *A Real Space Description of Field Induced Melting in the Charge Ordered Manganites: I. The Clean Limit,* arXiv: 0811.3563.
2. Anamitra Mukherjee and Pinaki Majumdar, *A Real Space Description of Field Induced Melting in the Charge Ordered Manganites: II. The Disordered Case,* arXiv: 0811.3746.
3. Prabuddha Sanyal and Pinaki Majumdar, *A Magnetic Model for the Ordered Double Perovskites*, arXiv: 0812.1182.

Prasenjit Sen

1. J. U. Reveles, P. A. Clayborne, A. C. Reber, S. N. Khanna, K. Pradhan, P. Sen and M. R. Pederson, *Designer magnetic superatoms*, (submitted).
2. R. P. Bose, P. Sen and B. C. Gupta, *A density functional study of Au clusters adsorbed on Si(001): Formation of cluster lattice and a transition from non-metallicity to metallicity*, (in preparation).
3. D. Bandyopadhyay and P. Sen, *Study of structural and electronic properties of Ni-doped germanium clusters: A density functional investigation*, (in preparation).

Priyotosh Bandyopadhyay

1. Priyotosh Bandyopadhyay, *Probing non-universal gaugino masses via Higgs boson production under SUSY cascades at the LHC: A Detailed study,* arXiv: 0811.2537

Punita Batra

1. Tanusree Khandai and Punita Batra, *Representations of Lie Tori of type A_l coordinated by Cyclotomic Quantum Tori.*

Rajarshi Tiwari

1. Rajarshi Tiwari and Pinaki Majumdar, *Modeling Double perovskite with two magnetic sites*. (in preparation)

Rajeev Kumar Jain

1. Rajeev Kumar Jain, P. Chingangbam and L. Sriramkumar, *Reheating in tachyonic inflationary models: Effects on the large scale curvature perturbations*, arXiv:0902.1067 [astro-ph.CO].
2. Rajeev Kumar Jain, P. Chingangbam, L. Sriramkumar and T. Souradeep, *The tensor-to-scalar ratio in punctuated inflation*, arXiv: 0904.2518 [astro-ph.CO].

B. Ramakrishnan

1. M. Manickam, V. Kumar Murty and B. Ramakrishnan, *Non-vanishing of L-functions of half-integral weight* (revised version).
2. S. Gun and B. Ramakrishnan, *Divisors of modular forms for* $\Gamma_0(N)$ (in preparation).
3. J. Meher and B. Ramakrishnan, Pseudo-eigenvalues of the W-operators on modular forms of half-integral weight, (in preparation).

P. K. Ratnakumar

1. S. Parui, P. K. Ratnakumar, S. Thangavelu, *Analyticity of the Schrödinger propagator on the Heisenberg group.*
2. E. K. Narayanan and P. K. Ratnakumar, *Benedick's theorem for the Heisenberg Group.*

V. Ravindran

1. Neelima Agarwal, M. C. Kumar, Prakash Mathews, V. Ravindran, Anurag Tripathi, Di-jet production at the LHC through unparticles. arXiv: 0903.0202

2. G. Grunberg, V. Ravindran, On threshold resummation beyond leading 1-x order, arXiv: 0902.2702

Rukmini Dey

1. Shilpi Agarwal, Tapas Das, Rukmini Dey *Transonicity in black hole accretion — a mathematical study using generalized Strum chains* (in preparation)
2. Rukmini Dey, *Addendum: Geometric prequantization of the moduli space of the vortex equations on a Riemann surface ,* (in preparation)

Abhijit Samanta

1. R. Gandhi, A. Samanta and A. Watanabe *"The Role and Detectability of the Charm Contribution to Ultra High Energy Neutrino Fluxes"*, arXiv:0905.2483 [hep-ph]
2. A. Samanta *"Exceptional sensitivities of neutrino mixing parameters with atmospheric neutrinos"*, arXiv:0812.4639 [hep-ph]

Sandhya Choubey

1. Abhijit Bandyopadhyay, Sandhya Choubey, Srubabati Goswami, S. T. Petcov, D. P. Roy, *Neutrino Oscillation Parameters After High Statistics KamLAND*, arXiv: 0804.4857
2. Sanjib K. Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, *Probing neutrino parameters with a Two-Baseline Beta-beam set-up*, arXiv: 0811.1828 [hep-ph].
3. Sanjib K. Agarwalla, Sandhya Choubey, Amitava Raychaudhuri, CERNINO *magical Beta-beam experiment: A high precision probe for neutrino parameters*, arXiv: 0811.1822 [hep-ph].

Sanjoy Biswas

1. Sanjoy Biswas and Biswarup Mukhopadhyaya, *Chargiino reconstruction in supersymmetry with long-lived staus,* (in preparation)

Sashideep Gutti

1. Anne Franzen, Sashideep Gutti, Claus Kiefer,*Quantum Gravitational Collapse in the Lemaitre-Tolman-Bondi (LTB) model with a positive cosmological constant,* (in preparation).

Satchidananda Naik

1. Satchidananda Naik, *Self-Dual $\mathcal{N}$=8 Supergravity as a Closed String Field Theory in Twistor Space,* hep-th: 0903.2872

Satya Deo

1. Mathiew Baillif, Satya Deo and David Gauld, *Mapping class groups of the powers of the long ray*.
2. Satya Deo, *Cohomological dimension and finitistic spaces*, (in preparation)

Soumya Das

1. Soumya Das, *Non vanishing of Jacobi Poincaré series,* AA5916.
2. Soumya Das, *On Hermitian Jacobi forms,* IJNT-D-09-00050.
3. Soumya Das, *Restriction maps on Hermitian Jacobi forms of small index,* Submitted.
4. Soumya Das, *Estimation of Fourier coefficients of Hermitian modular forms* In preparation.

L. Sriramkumar

1. S. Sarkar, S. Shankaranarayanan and L. Sriramkumar, *Corrections to the Bekenstein-Hawking entropy in the brick wall approach*, To appear in the Proceedings of the Meeting on Black Holes in General Relativity and String Theory, August 24–30, 2008, Veli Losinj, Croatia.
2. R. K. Jain, P. Chingangbam and L. Sriramkumar, *Reheating in tachyonic inflationary models: Effects on the large scale curvature perturbations*, arXiv:0902.1067.

Subhaditya Bhattacharya

1. Subhaditya Bhattacharya, Joydeep Chakraborty *Gaugino mass non-universality in an SO(10) supersymmetric Grand Unified Theory: Low-energy spectra and collider signals,* arXiv:0903.4196[hep-ph]
2. Subhaditya Bhattacharya *Signatures of non-universal gaugino and scalar masses at the Large Hadron Collider,* arXiv:0809.2451[hep-ph]

Sudipta Das

1. Sudipta Das and Narayan Banerjee, *Can neutrino viscosity drive the late time cosmic acceleration?*, arXiv:0806.3666 [gr-qc]
2. Anjan A Sen, Gaveshna Gupta and Sudipta Das, *Non-Minimal Quintessence with Nearly Flat Potential*, arXiv:0901.0173 [gr-qc]

Sumathi Rao

1. Amit Agarwal, Sourin Das, Sumathi Rao and Diptiman Sen, *Enhancement of tunneling density of states at a junction of three Luttinger liquid wires* cond-mat/0810.3513, to be published in Phys. Rev. Lett.

2. Sourin Das, Sumathi Rao and Arijit Saha, *Resonant transmission of pure spin current through a t-stub coupled to a superconductor* cond-mat/0811.06-60, submitted to Europhys. Lett.
3. Arijit Kundu, Sumathi Rao and Arijit Saha, *Resonant spin transport through a superconducting double barrier structure*, in preparation.

D. Surya Ramana

1. J. Cilleruelo, D. S. Ramana and O. Ramaré, *The number of rational numbers determined by large sets of integers*, arXiv:0903.2714v1.

Konar Sushan

1. Raka Dona Ray Mandal, Sushan Konar, Mira Dey, Jishnu Dey, *The micro-glitch in PSR B1821-24 : A case for a strange pulsar?*, arXiv:0904.2559.
2. Sushan Konar, *Trends in pulsar current : Millisecond pulsars in galactic disc and globular clusters* (in preparation)

Suvrat Raju

1. Shailesh Lal and Suvrat Raju, *The Next-to-Simplest Quantum Field Theories?*, HRI/ST/0911, TIFR/TH/09-08

Tanusree Pal

1. Vyjayanthi Chari, Ghislain Fourier, and Tanusree Khandai, *A Categorical Approach to Weyl Modules*, arXiv:0906.2014
2. Tanusree Khandai and Punita Batra, *Representations of Lie tori of type A_ℓ coordinated by a cyclotomic quantum tori*, (in preparation)

Tapas Kumar Das

1. Bhattacharjee, J. K., Bhattacharya, A., Das, T. K., & Ray, A. K., *Quasi-viscous accretion flow – I: Equilibrium conditions and asymptotic behaviour*, Monthly Notices of the Royal Astronomical Society (To Appear).
2. Das, T. K., & Czerny, B., *Hysteresis effects and diagnostics of the shock formation in low angular momentum axisymmetric accretion in the Kerr metric*, Monthly Notices of the Royal Astronomical Society (Submitted).
3. Agarwal, S., Das, T. K., & Dey, R., *Transonicity in black hole accretion - A mathematical study using generalized Sturm chains*, Monthly Notices of the Royal Astronomical Society (Submitted).
4. Chakraborti, I., Barai, P., Das, T. K., & Wiita, P. J., *Behaviour of relativistic accretion close to the event horizon*, arXiv:0902.4093v1 [astro-ph.HE].

R. Thangadurai

1. F. Luca and R. Thangadurai, *Distribution of residues modulo p – II,* (2008).
2. B. K. Moriya, M. N. Chintamani, W. D. Gao, P. Paul and R. Thangadurai, *On Davenport's Constant* (2009).
3. R. Balasubramanian, F. Luca, and R. Thangadurai, *Degree of $\mathbb{Q}(\sqrt{a_1}, \sqrt{a_2}, \cdots, \sqrt{a_n})$ over $\mathbb{Q}$* (2009).
4. R. Thangadurai, *A variant of Champernowne number which is transcendental and simply normal in any base b* (2009).

Tirthankar Roy Choudhury

1. Tirthankar Roy Choudhury, *Analytical Models of the Intergalactic Medium and Reionization,* arXiv:0904.4596

Library

The Institute's library is one of the best equipped in the region. During 2008–09, too, it provided required support for academic and research activities. It remained open on all working days from 8 am to 2 am including Saturdays. It also added 494 volumes in its fold, which includes 458 purchased books and 36 gifted books. This increases the total number of books to 17,887. It also added 1,787 bound journal volumes during this period. This increased number of bound volumes to 31,134. The library has a total collection of 49,021 books and bound volumes. It subscribed to 235 journals.

More space was arranged for users during this year by shifting little used back volumes to the first floor storage area and rearranging display racks. We provided better computer systems for users to browse library OPAC and procured a new photocopying machine. We inducted one library trainee to provide training in library activities under the XI plan Library Development Project. We enriched our digital repository of articles, theses, lectures, etc. submitted in HRI, updated the library web page to provide more information such as subscription databases, archives, library rules, library staff, online journals and other useful links. Emphasis was given to procure more online journals; we currently provided onine access to 111 journals.

We provide web enabled library catalogue to our users. The library is thus completely automated with acquisition, cataloguing, circulation, search, etc. This also encouraged use of our resources by other organizations like INSDOC, TIFR, etc. through the Document Delivery Service (DDS). We normally provide DDS through post at nominal cost, but requests were also entertained through e-mail. We encouraged libray usage by providing library consultation facility to research scholars from neighbouring institutes. We strengthened security by implementing electromagnetic tattle tapes to reduce loss.

Computer Section

1. Further expansion of the local area network to several other points of Institute buildings was commissioned and made operational.
2. A few rack mount Pentium Xeon servers were purchased and installed.
3. Newer versions of different distributions of Linux operating systems were loaded on the desktops.
4. Internet bandwidth through Sify Ltd. was upgraded to 4 Mbps to match the increased Internet usage.
5. 16 Mbps broadband Internet bandwidth through Reliance Communications was purchased and commissioned. A reliable proxy server on this link was set up for the users.
6. A new webmail server was set up for the Institute e-mail users.
7. New internal mail server and domain name server were set up.
8. Computing for participants of conferences, meetings, etc. was ararnged in the conference computer room.
9. New versions of several applications software were loaded on users' systems and on conference room computers.
10. Existing CRT monitors were replaced with 17" TFT colour monitors.
11. Purchase process of a few high end ONLINE central UPS with parallel redundancy (N+1) has been completed. The supply, installation and commissioning will take place in the current year.
12. Expansion of wireless networking to cover up most of the places of Institute building and library building has been completed.

Current activities and plans

1. Up-gradation of existing Local Area Network with Optical Fiber Cable backbone is being processed.
2. Up-gradation of existing file server with high end Network Storage Systems (NAS) with redundancy and automated backup facility are being processed.
3. Purchase of a colour laser printer is being processed.
4. Purchase of two mono laser printers is under plan.
5. Up-gradation of Institute's Mail Server, Name Server, Web Server, firewall servers are being planned.

Construction Work

1. The UPPCL has completed overhead line work for 33 KV power supply and work in the switchyard area is in progress. The work associated with the 33 KV line that is within the scope of the institute is also in progress. Energising of the 33 KV power line is expected by August 2009.
2. Engineering consulting services for the construction of Hostel-3, institute expansion, engineering section, and the Community Centre annexe are in progress.
3. The existing area of the Library building was modified to provide new housing for the Computer Cluster.
4. The Institute's EPABX system software was upgraded. The EBABX sytem was connected to BSNL's optical fibre cable (OFC) network.
5. The following miscellaneous construction work was also carried out:
   (a) Upgradation of servant quarter bathroom in nine type-E houses.
   (b) Additional civil and internal electrical work in RECAPP office.
   (c) Heat insulation and internal electrical connection in the ceiling of the first floor of the library building.
   (d) Construction of room for the 33 KV power line.

Vigilance

There is nothing to report from vigilance point of view for the period up to March 31, 2009.