



Chennai Mathematical Institute

Annual Report

2012–2013

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# 1 Preface

It gives me great pleasure to present the Annual Report of the Chennai Mathematical Institute for the year 2012-13.

The Institute will be celebrating its silver jubilee in 2014, and in this short span of less than 25 years, it has firmly established itself as a premier place for research and teaching in mathematical sciences in India.

Over 70% of graduates from CMI in the past decade have gone on to pursue further studies at the best academic institutions in India and abroad. Of these, 30% of these have completed their PhD. The institutions where our students have gone include Berkeley, Caltech, Chicago, Harvard, MIT, NYU (Courant), Princeton, Penn, Yale in USA, ENS Paris, ENS Cachan, Univ Paris-Sud and Univ Bordeaux in France, the Max Planck Institutes and Humboldt University in Germany and the Harish-Chandra Research Institute, IITs, IMSc, ISI and TIFR in India.

About a dozen CMI graduates have returned to India after their PhDs to take up academic positions at institutions like CMI, IMSc, IIT Bombay, IIT Kanpur, TIFR, IISER Kolkata, IISER Mohali, IISER Pune as well as in research labs such as Microsoft Research, ABB Research and IBM India Research Lab. Another dozen have faculty or postdoctoral research positions at academic and research institutions across the world. Students with PhDs from CMI are faculty members at IIT Bombay, IIT Guwahati and IIM Indore.

CMI graduates have also moved into areas such as financial mathematics, management and economics, both in India and abroad, in addition to the software industry. The places where they have found placements include IBM, TCS R&D, Veritas, Barclays, Goldman Sachs, HSBC, ICICI, Mu Sigma and some startups.

Chennai Mathematical Institute has exchange programmes with leading French institutions such as the Ecole Normale Supérieure in Paris and Cachan as well as the Ecole Polytechnique. CMI is one of three non-European partners in the Erasmus Mundus Master Programme ALGANT (ALgebra Geometry And Number Theory), funded by the European Union. The ALGANT programme allows students to pursue Masters and Doctorate degrees across the institutions participating in the programme.

At a research level, CMI has recently entered into two important international collaborations. In Computer Science, CMI, along with IMSc and IISc, is part of an International Associated Laboratory set up by the French National Centre for Scientific Research (CNRS). In Mathematics, CMI along with IMSc, ISI and IISc has a partnership with ICERM at Brown University and Statistical and Mathematical Sciences Institute (SAMSI), North Carolina to form a Virtual Institute in Mathematical and Statistical Sciences (VI-MSS). This is part of the Science Across Virtual Institutes (SAVI) programme of the National Science Foundation, USA and is supported by the Department of Science and Technology (DST), India.

Over the last few years, several young faculty members have joined CMI, making it a vibrant place. CMI has already established itself in areas of research and Teaching. Our

vision is for CMI to make its mark in the area of applications of mathematics and interaction between academia and industry. We hope to expand our visibility in this area.

CMI hosts a number of distinguished academic visitors every year and during the past year, as usual, there were many seminars delivered by visiting scholars. We had a workshop on *Syzygies and Free Resolutions* under the Mathematical Panorama Lectures series during December 2012. Professor David Eisenbud, University of California, Berkeley, USA, was the main speaker. CMI in collaboration with SAMSI, North Carolina conducted a workshop on *Topics in Probability* in December 2012 under the SAVI programme. A workshop on *Making Formal Verification Scalable and Useable* was held during January 2013.

We have initiated a series of programmes under our Arts Initiative. On each theme, we had a three or four day event with lectures and demonstrations. The themes this year were *Art Appreciation* by Sadanand Menon, *A Walk through Karnatik Music* by T.M. Krishna, *Reading Ramayana in the 21st Century* by Arshia Sattar and *An Interaction with Bharatanatyam* by Priyadarsini Govind.

CMI gets its major funding from the Department of Atomic Energy via the National Board of Higher Mathematics. The UGC has given us funds for the construction of a multi-story building. The new building includes a smart classroom through which CMI will be part of the National Knowledge Network, or NKN, set up by the government of India to share lectures across institutions throughout the country.

In addition to the generous support from the DAE, CMI also receives support from private sources. I take this opportunity to thank the Shriram Group Companies, Tata Consultancy Services and Infosys Foundation for their support.

We have established a Faculty Development Fund for supporting research activities at the institute and we have received generous donations from well wishers.

Dr. Swaminathan made a generous endowment in the memory of his uncle Mr. K. Lakshmanan and Mrs. Usha Rubugunday made a similar endowment in memory of her husband. This has led to annual Lakshmanan and Rubugunday memorial lectures at CMI. This year, Professor Nitin Nitsure, TIFR, Mumbai gave the Lakshmanan memorial lecture and Professor S. Kesavan from the Institute of Mathematical Sciences, Chennai delivered the Rubugunday memorial lecture.

The family of Shri Madhav Sarma, who was Secretary of the CMI Trust, has made a donation for an annual lecture in his memory. Professor Bimal Roy, Director ISI, delivered the first Madhav Sarma memorial lecture.

We have been exploring possibilities of additional funding to CMI for the expansion plan. We hope that we succeed in getting some additional funding over and above the generous support we are getting from the DAE. I am sure that CMI will grow to be an important institution on the Indian academic scene.

**Rajeeva L. Karandikar**  
Director

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## 5 Academic Members

Director	Rajeeva L. Karandikar
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Visiting Faculty      Priyavrat C. Deshpande  
                                 Alok Laddha  
                                 Ananya Lahiri  
                                 Abhijit Pal  
                                 Sarbeswar Pal  
                                 K Srilata (till December, 2012)  
                                 Archana Subhash Morye (till January, 2013)  
                                 Prem Prakash Pandey  
                                 Preena Samuel (till January, 2013)  
                                 Kavita Sutar

Adjunct Professors    T. R. Govindarajan  
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                                 Ramesh Hariharan  
                                 R. Jagannathan  
                                 Neeraj Kayal  
                                 S. Kesavan  
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## 6 Faculty Profiles

### **Rajeeva Karandikar**

Rajeeva Karandikar received his B.Sc. from Indore University, Indore (1976), M.Stat. from Indian Statistical Institute, Kolkata (1978) and Ph.D. from Indian Statistical Institute, Kolkata (1981).

He has been an Associate Professor at the Indian Statistical Institute, Delhi (1984-89), a Professor at the Indian Statistical Institute, Delhi (1989-2006), Professor-in-Charge at the Indian Statistical Institute, Delhi (2000-2002), Head, Delhi Center at the Indian Statistical Institute, Delhi (2000) and (2004-2006) and an Executive Vice-President at Cranes Software International Limited.

His research interests are Probability theory and Stochastic Processes, Applications of Statistics and Cryptography.

### **C.S. Seshadri**

C.S. Seshadri received his B.A. Hons. (Mathematics) from Madras University (1953) and his Ph.D. from Bombay University (1958).

He was at the School of Mathematics, Tata Institute of Fundamental Research, Bombay from 1953 to 1984 starting as a Research Scholar and rising to a Senior Professor. He was then a Senior Professor at the Institute of Mathematical Sciences, Madras (1984-89).

He has been a Visiting Professor at the University of Paris, France; Harvard University, Cambridge, U.S.A.; Institute for Advanced Study, Princeton, U.S.A.; University of California at Los Angeles, Los Angeles, U.S.A.; Brandeis University, U.S.A.; University of Bonn, Bonn, Germany; Kyoto University, Kyoto, Japan.

He has given invited talks at many international conferences including the International Congress of Mathematicians, Nice, France, 1970.

He has received the Shanti Swarup Bhatnagar Award (1972) and the Srinivasa Ramanujan Medal of Indian National Science Academy (INSA). He was awarded the D.Sc. (Honoris Causa) of Banaras Hindu University, Varanasi (1985) and the Doctor of Science (Honoris Causa) of the University of Hyderabad (2012). He has been awarded the Shanti Swarup Bhatnagar Medal (1995) of INSA and Srinivasa Ramanujan Birth Centenary Award (1995-96) of Indian Science Congress Association (ISCA). He has received G.M. Modi Science Award (1995), The Trieste Science Prize of the Academy of Sciences for the Developing World in (2006) and H.K. Firodia Award for Excellence in Science & Technology, Pune (2008). He has also been awarded Padma Bhushan by the President of India (2009).

He is a Fellow of the Indian Academy of Sciences, Indian National Science Academy, the National Academy of Science, USA, the American Mathematical Society and the Royal Society. He has been appointed National Research Professor of the Ministry of Human

Resource Development Government of India in 2006.

His research interests are Algebraic Geometry and Algebraic Groups.

### **Madhavan Mukund**

Madhavan Mukund received his B.Tech. (Computer Science and Engineering) from the Indian Institute of Technology, Bombay (1986) and his Ph.D. (Computer Science) from Aarhus University, Aarhus, Denmark (1992).

He is a member of the Executive Council and President of the Indian Association for Research in Computing Science (IARCS), as well as a member of the ACM India Council.

His research interests include models for concurrent and distributed systems, formal verification and distributed algorithms.

### **V. Balaji**

V. Balaji received his B.A. Hons. (Mathematics) from University of Delhi (1982), his M.A. (Mathematics) from University of Delhi (1984), his Ph.D. from University of Madras (1991).

He has been an NBHM Post-doctoral Fellow at the Chennai Mathematical Institute (1989–92).

His research interest is Algebraic Geometry.

### **Samir Datta**

Samir Datta received his B.Tech. (Computer Science and Engineering) from the Indian Institute of Technology, Kanpur (1995), M.S. from Rutgers University (1997) and Ph.D. from Rutgers University (2004).

He has been a Network Architect at Tellium Inc. (2000-03) and a Post Doctoral Fellow at WINLAB, Rutgers University (2004-05).

His research interests are Complexity Theory, Wireless and High Speed Networking.

### **K. Narayan Kumar**

K. Narayan Kumar received his M.Sc. (Tech.) in Computer Science from Birla Institute of Technology and Science, Pilani (1990). He received his Ph.D. from the University of Bombay (1997).

His research interests include Logic, Automata theory and Concurrency.

## **Pramathanath Sastry**

Pramathanath Sastry received his B.Sc. (Hons) in Mathematics from University of Delhi, New Delhi (1982), M.Stat. from the Indian Statistical Institute, New Delhi (1984) and Ph.D. (Mathematics) from Purdue University, U.S.A. (1990).

He has been a Teaching Assistant, a Research Assistant at Purdue University, U.S.A. (1984-1990), a Visiting Assistant Professor at University of Missouri, U.S.A. (1990-1991), a Visiting Fellow at the Tata Institute of Fundamental Research, Mumbai (1991-1992), a Fellow at SPIC Science Foundation (1992-1995), a Reader at SPIC Science Foundation (1995-1996), a Reader at Harish-Chandra Research Institute, Allahabad (1996-1999), a Reader F at Harish-Chandra Research Institute, Allahabad (1999-2001), a Visiting Assistant Professor at Purdue University, U.S.A. (1999-2001), an Asst. Assoc. Professor (Term) at the University of Toronto, Canada (2001-2006), CLA at McMaster University, Canada (2006) and an Assistant Professor at East Carolina University, U.S.A. (2007-2009).

His research interest is Algebraic Geometry.

## **S. Senthamarai Kannan**

S. Senthamarai Kannan received his B.Sc. from HKRH College, Uthama Palayam (1985–88), M.Sc. from the Madurai Kamaraj University (1988–90) and Ph.D. from the Chennai Mathematical Institute, (1992–98). He has been a Post-doctoral Fellow at the International Centre for Theoretical Physics (1999–2000).

His research interests are Representation Theory and Algebraic Geometry.

## **Shiva Shankar**

Shiva Shankar received his B.Tech. (Electrical Engineering) from the Indian Institute of Technology, Delhi (1978) and his Ph.D. from SUNY, Stony Brook (1983).

He has been an Assistant Professor, at the Department of Applied Mathematics, SUNY, Stony Brook (1983–84), a Visiting Fellow at the School of Mathematics, Tata Institute of Fundamental Research, Bangalore (1984–88), an Associate Professor at the Department of Electrical Engineering, Indian Institute of Technology, Bombay (1988–2000).

Visiting Positions include Institute of Mathematical Sciences, Chennai, and at Mathematics Institute, University of Groningen.

His research interests are Partial Differential Equations, Mechanics and Control Theory.

### **V.V. Sreedhar**

V.V. Sreedhar received his B.Sc. from Andhra University, Visakhapatnam, M.Sc. (Physics) from the Indian Institute of Technology, Madras and received his Ph.D. (Physics) from Saha Institute of Nuclear Physics, Jadavpur University, Calcutta.

He has been an Assistant Professor in the Department of Physics at the Indian Institute of Technology, Kanpur, a Post-doctoral researcher at the School of Theoretical Physics, Dublin Institute of Advanced Studies, Dublin, Ireland and a Post-doctoral researcher at the Institute for Theoretical Physics, Uppsala University, Uppsala, Sweden.

His visiting positions include stints at the S. N. Bose National Centre for Basic Sciences, Kolkata, Raman Research Institute, Bangalore, Universities of Rochester, New York and Cincinnati, Ohio, U.S.A. and the High Energy Research Organization (KEK), Tsukuba, Japan.

His research interests are Quantum Entanglement, Classical and Quantum Field Theory and Fluid Dynamics.

### **K.V. Subrahmanyam**

K.V. Subrahmanyam received his B.Tech. (Computer Science and Engineering) degree from the Indian Institute of Technology, Bombay (1986) and M.S. from Vanderbilt University, U.S.A. in 1987. He received his Ph.D. from the University of Bombay in December, 1995.

His research interests are Circuit Complexity, Algebraic methods in Complexity theory.

### **Sourav Chakraborty**

Sourav Chakraborty received his B.Sc. from Chennai Mathematical Institute (2003), M.S. from University of Chicago (2005) and Ph.D. from University of Chicago (2008).

He has been a Post-doctoral researcher at Technion, Israel (2008-2009) and a Post-doctoral researcher at CWI, Amsterdam (2009-10).

His research interests are Complexity and Algorithms

### **Clare D' Cruz**

Clare D' Cruz received her M.Sc. (Mathematics) from the Indian Institute of Technology, Bombay (1991) and her Ph.D. (Mathematics) from the Indian Institute of Technology, Bombay (1996).

She has been a Post-Doctoral Fellow at the Tata Institute of Fundamental Research, Mumbai (1996–98) and a Visiting Scholar at the Northeastern University, Boston, U.S.A. (1997–98).

Her research interest is Commutative algebra.

## **Govind S. Krishnaswami**

Govind S. Krishnaswami received his B.Sc. (Physics), B.A. (Mathematics) from University of Rochester, U.S.A. (1999), M.A. (Physics), from University of Rochester, U.S.A. (2001) and Ph.D. (Physics) from University of Rochester, U.S.A. (2004).

He has been a Marie Curie Fellow, Spinoza Institute & Institute for Theoretical Physics, Utrecht University, The Netherlands.

His research interests are Quantum Field Theory, Hydrodynamics and Mathematical Physics

## **Upendra Kulkarni**

Upendra Kulkarni received his B.Tech. (Computer Science and Engineering) from the Indian Institute of Technology Bombay, Mumbai (1992) and Ph.D. (Mathematics) from Brandeis University, U.S.A. (1998).

He has been a Visiting Assistant Professor at the University of Massachusetts Amherst (1998-2000), an Assistant Professor at the Truman State University (2000-05), An Associate Professor at the Truman State University (2005), a Visiting Scientist at the Indian Statistical Institute, Bangalore (2005-06) and a Visiting Fellow at the Tata Institute of Fundamental Research, Bangalore (2006-07).

His research interests are Representations of algebraic groups over the integers and in characteristic  $p$ , Algebraic aspects of Lie representation theory including Lie algebras, quantum groups and related combinatorics and in solving elementary challenging problems.

## **K. Narayan**

K. Narayan received his B.Tech. (Engineering Physics) from the Indian Institute of Technology Bombay, Mumbai (1997), M.S. (Physics) from the Cornell University, U.S.A. (1999) and Ph.D. (Physics) from the Cornell University, U.S.A. (2002).

He has been a Research Assistant at the Cornell University, U.S.A. (1998-2001), a Research Assistant at the Cornell University, U.S.A. (2001-02), a Postdoctoral Research Fellow at the Duke University, U.S.A. (2002-04) and a Postdoctoral Research (Visiting) Fellow at the Tata Institute of Fundamental Research, Mumbai (2004-07).

His research interests are String theory and cosmology, Stringy geometry and D-brane gauge theories.

## **Purusottam Rath**

Purusottam Rath received his Ph.D. (Mathematics) from Harish Chandra Research Institute, Allahabad (2006).

He has been a Visiting Fellow at the Institute of Mathematical Sciences, Chennai (2006–2007) and a Coleman Research Fellow at Queen’s University, Canada (2007–2008).

His research interests are Combinatorial Number Theory, Diophantine Approximation and Transcendental nature of special values of  $L$ -functions.

### **R. Srinivasan**

R. Srinivasan received his Ph.D. degree in Mathematics from the Indian Statistical Institute and the Institute of Mathematical Sciences (1998).

He has been a Visiting Fellow at the Harish-Chandra Research Institute, Allahabad (1998–2000), a Post Doctoral Fellow at the Indian Statistical Institute (2000–01), a Post Doctoral Fellow at Universite d’Orleans, France (2001–02), a Visiting Scientist at the Indian Statistical Institute (2002–03), a Visiting Fellow at ICTP, Trieste, Italy (2003) and a JSPS Post Doctoral Fellow at University of Tokyo, Japan (2003–2005).

His research interests are Operator Algebras and Operator Theory.

### **M. Sundari**

M. Sundari received her M.Sc. (Mathematics) from the University of Hyderabad, Hyderabad (1988), M.Phil. (Mathematics) from the University of Hyderabad, Hyderabad (1990) and Ph.D. (Mathematics) from the Indian Statistical Institute, Bangalore (1996).

She has been a Visiting Mathematician at the International Center for Theoretical Physics, Trieste, Italy (1996), a Research Associate at the University of New South Wales, Sydney, Australia (1996–97), an Assistant Professor in the Effat College, Jeddah, Saudi Arabia (2000–01), a Faculty member at the ICFAI Institute of Science and Technology, Hyderabad (2003–04) and an Assistant Professor at the Indian Institute of Technology Roorkee, Roorkee (2004–06).

Her research interests are Representation theory of Lie groups, Uncertainty Principles in Harmonic Analysis, Wiener-Tauberian theorems.

### **S.P. Suresh**

S.P. Suresh received his M.C.A. from R.E.C. Trichy (1996), his M.Sc. (by Research) from Anna University (1999), and his Ph.D. from the Institute of Mathematical Sciences (2003).

His research interests are Logic in Computer Science, Reasoning about Security protocols and Classical Indian Epistemology.

### **M.K. Vemuri**

M.K. Vemuri received his M.S. (Mathematics) from Syracuse University, U.S.A. (1989) and Ph.D. from the University of Chicago, U.S.A. (1997).

He has been a Visiting Assistant Professor at Colgate University, U.S.A. (1997–99), an Instructor at Polytechnic University, U.S.A. (1999–2000) and a Teaching Research Associate at Syracuse University, U.S.A. (2000–2002).

His research interest is Analysis.

### **K.G. Arun**

K.G. Arun received his B.Sc. (Physics) from Calicut University, Calicut (1998), M.Sc. (Physics) from Cochin University of Science and Technology (2001) and Ph.D. (Physics) from Raman Research Institute, Bangalore.

He has been a Postdoctoral Research Associate, Washington University in St Louis and VESF Fellow, LAL Orsay & IAP, Paris (2009-2010).

His research interests are Gravitational Wave Astrophysics, Modelling compact binaries, High energy Astrophysics and Cosmology, Tests of General Relativity and Alternative theories of gravity.

### **Krishna Hanumanthu**

Krishna Hanumanthu received his B.Sc. (Mathematics) from the Chennai Mathematical Institute (2001), M.Sc. (Mathematics) from the Chennai Mathematical Institute (2003) and Ph.D. (Mathematics) from the University of Missouri (2008).

His research interests are Algebraic Geometry and Commutative Algebra.

### **Manoj Kummini**

Manoj Kummini has received his B.Tech. (Electronics and Communication Engineering) from the University of Calicut (1999), M.E. (Telecommunication Engineering) from the Indian Institute of Science, Bangalore (2002), M.A. (Mathematics) from the University of Kansas, Lawrence (2005) and Ph.D.] from University of Kansas, Lawrence (2008).

He has been a Software Engineer at Sasken Communication Technologies, Bangalore (1999-2000), a Senior Design Engineer (2003) & Design Engineer (2002-2003) at Texas Instruments India, Bangalore, Graduate Teaching Assistant, University of Kansas, Lawrence, KS, U.S.A. (2003-2008), Research Assistant Professor, Purdue University, West Lafayette, IN, U.S.A. (2008-2011) and a Post-doctoral Fellow at Mathematical Sciences Research Institute, Berkeley, CA, U.S.A. (2012).

His research interests is commutative algebra.

### **Sukhendu Mehrotra**

Sukhendu Mehrotra received his B.Sc. (Hons) in Mathematics from Delhi Univeristy (1998), M.S. in Mathematics from the University of Delawre (2000) and Ph.D. in Mathematics from the Univeristy of Pennsylvania (2005).

He has been a Visiting Assistant Professor at the University of Massachusetts Amherst (2005–2009) and Van Vleck Visiting Assistant Professor at the University of Wisconsin Madison (2009–2012).

His research interests are algebraic geometry and homological algebra—more specifically, derived categories, Bridgeland stability conditions and moduli problems, and string theory.

### **Partha Mukhopadhyay**

Partha Mukhopadhyay received his B.E. (Electronics & Telecommunication Engineering) from Jadavpur University, Kolkata (2000), M.Tech. (Computer Science) from the Indian Statistical Institute, Kolkata (2002) and Ph.D. from the Institute of Mathematical Sciences, Chennai (2009).

He has been a Software Engineer at Motorola India Electronics Ltd., Bangalore (2002-2003), a Research Associate at the Indian Statistical Insitute, Kolkata (2003-2004) and a Postdoctoral Fellow at Technion, Israel (2009-2010).

His research interests are Complexity Theory and Additive Combinatorics.

### **Prajakta Nimbhorkar**

Prajakta Nimbhorkar received her B.E. (Computer Science and Engineering) from Government College of Engineering, Aurangabad (2003), M.Tech. (Information Technology) from Indian Institute of Technology, Bombay (2005) and Ph.D. from The Institute of Mathematical Sciences, Chennai (2010).

Her research interests are Complexity and Algorithms.

### **Dishant M. Pancholi**

Dishant M. Pancholi received his B.Sc. from M.S. University of Baroda, Vadodara (1996), M.Sc. from M.S. University of Baroda, Vadodara (1998) and Ph.D. from Tata Institute of Fundamental Research, Mumbai (2006).

He has been a Visiting Fellow at TIFR Centre, Bangalore (2006-07) and a Post doctoral Fellow at the International Centre for Theoretical Physics, Trieste, Italy (2008-10).

His research interests are Contact and symplectic topology.

### **Sasanka Roy**

Sasanka Roy received his B.Sc. (Mathematics) from A.B.N. College, West Bengal, M.C.A. from North Bengal University, West Bengal (2001) and Ph.D. from Indian Statistical Institute, Kolkata (2007).

He has been a Scientist at the Tata Research Development and Design Centre, Pune (2006-09) and a Centenary Postdoctoral Fellow at the Indian Institute of Science, Bangalore (2009-10).

His research interests are Computational Geometry and Algorithms.

### **Shrihari Sridharan**

Shrihari Sridharan received his B.Sc. (Mathematics) from Barathidasan University, Trichy (1998), M.Sc. (Mathematics) from Anna University, Chennai (2000) and Ph.D. (Mathematics) from the University of Manchester, Manchester (2004).

He has been a Post-doctoral Fellow at the Institute of Mathematical Sciences, Chennai (2004–2006), a Post-doctoral Fellow at the Indian Institute of Science, Bangalore (2006–2007) and a Senior Lecturer at the Department of Mathematics, Indian Institute of Technology, Guwahati (2007–2008).

His research interests are Complex Dynamics and Ergodic Theory.

### **S. Sundar**

S. Sundar received his B.Sc. (Mathematics) from Manonmanian Sundaranar University (2005), M.Sc. (Mathematics) from the Homi Bhabha National Institute (2007) and Ph.D. (Mathematics) from the Homi Bhabha National Institute (2010).

He has been a Post-doctoral researcher at the University of Caen, France (2010–2011) and Visiting Scientist at the Indian Statistical Institute, Delhi (2011–2012).

His research interest is operator algebras—in particular, noncommutative geometry,  $K$ -theory, inverse semigroups and their  $C^*$ -algebras.

## **7 Awards**

- C.S. Seshadri has been awarded the degree of Doctor of Science (Honoris Causa) by the University of Hyderabad in 2012.
- C.S. Seshadri has been elected Fellow of the American Mathematical Society, U.S.A. in 2013.

## 8 Research Activities

### Mathematics

Research was carried out in the following areas: algebraic geometry, combinatorics, commutative algebra, dynamical systems, functional analysis and operator algebras, geometry and topology, harmonic analysis, probability theory, and number theory.

In the field of algebraic geometry, work is being done on a complete classification of Kuga fibre varieties. A strategy is being developed to use the Picard variety of a principally polarised abelian variety for cryptography. The Picard variety (i.e., the ‘dual’ abelian variety) is the quotient by a suitable scheme-theoretic equivalence relation, of a Hilbert scheme. Therefore points on the dual variety can be represented by points on a subvariety of a Grassmannian, which in turn can be represented by matrices. The questions involved are: Having a membership test for points on this locus, using linear algebraic methods on matrices. Representing addition and group operations on the dual abelian variety using linear algebraic algorithms on the representative matrices.

There is work also on writing out the free resolution of the structure sheaf of a Schubert cell in a Grassmannian using the so-called ‘geometric technique’ of Weyman. It should be noted that Weyman used this to get Lascoux’s resolution for determinantal varieties. This would be a generalisation. The right geometric setup to deal with the question is found. Differential operators on Cousin complexes are being studied.

The automorphism group of a smooth Schubert variety was studied using the restriction of the tangent bundle of the flag variety. In the course, it was proved that all higher cohomologies vanish. There is ongoing work on the automorphism group of a Bott-Samelson-Demazure-Hansen (BSDH) variety. It is proved there are many non-isomorphic classes of BSDH varieties corresponding to the full flag variety.

There is ongoing work on noncommutative deformations of K3 surfaces. Positivity of vector bundles in positive characteristic was studied. Work is continuing on calculating complexes that resolve the coordinate rings of quiver loci for Dynkin quivers of arbitrary orientation. There is continued study of polynomial functors.

If  $X$  is an irreducible smooth projective algebraic curve of genus  $g \geq 2$  over the ground field  $\mathbb{C}$  and  $G$  is a semisimple simply connected algebraic group, the notion of *semistable and stable parahoric* torsors under a certain Bruhat-Tits group scheme  $\mathcal{G}$  was introduced and the moduli space of semistable parahoric  $\mathcal{G}$ -torsors was constructed. The underlying topological space of this moduli space was identified with certain spaces of homomorphisms of Fuchsian groups into a maximal compact subgroup of  $G$ . The results give a generalization of the earlier results of Mehta and Seshadri on parabolic vector bundles.

Work was also carried out on degenerations of the moduli space of semistable Hitchin pairs over smooth projective curves. The geometry of Hitchin pairs or Higgs bundles has been extensively studied in the last 25 years. In the present work, certain basic results

were obtained on the construction of a degeneration of the moduli space of Hitchin pairs as the smooth curve degenerates to an irreducible nodal curve with a single node. This degeneration has many salient properties, such as divisor with normal crossing singularities as well as the extension of the Hitchin map. The striking aspect of the degeneration is that it provides new compactifications of the classical Picard varieties where the newness lies in the normal crossing singularity that appears in the limit. In the known constructions of such compactifications this is not the case.

In the fields of combinatorics and algebraic geometry, a sufficiency condition on toric arrangements for which the cohomology algebra is generated in degree 1 was found.

In the field of commutative algebra, there is ongoing work on syzygies and free resolutions. Free resolutions of affine monomial curves is being investigated. Work is continuing on hyperplane restriction theorems in positive characteristic and integral closure.

In the field of dynamical systems, hyperbolic rational maps restricted to their Julia sets were studied with regard to the recurrence rate of typical orbits in arbitrarily small neighbourhoods around them and their relationship to the Hausdorff dimension of such small neighbourhoods.

There was also an investigation about whether analogues of Brolins theorem hold true when iterating a holomorphic correspondence on  $\mathbb{P}^1$ . Results were obtained that have the following character: if  $F$  is a holomorphic correspondence, then (under certain conditions)  $F$  admits an invariant measure, such that, for any point  $z$  drawn from a “large” open subset of  $\mathbb{P}^1$ , this measure is the weak\*-limit of suitably normalised sums of point masses carried by the preimages of  $z$  under successive iterates of  $F$ . Under the condition that the topological degree of  $F$  is more than that of its transpose, the above result is a small refinement of a set of recent results by Dinh and Sibony. A substantive result is obtained, under this condition, that the support of the invariant measure is disjoint from the normality set of  $F$ . There are many interesting correspondences on  $\mathbb{P}^1$  for which the reverse inequality about the topological degrees is true. Examples are the correspondences introduced by Bullett and collaborators. In such a case, the equidistribution cannot be expected in general, but it is showed that something close to classical equidistribution occurs if  $F$  has a repeller.

In the field of operator algebras, there was continued work on the endomorphism semigroups (called as  $E_0$ -semigroups) on general von Neumann algebras. R.T. Powers initiated the theory of  $E_0$ -semigroups on type I and type  $II_1$  factors. Though there has been enormous development in the area of  $E_0$ -semigroups on type I factors, there is almost no development on  $E_0$ -semigroups on type  $II_1$  factors, except a paper by Alexis Alevras. In 1988, R.T. Powers introduced a family of  $E_0$ -semigroups on hyperfinite  $II_1$  factors called as Clifford flows, and asked whether they can be distinguished up to an identification called as cocycle conjugacy. Though there has been some development by Alexis Alevras in 2004, the fundamental problem of distinguishing the Clifford flows remained open. This long standing open problem is solved as part of the ongoing work.

An ‘extendability problem for endomorphisms on factors’ was proposed. Given an en-

endomorphism acting standardly on a factor, there is a canonical way to associate a dual endomorphism on its commutant, through a theory developed by Tomita-Takesaki. The extendability problem is to determine whether it is possible to extend both these semigroups to the algebra of all bounded operators. There was crucial progress in determining whether many classes of endomorphisms/ $E_0$ -semigroups are ‘extendable’ or not. It is shown that many interesting examples like Clifford flows, free flows are not extendable.

Study is also initiated of  $E_0$ -semigroups on more complicated factors- the type  $II_\infty$  factors and type III factors. Several families, both countable and uncountable, were produced on these factors, and a systematic theory to study them was developed.

The  $C^*$ -algebras associated to semigroups were studied and groupoids were constructed for semigroup actions.

In the field of geometry and topology, there is ongoing work on finding topological conditions necessary for construction of symplectic and contact structures. Using techniques developed by Simon Donaldson and Yasha Eliashberg, necessary and sufficient conditions were given in dimension 5. A method was developed to detect softness versus hardness of geometric structures on manifolds. It is hoped this will possibly lead towards understanding which almost complex manifolds are indeed complex.

There is continuing work on Brylinskis Knot beta function.

In the field of harmonic analysis, work is initiated on a major improvement of a result of Benedicks for the Heisenberg group. Benedicks result on  $\mathbb{R}^n$  says that a function and its Fourier transform both cannot have supports of finite measure unless the function is trivial. An analogue of this in the case of Heisenberg group is done by E K Narayanan and P K Ratnakumar in two steps. Work is in progress to improve this result.

In the field of probability theory, work was done on the question of almost sure approximation of quadratic variation of a martingale and a pathwise formula for the same was obtained. The question of portfolio optimisation when the underlying assets follow a fat tailed distribution was also studied. There is ongoing work on estimation problems arising from mathematical finance, as well as in signal processing, spatial statistics, and random matrix theory.

In the field of number theory, the investigation of nature of special values of L-functions was extended to those defined over number fields. For instance, the questions of Milnor, which were originally defined over rationals, were extended to number fields.

There was also work on the possibility of applying explicit formulas in analytic number theory to address questions in transcendence. Conjecturally, for instance, every zero of the Riemann zeta function in  $Re(s) > 0$  is supposed to be simple and transcendental. In a different direction, the study of the applications of the Schmidt-Schlickewei-Evertse Subspace theorem to integrality questions of algebraic numbers is undertaken.

In the fields of number theory and combinatorics, an extension and alternate proof are given to a theorem of Deshouillers and Freiman. The study of ‘structure of subsets of

abelian groups, with small doubling constant' is a prominent theme of current research. Deshouillers and Freiman established a structure theorem for subsets of  $\mathbb{Z}/n\mathbb{Z}$  with small doubling constant. Current work improved this theorem.

## Computer Science

The decidability of MSO over multiply-nested words and its generalizations was studied. A simple measure, called split-width, on the structure of the runs of concurrent recursive programs has been proposed. It has been shown that for multiply-nested words as well as other graphs representing runs of concurrent recursive programs, bounding the split-width gives a natural technique to establish decidability of MSO.

A restriction on the class of ordered multi-pushdowns (OMPDS) called adjacent ordered multi-pushdowns (AOMPDS) has been proposed. The reachability and repeated reachability for this class is in EXPTIME and this has been used to obtain efficient decision procedures for a class of recursive programs communicating via queues. It has also shown that a 2EXPTIME reachability procedure for OMPDS may be obtained by a translation to AOMPDS.

A synthetic construction of deformations of irreducible  $U_q(gl_{2n})$ -modules with a commuting  $U_q(gl_2) \otimes U_q(gl_n)$ -action was shown. At  $q = 1$  this agrees with the action of  $U(gl_2) \otimes U(gl_n)$  on the corresponding irreducible  $U(gl_{2n})$ -module for the embedding of  $GL(2) \otimes GL(n)$  in  $GL(2n)$  given by the tensor product. In an earlier work we had demonstrated the construction of such deformations in the miniscule case.

Work was also done in trying to establish bounds on the degree of the generators of the ring of invariants of  $SL(n) \times SL(n)$  acting on an  $m$ -tuple of matrices.

A distributed probabilistic automaton model called deterministically communicating Markov Decision Processes (DMDPs) has been defined. The determinacy of communication allows the representation of the global behaviour of a DMDP as a Markov chain without introducing schedulers. Using Mazurkiewicz trace theory a valid measure on interleaved runs of the system has been defined allowing the design of a statistical model checking procedure that operates at the level of local interleavings, without having to construct and simulate the global Markov chain.

In distributed data structures, eventual consistency is a relaxation of strong consistency that guarantees that if no new updates are made to a replicated data object, then all replicas will converge. Conflict free replicated datatypes (CRDTs) are data structures whose inherent mathematical structure guarantees eventual consistency. Investigation of a fundamental CRDT called Observed-Remove Set (OR-Set) that robustly implements sets with distributed add and delete operations was carried out. A concurrent specification for OR-Sets without ordering constraints has been formalized and a generalized implementation of OR-sets without tombstones that provably satisfies strong eventual consistency has been proposed.

Version vectors are distributed time stamps that are used to compute the most up to date replica in an eventually consistent system. A partial order representation of eventually

consistent systems has been used to come up with a more efficient bounded representation of version vectors.

Work has been done on the following projects on scaling and applying model-checking to new domains.

The Lazy abstraction (IMPACT) symbolic analysis algorithm has been extended to Synchronous reactive systems and a proto-type tool for state-chart models has been implemented using the code-infrastructure of the CBMC/Impara tools built by Daniel Kroening's FV group at Oxford University. The ultimate goal of this project is to scale FV to state-chart systems with several hundreds of modules.

Pervasiveness of embedded systems has necessitated development of scalable methodologies for the FV of low-level firmware and HW-SW co-designs. Power-Management strategies for modern multi-core systems are one of the sub-system blocks that are increasingly being implemented as a mixture of HW-SW to make them more programmable and scalable. A methodology has been developed to formally verify such HW-SW mixed PM architectures and it has been demonstrated on the verification of the PM architecture of eLeon3 open-source multi-core System-On-Chip design using the HW-CBMC FV tool developed at Oxford University for verifying systems modelled in C and Verilog.

Tavenas recently proved that any  $n^{O(1)}$ -variate and degree  $n$  polynomial in  $VP$  can be computed by a depth-4 circuit of size  $2^{O(\sqrt{n} \log n)}$ . So to prove  $VP \neq VNP$ , it is sufficient to show that an explicit polynomial  $\in VNP$  of degree  $n$  requires  $2^{\omega(\sqrt{n} \log n)}$  size depth-4 circuits. Subsequently, using combinatorial design Kayal et al. have constructed an explicit polynomial in  $VNP$  that requires depth-4 circuits of size  $2^{\Omega(\sqrt{n} \log n)}$  and Fournier et al. have shown that iterated matrix multiplication polynomial (which is in  $VP$ ) also requires  $2^{\Omega(\sqrt{n} \log n)}$  size depth-4 circuits. A simple combinatorial property has been identified such that any polynomial  $f$  that satisfies the property would achieve similar circuit size lower bound for depth-4 circuits. In particular, it does not matter whether  $f$  is in  $VP$  or in  $VNP$ . As a consequence, a very simple unified lower bound analysis for the above mentioned polynomials has been obtained.

It has been proved that the determinantal complexity of the iterated matrix multiplication polynomial is  $\Omega(dn)$  where  $d$  is the number of matrices and  $n$  is the dimension of the matrices. So for  $d = n$ , we get that the iterated matrix multiplication polynomial achieves the current best known lower bounds in both fronts: depth-4 circuit size and determinantal complexity. This also settles the determinantal complexity of the iterated matrix multiplication to  $\Theta(dn)$ .

Over fixed-size finite fields, an explicit  $n^2$ -variate and  $n$ -degree polynomial has been constructed such that any depth-3  $\Sigma\Pi\Sigma$  circuit computing it must have size  $2^{\Omega(n \ln n)}$ . Previously, the best known depth-3 lower bound (over fixed size finite fields) for a  $n^2$ -variate and  $n$ -degree polynomial was  $2^{\Omega(n)}$ .

Research has been carried out on primal infon logic, a logic for access control and delegation. In particular, a cubic time algorithm for the derivability problem for the logic has been proposed. It is proposed to extend the approach employed here to other logics as well.

Preliminary work has been carried out in understanding the foundations of a logical theory of zero knowledge and partial secrecy as employed in security protocols.

A technique to uniformly collapse  $NC^1$  circuits with oracle gates which test if the value of an arithmetic function is zero as the family of arithmetic functions varies from very simple ( $GapNC^1$ ) to hard (GapP) via intermediate hardness (GapL and  $GapSAC^1$ ) has been proposed. This work subsumes many previous results in the area notably the collapse of the  $C = L$  hierarchy by Allender-Beals-Ogihara, with a minimal use of linear algebra which was crucial in the previous proof.

Space complexity of optimization problems in planar graphs such as MaxCut and SparsestCut both in the exact and approximate formulations has been studied.

In property testing a number of different problems like monotonicity, distribution testing and testing function isomorphism were considered and results have been obtained on their query complexity. In particular, progress has been made in our understanding of the problem of testing of function isomorphism.

In algorithmic game theory the matroid secretary problem has been studied. Significant progress has been made, improving the competitive ratio by a quadratic factor, thus moving one step closer to the conjecture that constant competitive ratio is achievable.

## Physics

Research in theoretical physics has been carried out in a variety of areas including statistical and stochastic physics, plasma and condensed matter physics, quantum field theory and particle physics, classical gravitation, mathematical physics, fluid mechanics, non-linear dynamics, astrophysics, the foundations of quantum mechanics, loop quantum gravity and string theory.

### Statistical and stochastic physics

1. Through a combination of numerical and analytical work, the equilibrium properties of a two dimensional point vortex gas have been studied. A universality has been established even in the non-equilibrium phases of the system.
2. The quantum Langevin equation and its modification is being studied. The modified equation is being applied to see how it differs from the standard picture for diamagnetism.

### Plasma and condensed matter physics

Recent theories of spin quantum plasmas, and claims of spin gradient-driven lasing in quantum plasmas were critically examined. These theories were found to contradict principles of

quantum and statistical physics in their treatment of degenerate fermions.

### **Quantum field theory and particle physics**

1. There has been work on elucidating the precise nature of flux tubes in Yang-Mills theories.
2. Unification of lepton and quark mixing under renormalization group evolution was examined in the context of the recent determination of the reactor neutrino angle.
3. There has also been work on (a) non-commutative geometry and quantum physics, (b) algebraic formulation of quantum physics and statistics and (c) quantum field theory on manifolds with boundary.

### **Classical gravitation**

1. The method of singular value decomposition of the Fisher information matrix was applied to obtain the three dominant phasing parameters of the compact binary gravitational wave signal. This identification of the dominant phasing parameters is important in carrying out tests of general relativity using gravitational wave observations.
2. The intrinsic geometry of the gravitational wave signal manifold for compact binaries with no spins and moving in circular orbits was investigated. The manifold of the intrinsic parameters is 2 dimensional, corresponding to the two mass parameters. The Ricci scalar for this 2 dimensional manifold was obtained for different post-Newtonian approximations, and its variation with masses of the binaries was studied.
3. The third post-Newtonian gravitational wave polarizations from compact binaries on elliptical orbits were computed. These, together with the energy and angular momentum fluxes from the binary system constitute the necessary ingredients for construction of templates for detecting gravitational wave signals from these binaries.
4. The effect of a Kaluza scalar on the geodesic equation was studied and applied to explain causality in a brane universe.

### **Mathematical Physics**

Simple physics ideas were used to derive an exact expression for a flat connection on the complement of a torus knot. Only an existential proof for such a connection was hitherto known in the mathematics literature.

As a sequel to the above work, a general method for deriving an exact expression for a flat connection on the complement of an arbitrary knot was developed. It consists of modeling the knot by wire segments carrying steady currents on a cubical lattice and using simple

physics ideas from classical electrodynamics to evaluate the flat connection. The expressions for a  $3_1$  (trefoil) and a  $4_1$  (figure-eight) knot were explicitly worked out.

These results are of some importance in constructing representations of the knot group—a topological invariant of the knot. They also have ramifications in the study of the Aharonov-Bohm effect generalized to a situation in which charged particles moving through force-free regions are scattered by fluxes confined to the interior of knotted impenetrable tubes.

## **Fluid dynamics**

1. The existence and regularity of solutions of Eulers equations is open. Vorticity could become unbounded, and it is not known whether viscosity can prevent this. Even without viscosity, conservative effects (such as dispersion in the KdV equation) could regularize the equation. Ongoing work concerns a new conservative regularization of compressible flow, guaranteeing finiteness of enstrophy.
2. A recently discovered cousin (SIdV) of the KdV equation of one-dimensional fluid flow was studied. This non-linear advection dispersion equation admits plane, solitary and cnoidal waves. Analytical and numerical investigations showed that it has two conserved quantities and displays recurrence, but not soliton scattering.

## **Non-linear dynamics**

Free rotation of a rigid body corresponds to geodesic motion on the orthogonal group, relative to a left-invariant ‘inertia metric. Stability of trajectories was determined by evaluating sectional curvatures in a basis of left-invariant 2-planes and used to study a geodesic instability in the tossing motion of a coin.

## **Astrophysics**

1. A radically new model for Magnetars was proposed.
2. Many astrophysical scenarios arising from dark atoms formed by stable massive charged particles are being studied.

## **Foundations of quantum mechanics**

A connection between entanglement and minimum uncertainty has been found. In addition, the nature of weak measurements has been clarified.

## Loop quantum gravity

The main work over the past one year is related to the question: what are the dynamical equations underlying Loop Quantum Gravity (LQG), and in what sense is the theory diffeomorphism invariant? This question is directly associated to quantization of the so-called Hamiltonian constraint in the theory, which is considered to be one of the key open problems in the field. Over the past year, this question has been investigated in detail in the case of a toy model, namely an Abelian  $U(1)^3$  generally-covariant gauge theory, which is simpler than gravity, but nonetheless is diffeomorphism-invariant and in which the Hamiltonian is a constraint. It has been shown that there does exist a quantization of the constraint within the LQG framework, such that the theory in the precise sense is diffeomorphism invariant. These ideas have also been applied to the quantization of four dimensional Euclidean gravity to obtain new results.

## String theory

Exploration of non-relativistic generalizations of AdS/CFT (holography) in string realizations has continued, building on previous work involving Lifshitz scaling. Related ideas were subsequently applied, realizing string constructions exhibiting “hyper-scaling violation. These admit the simple interpretation of excited states in the dual gauge theory with uniform light-cone momentum density and generalize to other CFTs too, giving a range of Lifshitz and hyper-scaling violation exponents. There are in fact more general such AdS null deformations with inhomogeneities. These excited states strikingly exhibit deviations from the “area law for entanglement entropy for certain subsystems, using the Ryu-Takayanagi holographic prescription. In later work, a systematic study of entanglement entropy was done for strip-shaped subsystems in these theories. For space-like subsystems, the entanglement entropy exhibits the familiar area law divergence as well as a finite cutoff-independent part. For large subsystem size, the finite part shows deviations from the area law, either logarithmic (4-dimensional super Yang-Mills CFTs) or stronger (3-dimensional Chern-Simons CFTs). This work suggests new physical mechanisms for deviations from the area law (other than Fermi surfaces) and is under further investigation. Certain aspects of the string constructions for Lifshitz scaling, of possible relevance to the mild IR singularities in the gravity duals, were also studied.

Separately, the physics of certain cosmological deformations of de Sitter space is being studied in the dS/CFT context, in part building on previous work on cosmological singularities in AdS/CFT.

## 9 Publications

### Journal Articles

#### Mathematics

- J1 Ananya Lahiri, D. Kundu and A.Mitra: Efficient algorithm for estimating the parameters of chirp signal, *Journal of Multivariate Analysis*, vol. 108, 15-27, 2012.
- J2 Ananya Lahiri, D. Kundu and Amit Mitra: On least absolute deviation estimators for one dimensional chirp model, *Statistics* (DOI:10.1080/02331888.2012.719519),
- J3 Ananya Lahiri: Efficient algorithm for estimating the parameters of two dimensional chirp signal, *Sankhya Series B* (DOI:10.1007/s13571-012-0048-x)
- J4 B. V. Rao, R. V. Ramamoorthi and J. Sethuraman: A note on Weak Convergence, *Sankhya*, Vol 74 Part 2, 269-276.
- J5 B. V. Rao: ‘Length’ at length, *Resonance*, June 2012 issue, 558-572.
- J6 V. Balaji, J. Kollár: Restrictions of stable bundles. *Contemporary Mathematics* Vol 564, Amer. Math. Soc., Providence, RI, 2012.
- J7 V. Balaji and C.S. Seshadri: Moduli of parahoric  $\mathcal{G}$ -tensors on a compact Riemann surface, Accepted for publication in the *Journal of Algebraic Geometry*.
- J8 Clare D’Cruz: On the Homology of Fiber Cone of ideals, To appear, *Communications in Algebra*
- J9 Kavita Sutar: Resolutions of defining ideals of orbit closures for quivers of type  $A_3$ , To appear in *Journal of Commutative Algebra*.
- J10 Krishna Hanumanthu and P. Banagere: Syzygies of surfaces of general type, To appear in *Geometriae Dedicata*
- J11 Sundari Maddala and Agneta Pasquale: Uncertainty principles for the Schrodinger equation on Riemannian symmetric spaces of noncompact type, *Annales de l’institut Fourier*, 62, No.3(2012), 859-886.
- J12 C. Berkesch, D. Erman, M. Kummini and S. Sam: Poset structures in Boij-Söderberg theory, *Int. Math. Res. Not. IMRN* 2012, no. 22, 5132–5160.
- J13 C. Berkesch, D. Erman, M. Kummini and S. Sami: Shapes of free resolutions over a local ring. *Math. Ann.* 354 (2012), no. 3, 939–954.

- J14 K. Dalili and M. Kummini: Dependence of Betti numbers on characteristic, Accepted for publication in Commun. Algebra
- J15 C. Berkesch and D. Erman and M. Kummini: Three flavors of extremal Betti tables Accepted for publication in “Commutative Algebra: Expository Papers Dedicated to David Eisenbud on the Occasion of His 65th Birthday”, Springer-Verlag.
- J16 Murali Vemuri: Two functionals connected to the Laplacian in a class of doubly connected domains in rank-one symmetric spaces of non-compact type, Geometriae Dedicata.
- J17 Priyavrat Deshpande: On a generalization of Zaslavsky’s theorem for hyperplane arrangements, To appear in Annals of Combinatorics.
- J18 Purushottam Rath, S. Gun and M. Ram Murty: Linear Independence of Hurwitz zeta values and a theorem of Baker-Birch-Wirsing over number fields, Acta Arithmetica, 155 (2012), 297-309.
- J19 Purushottam Rath, S. Gun and M. Ram Murty: A note on special values of L-functions, Accepted for publication in the Proceedings of American Math. Society.
- J20 Purushottam Rath and S.D. Adhikari: Remarks on monochromatic configurations for finite colourings of the plane, Accepted for publication in Note di Matematica.
- J21 R. Sridharan, Raja Sridharan and M.D.Srinivas: Narayana Pandita’s Enumeration of Combinations and associated representation of numbers as sums of Binomial Coefficients, Indian Journal of History of Science, 47 (4) (2012) 607-631
- J22 R. Sridharan: A brief overview of Combinatorics in Ancient and Medieval India, Mathematics Newsletter of the Ramanujan Mathematical Society, Vol.21 and 22, No.4 and 1, March and June 2012, pp.116-118
- J23 R. Sridharan: Rational Quadrilaterals from Brahmagupta to Kummer, Chapter 24, pp.403-417, Math Unlimited - Essays in Mathematics, Science Publishers, CRC Press
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- J25 R. Sridharan: On the mathematical model of Eudoxus for planetary movements, Asia Pac. Math. Newsl. 2 (2012), no. 1, 20–27.
- J26 R. Sridharan: On the division by 5 or periods of elliptic functions and the existence of an outer-automorphism of  $S_6$ , Math. Student 80 (2011), no. 1-4, 111 (2012). (Reviewer: Matti Vuorinen)
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- J28 R. Srinivasan, Oliver T. Margetts: Invariants for  $E_0$ -semigroups on  $\text{II}_1$  factor, Accepted for publication in Comm. Math. Phys.
- J29 R. Srinivasan, Panchugopal Bikram, V.S.Sunder and Masaki Izumi: On extendability of endomorphism on factors, Accepted for publication in Kyushu Journal of Mathematics,
- J30 Rajeeva Karandikar and Tapen Sinha: Modelling in the spirit of Markowitz portfolio theory in a non-Gaussian world, Current Science: 2012, vol 103
- J31 Rajeeva Karandikar and B V Rao: On Quadratic Variation of Martingales, Accepted for publication in the Proceedings Mathematical Sciences, Indian Academy Of Sciences.
- J32 S. Senthamarai Kannan, Narasimha Chary, S.K.Pattanayak: Torus invariants of the homogeneous coordinate ring of  $G/B$  - connection with Coxeter elements, Accepted for publication in Communications in Algebra.
- J33 Shiva Shankar: The Hautus Test and Genericity Results for Controllable and Uncontrollable Behaviors, SIAM Journal of Control and Optimization, To appear.
- J34 Sukhendu Mehrotra, I. Biswas and A. J. Parameswaran: Nef cone of flag bundles over a curve: the case of the field  $\mathbb{F}_p$ , Arch. Math. (Basel) 101 (2013), no. 2, 105–110.

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- J36 Z. Karnin, P. Mukhopadhyay, A. Shpilka and I. Volkovich: Deterministic identity testing of depth-4 multilinear circuits with bounded top fan-in, To appear in SIAM J. of Computing.
- J37 B. Das, S. Datta and Prajakta Nimbhorkar: Log-space algorithms for paths and matchings in k-trees: In Theory of Computing Systems, 2013.
- J38 Olaf Beyersdorff, Samir Datta, Andreas Krebs, Meena Mahajan, Guido Scharfenberger-Fabian, Karteeek Sreenivasaiah, Michael Thomas, Heribert Vollmer: Verifying proofs in constant depth, TOCT 5(1): 2 (2013)
- J39 Sandip Banerjee, Bhargab Bhattacharya, Sandip Das, Arindam Karmakar, Anil Maheshwari and Sasanka Roy: On the Construction of a Generalized Voronoi Inverse of a Rectangular Tessellation, Accepted for publication in Transactions on Computational Science (Invited in special issue of ISVD 2012).

- J40 John Augustine, Sandip Das, Anil Maheshwari, Subhas Nandy, Sasanka Roy, and Swami Sarvattomananda: Localized Geometric Query Problems, Computational Geometry Theory and Applications, Vol. 46, 340-357, 2013.
- J41 Noga Alon, Eric Blais, Sourav Chakraborty, David Garcia-Soriano and Arie Matsliah: Nearly Tight Bound for Testing Function Isomorphism, To Appear in SIAM Journal of Computing (SICOMP).

## Physics

- J42 Alok Laddha: Constraint Algebra in LQG reloaded-II : Spatial Diffeomorphisms, Phys. Rev. D 88, 044029 (2013).
- J43 G. Rajasekaran: An angle to tackle the neutrinos, Current Science, 103(6):622, 2012.
- J44 G. Rajasekaran: High energy physics in 2012, Current Science, 103(3):250, 2012.
- J45 G. Rajasekaran: Manpower for fundamental physics experiments, Current Science, 103(1):19, 2012.
- J46 G. Rajasekaran: Standard model, higgs boson and what next?, Resonance (Journal of Science Education), 17(10):956, 2012.
- J47 A. Sen, D. Ahalpara, A. Thyagaraja and G. S. Krishnaswami: A KdV-like advection-dispersion equation with some remarkable properties, Communications in Nonlinear Science and Numerical Simulation 17 (2012), pp. 4115-4124.
- J48 K. Narayan: AdS null deformations with inhomogeneities, Phys.Rev.D 86, 126004, (2012), arXiv:1209.4348 [hep-th].
- J49 K. Narayan, Tadashi Takayanagi, Sandip Trivedi: AdS plane waves and entanglement entropy, J.High Energy Phys. 1304:051 (2013), arXiv:1212.4328 [hep-th].
- J50 K G Arun and Archana Pai: Tests of General Relativity and Alternative theories of gravity using Gravitational Wave observations, International Journal of Modern Physics D, Vol. 22, 1341012 (2013).
- J51 Archana Pai and K G Arun: Singular value decomposition in parametrised tests of post-Newtonian theory, Class.Quant.Grav. 30 (2013) 025011.
- J52 N. D. Hari Dass and V. Soni: Magnetars from Magnetized Cores by a Strong Interaction Phase, in Monthly Notices of the Royal Astronomical Society, 425(2012), p.1558-1566.
- J53 Asrarul Haque and T.R. Govindarajan: Twisted bosonization in two dimensional non-commutative spacetime, Mod. Phys. Lett. A27 (2012) 1250149.

- J54 A.P. Balachandran, T.R. Govindarajan, Amilcar R. de Queiroz, A.F. Reyes-Lega: Entanglement and Particle Identity: A Unifying Approach, *Phys.Rev.Lett.* 110 (2013) 080503
- J55 A.P. Balachandran, T.R. Govindarajan, Amilcar R. de Queiroz, A.F. Reyes-Lega: Algebraic Approach to Entanglement and Entropy, *Phys.Rev.* A88 (2013) 022301
- J56 V. V. Sreedhar: An exact expression for a flat connection of the complement of a torus knot, *Journal of Knot Theory and Its Ramifications* Vol. 22, No. 10 (2013) 1350054, World Scientific Publishing Company DOI: 10.1142/S0218216513500545

## Conference Papers

### Computer Science

- C1 Aiswarya Cyriac, Paul Gastin and K. Narayan Kumar: MSO Decidability of Multi-Pushdown Systems via Split-Width, *Proceedings of the 23rd International Conference on Concurrency Theory (CONCUR 2012)*:Springer LNCS 7454 (2012) 547-561.
- C2 M. F. Atig, A. Bouajjani, K. Narayan Kumar and P. Saivasan: Linear-Time Model-Checking for Multithreaded Programs under Scope-Bounding, *Proceedings of the 10th International Symposium on Automated Technology for Verification and Analysis (ATVA 2012)*:Springer LNCS 7561 (2012) 152-166
- C3 Samir Datta, Rameshwar Pratap: Computing Bits of Algebraic Numbers, *TAMC 2012*: 189-201
- C4 Minati De, Subhas C. Nandy, and Sasanka Roy: Minimum Enclosing Circle with Few Extra Variables, *Proc. of the Foundations of Software Technology and Theoretical Computer Science 2012 (FSTTCS 2012)*, pp. 510-521, 2012.
- C5 Sourav Chakraborty, Akshay Kamath and Rameshwar Pratap: Testing Uniformity of Stationary Distribution, *European Conference on Combinatorics, Graph Theory and Applications (EuroComb 2013)*. (Also presented at the 12th Cologne-Twente Workshop on Graphs & Combinatorial Optimization, 2013).
- C6 Sourav Chakraborty, Eldar Fischer, Yonatan Goldhirsh and Arie Matsliah: On the Power of Conditional Samples in Distribution Testing, *Innovations in Theoretical Computer Science (ITCS 2013)*.
- C7 Eldar Fischer, David García-Soriano and Arie Matsliah: Junto-symmetric functions, hypergraph isomorphism, and crunching, *27th Annual IEEE Conference on Computational Complexity (CCC 2012)*.

## Physics

- C8 K. Narayan: Cosmological singularities, AdS/CFT and de Sitter deformations, Proceedings of the ICGC 2011 conference, Dec 2011, arXiv:1204.3506 [hep-th].
- C9 C K Mishra, K G Arun, B R Iyer: 2.5PN kick from black-hole binaries in circular orbit: Nonspinning case, Proceedings of “Relativity and Gravitation - 100 Years after Einstein in Prague” Ed. J. Bicak (2013).
- C10 Sathyaprakash et al, Einstein Telescope Design Study Team: Scientific Objectives of Einstein Telescope, Sathyaprakash et al, Class. Quantum Grav. 29, 124013, 2012
- C11 N. D. Hari Dass: An incomplete summing up of Quantum Measurements, Invited Talk, To be published in “Nature’s Largest Threads: New Frontiers in the Mathematics and Physics of Information in Biology”, World Scientific, Eds. Janaki Balakrishnan and B.V. Sreekantan.
- C12 N. D. Hari Dass: The Superposition Principle in Quantum Mechanics - did the rock enter the foundations surreptitiously?, Invited Talk, To be published in the proceedings of the international conference “100 Years of the Bohr Atom 1913-2013” by the Royal Danish Academy of Sciences and Letters.
- C13 A. P. Balachandran, T R Govindarajan, Amilcar R. de Queiroz, A. F. Reyes-Lega: Algebraic theory of entanglement, Il Nuovo Cimento, Proc. of Mathematical structures in quantum systems and applications, Banescue, 2012.

## Preprints

### Mathematics

- P1 R L Karandikar and B V Rao: On quadratic variation of Martingales.
- P2 Dishant Pancholi: Contact blow-up (October 5, 2012), arXiv:1210.1687
- P3 Dishant Pancholi, Mahan Mj. and I. Biswas: Homotopical Height (February 4, 2013), arXiv:1302.0607
- P4 Kavita Sutar: Quiver loci of equioriented  $A_n$ .
- P5 P. Deshpande and K. Sutar: Deletion-restriction in toric arrangements.
- P6 M. Kummini and S. V Sam: The cone of Betti tables over a rational normal curve (2013), arXiv:1301.7005 [math.AC].
- P7 G. Caviglia and M. Kummini: Betti tables of p-Borel-fixed ideals (2012), arXiv:1212.2201 [math.AC]

- P8 S. El Khoury, M. Kummini and H. Srinivasan: Bounds for the Multiplicity of Gorenstein algebras (2012), arXiv:1211.1316 [math.AC].
- P9 Prem Prakash Pandey and R. Balasubramanian: On a theorem of Deshouillers and Freiman, submitted.
- P10 Priyavrat Deshpande: Salvetti-type diagram models for tangent bundle complements.
- P11 S. Senthmarai Kannan: On the automorphism group of a smooth Schubert variety.
- P12 S. Senthmarai Kannan: A note on negative dominant characters.
- P13 Shrihari Sridharan: The Recurrence Rate and Hausdorff Dimension of a Neighbourhood of some Typical Point in the Julia Set of a Rational Map.
- P14 Shrihari Sridharan and Gautam Bharali: The Dynamics of Holomorphic Correspondences of  $\mathbb{P}^1$  : Invariant Measures and the Normality set.
- P15 Sukhendu Mehrotra and E. Markman: A global Torelli theorem for rigid hyperholomorphic sheaves, arXiv: 1310.5782.

## Computer Science

- P16 M. F. Atig, A. Bouajjani, K. Narayan Kumar and P. Saivasan: Model checking Branching-Time Properties of Multi-Pushdown Systems is Hard, CoRR abs/1205.6928 (2012).
- P17 Bharat Adsul, Milind Sohoni, K V Subrahmanyam: A deformation of  $V_q(GL_{2m})$  with a  $U_q(GL_m) \otimes U_q(GL_2)$  action.
- P18 Sumit Kumar Jha, Madhavan Mukund, Ratul Saha and P S Thiagarajan: Deterministically Communicating MDPs
- P19 Madhavan Mukund, Gautham Shenoy R and S P Suresh: Optimized OR-Sets without Ordering Constraints
- P20 Madhavan Mukund, Gautham Shenoy R and S P Suresh: On Bounded Version Vectors
- P21 Pallab Dasgupta, Rajdeep Mukherjee and M. Srivas: Formal Hardware/Software Co-verification of Embedded Power Controllers, (Submitted to Transactions on Computer-Aided Design of Integrated Circuits and Systems)
- P22 Partha Mukhopadhyay and Suryajith Chillara: Depth-4 Lower Bounds, Determinantal Complexity : A Unified Approach
- P23 Partha Mukhopadhyay and Suryajith Chillara: An Improved Lower Bound for Depth-3 Arithmetic Circuits Over small finite fields.

- P24 A Baskar, R Ramanujam, and S P Suresh: Dolev-Yao theories with distributive encryption.
- P25 S. Datta and R. Kulkarni: Space complexity: what makes planar graphs special? Bulletin of the EATCS, 2013.
- P26 Sourav Chakraborty, Raghav Kulkarni, Satyanarayana V.Lokam and Nitin Saurabh: Towards the Fourier Entropy Conjecture.
- P27 Abhishek Bhrushundi, Sourav Chakraborti and Raghav Kulkarni: Property Testing Bounds for Linear and Quadratic Functions via Parity Decision Trees.

## Physics

- P28 Govind S. Krishnaswami, Rajaram Nityananda, Abhijit Sen, Anantanarayanan Thyagaraja: A critique of recent theories of spin half quantum plasmas, Feb 2013, under peer review.
- P29 K G Arun, B R Iyer and W.T. Ni: Fifth ASTROD Symposium and Outlook of Direct Gravitational-Wave Detection, Asia Pacific Physics Newsletter Vol. 01, No. 02, pp. 6-11, 2012.
- P30 N.D. Hari Dass, Saikishan Suryanarayanan and Roddam Narasimha: The turbulent mixing layer as a problem in the non-equilibrium statistical mechanics of a vortex gas, arXiv:1212.6586(physics.flu-dyn).
- P31 N. D. Hari Dass: A critique of Sadi Carnot's work and a mathematical theory of the caloric, arXiv:1306.1939 (physics.hist-ph).
- P32 N. D. Hari Dass: Does the first part of the second law also imply its first part?, arXiv:1306.1937 (physics.hist-ph).
- P33 R Parthasarathy: Calusality in brane Universe - OPERA and ICARUS: hep-ph/1203.6192.
- P34 R Parthasarathy: Influence of Kaluza Scalar on the Raychaudhuri Equation. hep-th/1311.0103.
- P35 V V Sreedhar: A general method for deriving an exact expression for a flat connection on the complement of a knot, Submitted to Journal of Knot Theory and Its Ramifications.

## Book

### Computer Science

- B1 M Mukund: Automata on Distributed Alphabets, Modern Applications of Automata Theory, Deepak D'Souza and Priti Shankar (eds), World Scientific (2012) 45-78.

- B2 M Mukund: Finite-state Automata on Infinite Inputs, Modern Applications of Automata Theory, Deepak D'Souza and Priti Shankar (eds), World Scientific (2012) 257-288.
- B3 K Narayan Kumar: The Theory of Message Sequence Charts, Modern Applications of Automata Theory, Deepak D'Souza and Priti Shankar (eds), World Scientific (2012).
- B4 S Chakraborty and M Mukund (eds): Proceedings of 10th International Symposium on Automated Technology for Verification and Analysis (ATVA 2012), Springer Lecture Notes in Computer Science, Vol 7561, (2012)

## 10 The National Undergraduate Programme

In 1998, CMI initiated an National Undergraduate Programme in the Mathematical Sciences in collaboration with Madhya Pradesh Bhoj Open University with a 3 year course in Mathematics and Computer Science, leading to a B.Sc. Honours degree. In 2001, this programme was extended to the postgraduate level with separate 2 year courses leading to M.Sc. degrees in Mathematics and Computer Science. The scope of the undergraduate programme was expanded in 2003 to incorporate a 3 year course leading to a B.Sc. Honours degree in Physics. CMI commenced a two year course leading to an M.Sc. degree in Applications of Mathematics in 2010.

From 2012, the B.Sc. Physics programme has been restructured as a B.Sc. programme in Mathematics and Physics. There is a common admission to the B.Sc. programmes in Mathematics and Computer Science and Mathematics and Physics and all students do the same courses in the first semester. Students choose their stream at the end of the first semester.

The undergraduate and postgraduate teaching programmes at CMI are both run in co-operation with the Institute of Mathematical Sciences (IMSc), Chennai. These programmes tap the teaching talent available at the elite research institutes of the country, which are normally outside the university system. Students are thus exposed to lectures by active researchers who bring a very different perspective to the teaching.

### **B.Sc. (Hons.) Mathematics and Computer Science**

In 2012, the fifteenth batch of students was admitted to the undergraduate programme. At the end of the first semester, 18 opted for B.Sc. in Mathematics and Computer Science. The second year B.Sc. class has 21 students in Mathematics and Computer Science and the third year B.Sc. class has 17 students. Out of the 14 students of the 2009 batch who took their degrees at the convocation in August, 2012, several have been placed in very prestigious institutions.

Name	Placement
Rupam Acharyya	CMI
Sarjick Bakshi	CMI
Amitayu Banerjee	
Wonjun Chang	Delhi University
Suprajo Das	CMI
Anup Dixit	CMI
Akshay D Kamath	CMI
Sudipta Kolay	CMI
Tulasimohan Molli	CMI
Shirsho Mukherjee	
Ratul Saha	CMI
Akash Sengupta	CMI
Ananth Shankar	Harvard

## B.Sc. (Hons.) Physics

This programme was started in 2003 with the assistance of the Physics Faculty of the IMSc., Chennai, and the active participation of physicists across the country.

The second and third year B.Sc. classes have 9 students each.

Out of the 10 students of the 2007 batch who took their degrees at the convocation in August, 2010, several have been placed in very prestigious institutions.

<b>Name</b>	<b>Placement</b>
Arpit Ranadive	
Sachin Phatak	CMI
S Prasanth	CMI
Rajeev Ranjan	
Nana Siddharth	CMI
Rohan Sinha	
Ronak M Soni	TIFR
Som Kanjilal	
Souvik Sarkar	
Uddhipan Thakur	

## B.Sc. (Hons.) Mathematics and Physics

Of the 23 students admitted to the undergraduate programme in 2012, 5 opted for B.Sc. in Mathematics and Physics at the end of the first semester.

## M.Sc. Mathematics

In 2012, 8 students have joined the programme. There are 3 students in the second year of the programme. Four students who joined the programme in 2009 have completed the programme successfully.

Name	Placement
Tushar Kanti Biswas	
Arpan Datta	
Sudip Mishra	
Apurv Nakade	

## M.Sc. Computer Science

In 2012, 9 students have joined the programme. There are 9 students in the second year of the programme. Seven students who joined the programme in 2010 have completed the programme successfully.

Name	Placement
Nikhil Balaji	CMI
Sandipan Bhattacharyya	Indix
Biswaroop Maiti	
Pranabendu Misra	IMSc
Gautham Shenoy R	CMI
Ramanathan Thinniyam Srinivasan	IMSc
Vignesh G	GE Research

## M.Sc. Applications of Mathematics

In 2012, 12 students have joined the programme. There are 10 students in the second year of the programme. One student who joined the programme in 2010 has completed the programme successfully.

Name	Placement
Kuntal Pal	Shriram Group

## Convocation

The 10th Annual Convocation of CMI was held on 1 August, 2012. Degrees were awarded to 36 successful candidates at various levels. Of these, 23 were B.Sc. candidates, 12 were M.Sc. candidates and 1 was a Ph.D. candidate. Mr. N. Lakshmi Narayanan, Vice-President, Cognizant Technology Solutions, gave away the degree certificates. Prof. R. Sridharan, Adjunct Professor, Chennai Mathematical Institute delivered the convocation address.

For the B.Sc. programmes, the CMI Medal of Excellence was awarded to Ananth Shankar in Mathematics and Computer Science and Ronak M. Soni in Physics for their outstanding performance at the undergraduate level. For the M.Sc. programmes, the CMI Medal of Excellence was awarded to Apurv Nakade in Mathematics and Gautham Shenoy R. in Computer Science.

## 11 Undergraduate/Graduate Courses

Course	Instructor
Algebra I	Clare D'Cruz
Calculus I	T Parthsarathy
Classical Mechanics I	H S Mani
English	Shreekumar Varma
Introduction to Programming (Haskell)	K Narayan Kumar
Algebra III	Purusottam Rath
Real Analysis	Partha Sarathi Chakraborty
Caculus III	Murali K Vemuri
Design & Analysis of Algorithms	Prajakta Nimbhokar
Theory of Computation	Sourav Chakraborty
Algebra IV	Upendra Kulkarni
Introduction to Logic	Madhavan Mukund
Electromagnetism II	R Parthasarathy
Mathematical Physics III	T R Govindarajan
Quantum Mechanics II	Eleonora dell'Aquila
Statistical Mechanics II	Prabha Mandayam
Physics Laboratory	M V Rao
Atomic and Molecular Physics	N D Hari Dass
Statistical Mechanics III	K Narayan
Quantum Field Theory	K P Yogendran
Probability and Statistics	Rajeeva L Karandikar
Linear Algebra	S Kavita
Analysis	Shrihari Sridharan
Introduction to Programming (Python)	Samir Datta
Simulation	Rajeeva L Karandikar
Econometrics I	Kausik Chaudhuri
Finance I	Sreejata Banerjee
Stochastic Processes I	B V Rao
Algebra	S Senthamarai Kannan
Real Analysis	Priyavarat Deshpande
Topology	Archana Morye
Differential & Integral Equations	Dishant Pancholi
Commutative Algebra	Krishna Chaitanya
Algebraic Topology	Sukhendu Mehrotra
Functional Analysis	Vasanth Srinivasan
Classical Mechanics	G Rajasekaran
Classical Electrodynamics	V V Sreedhar
Quantum Mechanics	Govind Krishnaswami

<b>Course</b>	<b>Instructor</b>
Mathematical Physics	K G Arun
Quantum Field Theory II	Alok Laddha
Tannakian Categories I	V Balaji/Pramath Sastry
Torsors I	V Balaji/Pramathanath Sastry
Approxiamtion Algorithms	Sasanka Roy
Computational Geometry	Sasanka Roy
Concurrent Programming	S P Suresh
Cryptography	K V Subrahmanyam
Verification	Mandayam Srivas
Automata Theory & Verification	K Narayan Kumar
Analysis of Boolean functions	Partha Mukhopadhyay
Discrete Mathematics	KV/Partha/Samir/Sourav
Recursion Theory	S P Suresh
Advanced Programming	Samir Datta
Algebra II	S S Kannan/Krishna Hanumanthu
Calculus II	Sunder Sobers
Discrete Mathematics	Sourav Chakraborty
Probability Theory	K V Subrahmanyam
Complex Analysis	Sarbeswar Pal
Differential Equations	Shiva Shankar
Topology	Manoj Kummini
Programming Language Concepts	S P Suresh
Quantum Mechanics I	G Rajasekaran
Economics	Malathi Velamuri
Classical Mechanics II	Govind Krishnaswami
Electromagnetism I	K Narayan
Physics Laboratory	M V Rao
Classical Mechanics III	Rakesh Nigam
Electromagnetism III	R Parthasarathy
General Relativity	N D Hari Dass
Quantum Mechanics III	R Jagannathan
Condensed Matter Physics	G Rangarajan
Nuclear & Particle Physics	H S Mani
Design & Analysis of Algorithms	Sasanka Roy
Measure Theoretic Probability	Rajeeva L Karandikar
Differential Equations	B V Rao
Econometrics II	Swaminathan Venkatraman
Stochastic Processes II	B V Rao
Finance II	Sreejata Banerjee
Algebra II (MSc)	Sukhendu Mehrotra
Complex Analysis	Abhijit Pal

**Course**

Differential Geometry  
Harmonic Analysis  
Measure Theory  
Advanced Functional Analysis  
Compact Riemann Surfaces  
Game Theory  
Homological Algebra & Derived Categories  
Reflection Groups  
Linear Algebraic Groups  
Transforms on Function Spaces  
Torsors II  
Time Series  
Advanced Functional Prog  
Automata Theory & Verification II  
  
Complexity Theory  
Data Mining & Machine Learning  
Logspace Computation  
Optimization  
Property Testing  
Randomized Algorithms  
Topics in Verification  
  
General Relativity  
Non-Abelian Gauge Theory  
NLD & Continuum Mechanics  
Quantum Field Theory  
Statistical Mechanics

**Instructor**

Dishant Pancholi  
Murali Vemuri  
Purusottam Rath  
R Srinivasan  
Pramathanath Sastry  
T Parthasarathy  
Upendra Kulkarni  
Priyavrat Deshpande  
S S Kannan/Krishna Hanumanthu  
Krishna Maddaly  
V Balaji/Pramathanath Sastry  
Ananya Lahiri  
K Narayan Kumar  
K Narayan Kumar/  
Prateek Karandikar  
Prajakta Nimbhorkar  
Madhavan Mukund  
Samir Datta  
K V Subrahmanyam  
Sourav Chakraborty  
Partha Mukhopadhyay  
Mandayam Srivas/  
Madhavan Mukund  
V V Sreedhar  
Alok Laddha  
K G Arun  
Alok Laddha  
T R Govindarajan

## 12 Special Lectures

- Bimal Roy, Director, Indian Statistical Institute, Kolkata, delivered the K. Madhava Sarma Memorial Distinguished Lecture on “Cryptology, Statistics and Combinatorics” (September, 2012)
- Alladi Sitaram, Emeritus Professor, Indian Statistical Institute, Bangalore, delivered a *Unity in Mathematics Lecture* on “From Fourier series to Fourier transforms and beyond” (December, 2012).
- R. Balasubramanian, Director, The Institute of Mathematical Sciences, Chennai, delivered a *Unity in Mathematics Lecture* on “Additive Combinatorics” (December, 2012).
- Rajeeva L Karandikar, Director, Chennai Mathematical Institute, delivered a *Unity in Mathematics Lecture* on “Introduction to Option Pricing” (December, 2012).
- S. Kesavan, Professor, The Institute of Mathematical Sciences, Chennai, delivered a *Unity in Mathematics Lecture* on “The Spectrum of the Laplacian” (December, 2012).
- S. Kesavan, Professor, The Institute of Mathematical Sciences, Chennai, delivered the R.K. Rubugunday Distinguished Lecture on “The method of moving planes and the classical isoperimetric inequality” (February, 2013).
- Nitin Nitsure, Professor, Tata Institute of Fundamental Research, Mumbai delivered the K. Lakshmanan Memorial Distinguished Lecture on “A glimpse into the Foundations of Mathematics” (February, 2013).

## 13 Workshops/Schools/Conferences

### Formal Methods Update Meeting 2012, July 2012

This is an annual event where speakers present recent developments in areas related to formal methods. The list of talks at the workshop was as follows:

- Deepak D'Souza, IISc  
*Program Analysis Techniques for Under and Over Approximations*
- Shibashis Guha, IIT Delhi  
*Prebisimulation for Timed Automata*
- Kamal Lodaya, IMSc  
*Verification of Probabilistic Systems*
- Bastien Maubert, IRISA  
*Dependence Logic*
- Madhavan Mukund, CMI  
*Statistical Model Checking*
- Prakash Saivasan, CMI  
*Parity Games on Higher Order Push Down Systems*
- Gautham Shenoy R, CMI  
*Convergent/Commutative Replicated Data Types (CRDTs)*
- Mandayam Srivas  
*Application of Bounded-Model-Checking (BMC) in an Industrial Setting*
- S P Suresh, CMI  
*Selected Papers from LICS 2012*

### Ninth AFS-1, NBHM Advanced Training in Mathematics School, December 2012

This AFS covered Algebra, Analysis and Topology and Geometry. The resource persons were:

1. S. Senthamarai Kannan, CMI
2. Krishna Hanumanthu, CMI
3. S. Vishwanath, IMSc

4. Purusottam Rath, CMI
5. Amritanshu Prasad, IMSc
6. B.V. Rao, CMI
7. M. Sundari, CMI
8. E.K. Narayanan, IISc
9. Priyavrat Deshpande, CMI
10. Sukhendu Mehrotra, CMI
11. Vimala Ramani, Anna University
12. Mahan Mj, RKM Vivekananda University

## **Mathematical Panorama Lectures series workshop on Syzygies and Free Resolutions, December 2012**

This workshop was organized as part of the Mathematical Panorama Lectures during the National Mathematical Year (2012) celebrations on the occasion of the 125th birthday of Srinivasa Ramanujan. It consisted of a week-long preparatory workshop (17–22 December 2012), for graduate students and young researchers, on syzygies and free resolutions followed, in the next week (24–28 December 2012), by lectures on recent developments in this area. The principal speaker for the second week was Prof. David Eisenbud (University of California, Berkeley, USA), who gave a series of lectures on free resolutions. In addition to Prof. Eisenbud's talks, there were a series of lectures by experts in the area of syzygies and free resolutions.

Speakers for the preparatory workshop (17–22 December 2012):

- Krishna Hanumanthu, CMI, Siruseri.
- Manoj Kummini, CMI, Siruseri.
- Pramathanath Sastry, CMI, Siruseri.
- Sudhir Ghorpade, IIT Bombay, Mumbai.

Speakers at the workshop (24–28 December 2012).

- Srikanth Iyengar, University of Nebraska, USA.
- Jaya Iyer, IMSc, Chennai.
- Vikram Mehta, TIFR, Mumbai.
- Bangere Purnaprajna, University of Kansas, USA.
- S. Ramanan, CMI, Siruseri.
- Hema Srinivasan, University of Missouri, USA.
- Kavita Sutar-Deshpande, CMI, Siruseri.

## Topics in Probability, December 2012

This workshop was jointly organized by Chennai Mathematical Institute (CMI), the Institute of Mathematical Sciences (IMSc) and the Statistical and Mathematical Sciences Institute (SAMSI) as an activity of the DST-NSF Indo-US Virtual Institute for Mathematical and Statistical Sciences (VI-MSS).

The list of talks at the workshop was as follows:

- Siva Athreya, Indian Statistical Institute, Bangalore  
*Convergence of Nearest Neighbor Markov chains on discrete trees towards Brownian Motion on real-trees*
- Richard Bass, University of Connecticut  
*A stability theorem for the elliptic Harnack inequality*
- Vivek Borkar, Indian Institute of Technology Bombay, Mumbai  
*Certain small noise limits for diffusions*
- Arup Bose, Indian Statistical Institute, Kolkata  
*Limiting spectral distribution of patterned random matrices*
- Sandra Cerrai, University of Maryland  
*Pathwise uniqueness of stochastic partial differential equations in Banach spaces*
- Manjunath Krishnapur, Indian Institute of Science, Bangalore  
*Nodal length of random eigenfunctions of the Laplacian on the 2-d torus*
- Tom Kurtz, University of Wisconsin  
*Time-change equations for diffusion processes*
- Krishanu Maulik, Indian Statistical Institute, Kolkata  
*Rates of convergence of color count in balanced urn models*
- Anish Sarkar, Indian Statistical Institute, Kolkata  
*Brownian Web in the Scaling Limit of Supercritical Oriented Percolation in Dimension  $1 + 1$*
- Ramon Van Handel, Princeton University  
*Conditional ergodicity in infinite dimension*
- Mathukumalli Vidyasagar, University of Texas at Dallas  
*A metric between probability distributions of different sizes and applications to order reduction*

## Making Formal Verification Scalable and Useable, January, 2013

While Formal Methods (FM) and Formal Verification (FV) have had an impact in specific areas, notably in hardware (HW) and protocol verification, they are far from realizing their promise and potential in practice, especially in software (SW) and embedded systems. The main bottlenecks blocking wider application of FM/FV techniques are their lack of scalability and the lack of enough successful models using these techniques in a way that can be replicated.

The aim of this workshop was to bring together a group of experts from both industry and academia to share their experiences and exchange new ideas and solutions to this problem. The presentations and discussions at the workshop included the following topics.

- State-of-art FV tools and techniques in use in industry
- Technical challenges and bottlenecks for scalability and useability
- New areas of applications and related correctness issues
- New techniques and solutions for scaling FM/FV

The list of talks at the workshop was as follows:

- Jason Baumgartner, IBM  
*Formal Verification at IBM: Applications and Algorithms*
- Supratik Chakraborty, IIT Bombay  
*Practical Quantifier Elimination for Linear Bit-vector Inequalities*
- Pallab Dasgupta, IIT Kharagpur  
*Formal verification in informal worlds*
- Manoj Dixit, Mathworks  
*Early time-budgeting in Distributed Embedded Control Systems*
- Deepak D'Souza, IISc  
*Verification of Free-RTOS*
- Ambar Gadkari and Pradeep Kumar Nalla, IBM  
*Formal Verification at IBM: Applications and Algorithms*
- A Kirankumar, Intel  
*Symbolic Trajectory Evaluation: The Prime Validation Vehicle for Intel's Next Generation Processor Graphics FPU*
- N V Krishna, IIT Madras  
*Correctness Issues in Transforming Task Parallel Programs*
- Daniel Kroening, Oxford  
*Reasoning about floating-point arithmetic with abstract conflict-driven clause learning*

- Aditya Nori, MSR  
*Program Verification via Machine Learning*
- Madhusudan Parthasarathy, UIUC/MSR  
*Natural Proofs for Verification of Dynamic Heaps*
- K V Raghavan, IISc  
*Precise, on-demand null-dereference verification for Java*
- Prahlad Sampath, Mathworks  
*Translation Validation for Stateflow Code Generation*
- Nishant Sinha, IBM  
*Big-step Bounded Model Checking for Software*
- R Venkatesh, TRDDC  
*Challenges in applying formal verification to industry applications*

## CMI Arts Initiative

The objective of the CMI Arts Initiative is to provide a space for students, professionals and anybody else keenly interested in the humanities and arts to interact and learn from experts in these areas.

To achieve this, CMI invites distinguished professionals and academicians from these fields to give a series of lectures and performances of about 15-20 hours, spread over two or three weekends, on a topic of their choice.

The following programmes were held in 2012–2013.

- *Art Appreciation* by Sadanand Menon, September, 2012
- *A Walk through Karnatik Music* by T.M. Krishna, October–November, 2012.
- *Reading Ramayana in the 21st Century* by Arshia Sattar, February, 2013
- *An Interaction with Bharatanatyam* by Priyadarsini Govind, March, 2013

## 14 Conferences, Visits and External Lectures

### Rajeeva L. Karandikar

- Visited Stanford University for Young Researchers Meet (Mathematics and Computer Science) during May 26-27, 2012. Also gave a talk on “Opinion Polls in the context of Indian Parliamentary Democracy”.
- Visited University of North Carolina at Chapel Hill, June 2012.
- Talked on “Introduction to Cryptography” at a conference for college teachers and students organised by IIT Bombay, Mumbai, January 2013.
- Talked on “Modeling in the Spirit of Markowitz Portfolio Theory in a Non Gaussian World” at IIM, Indore.
- Gave invited talks on “Opinion Polls in the context of Indian Parliamentary Democracy” at
  - IIT, Indore,
  - At the Bayes by the Bay conference organised by Institute of Mathematical Sciences, January 2013.
  - At the annual conference of International Indian Statistical Association at Chennai January 2013.
  - . At national seminar at St. Xavier’s College, Kolkata, January 2013.
- Invited talk on “Limit Theorems in Finitely Additive Probability Theory” at the conference on ”Limit theorems in probability” at IISc, January 2013.

### Madhavan Mukund

- Visited LaBRI, Bordeaux, France, LSV, ENS de Cachan, France, and IRISA, Rennes, France in May-June 2012. Presented a talk entitled “Tagging Makes Local Testing of Message-Passing Systems Feasible” at LaBRI, Bordeaux, France.
- Gave a talk on “Statistical Model Checking” at the 11th Update Meeting on Advanced Formal Methods, CMI, July 19–21, 2012.
- Gave a talk on “Timed Automata”, as part of the Golden Jubilee Thematic Lectures on “Automata for the Real World”, IMSc, July 21, 2012.
- Gave a talk on “Automata and Program Verification”, SSN College of Engineering, September 12, 2012

- Was Chair of the Programme Committee for 10th International Symposium on Automated Technology for Verification and Analysis (ATVA 2012), Thiruvananthapuram, India, October 3-6, 2012.
- Gave a talk on “Software Model Checking” at the Alan Turing Centenary Year Workshop on Advanced Topics in Theoretical Computer Science, Anna University, November 16–18, 2012.
- Attended 32nd conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2012) at IIT Hyderabad, in December 2012. Was a member of the Programme Committee and chaired a session.
- Visited Tata Research Development and Design Centre (TRDDC), Pune in December, 2012.
- Co-organizer of the ACM India Annual Event, IIT Madras, January 2013.
- Attended the MSR-ACM India Faculty Summit, New Delhi, February, 2013.

## V. Balaji

- Gave invited talk in Madrid in September 2012 in the Indo-Spanish Conference in honour of Professor M.S. Narasimhan’s 80th birthday.
- Gave a Course of Lectures in the “Geometry of Principal bundles” in University of Milan in September 2012.
- Gave invited talk in University of Roma I on “Higher dimensional analogues of Narasimhan-Seshadri theorem” in September 2012.
- Gave three invited talks in University of Paris 7 and Paris 8 on
  - (i) Higher dimensional analogues of Narasimhan-Seshadri theorem
  - (ii) Parahoric torsors on algebraic curves
  - (iii) Tensor product theorems of semistable bundles and Hitchin pairs.
- Gave invited talk in the International Conference in the Indian Institute of Science in honour of Professor M.S. Narasimhan.

## Samir Datta

- Participated in the Dagstuhl Seminar on Algebraic and Combinatorial Methods in Computational Complexity.
- Visited the University of Ulm, Germany and gave a talk entitled: “Bipartite Matching and Reachability: Topological Twins in Space”

## **K. Narayan Kumar**

- Visited LSV, ENS de Cachan in May 2012 and as part of the CNRS LIA "Informel".
- Attended the 10th International Conference on Automated Techniques for Verification and Analysis (ATVA 2012), Thiruvananthapuram, October 2012.
- Visited Uppsala University, Sweden, in Nov-Dec 2012.
- Attended the 32nd Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2012), IIIT, Hyderabad, December 2012.
- Gave a talk titled "Verifying Temporal Properties of Multi-pushdown Systems" at the IMPECS Workshop on Program Analysis, IISc Bangalore.

## **Pramathanath Sastry**

- Visited the University of Toronto May–July, 2012. Gave four lectures at the GANITA Lab at University of Toronto during this period.
- Attended the Workshop on Syzygies and Free Resolutions at CMI, December 24–28, 2012.
- Attended the ATM Workshop on Singularity Categories in Algebraic Geometry and Commutative Algebra, IIT Madras, January 2–12, 2013.

## **S Senthamarai Kannan**

- Attended the Groups and Geometry Conference at ISI, Bangalore in December, 2012.
- Attended the Algebraic Geometry Conference at KSOM, Kozhikode in March, 2013.

## **Shiva Shankar**

- Visited the University of Padova, September-October 2012, and gave a graduate level course on control of systems of PDE.
- Gave two seminar talks at the Institute of Mathematics, Innsbruck, Austria, October, 2012.
- Attended the Ramanujam Mathematical Society Annual Meeting, Bangalore, 2013 and delivered a plenary talk on "The Fundamental Principle: from Euler to Palamodov".

## V V Sreedhar

- Visited Theoretisch-Physikalisches-Institut Friedrich-Schiller-Universität, Jena, Germany, 16–18 July, 2012, and gave a talk on “Electromagnetic Field of Torus Knots”.
- Attended the 3rd O’Raifeartaigh Conference on Symmetry and Integrability, July 19–21, 2012, Arnold Sommerfeld Centre for Theoretical Physics, Ludwig Maximilians Universität, Munchen, Germany, and gave a talk on “An Exact Expression for a Flat Connection on the Complement of a Torus Knot”.
- Visited Institut für Theoretische Physik, Heidelberg, Germany, 22–28 July, 2012, and gave a talk on “An Exact Expression for a Flat Connection on the Complement of a Torus Knot” at
- Attended the International Conference on New Trends in Field Theories, 23–26 November 2012 at DST-Centre for Interdisciplinary Mathematical Sciences & Department of Physics, Faculty of Science Banaras Hindu University, Varanasi and gave a talk on “An Exact Expression for a Flat Connection on the Complement of a Torus Knot”.
- Visited University of Hyderabad on 18–20 January, 2013, and gave a talk on “An Exact Expression for a Flat Connection on the Complement of a Torus Knot”
- Visited IISER, Pune on 24–27, February, 2013 and gave a talk on “An Exact Expression for a Flat Connection on the Complement of a Torus Knot”

## Sourav Chakraborty

- Attended the conferences CCC 2012, FSTTCS 2012, CTW 2012.
- Attended the Mysore Park Workshop on Algorithms and Complexity in August 2012.
- Gave a talk on “Testing of Function Isomorphism”, Dagstuhl Seminar on Algebra in Computational Complexity, 2012.
- Visited Eldar Fischer at Technion, Israel in the month of May 2012.
- Visiting MPI, Saarbrücken for one month in June 2012.
- Visited Raghav Kulkarni at CQT, Singapore for couple of weeks in December 2012.
- Visited Harry Buhrman at CWI, Amsterdam for couple of weeks in October 2012.
- Visited Anna Gal at University of Texas, Austin for couple of weeks in March 2013. Gave a talk on “Property Testing”.
- Visited Alexander Razborov at University of Chicago for couple of weeks in March 2013. Gave talk on “Testing of Junta-symmetric Functions”.
- Visited Satya Lokam at Microsoft Research, India multiple times.

## Clare D'Cruz

- Gave a talk on “Solving polynomial equations, Groebner basis and applications” on June 15, 2012 at the Development program on Discrete Mathematics from 11–18 June, 2012.
- Visited the Department of Mathematics, ISI Calcutta, July 20–August 3, 2012.
- Attended the ATM Workshop on Singularity Categories in Algebraic Geometry and Commutative Algebra, IIT Madras, Jan 2–12 2013
- Gave a talk on “Integral points, convex polytopes and applications” at the Department of Mathematics, Anna University, Chennai on January 4, 2013.
- Gave a talk on “Polynomials, Blowing up and Integrally closed ideals” at the National Conference on Topics in Commutative Algebra, Institute of Science, Mumbai on January 25, 2013.
- Gave a talk on “Polynomial, blowing up and integrally closed ideals” at the Department of Mathematics, Periyar University, Salem in March 2013.

## Govind Krishnaswami

- Attended the first Meeting of DST-Ramanujan Fellows, Pune, 4–6 May, 2012.

## K. Narayan

- Visited the Kavli Institute for Theoretical Physics (KITP), University of California Santa Barbara, and the Physics Departments at Stanford University and University of Kentucky, USA, May–Jun 2012. Gave a talk on “Aspects of Lifshitz scaling in string theory” at KITP and the University of Kentucky.
- Attended the Indian Strings Meeting (ISM2012), international string theory workshop, Puri, India, Dec 2012. Gave a talk on “*AdS* plane waves, Lifshitz scaling, hyperscaling violation and entanglement entropy”.
- Visited the International Center for Theoretical Sciences (ICTS) and attended “Discussion Meeting on String Theory”, Bangalore, Jun 2012. Gave a talk on “Aspects of Lifshitz scaling in string theory”.
- Visited the String Theory group, TIFR, Mumbai, July 2012.
- Gave a Seminar at the Institute of Mathematical Sciences (IMSc), Chennai, Sep 2012 on “Lifshitz scaling and hyperscaling violation in string theory”.

- Attended the workshop on “Non-perturbative gauge theories, holography and all that”, Center for High Energy Physics, IISc, Bangalore, Jan 2013. Gave a talk on “Hyper-scaling violation and entanglement entropy in gauge/string theory”.
- Attended the Discussion Meeting on “String Theory”, TIFR, Mumbai, Jan 2013.

### **Purusottam Rath**

- Gave an invited talk in the international conference on “The Legacy of Srinivasa Ramanujan” held at New Delhi commemorating the 125th birth anniversary of Srinivasa Ramanujan.

### **R. Srinivasan**

- Attended the conference on “Operator Algebras in Non-Equilibrium Statistical Mechanics” between December 17-21, 2012, at Bambolim Resort, Goa. Gave a talk titled “Invariants for  $E_0$ -semigroups on type  $II_1$  factors”.
- Attended a workshop and a subsequent conference on “Recent advances in Operator Theory and Operator Algebras”, between December 31, 2012 and January, 11, 2013, held at Indian Statistical Institute, Bangalore. Gave a talk titled “Non-cocycle-conjugate  $E_0$ -semigroups on non-type-I factors”.

### **S.P. Suresh**

- Attended 32nd conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2012) at IIIT Hyderabad, in December 2012.
- Attended the Conference on Theoretical Aspects of Rationality and Knowledge (TARK) 2013, January 7–9, 2013 at IMSc, Chennai.
- Attended the Indian Conference on Logic and its Applications (ICLA) 2013, January 10–12, 2013 at IMSc, Chennai.

### **K.G. Arun**

- Visited IISER Thiruvananthapuram in May 2012.
- Visited IUCAA, Pune in June-July 2012 (IndIGO data analysis camp).
- Attended the ASTROD symposium at the Raman Research Institute, Bangalore, July 2012. Gave an invited talk on “Testing General Relativity & Alternative theories of gravity using space-based GW detectors”.

- Visited IISER, Thiruvananthapuram in December 2012 (Indo-Japanese collaboration meeting).
- Attended the IUCAA workshop on Gravitational Wave Data Analysis at Birla Institute of Technology, Goa Campus in December 2012. Gave a set of 2 lectures.
- Visited Cardiff University, UK in February 2013 and attended the Conference on “Astronomy with the Global Gravitational-Wave Detector Network”. Gave an invited talk on “Strong field tests of General Relativity using Gravitational Wave observations”.
- Visited Osaka University Japan, March 2013.

### **Krishna Hanumanthu**

- Attended the ATM Workshop on combinatorial commutative algebra. at IIT Madras in May, 2012. Lectured on combinatorial commutative algebra .
- Attended the 27th Annual Conference of Ramanujan Mathematical Society, New Delhi, October 2012. Gave a lecture on “Bounding first Hilbert coefficient”.
- Attended the ATM Workshop on singularity categories in algebraic geometry and commutative algebra at IIT Madras in January, 2013. Tutorial instructor on singularity categories.

### **Manoj Kummini**

- Visited Mathematical Sciences Research Institute (MSRI), Berkeley during August-December 2012.
- Attended the Joint Introductory Workshop: Cluster Algebras and Commutative Algebra at MSRI, Berkeley in August-September, 2012.
- Visited Purdue University in August 2012, University of Missouri, Columbia in September 2012 and Northeastern University in October 2012.
- Attended KUMUNU at University of Missouri, September 2012.
- Gave a talk on “Hilbert functions and Betti numbers” at University of Missouri, Columbia in September 2012.
- Gave a talk on “Multilinear free resolutions from higher tensors”, Washington University, St. Louis, in September 2012.
- Attended Combinatorial Commutative Algebra and Applications at MSRI, Berkeley in December, 2012.

- Gave a talk on “Poset embeddings of Hilbert functions” at City University of New York, New York, NY in October, 2012.
- Gave a talk on Local Boij-Söderberg theory, Northeastern University, Boston, MA. October 2012.
- Lectured in the preparatory workshop for Panorama Lectures on “Syzygies and Free Resolutions” by David Eisenbud in CMI in December, 2012.
- Lectured in the ATM workshop on Singularity Categories in Algebra and Geometry in IIT Madras in Januar, 2013.

### **Sukhendu Mehrotra**

- Attended the workshop on “Brauer groups and obstruction problems” at the American Institute of Mathematics, Palo Alto from February 25 to March 1, 2013.
- Visited the National University of Singapore from November 6–11, 2012. Gave a talk on “Hyperholomorphic sheaves and deformations of K3 surfaces” in the Geometry Seminar on November 9, 2012.
- Lectured in Module 2, Geometry and Topology in the Ninth AFS at CMI in December, 2012.
- Lectured in the ATM Workshop on Singularity Categories in Algebraic Geometry and Commutative Algebra at IIT Madras, January 2–12, 2013.
- Visited TIFR, Mumbai from January 27 to February 1, 2013. Gave a Colloquium on “Hyperholomorphic sheaves and deformations of K3 surfaces” on January 31, 2013.

### **Dishant M. Pancholi**

- Visited the International Centre for Theoretical Physics (ICTP), Tiest, Italy from 7–14 January, 2013.

### **Sasanka Roy**

- Invited talk on “Point location and Voronoi diagram of point sets”, IMSc Golden Jubilee Thematic Lectures in Theoretical Computer Science, 20 October, 2012.
- Invited talk on “Data Structures for Optimizing Localized Geometric Query”, Alan Turing Centenary Year Workshop on Advanced Topics in Theoretical Computer Science, Anna University, November 16–18, 2012.

- Attended 32nd conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2012) at IIIT Hyderabad, in December 2012.
- Invited talk on “Introduction to Computational Geometry” at Research Promotion Workshop on “Introduction to Graph and Geometric Algorithms” held at BITS, Pilani, January 17–19, 2013.
- Attended WALCOM preschool, ISI Kolkata, in February, 2013.

### **Shrihari Sridharan**

- Visited the Indian Institute of Science, Bangalore during May–July 2012.
- Gave a lecture titled, “Arbitrarily long Arithmetic Progressions” in the Summer Seminar Series in the Institute of Mathematical Sciences, Chennai during July 2012.
- Visited the Indian Institute of Science Education and Research - Thiruvananthapuram during January–May 2013.

### **S. Sundar**

- Visited Université d’Orleans, France from September 23 to October 18, 2012.

### **Priyavrat C. Deshpande**

- Lectured on differential topology in the Ninth AFS at CMI in December, 2012.
- Attended the AIS workshop in Topology held at IMSc, Chennai in February 2013.
- Gave a talk on “Submanifold arrangements - a rich interplay between combinatorics and topology” on February 6, 2013 at IMSc.

### **Alok Laddha**

- Institute Colloquium entitled “Hamiltonian constraint in Loop Quantum Gravity” at Institute of Mathematical Sciences, Chennai.
- Plenary talk entitled “Recent advances in Loop Quantum Gravity” at 27th Meeting of the Indian Association for General Relativity and Gravitation (IAGRG-13), Garhwal University, Uttarakhand, March 2013.

### **Ananya Lahiri**

- Visited Indian Statistical Institute, Delhi from 25 November–1 December, 2012 and gave two talks.
- Attended Lectures on Probability and Stochastic Processes (LPS)VII at ISI, Delhi, 30 November–4 December 2012.
- Attended the Conference on Topics in Probability at CMI, Chennai, 18–20 December 2012.
- Attended the Workshop and Conference on Limit Theorems in Probability at IISc Bangalore, 2–11 January 2013.

### **Kavita Sutar**

- Attended the Workshop on Syzygies and free resolutions at CMI in December 2012. Gave a talk on “Orbit closures of quiver representations and their resolutions”.
- Attended the Conference on Representation Theory, Homological Algebra, and Free Resolutions at MSRI Berkeley, February 11–17, 2013. Gave a talk on “Resolutions of orbit closures of quiver representations”.

### **T. R. Govindarajan**

- Visited University of Bogota, Colombia, 15 July–15 August, 2012.
- Attended the International Conference on New Trends in Field Theories, BHU, Varanasi, 23–26 November, 2012. Gave a talk on “QCD -  $\theta$  - and CP violation”.
- Attended AD’65 meeting, IISER Kolkata, March 16–17, 2013. Gave a talk on “ $\eta$  and  $\theta$  in QCD”.
- Gave a TPSC talk on “Life at the Edge: Novel bound states on manifolds with boundary” at BHU, Varanasi, 25 November, 2012.

### **N. D. Hari Dass**

- Gave a series of three talks on “Quantum measurements, Uncertainty relations and Minimum uncertainty states” at the CQIQC Summer School - 2012, 21–23 May 2012 at Indian Institute of Science (IISc), Bangalore.
- Visited the National University of Singapore (NUS) on 2 July 2012. Gave a seminar on “Some results on the effective string description of QCD flux tubes”.

- Attended the Subrahmanyan Chandrasekhar Discussion meeting 2012, held at IISc, Bangalore from 19–21 December, 2012.
- Attended the International Conference on Quantum Information and Quantum Computing at IISc, Bangalore, 7–11 January 2013,
- Attended the workshop on “Applications of Physics, Mathematics to Cognition and Consciousness” at NIAS, Bangalore. 11–12 March, 2013
- Gave a talk on “Fault tolerant Quantum Computing” at the National Seminar on Quantum Computers at Vellore Institute of Technology, Chennai Campus, 23 February 2013.
- Delivered the IISc Physics Colloquium on “From Strings to Strings”, 15 March 2013.
- Delivered a colloquium entitled “Some surprises from Particle Physics” at IMSc, Chennai, 27 March 2013.

### **H.S. Mani**

- Attended Asiad Physics Olympiad May 2012.
- Invited lecture on “Quantum Langevin’s Equation” at the Hyderabad Central University, 25 February, 2013.

### **G. Rajasekaran**

- Participated in Collaboration Meeting on DINO (Darkmatter at INO) held at IIT, Mumbai during April 26–27, 2012.
- Participated in Summer Training Program In Physics held at Department of Nuclear Physics, University of Madras during June 5–15, 2012. Gave two lectures: 1. “A journey through microcosmos”, 2. “The elusive neutrinos and INO”.
- Participated in Academy Symposium on “Bridging the gap between Earth and Life sciences” held at Indian Institute of Science, Bangalore on Jul 12, 2012.
- Participated in Meeting of the Joint Science Education Panel of the Academy held at Indian Academy of Sciences, Bangalore on Jul 12, 2012.
- Visited Centre for High Energy Physics, Indian Institute of Science, Bangalore on July 12, 2012. Gave a seminar on “Unification of lepton and quark mixing through renormalization group evolution”.
- Participated in Mid-Year Meeting of the Indian Academy of Sciences held at Indian Institute of Science, Bangalore during July 13–14, 2012.

- Visited Indian Institute for Astrophysics, Bangalore on August 6, 2012. Gave a Colloquium entitled “Standard Model and Higgs”.
- Participated in INO Collaboration Meeting held at Theni (near Neutrino Nagar) during August 9–11, 2012.
- Participated in Recent developments in Theoretical Physics held at University of Madras during August 10–11, 2012. Gave an invited talk on “Standard Model and Higgs”.
- Colloquium Talk at IMSc on Aug 13, 2012. Gave a Colloquium talk on “Standard Model, Higgs Boson and What Next?”
- Colloquium at CMI on Aug 16, 2012. Gave a Colloquium talk on “Standard Model, Higgs Boson and What Next?”
- Participated in “Top-Higgs” held at Centre for High Energy Physics, Indian Institute of Science, Bangalore during August 24–26, 2012.
- Participated in Academy Workshop on “Higgs and Neutrinos” held at The American College, Madurai during August 28–29, 2012. Gave two talks: 1. “Introduction to the Standard Model and the discovery of the Higgs boson”, 2. Tamil version with same content.
- Visited Madurai Kamaraj University on August 29, 2012. Gave two talks: 1. “Standard Model, Higgs Boson and What Next?”, 2. “Neutrinos and INO”.
- Participated in National Conference on “The Contributions of Madras Christian College in the Making of Modern India: a Historical Perspective” held at Madras Christian College, Tambaram on October 26, 2012.
- Participated in Refresher Course in Physics held at Madurai Kamaraj University during November 16–17, 2012. Gave two lectures on “Basic Principles of Quantum Mechanics” and one lecture on “Neutrinos and INO”.
- Participated in Conference on “Quantum Field Theory” held at Banares Hindu University during November 23–26, 2012. Gave a talk on “Standard Model, Higgs Boson and What Next?”
- Visited Madras Christian College, Tambaram on December 6, 2012. Gave a talk on “Standard Model, Higgs Boson and What Next?”
- Participated in One-day seminar on “Higgs and Neutrinos” held at Department of Nuclear Physics, University of Madras on December 7, 2012. Gave two lectures: 1. “Standard Model, Higgs Boson and What Next?”, 2. “The Elusive Neutrinos and INO”.

- Participated in Conference on “Frontiers in High Energy Physics” held at IMSc, Chennai during December 10–13, 2012.
- Participated in IMSc Golden Jubilee Meeting held at IMSc during January 2–4, 2013. Gave a talk on “A partial history of IMSc: Ups and Downs”.
- Participated in Centenary Meeting of the Indian Science Congress held at Kolkata on January 5, 2013. Gave an Invited Talk on “Manpower for Fundamental Physics Experiments” in the Homi Bhabha Session on Mega Science and India.
- Participated in Workshop on “Recent Developments in Physics” held at Sri GVG Visalakshi College for Women, Udumalpet during February 6–7, 2013. Gave a talk on “Understanding the ultimate structure of matter”.
- Participated in Conference on “Advances in Quantum Theory” held at University of Hyderabad during February 25–26, 2013. Gave a talk on “Standard Model and Higgs Boson”.
- Participated in INO Collaboration Meeting held at BARC, Mumbai during March 5–Mar 7, 2013.
- Participated in Conference on “Current state of HEP” held at IISER, Kolkata during March 15–16, 2013. 1. Talked on “A stable massive charged particle”. 2. Gave a Colloquium on “Standard Model, Higgs Boson and What Next?”
- Wrote a popular science article in Tamil on “Hundred years of fundamental physics and the Higgs boson” published in “Mulumai Ariviyal Udayam”, July 2012.
- Popular Science article “The Long Journey” in the News Magazine “Front Line”, 27 July 2012.
- Popular lectures in Science at Danalakshmi College of Engineering, Tambaram on December 19, 2012. Gave two lectures: 1. “Standard Model of Particle Physics”, 2. “Neutrinos and INO”.
- Organized a meeting at Madras Christian College, Tambaram on December 11, 2012 on the occasion of the visit of Professor TWB Kibble to Chennai, to expose to the students and others the outstanding contributions of Kibble in the development of the Standard Model of HEP.
- Gave an elementary talk on “Neutrinos and INO” to School students at CMI on January 12, 2013, in a program sponsored by the National Academy of Sciences, Allahabad.

## **B.V. Rao**

- Gave a talk on “Large Deviations” at Sunderfest (V. Sunder’s Sixtieth Birthday meet) at IMSc Chennai, April 4–6, 2012.
- Gave a talk on “Some Elementary Probability” at the conference on History Aspects and Prospects of Mathematics in India at IMSc, Chennai (June 18–19, 2012) and IISc, Bangalore (June 20–21, 2012).
- Gave a series of lectures in Probability at the Annual LPS series, ISI Delhi, November 30–December 4, 2012. ı
- Gave a series of lectures on “Measure theory” at the Ninth AFS at CMI in December, 2012.
- Attended the Conference on Limit Theorems in Probability at IISc, Bangalore, January 9–11, 2013;
- Gave a lecture on “Urn Models in Probability” at NISER, Bhubaneswar, February 17, 2013.
- Gave a series of lectures on “Set Theory” at the Workshop on Set Theory and Logic, KSOM Calicut February 18–March 1, 2013.
- Gave a lecture on “Urn Models” for school students, PSB SS School, K K Nagar Chennai on February 25, 2013.
- Gave a lecture on “Concentration Inequalities” at the Kerala Statistical Association annual meet, National Seminar on Statistical Theory and Applications, Palai, Kerala, March 15–16, 2013.
- Gave a semi-technical talk on “A Probabilistic Diffusion Model” at the Sciencefest, CMI, March 31, 2013.

## **Mandayam Srivas**

- Participated in panel discussion on Automotive Software Safety, Automotive Electronics Conference, Pune, Dec 13, 2012.
- Visited Daniel Kroening at the Computer Science Department, University of Oxford, December 19–24, 2012.
- Full Day Tutorial on “Formal Techniques for HW-SW Co-verification”, at the conference on VLSI Design and Embedded Systems, Pune, India, January 6, 2013.
- Gave a talk on “Test-Vector-Less Verification of Embedded Systems” at the Curriculum upgrade Research discussions, Thiagarajar College of Engineering, Madurai, January 30–31, 2013.

## 15 Other Professional Activities

### Rajeeva L. Karandikar

- Appointed as Chairman by National Sample Survey Organisation for the working group of its 71st round
- Nominated as member of the Governing Council of Indian Statistical Institute
- Elected as a member of Governing Council of Indian National Science Academy.
- Organised a conference on “Topics in Probability” at CMI in December 2012 under the SAVI programme of collaboration between CMI, IMSc and The Statistical and Applied Mathematical Sciences Institute (SAMSI).

### Madhavan Mukund

- Member, Editorial Board, LIPIcs–Leibniz International Proceedings in Informatics.
- Member, Editorial Board, Transactions on Petri Nets and Other Models of Concurrency (ToPNoC).
- Member, Programme Committee, 33rd International Conference on Application and Theory of Petri Nets and Other Models of Concurrency (Petri Nets 2012), Hamburg, Germany, June 2012.
- Member, Programme Committee, 9th International Colloquium on Theoretical Aspects of Computing (ICTAC 2012), Bangalore, India, September 2012.
- Co-Chair, Programme Committee, 10th International Symposium on Automated Technology for Verification and Analysis (ATVA 2012), Thiruvananthapuram, India, October 2012.
- Member, Programme Committee, 33rd International Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2012), Hyderabad, India, December 2012.
- President, Indian Association for Research in Computing Science (IARCS).
- Member ACM India Council, Association of Computing Machinery (ACM).
- Executive Director, International Olympiad in Informatics.
- National Coordinator, Indian Computing Olympiad.
- Member, Scientific Board, Mysore Park Workshop Series.

- Member, Board of Studies in Mathematical Sciences, Homi Bhabha National Institute.
- Member, Board of Studies in Computer Science, PSG College of Technology, Coimbatore.
- Co-organizer, CMI Arts Initiative.

### **K Narayan Kumar**

- Member, Program Committee, 10th International Symposium on Automated Technology for Verification and Analysis (ATVA 2012).
- Coach, Indian Computing Olympiad.
- Leader of the Indian team, International Olympiad in Informatics, Sirmione, Italy, 2012.

### **Shiva Shankar**

- Associate editor, Multidimensional Systems and Signal Processing, (Springer).

### **K V Subrahmanyam**

- Co-organizer, CMI Arts Initiative

### **Sourav Chakraborty**

- Program Committee Member in FSTTCS 2012.

### **Clare D'Cruz**

- Organised AFS I School, Dec 3–29 2012, CMI.

### **K. Narayan**

- Member, National Organizing Committee, Indian Strings Meeting (ISM 2012), international strings conference, Puri, India, Dec 2012.

### **K.G. Arun**

- Member of LIGO Scientific collaboration (coalescing compact binaries group) and IndIGO consortium

**Manoj Kummini**

- Organized “Syzygies and Free Resolutions”, Panorama lectures of David Eisenbud in CMI (along with D. S. Nagaraj from IMSc.)

**T. R. Govindarajan**

- Editor, Physics Education, IAPT.
- Member, Promotion/Assessment Committee, S N Bose Institute.

**N. D. Hari Dass**

- Editor, ‘Quanta’.
- Editor, Applied Mathematics and Information Sciences Letters.

**H.S. Mani**

- Organised a workshop for school students in CMI in January 2013, with the support of the National Academy of Sciences, Allahabad.

**G. Rajasekaran**

- Member of Scientific Steering Committee of INO

**Mandayam Srivas**

- Co-organized Workshop on “Making Formal Verification Scalable and Useable”, CMI, January 9–10, 2013,

## 16 Visitors

- Tanmoy Chakraborty, Harvard University, U.S.A. Gave talks on “Introduction to Mechanism Design” and “Pricing vs Auctions” (March 2012).
- Anshuman Maharana, Cambridge, U.K.. Gave a talk on “Symmetry Breaking in Local Model Building” (March 2012).
- Amitabh Trehan, Technion, Haifa, Israel. Gave a talk on “Self-healing distributed networks and data structures: Forgiving Graph and Xheal” (March 2012).
- Sylvia Wiegand, University of Nebraska, U.S.A. Gave a talk on “Prime ideals in Noetherian rings” (March 2012).
- Christophe Mourougane, University of Rennes, France. Gave a talk on “Sections of families of hypersurfaces of large degree” (March 2012).
- Sudarshan Ananth, IISER, Pune. Gave talks on “The trouble with gravity” and “Gravity and Yang-Mills theory” (April 2012).
- Rohit Chadha, INRIA and LSV, ENS Cachan, France. Gave a talk on “Automated verification of cryptographic protocols” (April 2012).
- Tom Farrell, Binghamton University, U.S.A. Gave a talk on “Introduction to topological rigidity” (April 2012).
- Varadharaj Srinivasan. Gave a talk on “Liouvillian extensions and the Galois theory of linear differential equations” (April 2012).
- Abhik Ganguli. Gave a talk on “Mod  $p$  reduction of certain  $p$ -adic Galois representations” (April 2012).
- Krishna V. Kaipa, IIT Bombay, Mumbai. Gave a talk on “Automorphism groups of Codes associated to the Grassmannian and its Schubert divisor” (June 2012).
- Umesh Dubey, Harish Chandra Research Institute, Allahabad. Gave two talks on “A functorial approach to construction of moduli of sheaves” (June 2012).
- Ashok Das, University of Rochester, U.S.A.. Gave a talk on “Supersymmetry, shape invariance and the Legendre equations” (August 2012).
- R. Parimala, Emory University, U.S.A.. Gave a talk on “Splitting ramification of Brauer classes on arithmetic surfaces” (August 2012).
- S Palaniappan, South Asia Research and Information Institute. Gave a talk on “Going to Hell or Being Low-Born?: An Inter-Disciplinary Analysis of the origin of Untouchability in South India” (August 2012).

- Sudeshna Basu, George Washington University, U.S.A.. Gave a talk on “Ball separation properties in Banach spaces” (August 2012).
- Hema Srinivasan, University of Missouri, U.S.A.. Gave a talk on “When are Gorenstein ideals determinantal?” (August 2012).
- Sathya Peri, IIT Patna. Gave a talk on “Correctness of Closed Nesting in Software Transactional Memory Systems” (September 2012).
- K Srilata, IIT Madras and CMI. Readings from works in progress (novella and poems) (September 2012).
- Shekar Dattatri. Gave a talk on “Wildlife conservation in India” (August 2012).
- Helmut Seidl, Technical University of Munich, Germany. Gave a talk on “Minimization of Tree Transducers” (September 2012).
- Kavitha Telikepalli, TIFR, Mumbai. Gave talks on “Small Stretch Pairwise Spanners” and “Greedy Matchings” (September 2012).
- Ramesh Sreekantan, ISI Bangalore. Gave a talk on “Higher Chow cycles on Abelian surfaces” (October 2012).
- David Claman, Lehman College, City University of New York, U.S.A. Gave talks on “Where did Rock Music come from?”, and “Harmonic Tension” (October 2012).
- Arnab Kundu, U. Texas, Austin, U.S.A. Gave a talk on “Dynamics of Fundamental Flavours and Holographic Duals of Large N Gauge Theories” (October 2012).
- Dr V K Viswanathan, Retired Scientist, NASA and Los Alamos National Laboratory, U.S.A.. Gave a talk on “Global Optimization Techniques in Solving Practical Engineering Problems” (October 2012).
- Arjun Bagchi, University of Edinburgh, U.K.. Gave a talk on “Constructing Holography for Flat Spacetimes” (November 2012).
- Amritanshu Prasad, IMSc, Chennai. Gave a talk on “Orbits of tuples and subgroups in abelian groups” (December 2012).
- A. Thyagaraja, Bristol University, U.K.. Gave a talk on “Adjoint Variational Principles for Regularized Conservative Systems” (December 2012).
- Rajaram Nityananda, National Centre for Radio Astrophysics, Pune. Gave a talk on “Geometry of polarised light” (December 2012).
- Sanming Zhou, University of Melbourne, Australia. Gave a talk on “Two classes of network structures that enable efficient information transmission” (December 2012).

- Mohamed Faouzi Atig, Uppsala University, Sweden. Gave a talk on “Counter-Example Guided Fence Insertion under TSO” (December 2012).
- Oliver Margetts, Lancaster University, U.K. Gave a talk on “Invariants for  $E_0$ -semigroups on  $II_1$  factors” (December 2012).
- Parameswaran Nair, CUNY, U.S.A.. Gave a talk on “Wave functionals, boundary conditions and Casimir effect” (January 2013).
- Daniel Kroening, Computer Science Department, University of Oxford, U.K.. Gave a talk on “Verification of concurrent C programs with an unbounded number of threads” (January 2013).
- Aiswarya Cyriac, LSV, ENS Cachan, France. Gave a talk on “MSO Decidability of Multi-Pushdown Systems via Split-Width” (January 2013).
- Suhas J Pandit, ICTP, Trieste, Italy. Gave a talk on “The complex of HNN-extensions for free groups of rank  $n$ ” (January 2013).
- Ramarathnam Venkatesan, Microsoft Research. Gave a talk on “Cryptographic and Security Issues for the Cloud” (February 2013).
- Pierre-Yves Bienvenu, ENS Paris, France. Gave a talk on “Approaches to Szemerédi’s theorem” (February 2013).
- Pascal Weil, CNRS and Universite de Bordeaux, France. Gave a series of three lectures on “Algebraic Theory of Languages” (February 2013).
- Kameswara Rao Bhiravabhatla, iGATE. Gave a talk on “Are you a Statistician? Let’s talk Business!” (February 2013).
- Arun Mani, University of Melbourne. Gave a talk on “The Tutte polynomial of square lattice graphs” (February 2013).
- Shamik Ghosh, Jadavpur University. Gave a talk on “Interval graphs and its variations” (February 2013).
- Nitin Nitsure, TIFR, Mumbai. Gave a talk on “Cohomology of algebraic stacks and application to quadrics” (February 2013).
- Dr Srinivas Bhogle, TEOCO Software Pvt Ltd. Gave a talk on “Cricket Analytics: Yesterday, Today and Tomorrow” (March 2013).
- Francisco Presas Mata, ICMAT-CSIC, Spain. Gave a talk on “Orderability and contact fibrations” (February 2013).
- Ahmed Bouajjani, LIAFA, Univ Paris 7, France. Gave a talk on “Verifying Concurrent Programs against Sequential Specifications” (February 2013).

- Ankit Sharma, Carnegie Mellon University. Gave a talk on “Welfare and Profit maximization with Procurement costs” (February 2013).
- Meghana Nasre, University of Texas at Austin, U.S.A. Gave a talk on “Popular Matchings - structure and cheating strategies” (March 2013).
- Gregoire Sergeant-Perthuis, ENS Paris, France. Gave a talk on “Rudiments of 2d conformal field theory” (March 2013).
- Oleg Evnin, Chulalongkorn University, Bangkok, Thailand. Gave a talk on “Quantum backreaction in string theory” (March 2013).
- Steve Avery, IMSc, Chennai. Gave a talk on “Entanglement Entropy in the D1D5 CFT: Twists of Twists” (March 2013).
- Pablo Solis, University of California at Berkeley, U.S.A. Gave a talk on “A Wonderful Embedding of the Loop Group” (March 2013).
- Rajaram Nityananda, IISER, Pune. Gave a talk on “The optics mechanics analogy” (March 2013).
- L. Sriramkumar, IIT Madras. Gave a talk on “The inflationary scalar bispectrum: Status and possibilities” (March 2013).

## **17 Audited Statement of Accounts 2012-2013**