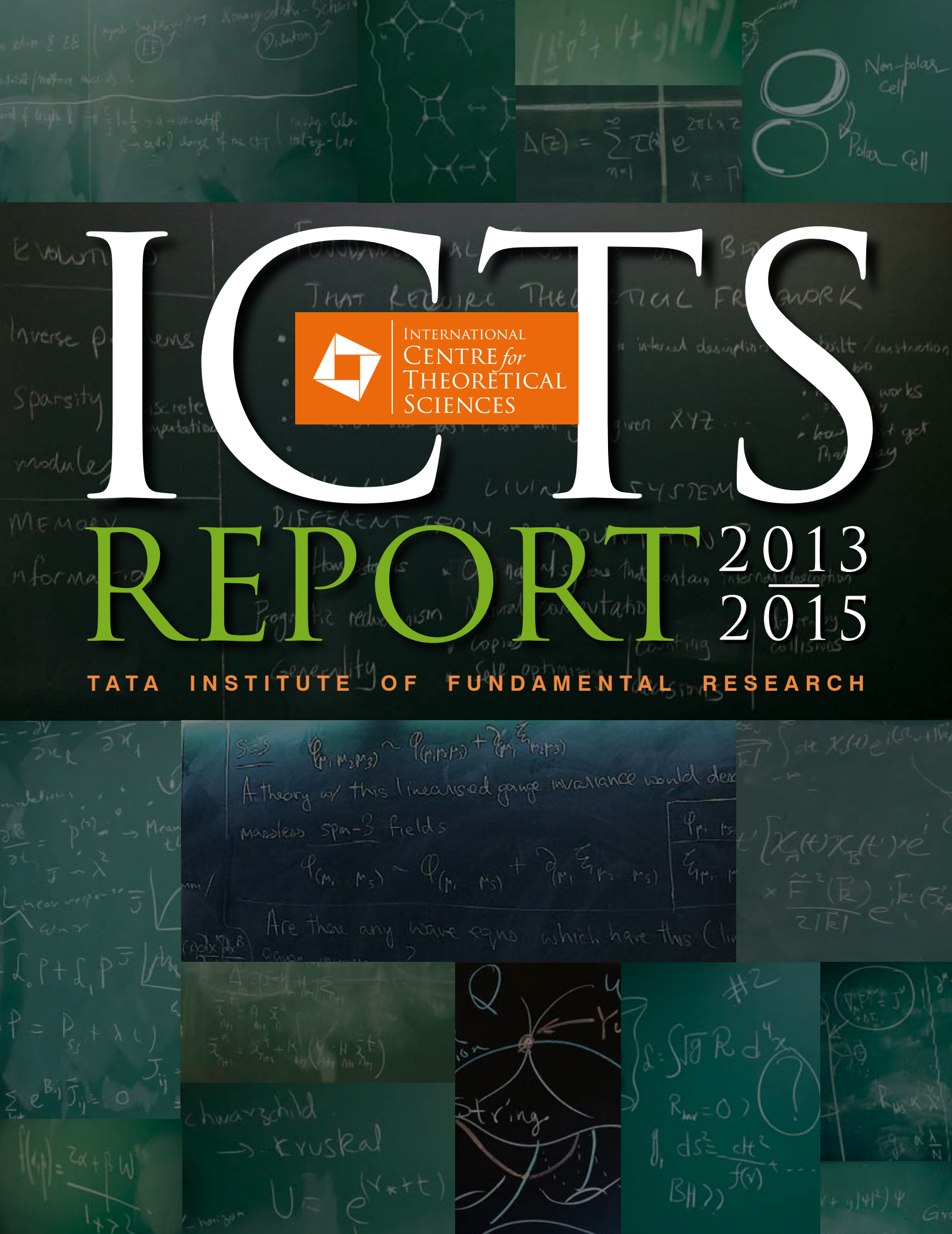

ICTS REPORT 2013–2015

INTERNATIONAL CENTRE *for* THEORETICAL SCIENCES

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

CONTENTS

Editor: Ananya Dasgupta
Design: Anisha Heble
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DIRECTOR'S REPORT

This report is about the road we have travelled since the end of 2012. Now we have reached a meadow from where we can survey what has passed and look into the future as we move on and climb higher.

First, let me mention some *foundational aspects* of the ICTS that have been firmed up during the past two and a half years.

The TIFR Council has formally constituted the ICTS faculty. Subhro Bhattacharjee (condensed matter physics), Rukmini Dey (mathematics), Rajesh Gopakumar (string theory), Vijay Kumar Krishnamurthy (physical biology) and Anupam Kundu (statistical physics) are our new faculty members. Bala Iyer also joined us as a Visiting Professor in 2015.

The in-house research at ICTS is organized as a union of families of researchers. The scientific questions that drive the current ICTS faculty research are from the broad areas of *Astrophysical Relativity, Data Assimilation and Dynamical Systems, Statistical Physics, Condensed Matter Physics, Physical Biology and String Theory*. There is a dedicated effort to establish a unit in *interdisciplinary/exploratory mathematics*.

ICTS has a vigorous Ph.D students' program. The students are stationed in Bengaluru and their course requirements for a degree from TIFR are partly fulfilled by arrangements with various institutions in Bengaluru. A strong postdoctoral program has also been initiated. ICTS has also recently initiated the ICTS-S.N. Bhatt Memorial Excellence Fellowship Program to support eight-week long summer internship for exceptional undergraduate students from around the country.

Several members of our faculty have been recognized with awards, grants and fellowships within India as well as internationally. The details have been provided within the report.

ICTS was awarded in 2015 the prestigious 'Targeted Grants to Institutes' from the Simons Foundation, USA. The AIRBUS Corporate Foundation grant for an international teaching and research chair entitled 'Mathematics of Complex Systems', which ICTS shares with the Centre for Applicable Mathematics, underwent a successful annual review and continues. Both these grants lend enormous encouragement to a fledgling Centre and enhance the ability of ICTS to conduct programs, invite outstanding post-docs and long term visiting professors.

The new ICTS Campus has started functioning. The campus is equipped with a modern library that will provide access to books and electronic resources on advanced topics; state-of-the-art computing and networking infrastructure; a data centre with high-speed connectivity and extensive storage facility for doing big-data sciences; conference and lecture halls equipped with high-end audio-video equipment for recording and broadcasting ICTS programs; healthcare, childcare and recreational facilities for members and visitors.

An elevated drawing of the new ICTS campus by the architects Venkatramanan and Associates

Besides its regular scientific activities, ICTS also provides a platform for new science initiatives in India. A Tier-2 LIGO data center and grid-computing site has already begun to take shape at ICTS. In addition, a proposal has been submitted to continue "IndiaLight", India's first fully dedicated large-data optical connectivity to the GLORIAD research network (http://www.gloriad.org/).

Given a strong faculty and excellent infrastructure, the third foundational component is administrative and technical support for faculty and visitors. ICTS has succeeded in putting together an excellent proactive team.

Eminent scientists Nima Arkani-Hamed, Sankar Das Sarma and Boris Shraiman have joined as new members of the International Advisory Board.

ICTS strongly believes in the importance of forging partnerships between basic sciences, technology and industry in order to sustain a healthy and productive interaction between these endeavors. Hence besides distinguished scientists the ICTS Board needs guidance in its interface with civic society and to create a sustainable social

and financial support system for itself. I am happy to say that Kris Gopalakrishnan, co-founder of the iconic Infosys Technologies of Bengaluru agreed to be a member of the IAB and partner and advise ICTS to take this forward.

ICTS has continued to organize programs and discussion meetings. This way we continue to provide the platform and resources for researchers to congregate over extended periods of time. ICTS encourages cross-disciplinary collaborations and interactions between theorists and experimentalists, and fosters research areas of importance to India.

In 2013, ICTS and ICTP, Trieste, got together to form the ICTP-ICTS Joint Program in Biology. Every year a Winter School on Quantitative Systems Biology is held alternately in Trieste and Bengaluru. This year in December, the fourth school in this series will be held in ICTS.

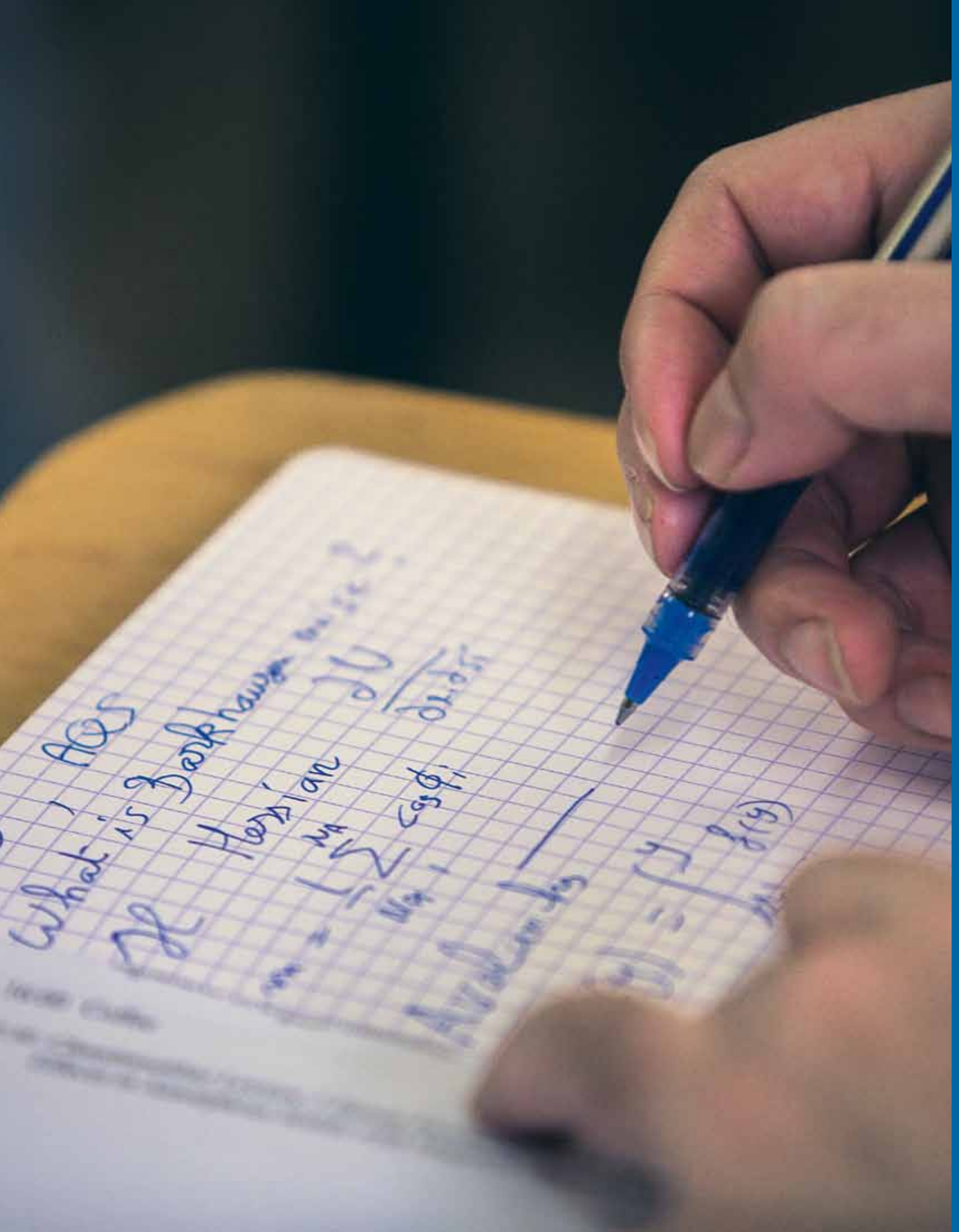
Another central activity of the ICTS is outreach, a crucial component of which is to organize public lectures by distinguished scientists. During this period, Cumrun Vafa (Harvard University), Boris Shraiman (KITP, Santa Barbara), Stuart Parkin (Director Max Planck Institute for Microstructure Physics) and Sankar Das Sarma (University of Maryland) visited ICTS and delivered public lectures.

In 2013 ICTS joined hands with other mathematical sciences organizations across the world for the Mathematics of Planet Earth 2013 (MPE 2013). In collaboration with Visvesvaraya Industrial and Technological Museum (VITM), TIFR Centre for Applicable Mathematics and the National Council for Science Museums (NCSM), we put together a world-class exhibition on mathematics at VITM, which saw 32,000 visitors in ten days!

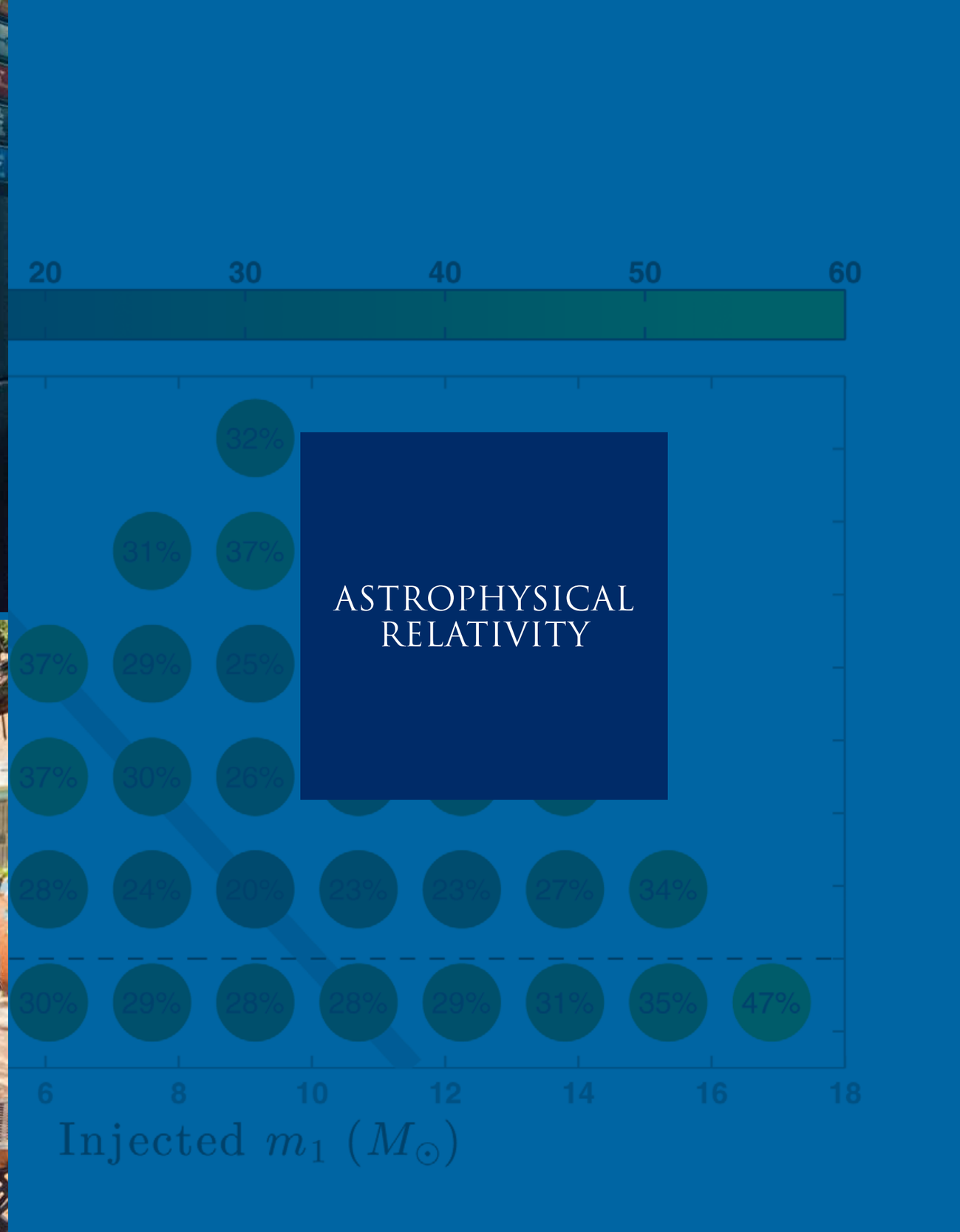
For all the reasons outlined above we are confident that ICTS will fulfill its unique multi-fold mission in India. I look forward to this exciting journey ahead.

Spenta R. Wadia
Bengaluru, May 2015

The new ICTS campus is located in Hessarghatta, north Bengaluru, and spread over 78,000 square meters



RESEARCH REPORTS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PARAMESWARAN AJITH

Parameswaran Ajith completed his PhD in Physics from the Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Germany, in 2007 under the supervision of Bernard F. Schutz. He went on to join postdoc positions at the Albert Einstein Institute and California Institute of Technology before joining the ICTS faculty. He heads the Max Planck Partner Group at ICTS.

RECENT COLLABORATORS

R. Adhikari (Caltech, USA), K. G. Arun (CMI, India), S. Babak (AEI, Germany), S. Bose (WSU, USA), Y. Chen (Caltech, USA), N. Christensen (Carlton, USA), N. Fotopoulos (Caltech, USA), A. Ghosh (ICTS, India) H. Grote (AEI, Germany), M. Hannam (Cardiff, UK), M. Hewitson (AEI, Germany), S. Hild (Glasgow, UK), S. Husa (UIB, Spain), B. R. Iyer (ICTS, India), T. Isogai (MIT, USA), D. Keppel (Caltech, USA), B. Krishnan (AEI, Germany), N. Mazumder (WSU, USA), C. K. Mishra (ICTS, India) F. Ohme (Cardiff, UK), D. Pollney (UIB, Spain), S. Privitera (Caltech, USA), M. Pürrer (Cardiff, UK), L. Rezzolla (AEI, Germany), B. S. Sathyaprakash (Cardiff, UK), A. M. Sintes (UIB, Spain), J. R. Smith (Fullerton, USA), U. Sperhake (Caltech, USA), K. A. Strain (Glasgow, UK), A. J. Weinstein (Caltech, USA).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Archisman Ghosh (postdoc, ICTS), Chandra Kant Mishra (postdoc, ICTS), Nathan Johnson McDaniel (postdoc, ICTS), Arunava Mukherjee (postdoc, ICTS), Abhirup Ghosh (PhD student, ICTS), Vijay Varma (masters thesis, ICTS), Ashok Choudhary (masters thesis, ICTS), Amruta Jaodand (masters thesis, ICTS), Siddharth Mohite (masters thesis, ICTS).

ICTS PROGRAMS ORGANIZED

- ICTS Program on Numerical Relativity, Bengaluru, 10 June - 5 July, 2013.
- Planck Day @ ICTS, April 6, 2013.
- ICTS Winter School on Experimental Gravitational-Wave Physics, Indore, 23-28 December, 2013.

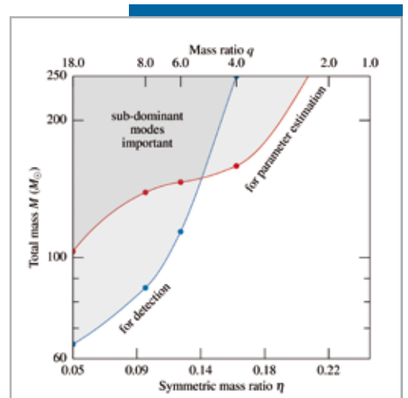
Upcoming

- ICTS Summer School on Gravitational-Wave Astronomy, 29 June - 10 July, 2015.

RESEARCH REPORT

My research concerns with various theoretical and observational aspects of gravitational-wave (GW) physics and astronomy. The first direct detection of GWs is expected to happen in the next few years, which will open up a unique observational window to the Universe.

Among the most promising sources for the first detection of GWs are the coalescence of black-hole binaries. GWs from such systems are to be detected by cross-correlating the data with a 'bank' of theoretical templates. Astrophysical black holes can have significant spin angular momentum, which significantly increases the parameter space of such systems to be searched over. It is practically impossible to cover the full parameter space of black-hole spins in a GW search. One major aspect of my recent work dealt with identifying a reduced set of the binary parameters which will significantly improve our sensitivity for GWs from spinning black-hole binaries. My recent work includes the calculation of theoretical waveform templates described by a single spin parameter, construction of template 'banks' for such waveforms making use of stochastic sampling algorithms, and implementation and demonstration of a search pipeline that significantly improved the search sensitivity for GWs from spinning black-hole binaries in the data of the Laser Interferometer Gravitational-Wave Observatory (LIGO). This body of work was done in collaboration with several members of the LIGO Scientific Collaboration including ICTS associates *S. Husa* and *M. Hannam*.



This plot summarizes the region in the parameter space of non-spinning black-hole binaries where contributions from non-quadrupole modes (arising due to the higher multipoles of the source) are important for gravitational-wave detection and parameter estimation. The bottom horizontal axis reports the symmetric mass ratio of the binary while the top horizontal axis shows the mass ratio $m1/m2$. The vertical axis reports the total mass $m1 + m2$. Shaded areas show the regions in the parameter space where the loss of detection rate due to neglecting non-quadrupole modes is larger than 10% and/or the systematic bias in the estimated parameters is larger than the expected statistical errors for a sky-averaged signal-to-noise ratio of 8. [*Phys. Rev. D 90, 124004 (2014)*]

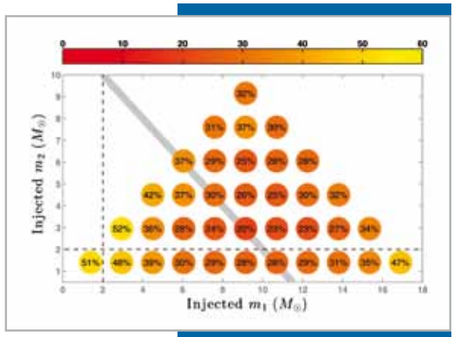
In a recently completed study, we computed a metric in the Riemannian manifold of gravitational-waveforms produced by the complete inspiral, merger and ringdown of binary black holes. Such waveforms have been possible due to the recent advances in numerical relativity in solving the two-body problem in full General Relativity. This metric will aid the construction of template banks for searches for GWs from binary black holes using upcoming GW observatories like Advanced LIGO. This work was done in collaboration with ICTS visiting student *C. Kalaghatgi* and ICTS associate *K. G. Arun*.

I am involved in systematically characterizing the effect of various higher order effects in GW waveforms (such as the effect of non-quadrupole modes, spins, etc.) in the observation of GWs from binary black holes (both in the detection of signals and in the extraction of source parameters). A recently completed study on the effect of non-quadrupole modes concluded that waveform templates modelling only the quadrupolar modes are sufficient for the detection of GWs from binaries with comparable mass ratios. Neglecting non-quadrupole modes will cause unacceptable systematic errors for binaries with large, unequal masses. This study was led by ICTS visiting student *V. Varma*. There is also the ongoing work of constructing an analytical waveform template family that include the effect of non-quadrupole modes produced by coalescing binary

black holes. This is done by combining large-scale numerical relativity simulations with semi-analytical calculations making use of post-Newtonian methods and black-hole perturbation theory. The work is done mainly in collaboration with ICTS postdocs *C. K. Mishra*, *N. J.-McDaniel* and *A. Mukherjee*.

There is also ongoing work in the ICTS group on the estimation of cosmological parameters (such as the Hubble constant and matter fraction of the Universe) from GW observations of coalescing binary black holes. From the observed GW signal, the luminosity distance to the source can be directly estimated without resorting to the cosmic distance ladder. Combining the measured luminosity distance with the cosmological redshift measured by electromagnetic observations of potential host galaxies, the cosmic expansion rate can be constrained. In an ongoing work led by ICTS postdoc *A. Ghosh*, we are developing a Bayesian method that combines multiple GW observations for cosmological parameter estimation and quantify the expected constraints from advanced GW observatories.

The ICTS Astrophysical Relativity group has active involvement in the LIGO Scientific Collaboration. We are in the process of setting up a LIGO Tier-3 grid computing facility at ICTS, which will have a peak computing power of 20 Teraflops and 200 Terabytes of storage space.



Expected increase in the rate of gravitational-wave detections of compact binary inspirals using a search that considers the spin of the compact objects (using a single effective parameter) as compared to a search that neglects the spin effects. Proper consideration of the spin effects is expected to bring in about 20%–52% increase in the average detection rates of Advanced LIGO observatories. [*Phys. Rev. D 89, 084041 (2014)*]

PUBLICATIONS (2013-2015)

1. *Template-space metric for searches for gravitational waves from the inspiral, merger and ringdown of binary black holes*, C. Kalaghatgi, **P. Ajith** and K. G. Arun. To appear in Phys. Rev. D (2015). arXiv:1501.04418v1
2. *Gravitational-wave observations of binary black holes: Effect of non-quadrupole modes*, V. Varma, **P. Ajith**, S. Husa, J. C. Bustillo, M.Hannam and M.Puerrer. Phys. Rev. D 90, 124004 (2014).
3. *Instrumental vetoes for transient gravitational-wave triggers using noise-coupling models: The bilinear-coupling veto*, **P. Ajith**, T. Isogai, N. Christensen, R. Adhikari, A. B. Pearlman, A. Wein, A. J. Weinstein, B. Yuan. Phys. Rev. D 89, 122001 (2014).
4. *An effectual template bank for the detection of gravitational waves from inspiralling compact binaries with generic spins*, **P. Ajith**, N. Fotopoulos, S. Privitera, A. Neunzert, N. Mazumder, A. J. Weinstein. Phys. Rev. D 89, 084041 (2014).
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- *An effectual template bank for the detection of gravitational waves from inspiralling compact binaries with generic spins*, **P. Ajith**, N. Fotopoulos, S. Privitera, A. Neunzert, N. Mazumder, A. J. Weinstein. Phys. Rev. D 89, 084041 (2014).
- *Gravitational-wave observations of binary black holes: Effect of non-quadrupole modes*, V.Varma, **P. Ajith,** S.Husa, J.C.Bustillo, M.Hannam and M. Puerrer. Phys. Rev. D **90**, 124004 (2014).
- *Addressing the spin question in gravitational-wave searches: Waveform templates for inspiralling compact binaries with non-precessing spins*, **P. Ajith**. Phys. Rev. D 84 084037 (2011).
- *Inspiral-merger-ringdown gravitational-waveforms for black-hole binaries with non-precessing spins*, **P. Ajith**, M.Hannam, S.Husa, Y.Chen, B.Bruegmann, N.Dorband, D.Mueller, F. Ohme, D. Pollney, C. Reisswig, L. Santamaria, and J. Seiler. Phys. Rev. Lett. 106, 241101 (2011).
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- *Estimating the parameters of non-spinning binary black holes using ground-based gravitational-wave detectors: Statistical errors*, **P. Ajith** and S. Bose. Phys. Rev. D **79** 084032 (2009).
- *Gravitational-wave data analysis using binary-black-hole waveforms*, **P. Ajith**. Class. Quantum Grav. **27**114033 (2008).
- *Template bank for gravitational waveforms from coalescing binary black holes: non-spinning binaries*, **P. Ajith**, S. Babak, Y. Chen, M. Hewitson, B. Krishnan, A. M. Sintes, J. T. Whelan, B. Bruegmann, P. Diener, N. Dorband, J. Gonzalez, M. Hannam, S. Husa, D. Pollney, L. Rezzolla, L. Santamaria, U. Sperhake, J. Thornburg. Phys. Rev. D 77**,** 104017 (2008).
- *Phenomenological template family for black-hole coalescence waveforms*, **P. Ajith**, S. Babak, Y. Chen, M. Hewitson, B. Krishnan, J. T. Whelan, B. Bruegmann, P. Diener, J. Gonzalez, M. Hannam, S. Husa, M. Koppitz, D. Pollney, L. Rezzolla, L. Santamaria, A. M. Sintes, U. Sperhake, J. Thornburg. Class. Quantum Grav. 24 S689–S699 (2007).
- *Physical instrumental vetoes for gravitational-wave burst triggers*, **P. Ajith**, M. Hewitson, J. R. Smith, H. Grote, S. Hild and K. A. Strain. Phys. Rev. D **76** 042004 (2007).

BALA IYER

Bala Iyer worked under the guidance of Arvind Kumar for his PhD from Bombay University in 1980. Before joining ICTS in 2015, he was a faculty member at the Raman Research Institute since 1992. He is a member of the International Society on General Relativity and Gravitation, Gravitational Wave International Committee (GWIC), International Astronomical Union (IAU), Indian Association for General Relativity and Gravitation (IAGRG), the Indian Physics Association Bangalore Chapter and the American Physical Society (APS), USA. Iyer is the Chair of the IndIGO Consortium and one of the principal leads of the LIGO-India project proposal. He is the Principal Investigator of IndIGO-LSC, the Indian participation in the LIGO Scientific Collaboration (LSC). Iyer is also the Subject Editor of Gravitational Waves for the Living Reviews in Relativity.

RECENT COLLABORATORS

L. Blanchet, G. Faye (Institut d'Astrophysique de Paris, Paris, France.), C.K. Mishra (ICTS-TIFR), K.G. Arun (CMI, Chennai), V. Varma (BITS, Pilani), R. Fujita (Univ. de les Illes, Balears, Spain), A. Choudhary (IISER, Pune).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Chandrakanth Mishra (PhD student, now at ICTS-TIFR), Siddhartha Sinha (PhD student, now at St Xavier's College, Kolkata), Mohammed S S Qusailah (PhD student, now at Sana'a University, Yemen), K.G. Arun (PhD student, now at Chennai Mathematical Institute), A. Gopakumar (PhD student, now at TIFR, Mumbai), Kanti R. Jotania (postdoc, now at M.S. University of Baroda, Vadodara), Anshu Gupta (postdoc), Srirang S. Deshingkar (postdoc), Ryuichi Fujita (postdoc, now at University of Lisbon, Portugal).

ICTS PROGRAMS ORGANIZED

- Summer School on Gravitational wave astronomy, ICTS-TIFR, 29 June - 10 July, 2015
- What is Einstein's General Relativity? ICTS outreach, Jain University, 13 September 2014
- ICTS Winter School On Experimental Gravitational-Wave Physics, RRCAT, Indore, 23-28 December 2013
- Summer School on Numerical Relativity, ICTS, Bengaluru, 24 June – 5 July 2013

- Workshop: Interface of Numerical Relativity with Gravitational-Wave Astronomy, Neutrino Physics and High-Energy Astrophysics, ICTS, Bangalore, 10 June -5 July 2013

RESEARCH REPORT

Non-linear multipole interactions and gravitational-wave octupole modes for inspiraling compact binaries to third-and-a-half post-Newtonian order

This work is motivated by the need to improve the post-Newtonian (PN) amplitude accuracy of waveforms for gravitational waves generated by inspiraling compact binaries, both for use in data analysis and in the comparison between post-Newtonian approximations and numerical relativity computations. It provides: (i) the non-linear couplings between multipole moments of general post-Newtonian matter sources up to order 3.5PN, including all contributions from tails, tails-of-tails and the non-linear memory effect; and (ii) the source mass-type octupole moment of (non-spinning) compact binaries up to order 3PN, which permits to complete the expressions of the octupole modes $(3,3)$ and $(3,1)$ of the gravitational waveform to order 3.5PN. As an aside it reconfirms by means of independent calculations our earlier results concerning the source mass-type quadrupole moment to order 3PN. Related discussions on factorized re-summed waveforms and the occurrence of logarithmic contributions to high order are also provided.

Spherical harmonic modes of the third post-Newtonian gravitational waveform for inspiraling compact binaries in general orbits: instantaneous terms

Though most of the prototypical inspiraling compact binaries in their final stages are expected to have circularised, there are other classes of sources where the binaries possess significant eccentricities when they enter the sensitive bandwidths of the terrestrial GW detectors. This work computes the spherical harmonic modes of the gravitational waveform at 3PN accuracy for such eccentric systems. It deals with all the terms in the waveform propagating on the light cone and referred to as the `instantaneous' terms. Using the multipolar post Minkowskian (MPM) formalism, all the instantaneous terms in the radiative moments are obtained going via the two canonical moments and their relation to the six source moments. The STF radiative moment then allows one to compute the spherical harmonic decomposition of the gravitational waveform. The modes are then re-expressed using the 3PN generalized quasi-Keplerian representation for the elliptical orbit case.

Comparison of post-Newtonian templates for extreme mass ratio inspirals

Extreme mass ratio inspirals (EMRIs), the inspirals of compact objects into supermassive black holes, are important gravitational wave sources for the Laser Interferometer Space Antenna (LISA). The performance of various post-Newtonian (PN) template families relative to the high precision numerical waveforms are investigated in the context of EMRI parameter estimation with LISA. Expressions for the time domain waveforms TaylorT1, TaylorT2, TaylorT3, TaylorT4 and TaylorEt are derived up to 22PN order beyond the Newtonian term, for a test particle in a circular orbit around a Schwarzschild black hole. The phase difference between the above 22PN waveform

families and numerical waveforms are evaluated during two-year inspirals for two prototypical EMRI systems with mass ratios 0.0001 and 0.00001 and it is shown that using 22PN TaylorT1 or TaylorT2 waveforms for parameter estimation of EMRIs will result in accuracies comparable to numerical waveform accuracy for most of the LISA parameter space. On the other hand, from the dephase results, it is found that TaylorT3, TaylorT4 and TaylorEt fare relatively poorly as one approaches the last stable orbit.

PUBLICATIONS (2013-2015)

1. *The third post-Newtonian gravitational waveforms for compact binary systems in general orbits: instantaneous terms*, Chandra Kant Mishra, K. G. Arun and **Bala R Iyer**, Phys. Rev. D 91, 084040 (2015)
2. *Topical Collection: The First Century of General Relativity: GR20/Amaldi10*, Eds. Jurek Lewandowski, Bala Iyer and Sheila Rowan, Springer (2015).
3. *A directed search for gravitational waves from Scorpius X-1 with initial LIGO*, The LIGO Scientific Collaboration, The Virgo Collaboration, Phys. Rev. D 91, 062008 (2015)
4. *Advanced LIGO*, The LIGO Scientific Collaboration, Class. Quant. Grav, 32 074001 (2015)
5. *Searching for stochastic gravitational waves using data from two co-located LIGO Hanford detectors*, The LIGO Scientific Collaboration, The Virgo Collaboration, Phys. Rev. D 91, 022003 (2015)
6. *Non-Linear multipole interactions and gravitational-wave octupole modes for inspiraling compact binaries to third-and-a-half post-Newtonian order,* G. Faye, L. Blanchet and B. R. Iyer, Class. Quant. Gr., 32, 045016 (2015). arXiv:1409.3546. Selected for Inclusion in IOPselect, http://Select.iop.org
7. *Narrow-band search for continuous gravitational-wave signals from Crab and Vela pulsars in Virgo VSR4 data*, The LIGO Scientific Collaboration, The Virgo Collaboration, (2014)
8. *Searches for continuous gravitational waves from nine young supernova remnants*, The LIGO Scientific Collaboration, The Virgo Collaboration, (2014)
9. *Characterization of the LIGO detectors during their sixth science run*, The LIGO Scientific Collaboration, The Virgo Collaboration, (2014)
10. *Improved Upper Limits on the Stochastic Gravitational-Wave Background from 2009-2010 LIGO and Virgo Data*, The LIGO Scientific Collaboration, The Virgo Collaboration, Phys. Rev. Lett. 113, 231101 (2014)
11. *First all-sky search for continuous gravitational waves from unknown sources in binary systems,* The LIGO Scientific Collaboration, The Virgo Collaboration, Phys. Rev. D 90, 062010 (2014)
12. *Search for gravitational radiation from intermediate mass black hole binaries in data from the second LIGO-Virgo joint science run*, The LIGO Scientific Collaboration, The Virgo Collaboration, Phys. Rev. D 89, 122003 (2014)
13. *Search for gravitational waves associated with gamma-ray bursts detected by the Inter- Planetary Network*, LIGO Scientific Collaboration, Virgo Collaboration, Phys. Rev. Lett. 113, 011102 (2014)
14. *Search for gravitational wave ringdowns from perturbed intermediate mass black holes in LIGO-Virgo data from 2005-2010*, LIGO Scientific Collaboration, Virgo Collaboration, Phys. Rev. D 89, 102006 (2014)
15. *Implementation of an F-statistic all-sky search for continuous gravitational waves in Virgo VSR1 data*, LIGO Scientific Collaboration, Virgo Collaboration, Class. Quant. Gr 31, 165014 (2014)
16. *The NINJA-2 project: Detecting and characterizing gravitational waveforms modelled using numerical binary black hole simulations*, LIGO Scientific Collaboration, Virgo Collaboration, Class. Quantum Grav. 31 115004, (2014)
17. *Application of a Hough search for continuous gravitational waves on data from the 5th LIGO science run*, LIGO Scientific Collaboration, Virgo Collaboration, Class. Quant. Gr., 31, 085014 (2014)
18. *Gravitational waves from known pulsars: results from the initial detector era*, LIGO Virgo Collaboration, Ap J 785, 119 (2014)
19. *2.5PN kick from black-hole binaries in circular orbit: Non-spinning case,* Chandra Kant Mishra, K G Arun, **Bala R Iyer,** Proceedings of Relativity and Gravitation - 100 Years after Einstein in Prague, 269 Ed. J. Bicak and T. Ledvinka, (Springer) (2014)
20. *Constraints on cosmic (super)strings from the LIGO-Virgo gravitational-wave detectors,* LIGO Virgo Collaboration, Phys. Rev. Lett. 112, 131101 (2013)
21. *A directed search for continuous Gravitational Waves from the Galactic Center*, The LIGO Scientific Collaboration, The Virgo Collaboration, Phys. Rev. D 88 102002, 2013
22. *Search for long-lived gravitational-wave transients coincident with long gamma-ray bursts,* The LIGO Scientific Collaboration, The Virgo Collaboration, Phys. Rev. D 88, 122004 (2013)
23. *Enhanced sensitivity of the LIGO gravitational wave detector by using squeezed states of light*, LIGO Scientific Collaboration, Nature Photonics, 7, 613 (2013)
24. *Prospects for Localization of Gravitational Wave Transients by the Advanced LIGO and Advanced Virgo Observatories*, LIGO Scientific Collaboration, Virgo Collaboration (2013)
25. *Comparison of post-Newtonian templates for extreme mass ratio inspirals,* Vijay Varma, Ryuichi Fujita, Ashok Choudhary, **Bala R Iyer**, Phys. Rev. D, 88, 024038 (2013)

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- *Gravitational-Radiation damping of compact binary systems to second post Newtonian order,* L. Blanchet, T. Damour, **B.R. Iyer**, C.M. Will and A.G. Wiseman, Phys. Rev. Lett., 74, 3515 (1995)
- *Improved filters for gravitational waves from inspiralling compact binaries,* T. Damour, **B. R. Iyer** and B.S. Sathyaprakash, Phys. Rev. D., 57, 885 (1998)
- *Third post-Newtonian dynamics of compact binaries: the equation of motion in the center of mass frame*, L. Blanchet, **B. R. Iyer**, Class. Quant. Grav. 20, 755 (2003).
- *Gravitational radiation from inspiraling compact binaries completed at the third post-Newtonian order,* L. Blanchet, T. Damour, G. Esposito-Farese and **B. R. Iyer**, Phys. Rev. Lett., 93 091101 (2004)
- *Dimensional regularization of the third post-Newtonian gravitational wave generation from two point masses*, L. Blanchet, T. Damour, G. Esposito-Farese and **B. R. Iyer**, Phys. Rev. D, 71, 124004 (2005)
- *Parameter estimation of inspiraling compact binaries using 3.5PN gravitational wave phasing: the non-spinning case*, K.G. Arun, **B. R. Iyer**, B.S. Sathya prakash, P. Sundarrajan, Phys. Rev. D 71, 084008 (2005) op cit D72, 069903 (2005)
- *A comparison of search templates for gravitational waves from binary inspiral,* T. Damour, **B. R. Iyer** and B.S. Sathyaprakash, Phys. Rev. D63, 044023 (2001) op-cit D72 029902 (2005).
- *Higher signal harmonics, LISA's angular resolution and dark energy*, K.G. Arun, **B. R. Iyer**, B.S. Sathyaprakash, S. Sinha, C. Van den Broek, Phys. Rev. D 76, 104016 (2007) op cit 76, 129903 (2007).
- *Improved resummation of post-Newtonian multipolar waveforms from circularized compact binaries*, Thibault Damour, **Bala R. Iyer** and Alessandro Nagar Phys. Rev. D., 79, 064004 (2009)
- *Third post-Newtonian angular momentum flux and the secular evolution of orbital elements for inspiraling compact binaries in quasi-elliptical orbits*, K.G. Arun, L. Blanchet, **B. R. Iyer** and S. Sinha, Phys. Rev D. 80 124018 (2009)
- *The third post-Newtonian gravitational wave polarisations and the associated spherical harmonic modes for inspiraling compact binaries in quasi-circular orbits*, L. Blanchet, G. Faye, **B. R. Iyer** and S. Sinha, Class. Quant. Grav. 25, 165003 (2008) op cit 29, 239501 (2012)

DATA ASSIMILATION AND DYNAMICAL SYSTEMS

AMIT APTE

Amit Apte received his PhD from the University of Texas, Austin, under the supervision of Phillip J. Morrison. His postdoc affiliations included the Statistical and Applied Mathematical Sciences Institute (SAMSI), the University of North Carolina and the Mathematical Sciences Research Institute, Berkeley. Before joining ICTS he was a faculty member at the Centre for Applicable Mathematics, TIFR, Bengaluru.

RECENT COLLABORATORS

Didier Auroux (U. Nice France), Alberto Carrassi (NERSC, Bergen Norway), Rafael de la Llave (Georgia Tech, Atlanta), K. Fuchss, Martin Hairer (Warwick UK), Christopher K.R.T. Jones (U. North Carolina, Chapel Hill), T.B. Krause (U Texas Austin), P.J. Morrison (U Texas Austin), Nikola P. Petrov (U Oklahoma, US), Mythily Ramaswamy (TIFR-CAM, Bangalore), Bjorn Sandstede (Brown University, US), Laura Slivinski (WHOI Woods Hole, US), Elaine Spiller (Marquette, Milwaukee, US), Andrew Stuart (Warwick UK), Jochen Voss (U Leeds UK), Alex Wurm (WNEC Springfield, US)

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Md Nurujjaman (postdoc, TIFR-CAM Bangalore); Sk Sarif Hassan (postdoc, ICTS-TIFR Bangalore); Karthik Gurumoorthy (postdoc, ICTS-TIFR Bangalore); Suman Acharyya (postdoc, ICTS-TIFR); Madhuresh (PhD student, TIFR-CAM Bangalore).

ICTS PROGRAMS ORGANIZED

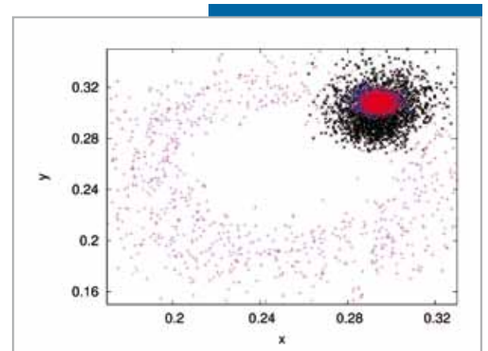
- Climate Variability: from Data and Models to Decisions, Lorentz Center, Leiden, Netherlands, 1-5 December 2014
- Nonlinear filtering and data assimilation, ICTS-TIFR, Bengaluru, 08-11 January 2014
- Mathematics of Planet Earth 2013: Mathematics for the billion, an interactive exhibition at the Visvesvaraya Industrial and Technological Museum, Bengaluru, 22 November - 1 December 2013 (and extended up to first week of January 2014)
- Advanced dynamical core modeling for atmospheric and oceanic circulations, Gadanki, 18-23 February 2013
- Mathematical Perspectives on Clouds, Climate, and Tropical Meteorology, ICTS-TIFR, Bengaluru, 21-25 January 2013. Also the Ramanujan lectures by Andrew Majda.
- Monsoon school on mathematical and statistical foundations of data assimilation and International conference on data assimilation, TIFR Centre for Applicable Mathematics and the Indian Institute of Science, Bengaluru, 04-23 July 2011
- Scientific discovery through intensive data exploration, Jawaharlal Nehru Center for Advanced Scientific Research, Bengaluru, 2-11 February 2011

RESEARCH REPORT

The main focus of research in my group is the applications of techniques from dynamical systems, statistics, and probability to study physical problems, particularly those related to earth sciences and plasma physics. Some of the specific areas of interest are as follows:

Bayesian data assimilation

We are working on developing a Bayesian approach to data assimilation and on illustrating its power through applications to highly nonlinear systems (such as the Lagrangian data assimilation problems described below). The conditional probability distribution for the state of the system conditioned on the observations provides a working benchmark against which other approaches can be evaluated. Some of the shortcomings of these other approaches can be understood using this comparison. We have also proved very general results about the consistency of the Bayesian posterior distribution for the linear inverse problem formulation of data assimilation and are working on extending it to certain nonlinear problems. Lagrangian data assimilation



This figure illustrates a highly non-Gaussian prior (magenta) around a centre fixed point in Lagrangian data assimilation, along with exact posterior (red) and the EnKF posterior (black)

The data collected by Lagrangian or semi-Lagrangian instruments such as floats, gliders, drifters, etc. is of great value, particularly for studying the oceans. Using ideas from the dynamical systems theory, we are working on developing techniques to make use of these data in an effective manner. In particular, we are developing hybrid ensemble Kalman filter (EnKF) - particle filter (PF) methods, in order to combine the complementary strengths of EnKF in large dimensional problems with the strength of PF in nonlinear problems.

Variational approaches

We are exploring the optimal control formulation of data assimilation problem and using it to study the relations to the problem of observability, using the tools from control theory. We are working on developing observers for linear and nonlinear partial differential equations, with the aim of using them as effective data assimilation methods. Dynamical systems approaches

We are studying the asymptotic properties of the linear and nonlinear filtering problems, using ideas from dynamical systems theory. Particularly, we have proved the result that the covariance matrix for a linear, Gaussian filtering problem may be rank deficient and the rank is in fact equal to the number of unstable directions of the system. This result was known numerically but the analytical proof now leads to further applications and opens up new areas of research such as understanding the spatial properties of these asymptotic covariances, localization as used in many EnKF methods, etc.

Simple models of monsoon dynamics

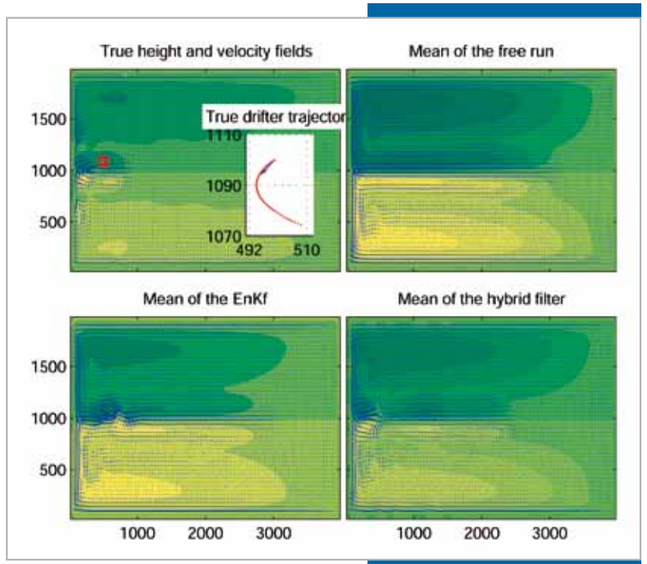
We have developed a simple model of the monsoon dynamics, based on previous work by Zickfeld et al. The main aim is to understand the basic physical phenomena behind the complex monsoon dynamics. One of the main questions we would like to address is whether the variability of the monsoon is driven by the internal dynamics of the monsoon system, or by the boundary conditions such as the oceans and the surrounding areas, or a combination of both.

PUBLICATIONS (2013-2015)

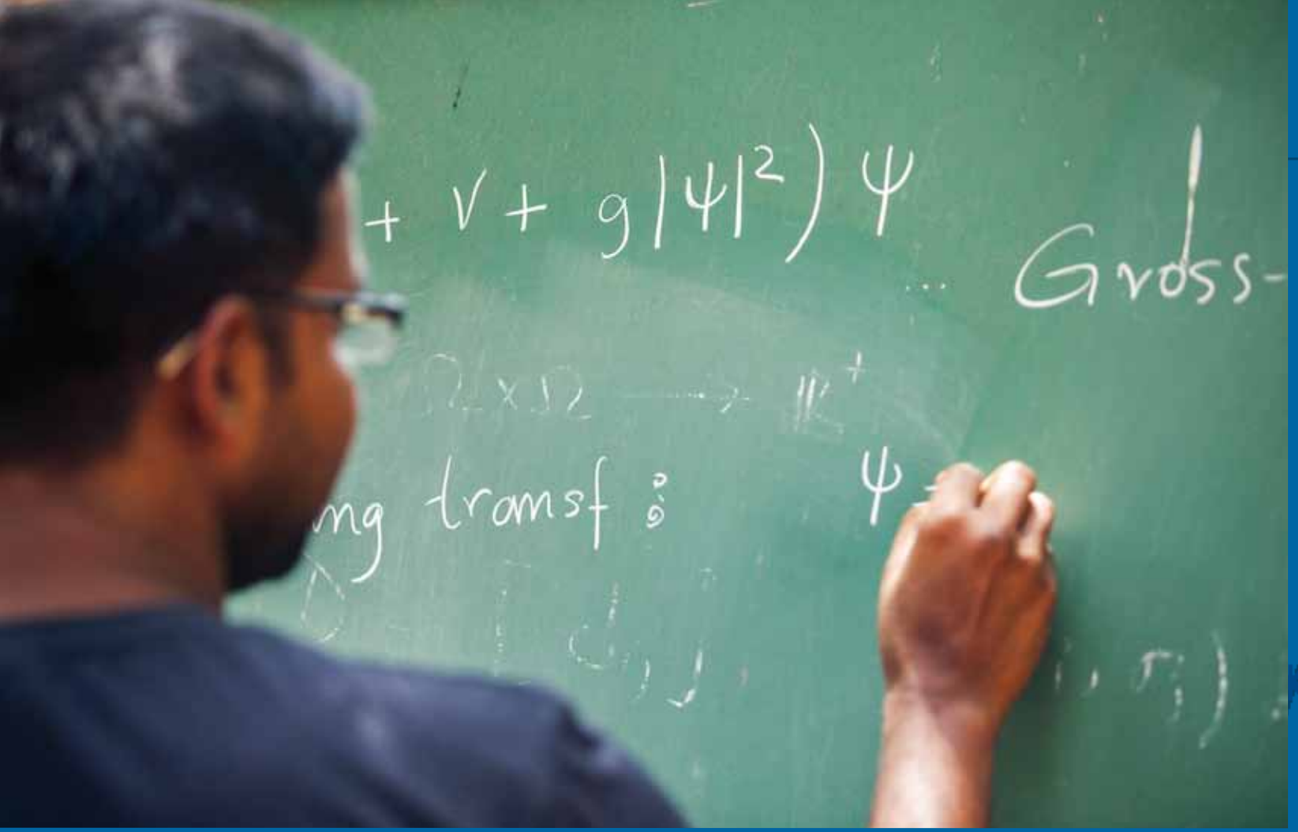
1. *Rank deficiency of Kalman error covariance matrices in linear perfect model*, Karthik S. Gurumoorthy, Colin Grudzien, Amit Apte, Alberto Carrassi, And Christopher K.R.T. Jones. arXiv:1503.05029
2. *Contraction rates for Bayesian inverse problems*, Madhuresh, Sreekar Vadlamani, Amit Apte. arXiv:1412.8016
3. *Observers for compressible Navier-Stokes equation*, Amit Apte, Didier Auroux, and Mythily Ramaswamy. Submitted to SIAM J. Control and Optimization. arXiv:1503.05259
4. *A hybrid particle-ensemble Kalman filter for high dimensional Lagrangian data assimilation*, L. Slivinski, E.T. Spiller, and Amit Apte. Lecture Notes in Computer Science. (2014)
5. *An introduction to data assimilation*, Amit Apte. Proceedings of Emerging Trends in Applied Mathematics: International Conference. (2014)
6. *A hybrid particle-ensemble Kalman filter for Lagrangian data assimilation*, L. Slivinski, E.T. Spiller, Amit Apte, and Bjorn Sandstede. Monthly Weather Review (2014)
7. *Assimilation of en route Lagrangian observations*, E.T. Spiller, Amit Apte, C.K.R.T. Jones. Tellus A v.65 pp.20319 (2013) /doi:10.3402/tellusa.v65i0.20319/pdf
8. *The impact of nonlinearity in Lagrangian data assimilation*, Amit Apte, C.K.R.T. Jones. Nonlinear Processes in Geosciences, v.20pp.1-13 (2013) /doi:10.5194/npg-_20-_329-_2013/pdf
9. *Data assimilation using ensemble transform Kalman filter (ETKF) in ROMS model for Indian Ocean*, Md. Nurujjaman, Amit Apte, P. Vinayachandran. European Physical Journal Special Topics v.222 pp.875-883 (2013)/doi:10.1140/epjst/e2013-_01890-_3/pdf

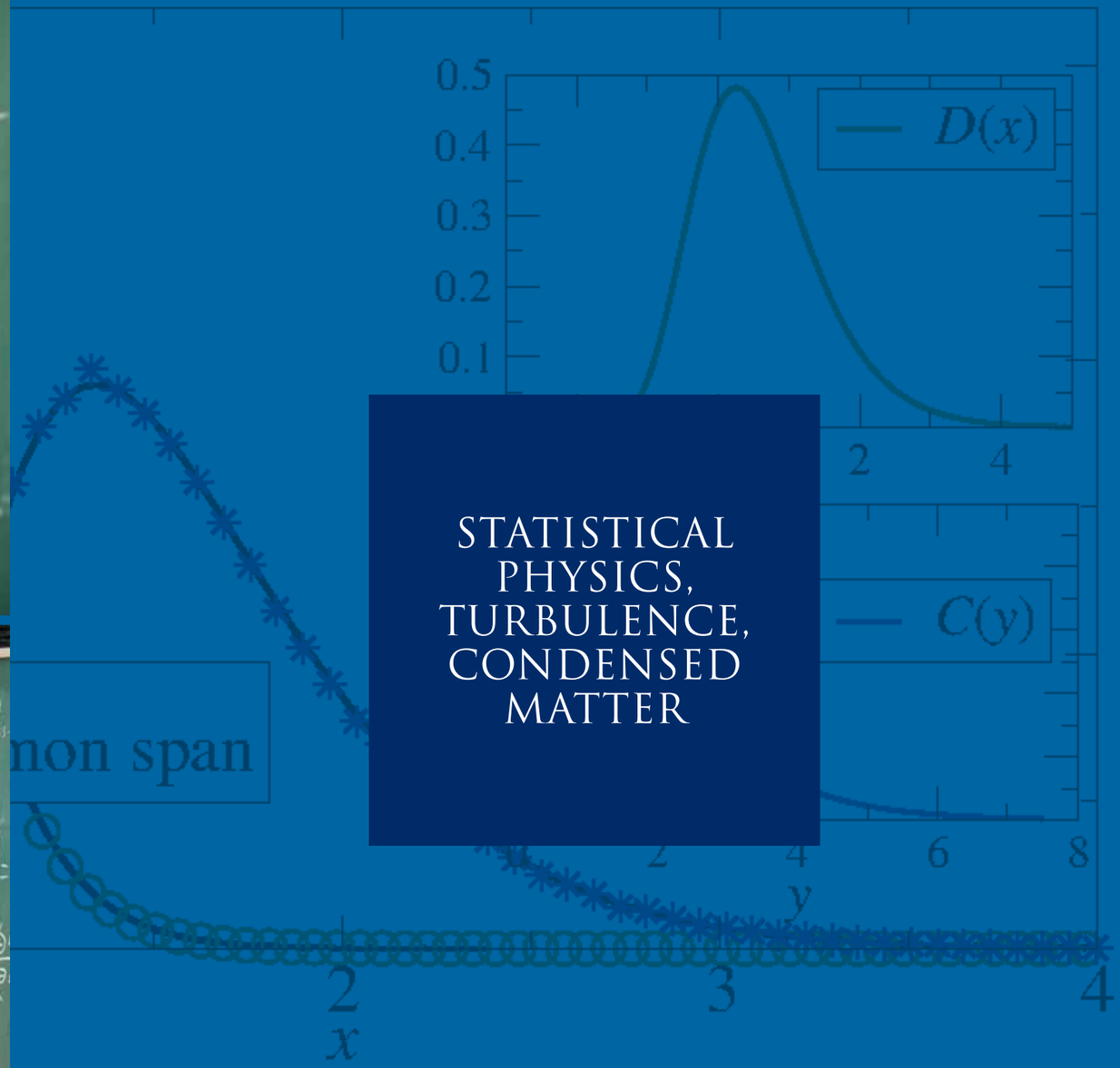
SELECTED PUBLICATIONS

- *A Bayesian approach to Lagrangian data assimilation*, Amit Apte, CKRT Jones, AM Stuart Tellus A 60 (2), 336-347 (2008)
- *Data assimilation: Mathematical and statistical perspectives*, Amit Apte, CKRT Jones, AM Stuart, J Voss. International journal for numerical methods in fluids 56 (8), 1033-1046 (2008)
- *Sampling the posterior: An approach to non-gaussian data assimilation*, Amit Apte, M Hairer, AM Stuart, J Voss. Physica D: Nonlinear Phenomena 230 (1), 50-64 (2007)
- *Meanders and reconnection-collision sequences in the standard non-twist map*, A Wurm, Amit Apte, K Fuchs, PJ Morrison Chaos 15 (2), 23108 (2005)
- *Renormalization and destruction of 1/γ2 tori in the standard non-twist map*, Amit Apte, A Wurm, PJ Morrison. Chaos: An Interdisciplinary Journal of Nonlinear Science 13 (2), 421-433 (2003)



The figure shows a comparison of the velocity and height fields at the end of the assimilation window, i.e., after 12.5 days, as given by the free run, the EnKF, and the hybrid EnKF-particle filter, for a quasigeostrophic model





STATISTICAL PHYSICS, TURBULENCE, CONDENSED MATTER

ABHISHEK DHAR

Abhishek Dhar worked under Deepak Dhar for his PhD at the Tata Institute of Fundamental Research, Mumbai. His postdoc positions were at the Indian Institute of Science, the Raman Research Institute and the University of California, Santa Cruz. Before joining ICTS, he was a faculty member at the Raman Research Institute, Bengaluru. Abhishek is an editorial board member of Pramana and Journal of Statistical Physics.

RECENT COLLABORATORS

Sanjib Sabhapandit (RRI, Bangalore), Ranjini Bandyopadhyay (RRI, Bangalore), Onuttom Narayan (UC Santa Cruz), Joel Lebowitz (Rutgers University), Herbert Spohn (TU Munich, Germany), Bernard Derrida (U. Paris, France), Keiji Saito (U. Keio, Japan), Debasish Chaudhuri (IIT, Hyderabad), Cedric Bernardin (U. Nice, France), Yonatan Dubi (U. Ben Gurion, Israel), Subinay Dasgupta (Calcutta University), Diptiman Sen (IISc, Bangalore), Pinaki Chaudhuri (IMSc, Chennai), Chandan Dasgupta (IISc, Bangalore), Manas Kulkarni (CUNY, USA), Satya Majumdar (LPTMS, France).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Suman Das, Chaitra Hegde (PhD students, RRI Bangalore), Aritra Kundu, Archak Purkayastha (PhD students, ICTS), Abhiram Soori (post doc, ICTS) Rahul Marathe (PhD student, now faculty at IIT Delhi), Dibyendu Roy (PhD student, presently at MPI Dresden; will join RRI faculty in October, 2015), Anupam Kundu (PhD student, now faculty at ICTS), Anjan Roy (PhD student, now at MPI, Potsdam), Abhishek Chaudhuri (postdoc, now at IISER Mohali), Subhashish Banerjee (postdoc, now at IIT Jodhpur).

ICTS PROGRAMS ORGANIZED

- Random matrix theory and applications, Bengaluru, 17 January-1 February, 2012
- Bangalore School on Statistical Physics, 1 April-13 April, 2013
- Bangalore School on Statistical Physics, 31 March-12 April, 2014
- Indian Statistical Physics Community Meeting 2015, Bengaluru, 13-15 February, 2015

RESEARCH REPORT

I work in the area of statistical physics. My main interest has been in transport and fluctuations in low dimensional systems and in small systems. One of the problems I have been looking at is the microscopic understanding of Fourier's law of heat conduction. Many studies have indicated that this law may not be valid in one and two-dimensional systems. Some open questions that I have been addressing are to establish the generality of this violation of Fourier's law and to develop an alternate theory of heat conduction in these systems. There are two approaches to heat transport. One is to apply a temperature gradient and measure the heat current and compute the conductivity. The second approach is to use equilibrium correlations from hydrodynamics theory and connect this to transport via linear response theory. I have been examining these two approaches and the problems in connecting the two in the case of anomalous transport. A second related problem that I am interested in is in developing a formalism of computing transport properties of small systems, e.g. a single molecule, where macroscopic theories of transport cannot be applied. I am currently exploring the feasibility of using two different techniques, namely the Caldeira-Leggett path integral method and the Lindblad method, for studying transport in nonlinear quantum systems.

I have also been working on the problem of microscopic derivation of Brownian motion. In this context I have been studying the motion of a single tagged particle in a one-dimensional gas of particles confined in a box and evolving under Hamiltonian Dynamics. The motivations for the study were to understand if the motion is diffusive in general and to understand the effects of the finite box size. New analytic results were obtained for a gas of hard point particles of equal masses, which is an integrable system. Apart from obtaining a simpler derivation of well-known earlier results for the mean square displacement of the tagged particle, the full large deviation function and all cumulants of the tagged particle displacement were found. For a gas where particle masses are not equal, the system is non-integrable and simulations showed that tagged particle motion is still diffusive. In this case, a hydrodynamics theory was developed to understand the simulation results.

Finally I have been interested in the problem of first passage problem in quantum systems. This examines the question of the time of detection at a screen of a quantum particle that is released from a box. Using the framework of repeated measurements made on a quantum system at finite time-intervals, some interesting results have been obtained for the detection time distribution.

PUBLICATIONS (2013-2015)

1. *Quantum time of arrival distribution in a simple lattice model*, S. Dhar, S. Dasgupta and **A. Dhar**, J. Phys. A: Math. Theor. 48, 115304 (2015)
2. *Heat transport and current fluctuations in harmonic crystals*, **A. Dhar** and R. Dandekar, Physica A 418, 49 (2015)

3. *Driven inelastic Maxwell gases*, V. V. Prasad, S. Sabhapandit and **A. Dhar**, Phys. Rev. E 90, 062130 (2014)

4. *Universal large deviations for the tagged particle in single-file motion*, C. Hegde, S. Sabhapandit and **A. Dhar**, Phys. Rev. Lett. 113, 120601 (2014)

5. *Numerical test of hydrodynamic fluctuation theory in the Fermi-Pasta-Ulam chain*, S. G. Das**, A. Dhar**, K. Saito, C. B. Mendl and H. Spohn, Phys. Rev. E 90, 012124 (2014)

6. *Heat Conduction in the α – β Fermi-Pasta-Ulam Chain*, S. G. Das, **A. Dhar**, O. Narayan, J. Stat. Phys. 154, 204 (2014)

7. *High-Energy Tail of the Velocity Distribution of Driven Inelastic Maxwell Gases*, V. V. Prasad, S. Sabhapandit, **A. Dhar**, Euro. Phys. Lett. 104, 54003 (2013)

8. *Exact solution of a Levy walk model for anomalous heat transport*, **A. Dhar**, K. Saito and B. Derrida, Phys. Rev. E 87, 010103(R) (2013)

9. *Tagged Particle Diffusion in One-Dimensional Gas with Hamiltonian Dynamics*, A. Roy, O. Narayan**, A. Dhar**, S. Sabhapandit, Jn. Stat. Phys. 150, 851 (2013)

SELECTED PUBLICATIONS

- *Heat Transport in low-dimensional systems*, **A. Dhar,** Adv. Phys. 57, 457 (2008)
- *Nonequilibrium Green's function formalism and the problem of bound states***, A. Dhar** and D. Sen, Phys. Rev. B 73, 085119 (2006)
- *Heat Conduction in Harmonic Lattices*, **A. Dhar** and D. Roy, J. Stat. Phys. 125, 801 (2006)
- *Heat conduction in a one-dimensional gas of elastically colliding particles of unequal masses*, **A. Dhar,** Phys. Rev. Lett. 86, 3554 (2001)
- *Heat conduction in the disordered harmonic chain revisited***, A. Dhar**, Phys. Rev. Lett. 86, 5882 (2001)

ANUPAM KUNDU

Anupam Kundu finished his PhD from Raman Research Institute under the supervision of Abhishek Dhar. Before joining ICTS, he was a Feinberg research fellow at the Weizmann Institute of Science, Israel. His other post-doc appointments have been with LPTMS, PCT, ESPCI, and CEA, France.

RECENT COLLABORATORS

Satya N. Majumdar (LPTMS, France), Gregory Schehr (LPTMS, France), David Lacoste (PCT, ESPCI, France), David Mukamel (Weizmann Institute of Science, Israel), Ori Hirschberg (Israel Institute of Technology, Technion).

RESEARCH REPORT

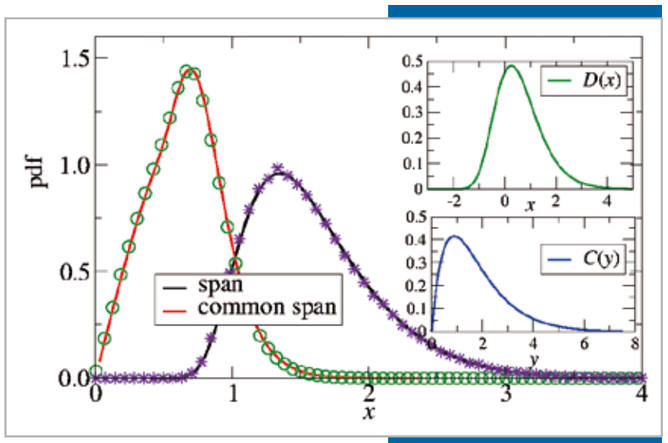
Fluctuations in small non-equilibrium systems: In the last few decades, exact predictions known as *fluctuation theorems* (FTs) have been discovered for systems far from equilibrium. Very often these results are described in terms of entropy production or the dissipation in the system. There are only a few model systems for which one can analytically compute the entropy production in NESS. On the other hand, in experiments one might not have complete knowledge about the dynamics of a system. However, one can record the trajectories of relevant variables in experiments and use them to estimate the dissipation in the system.

In a recent work, we illustrated a general method to infer the amount of dissipation present in a chemical system from a long trajectory of data. The method is non-invasive and does not require any knowledge of the underlying dynamics, which makes it ideally suited for applications in chemistry or biology. This method is very successful for discrete data sets but less successful for continuous data sets because it requires knowledge of all the elementary transitions with a single molecule resolution. Achieving such resolution in practice is very hard, which is why the estimate of entropy production is affected by the unavoidable coarse-graining of the original data. In another recent work, we attempted to understand this issue, where we studied the work and heat fluctuation of a manipulated colloid system both experimentally

and theoretically. We compared the average dissipated work evaluated from actual dynamics with a lower bound evaluated using only trajectory information.

Very recently there has been a lot of interest in the modification of the usual FTs in presence of measurement and feedback control. Assuming Markovian nature of measurements, we showed that an extra contribution (due to measurement process) added with the usual medium entropy production satisfies a relevant fluctuation relation.

Geometric properties and extreme statistics of random walks: Geometric properties of random walk trajectories can be characterized by their overall extent (span) and the size of their overlapping region (common span). These two quantities are relevant to various areas like physics, chemistry, biology, ecology and computer science. In one dimension, using a connection between these two quantities and the largest and smallest displacements of the walkers, we have computed the distributions of span and common span visited by N independent random walkers. For large N, the limiting distribution of span can be expressed as a convolution of two Gumbel distributions whereas the limiting distribution of common span can be expressed as a convolution of two Weibull distributions. We have also studied the global maximum distance traveled by N non-intersecting walkers till any one of the walker crosses the origin for the first time. In this case we show that the distribution $P_N(m)$ of the maximum distance m has a power law tail with exponent $\nu = N^2 + 1$. This exponent ν is related to the power law exponent $N^2/2 + 1$ at the tail of the distribution of the first passage time. Moreover we find that the prefactor in front of $P_N(m)$ grows as $\sim \exp[\,(N^2/2)\ln N\,]$ for large N, in contrast with a much slower growth $\sim \exp[\,(N/2)\ln\ln N\,]$ for independent walkers.



Distribution of span and common span for $N = 2$ and the functions $D(x)$ and $C(y)$

The winding numbers of a random walker moving on circular geometry is another interesting quantity which is quite relevant in mesoscopic transport through a ring, in polymer physics and in thermal fluctuations of vortex defects in superconductors. We computed the distribution of the number of turns made by the walker around a ring till time t.

PUBLICATIONS (2013-2015)

1. *Winding statistics of a Brownian particle on a ring,* **A. Kundu**, S. N. Majumdar, A. Comtet. J. Phys. A: Math. Theor. 47, 385001 (2014)

2. *Maximum distance travelled by* N *vicious walkers till their survival,* **A. Kundu**, S. N. Majumdar, G. Schehr. J. Stat. Phys. 157(1), pp. 124-157 (2014)
3. *Energetic versus information-theoretic estimations of dissipation using a pair of magnetic colloidal particles,* S. Stusch, **A. Kundu**, T. Blondel, G. Verley, D. D'Emoulin, V. Miralles, D. Lacoste, J. Baudry. Phys. Rev. Lett. 112, 180604 (2014)
4. *Exact Distributions of the Number of Distinct and Common Sites Visited by N Independent Random Walkers*, **A. Kundu**, S. N. Majumdar, G. Schehr. Phys. Rev. Lett. 110, 220602 (2013)
5. *Non-invasive estimation of dissipation from non-equilibrium fluctuations in chemical reactions*,
6. S. Muy, **A. Kundu** and D. Lacoste. J. Chem. Phys. 139, 124109 (2013)
7. *Nonequilibrium fluctuation theorem for systems under discrete and continuous feedback control*, **A. Kundu**. Phys. Rev. E 86, 021107 (2012)

SELECTED PUBLICATIONS

- *Energetic versus information-theoretic estimations of dissipation using a pair of magnetic colloidal particles,* S. Stusch, **A. Kundu**, T. Blondel, G. Verley, D. D'Emoulin, V. Miralles, D. Lacoste, J. Baudry. Phys. Rev. Lett. 112, 180604 (2014)
- *Exact Distributions of the Number of Distinct and Common Sites Visited by N Independent Random Walkers*, **A. Kundu**, S. N. Majumdar, G. Schehr. Phys. Rev. Lett. 110, 220602 (2013)
- *Nonequilibrium fluctuation theorem for systems under discrete and continuous feedback control*, **A. Kundu**. Phys. Rev. E 86, 021107 (2012)
- *Large deviations of heat flow in harmonic chains*, **A. Kundu**, Sanjib Sabhapandit, Abhishek Dhar. J. Stat. Mech. (2011) P03007
- *Fourier's law and phonon localization in mass disordered harmonic crystals*, A. Chaudhuri, **A. Kundu**, D. Roy, A. Dhar, J. Lebowitz and H. Sphon. Phys. Rev. B 81, 064301 (2010)
- *The Green-Kubo formula for heat conduction in open systems*, **A. Kundu**, A. Dhar and O. Narayan. J. Stat. Mech. L03001 (2009).

SAMRIDDHI SANKAR RAY

Samriddhi Sankar Ray completed his PhD from the Indian Institute of Science, Bengaluru, in 2010 under the supervision of Rahul Pandit. His post doc appointment was with Laboratoire Lagrange, Observatoire de la Côte d'Azur, CNRS, Nice, France. He is the Principal Investigator (PI) of AIRBUS Group Corporate Foundation Chair in Mathematics of Complex Systems established in ICTS and Co-PI and member of the Indo-French Centre for Applied Mathematics (IFCAM).

RECENT COLLABORATORS

C. Bardos (U. Paris, France), J. Bec (OCA, France), G. Bewley (MPI Goettingen, Germany), L. Biferale (U. Rome, Italy), E. Bodenschatz (MPI Goettingen, Germany), U. Frisch (OCA, France), T. Matsumoto (U. Kyoto, Japan) D. Mitra (NORDITA, Sweden), S. Nazarenko (U. Warwick, UK), R. Pandit (IISc, Bangalore), P. Perlekar (TCIS, Hyderabad), E.-W. Saw (OCA, France), D. Vincenzi (U. Nice, France).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Divya V. (postdoc, ICTS)

ICTS PROGRAMS ORGANIZED

- Transport of Particles in Turbulent Flows: Experimental, Computational and Theoretical Investigations, Bengaluru, 14-18 October 2013.
- Indian Statistical Physics Community Meeting 2014, Bengaluru, 1-3 February 2014.
- Indian Statistical Physics Community Meeting 2015, Bengaluru, 13-15 February 2015.
- The Nonlinear Physics of Complex Flows and Amorphous Solids and the associated CHANDRASEKHAR LECTURES, APRIL 2015.

Upcoming

- Geodynamo Research (GDR) 2015, Bengaluru, June 2015.
- Soft-matter: Young Investigators Meet, Bengaluru, December 2015.

RESEARCH REPORT

My research interests lie in the mathematical and statistical physics aspects of turbulent flows in various settings as well as in the area of turbulent transport and particles in turbulence.

In studies related to the statistical physics of turbulent flows, I have been involved in the study of turbulence in certain special, non-integer (critical) dimensions, where meaningful, equilibrium Gibbs states are obtained. We have shown that Fractal decimation reduces the effective dimensionality of a flow by keeping only a (randomly chosen) set of Fourier modes whose number in a ball of radius k is proportional to k^D for large k. At the critical dimension D=4/3 we showed that there is an equilibrium Gibbs state with a Kolmogorov spectrum. Through spectral simulations of fractally decimated two-dimensional turbulence we were able to show that the inverse cascade persists below D=2 with a diverging Kolmogorov constant. A related problem of the onset of thermalisation for hyperviscous hydrodynamic equations was also addressed by us recently.

Besides, recently, we also addressed the origins of the ubiquitous bottlenecks in energy spectra and the nature of anomalous scaling in two-point correlation functions seen in data from solar winds. At present, our group is studying problems related to, for example, the onset of thermalisation in truncated systems, the finite-time blow-up of the Euler and Navier-Stokes equations, multiphase flows via the Cahn-Hilliard model and obtaining minimal models for the Gross-Pitaevskii equations.

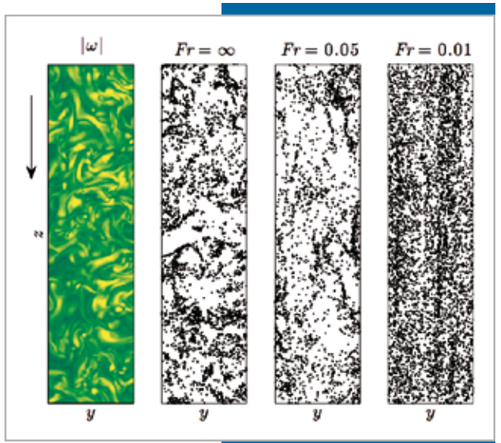
A second central theme of my research activity has been in the areas of inertial particles in turbulent flows. Consequently, we have studied the effects of purely elastic collisions on the dynamics of heavy inertial particles in a three-dimensional random incompressible flow to show that the statistical properties of inter-particle separations and relative velocities are strongly influenced by the occurrence of sticky elastic collisions. We provided a theoretical framework which also factored in the role of hydrodynamic interactions. We also developed a quantitative understanding of why heavy particles suspended in a turbulent flow settle faster than in a still fluid. We showed that this effect stems from a preferential sampling of the regions where the fluid flows downward and is quantified here as a function of the level of turbulence, of particle inertia, and of the ratio between gravity and turbulent accelerations. By using analytical methods and detailed, state-of-the-art numerical simulations, we showed that settling induces an effective horizontal two-dimensional dynamics that increases clustering and reduce relative velocities between particles. These two competing effects can either increase or decrease the geometrical collision rates between same-size particles and are crucial for realistic modeling of coalescing particles. In order to validate our theoretical model for particles in flows, we have compared experiments and direct numerical simulations to evaluate the accuracy of the widely used Stokes-drag model.

Furthermore using experiments, simulations and theory, we studied statistics at the

dissipation scale and on extreme values of relative particle velocities for moderately inertial particles. The probability distributions of relative velocities in the simulations were qualitatively similar to those in the experiments. We found that simulations underestimated the probability of extreme events which suggests that the Stokes drag model misses important dynamics. Beyond the spherical particle picture, I am also involved in the study of Lagrangian dynamics of semi-flexible macromolecules in laminar as well as in homogeneous and isotropic turbulent flows by means of analytically solvable stochastic models and direct numerical simulations. In the coming months, we will be extending our work to understand the time evolution of droplets undergoing coalescence in a typical cloud. This work extends beyond the mean field approach and involves massive simulations and new theories for collision/coalescence kernels.

PUBLICATIONS (2013-2015)

1. *Bending dynamics of semi-flexible macromolecules in isotropic turbulence*, A. Ali, **Samriddhi Sankar Ray**, and D. Vincenzi. arXiv:1403.4051 (2015).
2. *Thermalised solutions, statistical mechanics and turbulence: An overview of some recent results,* **Samriddhi Sankar Ray**, Perspectives in Nonlinear Dynamics, in press, (2015).
3. *Extreme fluctuations of the relative velocities between droplets in turbulent airflow,* E.W. Saw, G. P. Bewley, E. Bodenschatz, **Samriddhi Sankar Ray**, and J. Bec. Physics of Fluids Letters, 26, 111702 (2014).
4. *Transition from dissipative to conservative dynamics in equations of hydrodynamics,* D. Banerjee and **Samriddhi Sankar Ray**. Physical Review E (Rapid), 90, 041001(R) (2014).
5. *Gravity-driven enhancement of heavy particle clustering in turbulent flow,* J. Bec, H. Homann, and **Samriddhi Sankar Ray**. Physical Review Letters, 112, 184501 (2014).
6. *Multiscaling in Hall-Magnetohydrodynamic Turbulence: Insights from a Shell Model,* D. Banerjee, **Samriddhi Sankar Ray**, G. Sahoo, and R. Pandit. Physical Review Letters, 111, 174501 (2013).
7. Sticky elastic collisions, J. Bec, S. Musacchio, and **Samriddhi Sankar Ray**. Physical Review E, 87, 063013 (2013).
8. *Real-space Manifestations of Bottlenecks in Turbulence Spectra,* U. Frisch, **Samriddhi Sankar Ray**, G. Sahoo, D. Banerjee, and R. Pandit. Physical Review Letters, 110, 064501 (2013).



Snapshot of the vorticity modulus (Left; yellow = low values, green = high values) and of the particle positions for $R\lambda$ = 130, S = 1 and three different values of the Froude number in a slice of thickness 10η, width 130η, and height 520η. The vertical arrow indicates gravity. [Phys. Rev. Lett., 112, 184501 (2014)]

SELECTED PUBLICATIONS

- *Gravity-driven enhancement of heavy particle clustering in turbulent flow,* J. Bec, H. Homann, and **Samriddhi Sankar Ray**. Physical Review Letters, 112, 184501 (2014).
- *Dynamic Multiscaling in Two-dimensional Turbulence.* **Samriddhi Sankar Ray**, D. Mitra, P. Perlekar, and R. Pandit. Physical Review Letters, 107, 184503 (2011).
- *Resonance phenomenon for the Galerkin-truncated Burgers and Euler equations.* **Samriddhi Sankar Ray**, U. Frisch, S. Nazarenko, and T. Matsumoto. Physical Review E, 84, 016301 (2011).
- *Entire solutions of hydrodynamical equations with exponential dissipation,* C. Bardos, U. Frisch, W. Pauls, **Samriddhi Sankar Ray**, and E. S. Titi. Communications in Mathematical Physics, 293, 2, 519 (2009).
- *Hyperviscosity, Galerkin truncation and bottlenecks in turbulence.* U. Frisch, S. Kurien, R. Pandit, W. Pauls, **Samriddhi Sankar Ray**, A. Wirth, and J-Z Zhu. Physical Review Letters, 101, 144501 (2008).

SUBHRO BHATTACHARJEE

Subhro Bhattacharjee got his PhD from Indian Institute of Science under H.R. Krishnamurthy in 2010. He was a postdoctoral fellow at the University of Toronto and McMaster University, Canada (December 2010-December 2013). Before joining ICTS he was a long-term guest scientist at the Max Planck Institute for the Physics of Complex Systems, Dresden, Germany.

RECENT COLLABORATORS

Roderich Moessner (MPIPKS, Dresden), Frank Pollmann (MPIPKS, Dresden), Yong Baek Kim (Univ. of Toronto), Sung-Sik Lee (McMaster Univ., Canada), D.H. Lee (Univ. of California, Berkeley, USA), T. Senthil (MIT, USA), Vijay Shenoy (IISc, Bangalore), Eoin Quinn (postdoc, MPIPKS, Dresden), Johannes Knolle (postdoc, Univ. of Cambridge), Victor Jouffrey, (Master's student, Intern, MPIPKS, Dresden), Krishanu Roychowdhury (MPIPKS, Dresden), Robert Schaffer (Univ. Of Toronto), E.K.H. Lee (Univ. of Toronto), K. Hwang (Univ. of Toronto), Tyler Dodds (Univ. of Toronto).

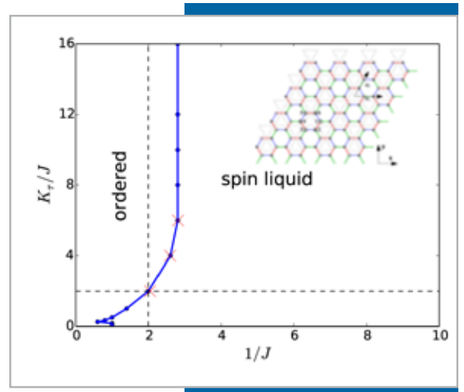
THESIS ADVISEES and POSTGRADUATE SCHOLARS

Victor Jouffrey (masters student, MPIPKS)

RESEARCH REPORT

My research focuses on understanding the properties of strongly correlated quantum manybody systems. A typical example is a system of interacting electrons in a solid. It is known that such interactions can produce remarkable 'emergent' behaviours like several types of magnets, superconductors, metals, semiconductors and insulators. Comprehensive description of these phases and associated phase transitions contributes to the success of the conventional theory of the solids. Over the last three decades, however, the discovery of material properties like high temperature superconductivity, integer and fractional quantum Hall effect, topological insulators, various magnetic insulators have repeatedly challenged the applicability of the above conventional paradigm to these materials. With the increasing number of examples, it is becoming clear that a more general framework is needed to describe many-body systems where quantum entanglement plays a key role.

I am interested in studying properties of various such 'quantum ordered phases' as well as associated phase transitions using a combination of analytical techniques starting from lattice level calculations to low energy effective field theories. A class of materials where such novel quantum orders are anticipated are frustrated magnets. These are two and three dimensional systems, typically transition metal oxides that are rendered insulating by electron-electron repulsion. In such a Mott insulator, the electrons localize at the lattice sites and the spins of different electrons interact mutually. In frustrated magnets, these local moments fail to develop long range magnetic or other ordering till the lowest experimentally available temperature. Instead they seem to form a highly quantum entangled state of matter called a quantum spin liquid. A significant fraction of my research involves understanding such quantum spin liquid phases. This includes efforts to understand novel quantum spin liquid phases and discussing their relevance to promising candidate materials. A related question of interest is the nature of quantum phase transitions in spin liquids which I have recently investigated in context of concrete microscopic models.



Transition between quantum spin liquid and magnetic order in a dimensional lattice model

Currently, I am interested in the effect of disorder in the class of quantum spin liquids. Another class of compounds, which has evoked, much interest recently is the 5d transition metal compounds containing Iridium. These materials have strong spin orbit coupling in addition to electron correlations. Together these two competing interactions render Iridates as potential candidates for supporting new quantum types of quantum orders. I have been interested in studying some of these in context of both two and three dimensional Iridates to understand their potential to harbour phases like topological insulators, quantum spin liquids as well as novel magnetically ordered states.

PUBLICATIONS (2013-2015)

1. *Signatures of spin-triplet excitations in optical conductivity of valence bond solids*, Kyusung Hwang, **Subhro Bhattacharjee**, Yong Baek Kim. New J. Phys. 16, 123009 (2014).

2. *Topological and magnetic phases with strong spin-orbit coupling on the hyper-honeycomb lattice*, Eric Kin-Ho Lee, **Subhro Bhattacharjee**, Kyusung Hwang, Heung-Sik Kim, Hosub Jin, Yong Baek Kim. Phys. Rev. B 89, 205132 (2014)

3. *Heisenberg-Kitaev model on the hyper-honeycomb lattice*, E. K.-H. Lee, Robert Schaffer, **Subhro Bhattacharjee**, and Yong Baek Kim. Phys. Rev. B 89, 045117 (2014)

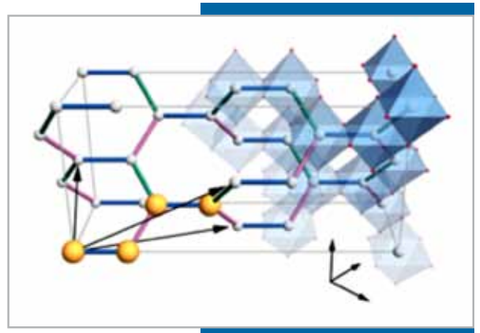
4. *Spin-orbital liquids in non-Kramers magnet on Kagome lattice*, Robert Schaffer, **Subhro Bhattacharjee**, Yong Baek Kim. Phys. Rev. B 88, 174405 (2013)

5. *Quantum spin liquids in the absence of spin-rotation symmetry: application to*

Herbertsmithite, Tyler Dodds, **Subhro Bhattacharjee**, Yong Baek Kim. Phys. Rev. B 88, 224413 (2013)

6. *Three-dimensional nematic spin liquid in the stacked triangular lattice 6H-B structure*, Kyusung Hwang, Tyler Dodds, **Subhro Bhattacharjee**, Yong Baek Kim. Phys. Rev. B 87, 235103 (2013).

7. *Magnetic excitations in Pyrochlore Iridates*, E. K.-H. Lee, **Subhro Bhattacharjee**, and Yong Baek Kim. Phys. Rev. B 87, 214416 (2013).



The Hyper-honeycomb Iridates can harbor interesting phases

SELECTED PUBLICATIONS

- *Phases and phase transitions of a perturbed Kekulé-Kitaev model*, Eoin Quinn, **Subhro Bhattacharjee**, Roderich Moessner. arXiv: 1501.07582v1 (2015)
- *Fractionalized topological insulators from frustrated spin models in three dimensions*, **Subhro Bhattacharjee**, Yong Baek Kim, Sung-Sik Lee, and Dung-Hai Lee. Phys. Rev. B 85, 224428 (2012)
- *Quantum phase transition in Heisenberg-Kitaev model*, Robert Schaffer, **Subhro Bhattacharjee**, and Yong Baek Kim. Phys. Rev. B 86, 224417 (2012)
- *Quantum destruction of spiral order in two-dimensional frustrated magnets*, **Subhro Bhattacharjee**. Phys. Rev. B 84, 104430 (2011)
- *Tunneling Conductance of Graphene NIS Junctions*, **Subhro Bhattacharjee** and K. Sengupta. Phys. Rev. Lett. 97, 217001 (2006)

VIJAY KUMAR KRISHNAMURTHY

Vijay Kumar Krishnamurthy completed his PhD at the Indian Institute of Science, Bengaluru, in 2010 under Sriram Ramaswamy. His postdoc affiliations were with Yale University and Max Planck Institute, Dresden, Germany. He was the co-organiser of the Dresden summer school in systems biology in 2014. He has been an undergraduate teacher at the Bangalore Association for Science Education weekend study circle.

RECENT COLLABORATORS

Sriram Ramaswamy (IISc, Bangalore & TCIS, Hyderabad), Madan Rao (RRI & NCBS, Bangalore), Adrian Baule (Queen Mary Univ London), N Kumar & Avinash Dhar (RRI, Bangalore), Frank Jülicher, Peter Gross, Antony Hyman (Max Planck Inst, Dresden), Stephan Grill (Max Planck Inst & Technical University, Dresden), Justin Bois (Caltech, Pasadena) Nate Goehring & Philipp Khuc Trong (London Research Inst, London), Evan Heller & Elaine Fuchs (The Rockefeller Univ, New York).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

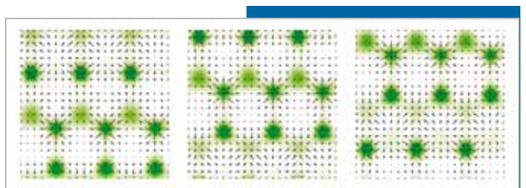
Coleman Broaddus (masters project, Technical University Dresden)

ICTS PROGRAMS ORGANIZED

- ICTS Summer program

Upcoming

- ICTS-ICTP Winter school on quantitative biology, December 2015
- ICTP Turing lectures 2016



Pulsatory patterns in active fluids

RESEARCH REPORT

My present research focuses on understanding active mechanobiological pattern formation in morphogenesis.

Active mechanical flows coupled to a biochemical regulator of the active stresses can lead to the emergence of spontaneous patterns. Such patterns are distinct from classical patterns observed in reaction-diffusion systems as forces and flows play an essential role in their generation. An example of an active pattern forming fluid is the actomyosin cortex of cells, which is a thin film of filamentous cytoskeletal proteins just underneath the cell membrane. It is seen that the cortex displays pulsatory patterns in certain regimes. Motivated by this, we recently showed that there are Turing-like criteria for the spontaneous emergence of oscillatory patterns in active fluids. Specifically, we demonstrated that in a thin active film where two chemical species regulate the active stress, an oscillatory pattern forming instability occurs when the following conditions are met: (i) the fast diffusing species up-regulates and the slow-diffusing species down- regulates active stress, or (ii) the active stress up-regulator turns over faster compared to the active stress down-regulator.

Active mechanical forces can also lead to pattern formation in an indirect manner. A dramatic example of such a mechanism is the establishment of cell polarity in the zygotes of the nematode Caenorhabditis elegans where certain membrane bound proteins, get asymmetrically distributed on the cell surface due to active mechanical flows generated in the cell cortex.

Cell polarity establishment is a generic process seen in many developmental organisms, and detailed studies have identified the chemical reaction networks that connect the key proteins involved. Various mathematical models based on reaction-diffusion equations have been used to study these reaction networks and understand cell polarity. Neglecting active mechanical flows, we studied the generic features of the chemical reaction networks in such cell-polarity models and established that rapid cytoplasmic diffusion and bistability via a cusp bifurcation of uniform states captures the essential phase-space topological features of these models. This allowed us to unify the common features of the chemical reactions in several distinct models of cell-polarity. However, diffusion and chemical reactions alone do not lead to self-consistent theories of cell polarity. Active mechanical flows are essential for the establishment of cell polarization.

The polarization of partitioning defective (PAR) proteins into anterior and posterior domains is a conserved mechanism in the zygotes of Caenorhabditis elegans. This segregation is driven by flows established in the actomyosin cortex. Passive advection of the PARs by these flows is known to lead a transient segregation of the PAR system. However, the mechanism by which the PAR proteins regulate the cortical flows is unclear. We have developed a closed and self-consistent theory which incorporates the feedback of the PAR concentration fields into cortical flows, via a coupling to the local myosin concentration. This theory leads to stable segregated states of the PAR-actomyosin system. Most of the parameters in our theory (such as chemical reaction-rates, viscosity of the cortex etc.) are experimentally measurable, while others are fit parameters to experimental data. We find that our theory agrees remarkably well with the measured spatial profiles of cortical flow and protein concentrations even over extended periods of time. Our study thus provides very strong evidence that an active matter description of the cortex can lead to a quantitative understanding of the process of cell polarization.

Mechanical forces resulting from cytoskeletal dynamics can not only lead to pattern formation but also deform tissues at larger scales. Local tissue deformations are the essential steps in global morphogenesis of developing embryos. Hence understanding the role of forces in tissue deformation is crucial. In collaboration with the laboratory of Elaine Fuchs at Rockefeller University, we studied the process of the eyelid closure in developing mouse embryos. Analyzing the deformations of the epithelial tissue constituting the mouse eyelid, we found that the regions of maximal tissue deformations are correlated with regions where the expression levels of actin and myosin are peaked. Our study uncovered a mechanism of tissue deformation that is distinct from those studied in the processes of wound-repair or dorsal closure. We found that cell intercalations parallel to the tissue front locally compress it perpendicularly, thereby stretching surrounding epidermal cells along the closure axis. This suggested a novel mode of epithelial closure in which forces generated by cell intercalation are leveraged to tow the surrounding tissue.

PUBLICATIONS (2013-2015)

1. *Mechanochemical patterning of the PAR polarity system in C. elegans embryos,* Peter Gross, **K. Vijay Kumar,** Justin S Bois, S W Grill and F Jülicher. Manuscript in preparation, (2015)

2. *Pulsatory Patterns in Active Fluids*, **K. Vijay Kumar**, Justin S Bois, F Jülicher, and S W Grill. Physical Review Letters, 112, 208101 (2014)

3. *Phase-space topology of models for cell polarity,* Philipp Khuc Trong, Ernesto M. Nicola, Nathan W. Goehring, **K. Vijay Kumar**, S W Grill. New Journal of Physics, 16, 065009 (2014)

4. *Forces Generated by Cell Intercalation Tow Epidermal Sheets in Mammalian Tissue* Morphogenesis, E Heller, **K. Vijay Kumar,** S W Grill and E Fuchs. Developmental Cell 28, 617, (2014)

SELECTED PUBLICATIONS

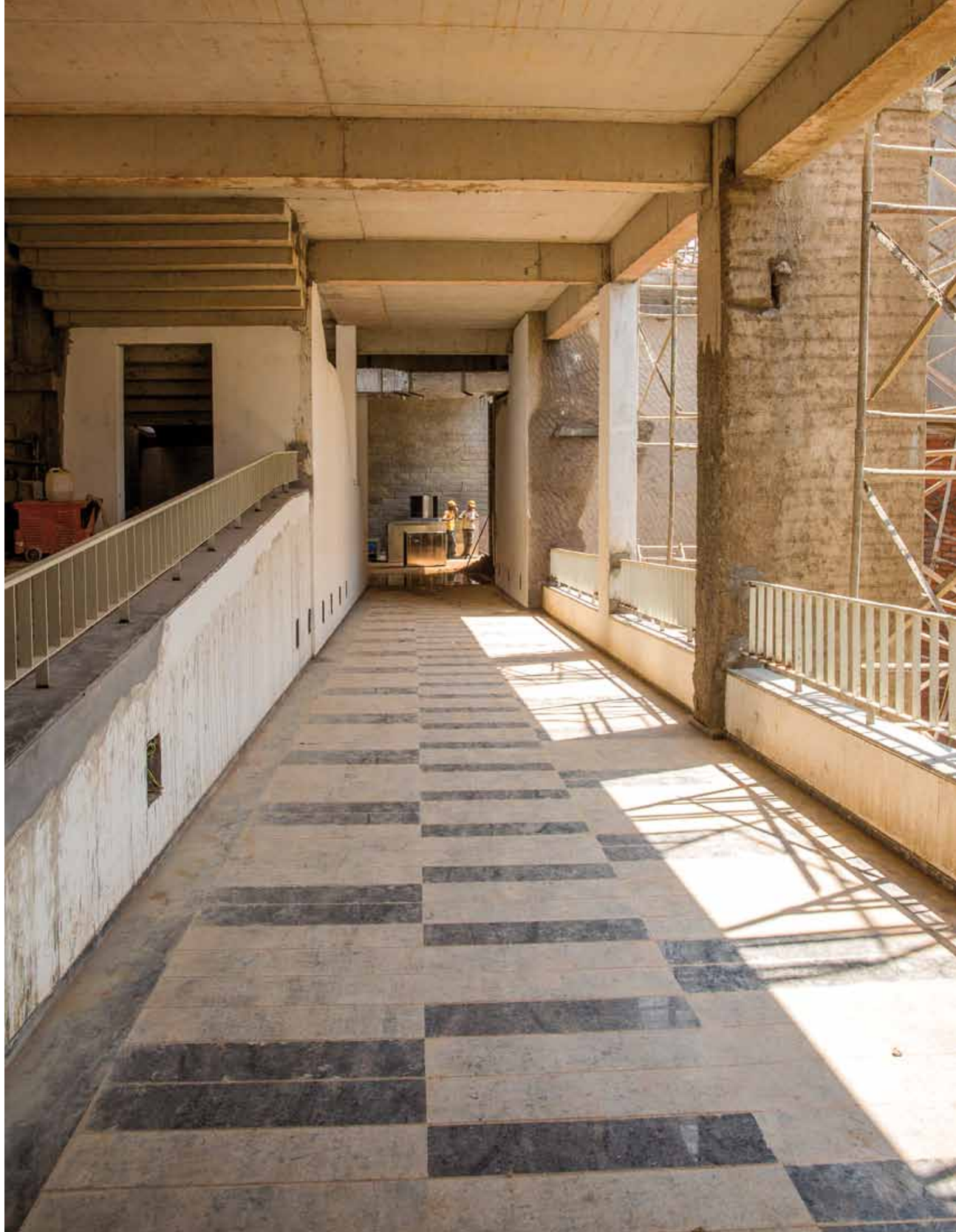
- *Pulsatory Patterns in Active Fluids,* **K. Vijay Kumar,** Justin S Bois, F Jülicher, and S W Grill. Physical Review Letters,112, 208101 (2014)

- *Phase-space topology of models for cell polarity,* Philipp Khuc Trong, Ernesto M. Nicola, Nathan W. Goehring, **K. Vijay Kumar,** S W Grill. New Journal of Physics, 16, 065009 (2014)

- *Forces Generated by Cell Intercalation Tow Epidermal Sheets in Mammalian Tissue Morphogenesis,* E Heller, **K. Vijay Kumar**, S W Grill and E Fuchs. Developmental Cell 28, 617, (2014)

- *Exact solution of a Brownian inchworm model for self-propulsion,* A Baule, **K. Vijay Kumar** and S Ramaswamy. J. Stat. Mech., P11008 (2008)

- *Active elastic dimer :Self-propulsion and current reversals,* **K. Vijay Kumar**, S Ramaswamy and M Rao. Phys. Rev. E77, 020102(R) (2008)



STRING THEORY, COSMOLOGY, HIGH ENERGY PHYSICS

PALLAB BASU

Pallab Basu received his PhD from the Tata Institute of Fundamental Research in 2007, working under Spenta R. Wadia. His postdoc appointments were at the University of British Columbia and University of Kentucky.

RECENT COLLABORATORS

Spenta Wadia (TIFR), Sumit Das (University of Kentucky), Leopoldo Pando Zayas (University of Michigan), Mark Van Raamsdonk (University of British Columbia), Moshe Rozali (University of British Columbia), Luis Alvarez-Gaume (CERN), Marcos Marino (University of Geneva), Shiraz Minwalla (TIFR), Anindya Mukherjee, Jian-Yang He, Hsien-Hang Shie, Chethan Krishnan (IISc), Ayush Saurav, R Loganayagam (IAS Princeton), Sayantani Bhattacharyya (IIT Kanpur), Jyotirmoy Bhattacharya (Durham University, UK), Archisman Ghosh (ICTS), Diptarka Das, Daniel Arean, Jae-hyuk Oh

RESEARCH REPORT

I work on string theory, emphasizing mostly on problems around AdS/CFT. AdS/CFT or holography is the conjectured correspondence between gravity and large-N gauge theories. A branch of AdS/CFT correspondence deals with AdS/CMT, where the holographic correspondence is used to model condensed matter phenomenon using the dual gravity description. My earlier work on AdS/CMT has focussed on the dual descriptions of Holographic superconductors and non-fermi liquids. More recently I have been concentrating on time dependent phenomenon. We have studied various problems related to quantum quench through holography. In a recent work we considered quantum quench by a time dependent double trace coupling. The bulk theory contains a self coupled neutral scalar field coupled to gravity with negative cosmological constant. We studied the scalar dynamics in the probe approximation in two backgrounds: AdS soliton and AdS black brane. In either case we found that in equilibrium there is a critical phase transition at a negative value of the double trace coupling below which the scalar condenses.

For a slowly varying homogeneous time dependent coupling crossing the critical point, we showed that the dynamics in the critical region is dominated by a single mode of the bulk field. This mode satisfies a Landau-Ginsburg equation with a time dependent mass, and leads to Kibble Zurek type scaling behavior. For the AdS soliton the system is non-dissipative and has z=1, while for the black brane one has dissipative z=2 dynamics. We also discussed the features of a holographic model which would describe the non-equilibrium dynamics around quantum critical points with arbitrary dynamical critical exponent z and correlation length exponent. These analytical results are supported by direct numerical solutions.

I also worked with the important problem of quantum chaos in the context of holography. We found that minisuperspace world sheet theory shows typical signature of quantum chaotic system in AdS soliton backgrounds. Another time dependent aspect we studied was classical chaos in the context of holography.

Recently, I have been looking at the issue of weak field thermalization in the context of AdS/CFT. Unlike strong field collapse, in this case a black hole forms after a long time following the initial perturbation has set in. In our work we give strong numerical evidence that a self-interacting probe scalar field in AdS, with only a few modes turned on initially, will undergo fast thermalization only if it is above a certain energetic threshold. Below the threshold the energy stays close to constant in a few modes for a very long time instead of cascading quickly. This indicates the existence of a Strong Stochasticity Threshold (SST) in holography. The idea of SST is familiar from certain statistical mechanical systems and we suggest that it also exists in AdS gravity. This would naturally reconcile the generic non-linear instability of AdS observed earlier. We identified conserved charges that have also been recently observed in the full gravity theory as well. We continue our investigation of the scalar field in AdS and provide evidence that in the Two-Time Formalism (TTF), even for initial conditions that are far from quasi-periodicity, the energy in the higher modes at late times is exponentially suppressed in the mode number. Based on this and some other related observations, we argue that there is no thermalization in the scalar 1 TTF model within time-scales that go as inverse of initial amplitude square.

ICTS PROGRAMS ORGANIZED

- S.N. Bhatt Memorial Excellence Fellowship Program 2014
- The Information Paradox, Entanglement and Black Holes, Bengaluru, 22-23 September, 2013

PUBLICATIONS (2013-2015)

1. *AdS (In)stability: Lessons From The Scalar Field*, **P. Basu**, C. Krishnan and P. N. B. Subramanian. arXiv:1501.07499 [hep-th] (2013-2015).
2. *Holographic quantum phase transitions and interacting bulk scalars*, P. Chaturvedi and **P. Basu**. Phys. Lett. B 739, 162 (2014).

3. *A Stochasticity Threshold in Holography and the Instability of AdS*, **P. Basu**, C. Krishnan and A. Saurabh. arXiv:1408.0624 [hep-th].

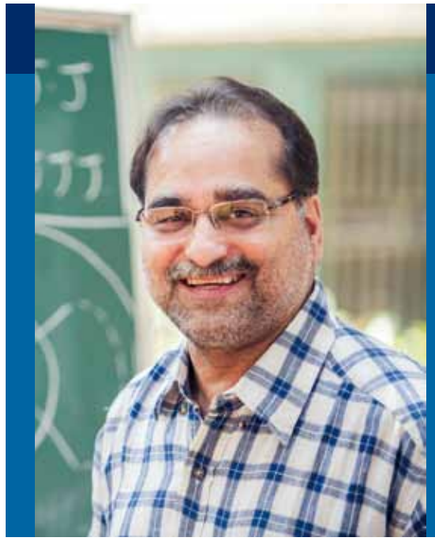
4. *Quantum Quench and Double Trace Couplings*, **P. Basu** and A. Ghosh, Phys. Rev. D 89, no. 4, 046004 (2014)

5. *Dissipative Nonlinear Dynamics in Holography*, **P. Basu** and A. Ghosh, Phys. Lett. B 729, 50 (2014)

6. *Confining Backgrounds and Quantum Chaos in Holography*, **P. Basu**, D. Das, S. R. Das and K. Sengupta, JHEP 1312, 070 (2013)

SELECTED PUBLICATIONS

- *Supercurrent: Vector Hair for an AdS Black Hole*, **P. Basu**, A. Mukherjee and H. H. Shieh. Phys. Rev. D 79, 045010 (2009)
- *Superconductivity from D3/D7: Holographic Pion Superfluid,* **P. Basu**, J. He, A. Mukherjee and H. H. Shieh. JHEP 0911, 070 (2009)
- *Hard-gapped Holographic Superconductors*, **P. Basu,** J. He, A. Mukherjee and H. H. Shieh. Phys. Lett. B 689, 45 (2010)
- *Chaos Rules out Integrability of Strings in AdS_5 x $T^{1,1}$*, **P. Basu** and L. A. Pando Zayas. Phys. Lett. B 700, 243 (2011)
- *Quantum Quench across a Holographic Critical Point*, **P. Basu** and S. R. Das, JHEP 1201, 103 (2012)
- *Quantum Quench Across a Zero Temperature Holographic Superfluid Transition*, **P. Basu**, D. Das, S. R. Das and T. Nishioka. JHEP 1303, 146 (2013)



AVINASH DHAR

Avinash Dhar completed his PhD under Virendra Gupta from the Tata Institute of Fundamental Research. He was a postdoc at the Stanford Linear Accelerator Centre (SLAC). He is a senior professor at the Tata Institute of Fundamental Research, Mumbai and also a member of the ICTS faculty.

RECENT COLLABORATORS

G. Mandal (Tata Institute for Fundamental Research), S.R. Wadia (Tata Institute for Fundamental Research), S.R. Das (University of Kentucky, USA), Y. Kitazawa (High Energy Accelerator Research Organization, Tsukuba, Japan), Justin R. David (Indian Institute of Science, Bangalore), S. Kalyana Rama (Inst of Mathematical Sciences, Chennai), A.M. Sengupta (Rutgers University, USA), Joseph J. Atick (currently Executive VP and CSO of L-1 Identity Solutions)

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Partha Nag (PhD student, now working with Daulat Finance)

ICTS PROGRAMS ORGANIZED

My involvement in program organization at ICTS has been at the level of soliciting pre-proposals, encouraging and helping promising pre-proposals to develop into full proposals for processing by the program committee and helping potential program organizers successfully implement suggestions of program committee about their proposals and address its concerns. Organization of a successful program often involves several rounds of refinements in the proposal to meet ICTS requirements and to satisfactorily take care of program committee suggestions. I have been donating the time required to do this for the last eight years, since the very beginning of ICTS.

RESEARCH REPORT

In my recent research, I have worked on holographic models of strong interactions and on a non-Lorentz invariant model having anisotropic scale invariance, with

applications to physics beyond the standard model. My recent research interests include new possibilities of connecting the standard model physics of electroweak symmetry breaking and beyond to physics in higher dimensions via the AdS/CFT correspondence.

My past research has been in the areas of (i) *Field theory and String Theory* – we were among the first to show that the Hawking decay rate in constituent models of black holes in string theory agrees with general relativity, a result that has implications for the resolution of the information puzzle; (ii) *Gauge theory/Gravity duality* – our work on renormalization flows and their connection with equations of general relativity in the context of noncritical strings anticipated the recent ideas of holographic RG; we developed the notion of Liouville mode as 'time' by coupling 25 scalar fields to 2-dim gravity and showed that in this way one can reproduce the exact Virasoro-Shapiro amplitude in 25+1 dims; we introduced and analyzed the effect of multi-trace deformations in the context of matrix models of string theory and discovered the W-infinity algebra associated with d=1 string theory; and (iii) *High energy physics* - our exact operator bosonization of two-dimensional non-relativistic systems containing a finite number of fermions solved the half-century old problem of Tomonaga; we found a gauge-invariant solution of the spectrum of the 't Hooft model of 2-dim. gauge theory with fermions by explicitly constructing the operators that create the infinite tower of meson modes as the generators of a W-infinity algebra on the light cone made up of bi-local fermion bilinears; we were among the first to discover a manifestly supersymmetric formulation of the Chapline-Manton theory; we were the first to propose a Nambu-Jona-Lasinio type phenomenological model for large N, long wavelength QCD and obtain the WZW term as a slowly varying 'Berry' phase over a curve in the space of the chiral field; we developed a method of doing renormalization scheme independent calculations in a general perturbative field theory, thereby enabling perturbative calculations in QCD free from scheme ambiguities.

SELECTED PUBLICATIONS

- *Asymptotically free four-fermi theory in 4 dimensions at the z=3 Lifshitz-like fixed point,* **A. Dhar,** G. Mandal and S.R. Wadia, Phys. Rev. D80 (2009) 105018
- *Bosonization of non-relativistic fermions on a circle: Tomonaga's problem revisited*, **A. Dhar** and G. Mandal. Phys. Rev. D74 (2006) 105006
- *Absorption VS decay of black holes in string theory and T-symmetry*, **A. Dhar**, G. Mandal and S.R. Wadia. Phys. Lett. B388 (1996) 51
- *Role of initial conditions in the classification of the rule space of cellular automata dynamics*, **A. Dhar**, G. Mandal, P. Lakdawala and S.R. Wadia. Phys. Rev. E51 (1995) 3032
- *String field theory of two-dimensional QCD: a realization of W_∞ algebra*, **A. Dhar**, G. Mandal and S.R. Wadia. Phys. Lett. B329 (1994) 15

- *New critical behaviour in d=0 large N matrix model*, S.R. Das, **A. Dhar,** A.M. Sengupta and S.R. Wadia. Mod. Phys. Lett. A5 (1990) 1041
- *Critical behavior in two-dimensional quantum gravity and equation of motion of the string*, S.R. Das, **A. Dhar** and S.R. Wadia. Mod. Phys. Lett. A5 (1990) 799
- *Superspace formulation of ten-dimensional N = 1 supergravity coupled to N=1 super Yang-Mills theory*, **A. Dhar**, J.J. Atick and B. Ratra. Phys. Rev. D33 (1986) 2824
- *Nambu-Jona-Lasinio type effective Lagrangian: Anomalies and non-linear Lagrangian of low-energy large-N QCD*, **A. Dhar**, R. Shankar and S.R. Wadia. Phys. Rev. D31 (1985) 3256

RAJESH GOPAKUMAR

Rajesh Gopakumar completed his PhD from Princeton University under the guidance of David Gross. He was a postdoc at Harvard University and a long term visiting member at the Institute for Advanced Study, Princeton. Before joining ICTS, he was a faculty member at the Harish-Chandra Research Institute in Allahabad. He is a founding member (now alumnus) of Global Young Academy (GYA), a council member, Indian National Science Academy and Member, Commission on Mathematical Physics, International Union of Pure and Applied Physics (IUPAP) (2011-present).

RECENT COLLABORATORS

Alejandra Castro (Harvard Univ., now University of Amsterdam), Matthias Gaberdiel (ETH, Zurich), Rajesh K. Gupta (HRI, Allahabad, now at ICTP, Trieste), Michael Gutperle (UCLA), Tom Hartman (IAS Princeton, now Cornell University), Aki Hashimoto (Univ. of Wisconsin-Madison), Igor Klebanov (Princeton University), Shailesh Lal (HRI Allahabad, now at Seoul National University), Joris Raeymakers (Czech Academy of Sciences), Suvrat Raju (HRI Allahabad, now ICTS-TIFR), Roji Pius (HRI, to join Perimeter Institute), Subir Sachdev (Harvard University), Mukund Rangamani (Durham University), Arunabha Saha (HRI Allahabad, now TIFR Mumbai), Kareljan Schoutens (University of Amsterdam).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Suvankar Dutta (PhD student at HRI, now at IISER, Bhopal), Ayan Mukhopadhyay (PhD student at HRI, now at CEA, Saclay, France), Roji Pius (PhD student at HRI, to join Perimeter Institute), Shailesh Lal (PhD student at HRI, now at Seoul National University), Arunabha Saha (PhD student at HRI, now at TIFR-Mumbai). Also mentored the thesis of Arjun Bagchi (PhD student at HRI, now at IISER, Pune).

ICTS PROGRAMS ORGANIZED

- Member, Program Committee, ICTS, 2008-present
- Monsoon Workshop in String theory, TIFR, Mumbai, June-August 2008
- Third Asian Winter School on String Theory, Particle Physics and Cosmology, Mahabaleshwar, January 2010

- ICTS Meeting on Random Matrix Theory and its Applications, ICTS, Bengaluru, January 2012
- Discussion Meeting on String Theory, ICTS-TIFR Bengaluru, June 2012
- Lecturer at 7th Asian Winter School on String Theory, Particle Physics and Cosmology, Puri, January 2014
- Workshop and Conference on Symplectic Topology, HRI and TIFR, Mumbai, December 2014

Upcoming

- Strings 2015, ICTS-TIFR, June 2015

RESEARCH REPORT

Especially in the last fifteen years or so, String Theory has demonstrated in several striking ways that it is an all-encompassing framework. This framework is not just adequate to address the question of a consistent quantum description of gravity but it also sheds new light on the pre-existing framework of Quantum Field Theory (QFT). This is significant because QFT has been one of our most successful paradigms for addressing physical problems in a variety of non-gravitational contexts ranging from cosmology and high energy physics through condensed matter physics and statistical mechanics. String theory, by encompassing within it quantum field theory, has managed to relate it to gravity in very unusual ways. This connection, known as gauge-string duality (or in a more restricted sense, AdS-CFT correspondence) has been continuously yielding new insights into quantum field theories as well as gravitational physics.

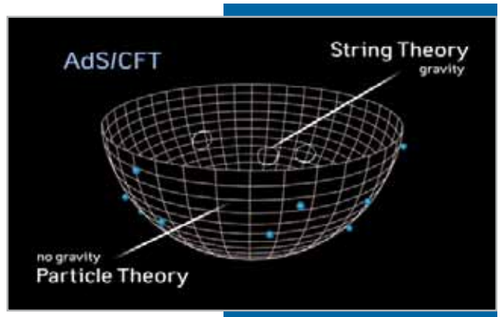
My own research has been, to a large extent, motivated by a desire to unravel the deeper origin of this remarkable relation of gravity and QFT. I have had a two pronged strategy to this end. On the one hand I have been aiming to understand the "nuts and bolts" of gauge-string duality by uncovering the structural reasons for this duality. This has led to the general insight that there is a very natural reorganising of the quantum worldline amplitudes of a QFT into world sheet amplitudes of string theory. My goal here has been to use this insight for deriving these gauge-string dualities in broad generality. On the other hand I have also been searching for sufficiently simple examples which nevertheless capture the essential features of this duality and yet are amenable to analytical understanding.

In this latter spirit, I have proposed (with M. Gaberdiel) and developed a new example of the AdS/CFT correspondence in the context of a class of non-supersymmetric two dimensional CFTs (which are vector-like and generalize statistical models like the Ising or Potts models) which turn out to be dual to so-called Vasiliev or higher spin theories on three dimensional AdS spacetime. In the last year or so we have been looking at how these dualities might teach us new things about string theories. In fact, it appears

as if the higher spin symmetries might play an important role in understanding the underlying symmetries of string theory. These symmetries presumably constrain the structure of string theory in a strong way.

At the same time I have also been studying simple large N matrix integrals (as toy models of gauge theories) expanded around the free gaussian one as a way of trying to explicitly construct the dual string amplitude. This is a specific realization of my general proposal on how string theory emerges from gauge theory. This is a particularly tractable case where one can actually try to identify the background spacetime of the dual string. One finds strong evidence for a dual topological string amplitude which localizes in the moduli space of Riemann surfaces to a class of holomorphic maps. I hope to exploit the simplicity of this example by embedding it as a solvable sector in a full-fledged string theory.

These endeavors give valuable insights into understanding more general non-supersymmetric quantum field theories in string theoretic terms. This is not just an idle theoretical fantasy because we have little conventional understanding of strongly coupled QFTs such as QCD and in strongly interacting materials. In these cases, string-like excitations often play an important role and are likely to be the better starting point for a description of the dynamics. I believe future explorations in this area will yield rich new insights.



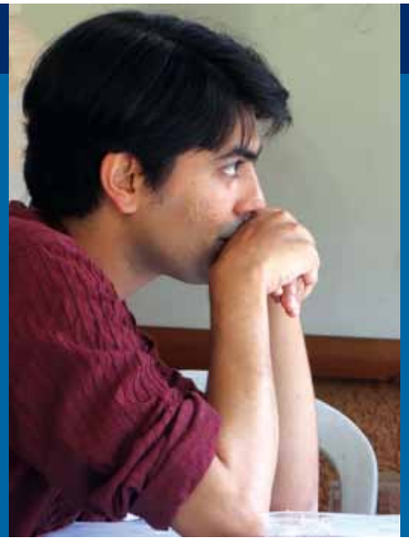
The holographic, gauge gravity or AdS/CFT duality relates non gravitational dynamics on the boundary to the gravitational physics of string theory in the bulk. Gopakumar has discovered new examples of this duality, and his work has illuminated several aspects of this correspondence

PUBLICATIONS (2013-2015)

1. *Stringy Symmetries and the Higher Spin Square*, M. R. Gaberdiel and **R. Gopakumar.** arXiv:1501.07236
2. *Higher Spins and Strings*, M. R. Gaberdiel and **R. Gopakumar.** JHEP 1411, 044 (2014)
3. *The Spectrum of Light States in Large N Minimal Models*, M. R. Gaberdiel, **R. Gopakumar** and M. Rangamani. JHEP 1401, 116 (2014)
4. *Large N=4 Holography*, M. R. Gaberdiel and **R. Gopakumar.** JHEP 1309, 036 (2013)
5. *Correlators in the Simplest Gauge-String Duality*, **R. Gopakumar** and R. Pius. JHEP 1303, 175 (2013)
6. *Minimal Model Holography*, M. R. Gaberdiel and **R. Gopakumar.** Invited review for special issue of J. Phys. A J. Phys. A 46, 214002 (2013)

SELECTED PUBLICATIONS

- *An AdS3 Dual for Minimal Model CFTs*, M. R. Gaberdiel and **R. Gopakumar.** Phys. Rev. D 83, 066007 (2011)
- *From Free Fields to AdS - II*, **R. Gopakumar.** Phys. Rev. D 70, 025010 (2004)
- *Noncommutative solitons*, **R. Gopakumar**, S. Minwalla and A. Strominger. JHEP 0005, 020 (2000)
- *On the gauge theory/geometry correspondence*, **R. Gopakumar** and C. Vafa. Adv. Theor. Math. Phys. 3, 1415 (1999)
- *M-theory and topological strings. II*, **R. Gopakumar** and C. Vafa. arXiv:hep-th/9812127



SUVRAT RAJU

Suvrat Raju has a PhD from Harvard University, working under the guidance of Shiraz Minwalla, in 2008. Before joining ICTS, he was a visiting fellow at the Harish-Chandra Research Institute, Allahabad, and then remained there as a Ramanujan fellow of the Department of Science and Technology.

RECENT COLLABORATORS

Nilay Kundu (HRI), Kyriakos Papadodimas (Groningen University & CERN), Sandip P. Trivedi (TIFR)

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Prashant Samantray (postdoc, ICTS), Sudip Ghosh (PhD student, ICTS)

ICTS PROGRAMS ORGANIZED

- Bangalore Area String Discussion Meeting, February 2015.
- Workshop on Information Paradox, Harish-Chandra Research Institute, February 2014
- Asian Strings School, Puri, January 2014
- Workshop on Entanglement, and the Information Paradox, International Centre for Theoretical Sciences, Bengaluru, October 2013
- International discussion meeting on Scattering without Spacetime concomitantly with the Chandrasekhar Lectures by Nima Arkani-Hamed on the same topic, Bengaluru, September 2012

RESEARCH REPORT

My primary research focus over the past two years has been on the black hole information paradox. In 1975, Hawking recognized, by combining well established principle of quantum field theory with general relativity, that black holes would emit thermal radiation irrespective of the initial details of their formation. This led to the information paradox. An important principle both in classical and quantum physics is that time evolution should be reversible. This principle would be violated if black holes were to evaporate in a way that tends to erase the memory of what constituted them. This paradox has recently been revived and sharpened by the work of Mathur, Marolf et al.

In work done with various collaborators — primarily Kyriakos Papadodimas (CERN, and the University of Groningen), but also Prashant Samantray (a postdoc at ICTS), and Souvik Banerjee (a postdoc at University of Groningen) — I have made some progress towards resolving this paradox in the context of the AdS/CFT conjecture. Our work relies on a construction that describes the interior of a black hole in anti-de Sitter (AdS) space in terms of holographic operators on the boundary conformal field theory (CFT). Using this, we were able to show that it is possible to preserve reversibility in the exact boundary theory, while preserving effective field theory (which is what leads to Hawking radiation) in the approximate gravitational description. Among other applications, our work also provides a precise realization of an old notion called black hole complementarity which is the idea that even separated regions of spacetime may have interdependent degrees of freedom. Recently, we discovered that our construction can also be applied to achieve a precise description of a recent conjecture between entanglement and geometric wormholes.

I have also been interested in applying the AdS/CFT conjecture to cosmological correlation functions. In this work, done in collaboration with Sandip Trivedi, Nilay Kundu, Ishan Mata (all at TIFR, Mumbai) and Archisman Ghosh (at ICTS), we considered both the leading and the subleading departures from Gaussianity in cosmological correlators. We were able to use symmetry to completely constrain a particular leading correction to the Gaussian spectrum. This is a difficult signal to observe but, in principle, our calculation, which is based just on symmetries and not a specific model, provides a sharp test of the hypothesis that the early universe witnessed a phenomenon called "inflation." We were also able to use AdS/CFT techniques to compute a particular subleading correction — which is universal, because it is controlled by gravitational interactions.

In the past, I have worked on modern techniques of understanding scattering amplitudes. With a student at ICTS, Sudip Ghosh, I have been trying to combine this interest with some of my recent work on the information paradox. In particular, we have been trying to understand whether gravitational perturbation theory may break down in surprising circumstances, and whether such a breakdown could be used to infer a breakdown of locality. Such non-local effects are potentially important for the information paradox, as explained above.

PUBLICATIONS (2013-2015)

1. *Conformal Invariance and the Four Point Scalar Correlator in Slow-Roll Inflation*, Archisman Ghosh, Nilay Kundu, **Suvrat Raju**, and Sandip Trivedi. JHEP 1407 (2014) 011.

2. *State-Dependent Bulk-Boundary Maps and Black Hole Complementarity,* Kyriakos Papadodimas and **Suvrat Raju**. Phys.Rev. D89 (2014) 8, 086010.

3. *The Black Hole Interior in AdS/CFT and the Information Paradox*, Kyriakos Papadodimas and **Suvrat Raju**. Phys. Rev. Lett. 112, 051301 (2014).

4. *Multipoint correlators of conformal field theories: implications for quantum critical transport*, D. Chowdhury, **S. Raju**, S. Sachdev, A. Singh and P. Strack. Phys.Rev. B, 87, 085138 (2013)

5. *The unreasonable effectiveness of exponentially suppressed corrections in preserving information*, Kyriakos Papadodimas and **Suvrat Raju**. Int.J.Mod.Phys., 1342030 (2013).

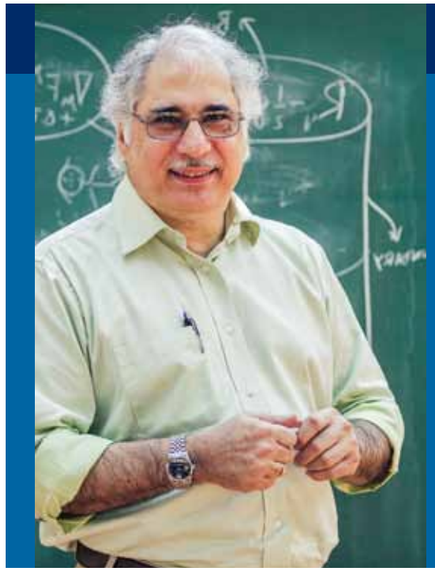
6. *CMB from CFT*, Ishan Mata, **Suvrat Raju** and Sandip Trivedi. JHEP, 1307, 015 (2013)

7. *An Infalling Observer in AdS/CFT*, Kyriakos Papadodimas and **Suvrat Raju**. JHEP, (2013) 212

8. *Local Operators in the Eternal Black Hole*, Kyriakos Papadodimas and **Suvrat Raju**. arXiv: 1502.06692

SELECTED PUBLICATIONS

- *State-Dependent Bulk-Boundary Maps and Black Hole Complementarity*, Kyriakos Papadodimas and **Suvrat Raju**. Phys.Rev. D89 (2014) 8, 086010
- *Local Operators in the Eternal Black Hole*, Kyriakos Papadodimas and **Suvrat Raju**, arXiv: 1502.06692.
- *An Infalling Observer in AdS/CFT*, Kyriakos Papadodimas and **Suvrat Raju**. JHEP, (2013) 212
- *Multipoint correlators of conformal field theories: implications for quantum critical transport*, D. Chowdhury, **S. Raju**, S. Sachdev, A. Singh and P. Strack. Phys.Rev. B, 87, 085138 (2013)
- *CMB from CFT,* Ishan Mata, **Suvrat Raju** and Sandip Trivedi. JHEP, 1307, 015 (2013)



SPENTA R. WADIA

Spenta Wadia received his PhD from the City University of New York in 1978 under the guidance of Bunji Sakita. He went on to a postdoc position at the University of Chicago. Wadia is the Founding Director of ICTS and a distinguished professor at the Tata Institute of Fundamental Research, Mumbai – where he has been since 1982. He is a member of the Council of the Indian Academy of Sciences, Bangalore; Member of the Science Council of the Asia Pacific Centre for Theoretical Physics (APCTP); Advisory Board member of Asia Pacific Newsletter, World Scientific; Program Advisory Committee, IAS Nanyang Technological University, Singapore and Editor, European Journal of Physics C.

RECENT COLLABORATORS

Shiraz Minwalla, Sandip Trivedi (TIFR, Mumbai), Sachin Jain (Tata Institute, presently at Cornell University), Shiroman Prakash (TIFR, Mumbai, presently at Din Dayal University, Agra), Tarun Sharma (TIFR, presently at Weizmann Institute), Tomohisa Takimi (TIFR, presently at HRI, India), Suichi Yokoyama (TIFR, presently at Technion, Israel), Simone Giombi (Perimeter Institute, presently at Princeton University), Xi Yin (Harvard University).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Sanjay Jain (PhD at TIFR now faculty of Delhi University), R. Shankar (PhD at TIFR now faculty at Institute for Mathematical Sciences, Chennai), Gautam Mandal (PhD at TIFR now faculty at TIFR-Mumbai), Anirvan Sengupta (PhD at TIFR now faculty at Rutgers University, USA), Porus Lakdawalla (PhD at TIFR now at Oracle Corporation, USA), Justin David (PhD at TIFR now faculty at Indian Institute of Science, Bengaluru), Pallab Basu (PhD at TIFR now faculty at ICTS-TIFR, Bengaluru, V. Ramanan (M. Phil at TIFR now financial analyst at Morgan Stanley Securities Management, Mumbai).

Sachin Jain (postdoc at TIFR, now at Cornell University), Tomohisa Takimi (post doc at TIFR, now at HRI, India), Suichi Yokoyama (post doc at TIFR, now at Technion, Israel), Manavendra Mahato (post doc at TIFR, now at IIT-Bhopal), Fawad Hassan (post-doc at CERN Geneva, now at University of Stockholm), Sachin Vaidya (post doc at TIFR, now at Indian Institute of Science, Bengaluru), N. Suryanarayana (post doc at DAMTP Cambridge, now at Institute for Mathematical Sciences, Chennai), Bobby Ezuthachan

(post doc at TIFR, now at Ramakrishna Mission Vivekananda University, Kolkata), Takehiro Azuma (post doc at TIFR, now at Setsunan University, Japan),

RESEARCH REPORT

One of the central problems of physics is to formulate a quantum theory of gravity in 3+1 dimensions. Within the framework of the AdS/CFT correspondence, 3+1 dimensions quantum gravity is dual to a 2+1 dimensions. Gauge theory and the supersymmetric ABJM theory conjecture is such a correspondence. The solubility of this theory, especially in the non-supersymmetric sector, is beyond our present capabilities because it has matrix valued matter fields. Hence we simplify the problem and study Chern-Simons theory coupled to vector matter. Even these simpler theories offer a rich arena to explore various issues pertaining to the solubility of QFT in the large N limit and its implications for the AdS/CFT correspondence.

We have studied the SU(N) gauge theory coupled to fundamental bosonic and fermionic matter in the limit of large N and large k (the Chern-Simons level). It turns out that various quantities in these theories are exactly calculable for all fixed values of $\lambda = N/k$. One can set up closed equations for at large N within the gauge theory and one can even solve them. These theories also have a natural representation in terms of higher spin weakly conserved currents and hence have a correspondence with Vasiliev's higher spin theory in AdS4. Among the most important results of these explorations by several groups is the discovery of a highly non-trivial fermion-boson duality in 2+1 dimensions.

Results

i) The thermal partition function of these theories is exactly calculable in this limit on S^2 and it exhibits the Fermion-Boson duality in 2 + 1 dimensions. This symmetry is a manifestation of the rank-level duality of pure Chern-Simons theory. This is a beautiful and mysterious fact that needs further understanding.

ii) The $2 \rightarrow 2$, S-matrix in the s, t and u channels generalizes the Aharonov-Bohm scattering to relativistic quantum field theory. The usual rules of crossing symmetry and analyticity for the S-matrix are (in summary) modified by the presence of 'anyons' in the theory. This S-matrix also exhibits the Fermi-Bose duality.

Future projects

i) Explore the implications of the fermion-boson duality at finite chemical potential. A natural implication of the fermion-boson duality would be the existence of a `bose metal'.

ii) We have explicitly constructed the operators that create anyonic excitations in the non-Abelian Chern-Simons matter theories. It would be good to make this construction useful for practical calculations.

iii) Describe general properties of the system at finite values of the rank of the gauge group and the Chern-Simons level. Progress in this direction will be of great interest in the topological quantum field theory approach to quantum coherence and its implications for quantum computing.

iv) The Chern-Simons plus matter gauge theory has been formulated in terms of 'gauge invariant' Wilson lines, which in a fixed gauge are bi-local fields. Their classical values are solutions to the large N saddle point equations. This is complementary to the AdS/CFT correspondence where usually the large N saddle point of the field theory is evaluated by solving Einstein type equations in one higher dimension with appropriate boundary conditions. It would be important to further understand this point in greater detail to lead the way to the emergence of the bulk geometry from the boundary theory.

PUBLICATIONS (2013-2015)

1. *Unitarity, Crossing Symmetry and Duality of the S-matrix in large N Chern-Simons Theories with Fundamental Matter*, S. Jain, M. Mandlik, S. Minwalla, T. Takimi, **S. R. Wadia** and S. Yokoyama. arXiv:1404.6373 [hep-th] (To appear in JHEP)

2. *Phases of large N Vector Chern-Simons Theories on S2 X S1*, S. Jain, S. Minwalla, T. Sharma, T. Takimi, **S. R. Wadia** and S. Yokoyama. arXiv:1301.6169 [hep-th], JHEP 1309, 009 (2013)

SELECTED PUBLICATIONS

- *Chern-Simons Theory with Vector Fermion Matter*, S. Giombi, S. Minwalla, S. Prakash, S. P. Trivedi, **S. R. Wadia** and X. Yin, Eur. Phys. J. C 72, 2112 (2012)
- *Finite temperature effective action, AdS_5 black holes, and 1/N expansion,* L. Alvarez-Gaume, C. Gomez, H. Liu and **S. R. Wadia**, Phys. Rev. D 71, 124023 (2005)
- *Aspects of semi-classical strings in AdS_5,* G. Mandal, N. V. Suryanarayana and **S. R. Wadia,** Phys. Lett. B 543, 81 (2002)
- *Absorption versus decay of black holes in string theory and T symmetry*, A. Dhar, G. Mandal and **S. R. Wadia**, Phys. Lett. B 388, 51 (1996)
- *Universal Cellular Automata and Class 4*, A. Dhar, P. Lakdawala, G. Mandal and **S. R. Wadia**. Phys. Rev. E 51, 3032 (1995)
- *Classical solutions of two-dimensional string theory*, G. Mandal, A. M. Sengupta and **S. R. Wadia**, Mod. Phys. Lett. A 6, 1685 (1991)
- *Quantization of the Liouville Mode and String Theory,* S. R. Das, S. Naik and **S. R. Wadia**, Mod. Phys. Lett. A 4, 1033 (1989).
- *Conformal Invariance and String Theory in Compact Space: Bosons,* S. Jain, R. Shankar and **S. R. Wadia**. Phys. Rev. D 32, 2713 (1985)

- *Nambu-Jona-Lasinio Type Effective Lagrangian-2: Anomalies and non-linear Lagrangian of low energy, large N QCD*, A. Dhar, R. Shankar and **S. R. Wadia.** Phys. Rev. D 31, 3256 (1985)
- *N = ∞ Phase Transition in a Class of Exactly Soluble Model Lattice Gauge Theories*, **S. R. Wadia**, Phys. Lett. B 93, 403 (1980)
- *The Role of Surface Variables in the Vacuum Structure of Yang-Mills Theory*, **S. R. Wadia** and T. Yoneya. Phys. Lett. B 66, 341 (1977)

POSTGRADUATE SCHOLARS AND RESEARCH STUDENTS

Amin Nizami (postdoc, ICTS)
Yuki Yokokura (postdoc, ICTS)
Kasi Jaswin (PhD student, ICTS)

INTERDISCIPLINARY MATHEMATICS

RUKMINI DEY

Rukmini Dey finished her PhD from S.U.N.Y. at Stony Brook University, USA, under Leon Takhtajan. Her postdoc positions were at the University of Texas, Austin, and the Indian Statistical Institute, Kolkata. Before joining ICTS, Rukmini was a faculty member at the Harish-Chandra Research Institute in Allahabad.

RECENT COLLABORATORS

Mathai Varghese (U. Adelaide, Australia), I. Biswas (TIFR. India), P. Kumar (Shiv Nadar University, India), Tapas Das (HRI, India), Samir K. Paul, (SN Bose Centre, India).

THESIS ADVISEES and POSTGRADUATE SCHOLARS

Pradip Kumar (PhD student, HRI), Rahul K. Singh (PhD student, HRI), Saikat Chatterjee (postdoc HRI), Varun Thakre (postdoc, HRI), Abhitosh Upadhyaya (postdoc, HRI)

ICTS PROGRAMS ORGANIZED

- Advanced School on Symplectic Geometry and Contact Topology, HRI (1st -12th Dec, 2014) and TIFR (15th to 22nd Dec, 2014).

RESEARCH REPORT

I work on geometric quantization of various moduli spaces of solutions of equations coming from physics. I also work on minimal surfaces, constant mean curvature surfaces and integrable systems. In a joint work with Mathai Varghese, we got a general result which basically says that given an integral Kahler form on a compact Kahler manifold, some tensor product of the corresponding line bundle is a Quillen determinant bundle. We show that for a general integral symplectic manifold an analogous statement is true. Thus from a certain point of view, the Quillen bundle (with suitable modifications) is universal in geometric quantization. I have also studied (jointly with Indranil Biswas and Saikat Chatterjee) the question of prequantization of the pathspace of a prequantized manifold. I am working (jointly with Dileep Jatkar and Samir Paul) on geometric prequantization of the Hamiltonians in finite Toda systems. I am working (jointly with Varun Thakre) on a project of interpreting various equations coming from gauge-theories as Lax pair equations and trying to find some interesting solutions using integrable system techniques. I have started working on a bifurcation phenomenon corresponding to multitranssonicity of blackhole accretion disc, i.e. points where the velocity of the accreting material crosses the velocity of sound. With three physicists, we have been able to analytically find the number of such points for the Schwarzchild black hole and thus an analytic solution to this problem has been given, which matches with numerical results. Another project I am embarked on is interpolation of two real analytic curves by piecewise minimal surfaces. A layman's description of the idea is as follows: given two wire frames, one can insert a series of wire frames such that there is a series of minimal surfaces interpolating between frame to frame. We use Bjorling problem and its solution and the inverse function theorem in infinite dimensions to prove the existence of these piecewise minimal surfaces. I have also studied (jointly with Pradip Kumar) some questions regarding Born-Infeld solitons, relating them to questions about minimal surfaces and vice versa. I have also studied (jointly with my student Rahul Kumar Singh) some rotational, helicoidal surfaces which are bi-analytically equivalent to algebraic surfaces.

PUBLICATIONS (2013-2015)

1. *Holomorphic Quillen determinant bundle over integral compact K¨ahler manifolds*, **R. Dey**, V. Mathai. Quart. J. Math. 64 (2013), 785-794, Quillen Memorial Issue

2. *One parameter family of solitons from minimal surfaces*, **R. Dey**, P. Kumar. Proc. Indian Acad. Sci., vol 123, no.1, pg. 55-65, 2013

3. *Geometric Prequantization on pathspace of a prequantized manifold*, I. Biswas, S. Chatterjee, **R. Dey**. Accepted in Inter. J. of Geometric Methods in Modern Physics.

SELECTED PUBLICATIONS

- *Holomorphic Quillen determinant bundle over integral compact K¨ahler manifolds*, **R. Dey**, V. Mathai. Quart. J. Math. 64 (2013), 785-794, Quillen Memorial Issue

- *An Analytical Study on the Multicritical Behaviour and Related Bifurcation Phenomena for Relativistic Black Hole Accretion*, S. Agarwal, T. K. Das, **R. Dey** and Sankhasubhra Nag. General Relativity and Gravity: Volume 44, Issue 7 (2012), Page 1637-1655

- *Hyper K¨ahler prequantization of the Hitchin system and Chern-Simons gauge theory with complex gauge group*, **R. Dey.** Adv. Theor. Math. Phys. 11 (2007) 819-837

- (1) *Geometric prequantization of the moduli space of the vortex equations on a Riemann surface,* **R. Dey.** Journal of Mathematical Physics, vol. 47, issue 10, (2006), page 103501-103508
  (2) *Erratum: Geometric prequantization of the moduli space of the vortex equations on a Riemann surface*, **R. Dey.** Journal of Mathematical Phys. 50, 119901 (2009)

- *The Weierstrass-Enneper representation using hodographic coordinates on a minimal surfaces*, **R. Dey.** Proceedings of Indian Academy of Sciences – Math.Sci. Vol.113, No.2, May (2003), pg 189-193

ASSOCIATE FACULTY

ICTS has the privilege of being associated with several world-class scientists who are deeply involved with various activities of the Centre. They form the wide group of ICTS Associate Faculty.

RANA ADHIKARI
California Institute of Technology
Gravitational-wave physics

SHIVANI AGARWAL
Indian Institute of Science, Bengaluru
Machine learning and learning theory

K. G. ARUN
Chennai Mathematical Institute
Gravitational-wave physics and astrophysics

GYAN BHANOT
Rutgers University, USA
Cancer Bioinformatics and Population Genetics

SAYANTANI BHATTACHARYYA
Indian Institute of Technology, Kanpur
String Theory, Fluid Mechanics

KEDAR DAMLE
TIFR, Mumbai & Joint Faculty ICTS-TIFR, Bengaluru
Condensed Matter Physics

SUBINOY DAS
Indian Institute of Astrophysics, Bengaluru
Cosmology

JUSTIN DAVID
Indian Institute of Science, Bengaluru
String Theory

NIVEDITA DEO
University of Delhi
Quantum Chaos, Complexity

ABHIJIT GADDE
Institute for Advanced Study, Princeton
String Theory

SIDHARTHA GOYAL
University of Toronto
Biophysics and Evolutionary Dynamics

SHRAVAN HANASOGE
Tata Institute of Fundamental Research, Mumbai
Helioseismology

MARK HANNAM
Cardiff University, UK
Numerical Relativity and Gravitational-Wave Astronomy

SASHA HUSA
Universitat de les Illes Balears, Spain
Theoretical Astrophysics

ZUBIN JACOB
University of Alberta
Quantum Photonics, Materials Design

SANJAY JAIN
University of Delhi
Theoretical Biology

KAVITA JAIN
Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru
Statistical Physics, Evolutionary Biology

DILEEP JATKAR
Harish-Chandra Reserach Institute, Allahabad
String Theory

SANDEEP KRISHNA
National Centre for Biological Sciences, Bengaluru
Decisions, Feedback and Games in Biological Systems

BADRI KRISHNAN
Albert Einstein Institute, Hannover
Mathematical Physics

MANAS KULKARNI
The City University of New York, USA
Condensed Matter and Statistical Physics

SWAPNA MAHAPATRA
Utkal University, Bhubaneswar
String Theory, Particle Physics

SUBHA MAJUMDAR
TIFR, Mumbai & Joint Faculty ICTS-TIFR, Bengaluru
Cosmology

SATYA MAJUMDAR
Directeur de Recherche in CNRS
Statistical Physics

MAYANK MEHTA
Department of Physics and Astronomy, UCLA
Neuroscience

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SANJOY MITTER
Massachusetts Institute of Technology
Electrical Engineering

RAVI NANJUNDIAH
Centre for Atmospheric and Oceanic Sciences, IISc
Earth Sciences

BIMAN NATH
Raman Research Institute
Cosmology

SURJEET RAJENDRAN
University of California, Berkeley, USA
High Energy Physics

MYTHILY RAMASWAMY
TIFR-CAM & Joint Faculty ICTS-TIFR, Bengaluru
Mathematics

MADAN RAO
Raman Research Institute, Bengaluru
Material Science, Complex Fluids, Biology

SUMATHI RAO
Harish-Chandra Reserach Institute, Allahabad
Condensed Matter Physics

SANJIB SABHAPANDIT
Raman Research Institute, Bengaluru
Statistical physics

DIPTIMAN SEN
Centre for High Energy Physics,
Indian Institute of Science, Bengaluru
Condensed Matter Physics, Quantum Field Theory

KRISHNENDU SENGUPTA
Indian Association for the Cultivation of Sciences, Kolkata
Condensed Matter Physics

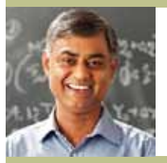
ANIRVAN SENGUPTA
Rutgers University, USA
Systems Biology

RAVI SHETH
International Centre for Theoretical Physics and the
University of Pennsylvania
Cosmology

ANINDA SINHA
Indian Institute of Science, Bengaluru
String Theory

TARUN SOURADEEP
IUCAA, Pune & Adjunct faculty ICTS-TIFR, Bengaluru
Cosmology

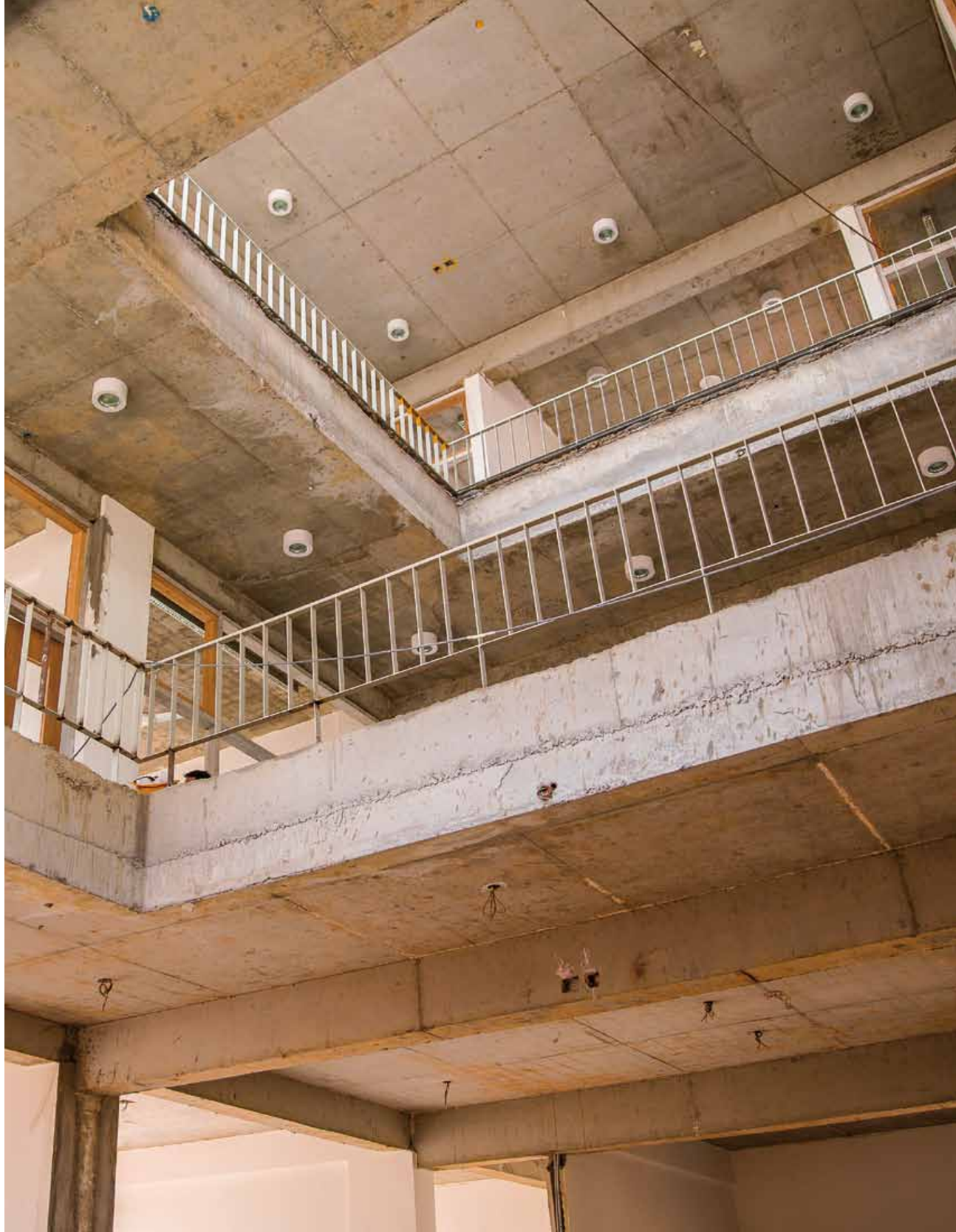
MUKUND THATTAI
NCBS-TIFR & Joint Faculty ICTS-TIFR, Bengaluru
Computational cell biology



SANDIP TRIVEDI
TIFR, Mumbai & Joint Faculty ICTS-TIFR, Bengaluru
String Theory

SREEKAR VADLAMANI
TIFR-CAM & Joint Faculty ICTS-TIFR, Bengaluru
Probability Theory

NISHEETH VISHNOI
École polytechnique fédérale de Lausanne EPFL
Theoretical Computer Science



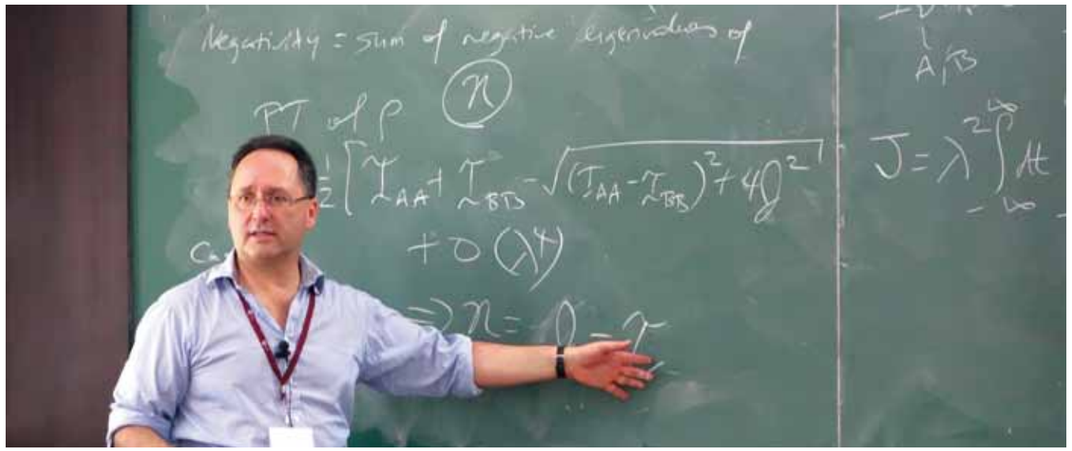
ACADEMIC ACTIVITIES

ICTS provides a platform for researchers to organize high quality programs of varying durations in theoretical and mathematical sciences. Programs in areas overlapping traditional fields of science are encouraged, keeping in mind that strength in individual disciplines lends to fruitful interdisciplinary collaborations. Besides the traditional areas of activity in mathematical and theoretical sciences, and their interconnections, activities in biological physics, complex systems and computational sciences are encouraged. An important character of the centre is its flexible response to organizing activities in emerging new areas of science. ICTS programs also encourage the interaction between experimentalists and theorists.

ICTS also supports activities that contribute to raising the level of scientific knowledge among Indian university students and faculty. Therefore, some of the high level activities are preceded by instructional workshops, to enable young participants to make the best use of the programs.

Anyone holding a faculty position at any research and educational institution can apply for organizing a program at the ICTS. The organizers must fill up a form for making a preliminary proposal. The proposals are then scrutinized by a Program Committee of the ICTS. Successful programs receive appropriate financial and administrative support from ICTS, including support for uploading audio-visual material collected from lecturers, etc.

ICTS long programs, with an embedded conference, have a large educational component. They aim to provide an introduction to current problems in an emerging area. The short programs are focused discussion meetings on a recent exciting development in a given field. They are also often organized around a leading lecturer on a theme related to her/his work. These meetings usually include a research-oriented participation and are frequently organized in conjunction with one of the following three named lecture series: Chandrasekhar (Physical Sciences), Ramanujan (mathematics) and Turing (Biology, Computer Science and Engineering).



PROGRAMS AND DISCUSSION MEETINGS

ORGANIZERS
Aurnab Ghose, Darius Koester, Roop Mallik, Satyajit Mayor, Thomas Pucadyil and Pramod Pullarkat

DATES
24 April-7 May, 2015

VENUE
NCBS and RRI, Bengaluru

MECHANICAL MANIPULATIONS AND RESPONSES AT THE SCALE OF THE CELL AND BEYOND

The understanding of biological processes at a cellular and sub-cellular scale has made a big leap forward, thanks to the new tools that have made the advance from a qualitative to a quantitative description possible. The application of a wide variety of techniques to mechanically manipulate single molecules or multi-cellular cell composites has allowed scientists to address the question of how organisms react to controlled mechanical cues. This two-week long program introduced a bouquet of techniques to gain quantitative information of responses of biological material (at all scales) to perturbations of a mechanical nature, and explores how the combination of theory and experiments will lead to a systematic deciphering of the physics of how living material engages with mechanical information. A discussion meeting was also held, to discuss recent results in the field of cell mechanics.

This was a joint program of ICTS with NCBS and RRI, Bengaluru.

SPEAKERS AND TALKS

Roop Mallik	*Cholesterol assembles armies of Motor proteins on Phagosomes*
Gautam Soni	*Nanopore Biophysics: From Molecular Detection to Biology*
Ravikrishnan Elangovan	*Minimum and Maximum Limit to Number of Myosin II Motors Participating in an Ensemble Motility*
Aurnab Ghose	*On Growth and FORMIN(g) neuronal filopodia*
Ranjith Padinhatheeri	*Microtubule shrinkage: Powerful elastic bending or stochastic thermal unzippering?*
Anita Joanna Kosmalska	*Physical principles of membrane remodelling during cell mechanoadaptation*
Rishita Changede	*Integrin Clusters of 100nm Form Early Adhesions and Depend on Talin*
Rumi De	*Dynamics of focal adhesions under time varying stretch*
Sampada Mutalik	*Regulation and functions of mechanical forces in neurons*
Mandar Inamdar	*Cell-cell adhesion, ECM topography and propensity of ECM proteolysis dictate the migration pattern of cancer cell collectives*
Mithilesh Mishra	*Studying cytokinesis in vitro*
Thomas Pucadyil	*Membrane curvature controls epsin-induced clathrin assembly*
Mohammed Saleem	*Membrane elasticity and polymerization energy modulate the shape*
Sukrut Kamerkar	*Biochemical screen for potential membrane fission catalysts*
Rahul Roy	*Hybrid Fluorescence-Force measurements for DNA-protein interactions*
ASR Koti	*Quantification of Protein Dynamics in terms of Flexibility/Rigidity by Single-Molecule Force Spectroscopy Experiments*
Debasish Chaudhuri	*Forced desorption of semiflexible polymers, adsorbed and driven by molecular motors*
Manindra Bera	*Force spectroscopy of lamins*
Jyoti Sharma	*Role of fumarate ion in changing bacterial flagellar motor from clockwise rotation to counterclockwise rotation*
Shivashankar	*Nuclear Mechanics and Genome Regulation*
Abhijit Majumdar	*Feel Thy Neighbor: Inter-cellular Force Interaction via Deformable Matrix*
Ramanujan Srinivasan	*Cytoskeleton in Prokaryotes: Assembly, Dynamics & Diversity*
Sriram Ramaswamy	*Activating Membranes*
Madan Rao	*Actomyosin Pulsation and Symmetry Breaking Flows drive Tissue Remodeling*
Pere Roca-Cusachs	*Understanding the cell-extracellular matrix mechanical link: from molecular roles to emerging behaviors*
Deepak Sinha	*Three-dimensional environment induces monocyte to macrophage differentiation*
Vijaykumar Krishnamurthy	*PAR polarity in C. elegans zygotes*
Maitrey Narasimha	*Anisotropies in cytoskeletal organization induced by ROS and Rho signaling underlie multicellular sensing and spatial patterning in a Drosophila epithelium.*
Sitikantha Roy	*Atomic Force Microscopy in Cell Mechanics*
Namrata Gundiah	*Directing cell migrations*
Dipanjan Bhattacharya	*Mechanobiological understanding of neurulation during zebrafish embryogenesis*
Bidisha Sinha	*Mapping membrane fluctuations in adherent cells*
Gautam Menon	*Spatio-temporal fluctuations in chromatin compaction states of stem cells*
Abhishek Chaudhuri	*Active clustering and pattern regulation in living cells*
Sarbari Bhattacharya	*Fine Tuning Membrane Stiffness of Red blood Cells with Bovine Serum Albumin*
Nagaraj Balasubramanian	*Integrin dependent caveolar trafficking in 3D microenvironments*

Madhulika Dixit	*Glucose metabolism and vascular progenitors: Is mechanosensing the missing link?*
Shamik Sen	*Crosstalk between matrix metalloproteases (MMPs) and the actomyosin cytoskeleton in breast cancer*
Satyajit Mayor	*Transient modulation of clathrin-independent endocytosis during cellular strain-relaxation offers a mechanism for regulating membrane tension*
Joseph Thottacherry	*Transient modulation of clathrin-independent endocytosis during cellular strain-relaxation offers a mechanism for regulating membrane tension*
Carl Flink	*Presentation by BLM – Bodystorm hits Bangalore*
Guatam Menon	*Biophysics: The Theoretical Minimum*
Thomas Pucadyil	*Membrane Fission - Background and assays for a mechanistic understanding of the process*
Aurnab Ghose	*Manipulating activities, microcontact printing and traction forces*
ASR Koti	*AFM based Dynamic Force Spectroscopy (DFS)*
Pramod Pullarkat	*An optical fiber based high-resolution force apparatus*

ORGANIZERS
Samriddhi Sankar Ray

DATES
6-8 April, 2015

VENUE
ICTS-TIFR, Bengaluru

NONLINEAR PHYSICS OF DISORDERED SYSTEMS: FROM AMORPHOUS SOLIDS TO COMPLEX FLOWS

In recent years significant progress has been made in the physics of disordered systems. As in nonlinear physics one can rarely employ standard methods - nonlinear systems require specialized thinking to provide useful progress. Nevertheless some generic techniques like scaling on the one hand and bifurcation theory on the other can find powerful ramifications in the explored issues. In this discussion meeting we focused on recent advances in this field and the outstanding open questions.

SPEAKERS AND TALKS

Srikanth Sastry	*Disentangling the role of structure and friction in shear jamming*
Eric Bertin	*Continuous descriptions for dry active matter*
Ranjini Bandyapodhyay	*A colloidal clay suspension as a model glass-former: some recent experimental results*
Smarajit Karmakar	*Phase Diagram of Glass Forming Liquids with Randomly Pinned Particles*
Chandan Dasgupta	*Activity-induced fluidization in glassy systems*
Itamar Procaccia	*Micro Big-Bangs and Quantized Vortex Dynamics in Turbulent Quantum Fluids* ***(Chandrasekhar Lecture I)***

Ajay Sood	*Yielding, irreversibility and non-equilibrium phase transition in colloidal glass and 2D Langmuir monolayer*
Surajit Sengupta	*Amorphization and yielding: Slow reorganization dynamics of crystals in a non-affine field*
Kirsten Martens	*Statistical physics of athermally sheared amorphous systems*
Damien Vandembroucq	*Finite size effects in a model for plasticity of amorphous composites*
Rajesh Ganapathy	*Using Colloid Simulations to Distinguish Between Competing* Theories of Glass Transition
Itamar Procaccia	*Plasticity and Material Failure in Amorphous Solids* ***(Chandrasekhar Lecture II)***
Prasad Perlekar	*Two-dimensional Turbulence: Binary mixture and polymer additives*
Ratul Dasgupta	*Laminar undular hydraulic jumps*
Rahul Pandit	*Particles and Fields in Superfluid Turbulence*
Abhishek Dhar	*Do thermal transport measurements show any signatures of a glass transition?*
Itamar Procaccia	*Cross Magneto-Mechanical Effects in Amorphous Solids with Magnetic Degrees of Freedom* ***(Chandrasekhar Lecture III)***

ORGANIZERS
Suvrat Raju

DATES
16-20 February, 2015

VENUE
ICTS -TIFR, Bengaluru

BANGALORE AREA STRING MEETING

This was the first in a sequence of meetings designed to bring together string theorists working in the Bangalore area. The meeting comprised a set of short talks, which were planned to rapidly communicate the recent research interests of the speakers. The meeting also featured a brief selection of interdisciplinary talks from other areas, and some longer talks from invited visitors.

SPEAKERS AND TALKS

Aninda Sinha	*Analytic bootstrap at large spin*
Yuki Yokokura	*Phenomenological Description of the Interior of Black Holes*
Satya Majumdar	*Free Fermions in a one dimensional harmonic trap and Gaussian random matrices (Seminar)*
Rajesh Gopakumar	*Stringy Symmetries and the Higher Spin Square*
Suvrat Raju	*Comments on state dependent operators*
Abhijit Gadde	1. *Geometry of dualities (colloquium)*

	2. Exact Solutions of 2d Supersymmetric Gauge Theories (chalk talk)
Pallab Basu	*Weak field thermalisation in Holography*
Justin David	*Higher spin corrections to Entanglement Entropy from CFT and Holography*
Shashi Thutupalli	*Active evolvable matter: A perspective from experiments with bacteria, worms, drops and clocks (colloquium)*
Chethan Krishnan	*An Inverse of Cosmic Censorship?*
Sudip Ghosh	*On the Entanglement Entropy for Gauge Theories*
Shashi Thutupalli	*Nonlinear dynamics of coupled oscillator communities and population dynamics of predator-prey interactions*
Loganayagam R	*Colloquium*
Avinash Raju	*A Grassmann path from AdS_3 to flat space*
Surbhi Khetrapal	*Thermalization of Greens functions and quasinormal modes*
Spenta Wadia	*S-Matrix in Chern-Simons matter theories and Fermi-Bose Duality*
Loganayagam R	*Fluids: Entropy, Eightfold way and Schwinger-Keldysh Effective theory*

ORGANIZERS
Abhishek Dhar, Kavita Jain, Rahul Pandit, Samriddhi Sankar Ray and Sanjib Sabhapandit

DATES
13-15 February, 2015

VENUE
IISc, Bengaluru

INDIAN STATISTICAL PHYSICS COMMUNITY MEETING 2015

The statistical-physics community in India has grown tremendously over the last few decades. Thus it is important to have a meeting every year where one can share ideas and scientific resources. Therefore, as part of the joint IISc-ICTS program, a discussion meeting of statistical physicists in India is held in Bangalore every year. The meeting is attended by scientists, postdoctoral fellows, and graduate students, from across the country, working in the broad area of statistical physics.

This meeting covers all the 10 Topics covered at STATPHYS meetings, namely:

- General and mathematical aspects of statistical physics thermodynamics, rigorous results, exact solutions, random matrices, stochastic field theory, information theory, optimizations, etc.
- Phase transitions and critical phenomena equilibrium and nonequilibrium.
- Nonequilibrium processes driven systems, transport theory, relaxation and response dynamics, random processes, anomalous diffusion, fluctuation theorems, large deviations, etc.
- Soft matter polymers, gels, liquid crystals, microemulsions, foams, membranes, colloids, granular materials, etc.
- Fluids and interfacial phenomena molecular and ionic fluids, metastable liquids, hydrodynamic instabilities, turbulence, growth processes, wetting, surface effects, films, crystals, confined systems, etc.
- Nonlinear dynamics dynamical systems, chaos (classical and quantum), pattern formation, chemical reactions, etc.
- Quantum systems strongly correlated electrons, cold atoms, graphene, soft quantum matter, mesoscopic quantum phenomena, fractional quantum Hall effect, low dimensional quantum field theory, quantum phase transitions, quantum information and entanglement, etc.
- Disordered and glassy systems percolation, spin glasses, structural glasses, jamming, glass transition, algorithmic problems, SAT, etc.
- Biophysics and biologically motivated problems molecular motors, dynamics at the scale of the cell, spatio-temporal organization in biological systems, biological membranes, biopolymer folding, genomics, biological networks, evolution models, evolutionary game theory, etc.
- Interdisciplinary topics in statistical physics networks and graphs, applied networks, econophysics, social phenomena, traffic flow, etc.

SPEAKERS AND TALKS

Punyabrata Pradhan	*Additivity Principle in Conserved Mass Transport Processes: Condensation Transition and Emergence of Power Laws*
Goutam Tripathy	*Disordered interacting ratchets*
Abhishek Dhar	*First Passage and Fluctuation Relations in Stochastic Thermodynamics*
Muktish Acharyya	*Nonequilibrium patterns and phases in RFIM at T=0*
Subir K. Das	*Aging in Domain Coarsening: Decay of autocorretion in Ising-like systems*
Rahul Pandit	*The Dynamics of Droplets in Turbulent Flows: Insights from Direct Numerical Simulations of the Two dimensional Cahn-Hilliard-Navier-Stokes Equations*
Subroto Mukerjee	*Localization and conservation laws*
Sanjay Kumar	*Rupture of DNA Aptamer: New insights from simulations*
Sanjib Sabhapandit	*Large Deviations for the Tagged Particle in Single File Motion*
Sriram Ramaswamy	*Granular flocks*

Ranjini Bandyopadhyay	*Aging dynamics in colloidal suspensions of charged disks*
Shradha Mishra	*Density and orientation field in an active nematic*
Prabal Maiti	*DNA liquid crystal phase*
Sanjay Puri	*Granular Gases*
Vijaykumar Krishnamurthy	*Pulsatory patterns in Active fluids*
Deepak Dhar	*Fragmentation of a sheet by propagating, branching and merging cracks*
Parongama Sen	*Exit probability in classical spin models*
Jaydeb Chakrabarti	*Cross-over in dynamical response in a driven colloid*
Debasish Chaudhuri	*Active Brownian particles: A stochastic thermodynamic approach*
Mustansir Barma	*Intermittency in an open aggregation fragmentation system*
Mahendra Verma	*Hysteresis and phase coexistence: a dynamical system perspective*
Marc Brachet	*Particles and Fields In Superfluids: Insights From The Two-Dimensional Gross-Pitaevskii Equation*
Giorgio Krstulovic	*Kelvin-wave cascade in low-temperature superfluids vortices*
Samriddhi Sankar Ray	*Gravitational Settling of heavy particles*
Pragya Shukla	*Classical dynamics with curl forces*
Prasad Perlekar	*Inverse cascade of two-dimensional turbulence in symmetric binary mixtures*
Sudipto Muhuri	*Oscillations in motor microtubule system*
Dibyendu Das	*Timescales of exposure of sites on DNA, under nucleosome kinetics*
Nivedita Deo	*Correlation Networks: Protein Structure and Function*
Gautam Menon	*The Wisdom of Crowding*
Ranjith Padinhateeri	*Statistical mechanics of microtubule protofilaments*
Abhishek Chaudhuri	*Dynamics of a semiflexible polymer, driven by molecular motors*
Anirban Sain	*Shape transformation during endospore formation in bacteria*
Vishwesha Guttal	*Stochastic transitions and precursors of financial meltdowns*
Dhrubaditya Mitra	*Deformable capsules in peristaltic flows*
Mandar M. Inamdar	*Force generation by growing filaments and collectively migrating motors*
Sakuntala Chatterjee	*Boundary induced phase transition with stochastic entrance and exit*
Sandeep Krishna	*Diversity in bacteria-virus ecosystems is facilitated by weak defences against viruses*
Varsha Banerjee	*Nano-Heaters for Therapeutic Applications*

Ronojoy Adhikari	*Nonequilibrium steady states in dissipative structures*
Rajesh Ravindran	*Shock propagation in driven granular systems*
Arnab Das	*Pulse Detection of Quantum Transitions: New Signature of a Quantum Phase Transition in Non-equilibrium Energy Absorption*
K L Sebastian	*Relaxation under Levy noise - unusual spectrum for the harmonic oscillator*
Kavita Jain	*Two point correlation function of an exclusion process*
Satya N. Majumdar	*Universal order and gap statistics for critical branching brownian motion*
Amit Ghosal	*Heterogeneity and stretched exponential decay of spatio-temporal* correlations in confinements
Arnab Sen	*A topological spin glass in diluted spin ice*
Pinaki Chaudhuri	*Cavitation in a model amorphous solid*
Srikanth Sastry	*Yielding, jamming and memory in sheared amorphous solids and fluids*
Bibhu Biswal	*Evolution of Overlapping Community Networks*
Rama Govindarajan	*Is a rising bubble the mirror image of a falling drop?*

ORGANIZERS
Kedar Damle, Subroto Mukerjee

DATES
12-16 January, 2015

VENUE
ICTS and IISc, Bengaluru

QUANTUM ENTANGLEMENT IN MACROSCOPIC MATTER

Condensed matter systems display a wide variety of interesting low temperature phases that are the product of the interplay between inter-particle interactions and the quantum statistics obeyed by the particles. The last few years have seen many exciting developments in this field highlighting the role of quantum entanglement. The aim of this discussion meeting was to understand these developments and their applications to physical systems by bringing together theorists and experimentalists working in the field of quantum condensed matter physics. The list of topics covered included thermalisation, many-body localization, hidden order, magnetic frustration and symmetry protected and enhanced topological order.

SPEAKERS AND TALKS

Ajay Sood	*Probing Non-equilibrium Carrier Dynamics in Graphene and MoS2 layers*
S. Hassan	*A Topological Fermi Liquid to a Algebraic Spin Liquid Transition in Kitaev Hubbard Model*
Diptiman Sen	*Majorana end modes: topological invariants, Floquet theory and* conductance
Krishnendu Sengupta	*Non-equilibrium dynamics of closed quantum systems: a tale of two stories*

Ehud Altman	*Universal dynamics and entanglement patterns near the many-body localization transition*
Rajdeep Sensarma	*Dynamic Ferromagnetic Response of a High Temperature Quantum Antiferromagnet*
T. Senthil	*Quantum entanglement in microscopic matter (**Chandrasekhar Lecture**)*
Joel Moore	*Dynamical effects from topology in metals*
Ribhu Kaul	*Deconfined criticality by design*
Olexei Motrunich	*Simple models of Symmetry Protected Topological phases and Symmetry Enriched Topological phases of bosons in two and three dimensions*
Vijay Shenoy	*Fermions in Synthetic Rashba Gauge Potentials*
Arindam Ghosh	*Experimental evidence of spontaneous time reversal symmetry breaking in interacting two-dimensional electron systems at half-filling*
Mukul Laad	*Superconductivity in the Iron Arsenides: A Strong-Coupling Route*
Brijesh Kumar	*A theory of magnetization plateaus in Shastry-Sutherland model & SrCu2 (BO3)2*
Subir Sachdev	*The pseudogap phase of the cuprate superconductors*
Anders Sandvik	*Spinons and holons: aspects of confinement and deconfinement in a two-dimensional valence-bond solid*

SCHOOL & DISCUSSION MEETING ON FRONTIERS IN LIGHT-MATTER INTERACTIONS

ORGANIZERS
Bhanu Pratap Das, Bimalendu Deb, Subhasish Dutta Gupta, Saikat Ghosh and Deb Shankar Ray

DATES
8-22 December, 2014

VENUE
Indian Association for the Cultivation of Science (IACS), Kolkata

Studies in light-matter interactions constitute a core area of research in atomic, molecular and optical sciences encompassing a wide range of highly interdisciplinary fields. At a fundamental level, quantum electrodynamical interactions of single atoms or ions with single-photons or even electromagnetic vacuum has led to new avenues of understanding light-matter interactions (for which 2012 Nobel Prize in physics was awarded to Serge Haroche and David J. Wineland). In a similar vein, atomic, ionic or molecular interactions of light carrying spatial singularity or orbital angular momentum are leading to new insights. In parallel to these developments, recent progress in light-matter interactions in diverse physical situations such as plasmonics, quantum dots, nanophotonics, cold atoms, molecules and matter waves has given an impetus to several fields leading to new physics, applications and devices.

In view of these current advances, this program was planned with two main objectives: First, to expose students and junior researchers to some of the modern facets of light-matter interactions as mentioned above; second, to motivate these young participants towards the excitement of research in basic sciences by holding discussion meetings on the latest cutting-edge developments in this field among leading scientists from around the world.

SPEAKERS AND TALKS

Ayan Banerjee	*Saturation spectroscopy*
Vaibhav Prabhudesai	*Basic molecular physics: Structure and spectra of diatomic molecules*
G. S. Agarwal	*Elements of quantum optics*
S. Chaturvedi	*Phase space and stochastic methods in quantum optics*
H. Ramachandran	*Single atoms and single photons*
B. N. Jagatap	*Laser cooling & trapping*
A. Mohapatra	*Non-linear optics using highly excited Rydberg atoms*
Subhadeep De	*Atomic clocks*
T. N. Dey	*EIT, EIA & CPT*
R. P. Singh	*Optical vortex: Experimental aspects*
D. S. Ray	*Density matrix approach to lightmatter interactions: System-reservoir theory*
S. Banerjee	*Open quantum systems: Density matrix formalism*
Nirmalya Ghosh	*Paraxial optics and spin-orbit interaction of light*
Ananda Jha	*Entangled photons*
J. K.Bhattacharjee	1. *BEC for trapped gases, Ginzburg Pitaevski equation and ramifications*

	2. *Weakly interacting fermions, BCS theory*
K. Thyagarajan	*Integrated quantum optics*
Sourav Dutta	*Cold molecules*
A. Gaeta	*Temporal magnification, compression, and cloaking of light*
S. Hughes	*1. Light-matter interactions in planar photonic crystals and on-chip nanophotonic resonators*
	2. Semiconductor cavity-QED using quantum dots – polaron master equation approach
	3. Quasimode theory of dissipative cavity systems and how to fix Purcell's formula
	4. Quantum optics of plasmonic resonator
A. Venugopal	*Fabrication techniques for plasmonic and photonic structures: Applications*
E. Brion	*Quantum optics with Rydberg atoms*
F. Bretenaker	*Laser noise and amplifier noise*
M. Mukherjee	*Entangled ions*
F. Bretenaker	*Phase sensitive amplification and squeezing*
G. Kurizki	*Dynamical control*

SPEAKERS

Discussion Meeting I

G. S. Agarwal, Oklahoma State University

Aashish Clerk, McGill University, Canada

Stephen Hughes, Queen's University, Ontario

Pulak Kumar Ghosh, Presidency University, Kolkata

Sankalpa Ghosh, IIT Delhi

G. Kurizki, Weizmann Institute of Science

Ozgur E. Mustecaplioglu, Koc University, Istanbul

Urbasi Sinha, RRI, Bangalore

Rajamani Vijayaraghavan, TIFR

Andreas Wallraff, ETH, Zurich

Hiroshi Yamaguchi, NTT Basic Research Laboratories, Kanagawa, Japan

Discussion Meeting II

N. Balakrishnan, University of Nevada

Holger Cartarius, Stuttgart University, Germany

Subhadeep Gupta, University of Washington

Sadiq Rangwala, RRI, Bangalore

Luis Santos, Hannover, Germany

Krishnendu Sengupta, IACS

Vijay B. Shenoy, IISc Bangalore

Yosuke Takasu, Kyoto University

Li You, Tsinghua University, Beijing

Rejish Nath, IISER, Pune

ENTANGLEMENT FROM GRAVITY

ORGANIZERS
Aninda Sinha

DATES
10-12 December, 2014

VENUE
ICTS-TIFR, Bengaluru

In the last few years, quantum entanglement considerations have led to profound insights in the connection with gravity. Entanglement entropy has been proposed as a probe to study the architecture of spacetime in quantum gravity. Connections with the Bekenstein-Hawking area law applicable to black holes have been found. This area law behavior finds support from various approaches to quantum gravity. This program focused on the lessons that various aspects of quantum entanglement have taught us about holography as well as what the holographic approach via the AdS/CFT correspondence has meant for entanglement.

SPEAKERS AND TALKS

Gautam Mandal	*Long time behavior of reduced density matrices in 2D quantum quench with conserved charges*
Shamik Banerjee	*Entanglement entropy and dilaton effective action*
Suvrat Raju	*Comments on State Dependent Operators in Quantum Gravity*
Barry Sanders	*Harvesting entanglement from the vacuum requires synchronization*
Robert Myers	*New Dialogues: Entanglement, Holography and Renormalization* (Chandrasekhar Lecture)
Justin David	*Higher spin Entanglement Entropy from CFT and Holography*
Ujjwal Sen	*Monogamy of correlations in a quantum world*
Dibyendu Mandal	*Modeling Maxwell's demon (Special ICTS Seminar)*
Barry Sanders	*Creating and Using Entanglement (ICTS-IISc Joint Colloquium)*
Arpan Battacharyya	*Deriving the entangling surface in higher curvature duals*
K. Narayan	*Limits and generalizations of extremal surfaces in (A)dS*
Rafael Sorkin	*Some stray thoughts and open questions on entanglement Entropy*

ADVANCES IN MATHEMATICAL BIOLOGY

ORGANIZERS
Pranay Goel, Sujatha Ramdorai and LS Shashidhara

DATES
7-16 December, 2014

VENUE
ICTS-TIFR, Bangalore, Indian Institute of Science Education and Research, Pune

This was a joint program of ICTS with the Indian Institute for Science Education and Research (IISER), Pune and Pacific Institute for the Mathematical Sciences (PIMS), Canada. The aim of this program was to bring together leading mathematical biology researchers from the PIMS together with Indian scientists to deliver a series of pedagogical lectures on contemporary topics of interest.

This program explored three themes in particular:

1. Ecology, Epidemiology and Immunology.
2. Statistical inference in biological systems.
3. Collective behavior in cellular and organismal biology.

The lectures were targeted at the Masters level students and were especially useful for PhD students and postdoctoral fellows. The purpose of the lectures was to intensively prepare young researchers planning to work in these and related areas in Mathematical Biology.

SPEAKERS AND TALKS

Mark Lewis	*The mathematics behind biological invasions*
Ram Rup Sarkar	*Mathematical and statistical modelling of malaria*
Milind Watve	*Inferring causation from correlations in a homeostatic steady state: the case of glucose regulation*
Daniel Coombs	1. *Stochastic approaches to within-host dynamics* *2. Individual and population approaches to biological motion*
Pauline van den Driessche	1. *Basic ideas of mathematical epidemiology* *2. Extension to cholera models*
Mark Lewis	*Mathematical models for carnivore territories*
Sutirth Dey	*Controlling the dynamics of populations: an experimental Biologist's perspective*
Subhash Lele	1. *Statistical reasoning in science: some fundamental concepts* *2. Reality bites: Complications and practicalities of statistical* analysis *3. Data cloning: How to trick Bayesians into giving frequentist answers*
Anil Gore	1. *Healthy numbers* *2. Clinical trials for health and beauty*

ICTP-ICTS WINTER SCHOOL ON QUANTITATIVE SYSTEMS BIOLOGY

ORGANIZERS
V. Balasubramanian, A. Celani, N. Chandra, S. Jain, M. Marsili, A. Sengupta, M. Thattai, A. Treves and M. Vendruscolo

DATES
1-12 December, 2014

VENUE
Miramare, Trieste, Italy

This school was held as part of the Program in Biology between International Centre for Theoretical Physics (ICTP) in Italy and ICTS.

New experimental techniques are opening windows on biological mechanisms inside the cell and in the brain, making these systems accessible to quantitative investigation. These advances have shown the importance of the concerted interaction of many agents in producing overall behaviors, and call for an understanding of biological functions at the systemic level. The series of Winter Schools in Quantitative Systems Biology, initiated in 2012, responds to the need to provide physicists with a broad exposure to quantitative problems in the study of living systems.

The school was particularly targeted at young researchers. It focused on Systems Neuroscience and covered different aspects of this rapidly developing field, such as: Neural coding and dynamics, Connectomics, Statistical inference in large neural datasets, Optogenetics and gene expression in the brain, Sensory systems: vision, olfaction, audition, Computational neuroscience, Synaptic plasticity, learning and memory, Neuroscience of reward and decision making, Spatial cognition, Higher order cognitive processes

SPEAKERS
Winfried Denk
Stefano Fusi
Kate Jeffery
Etienne Koechlin
Venkatesh Murthy
Israel Nelken
Botond Roska
Wolfram Schultz
Tatyana Sharpee
Misha Tsodyks
Fred Wolf

Research Talks
Mohammad Herzallah
Emilio Kropf
Gabriel Mindlin
Remi Monasson
Yasser Roudi
Gasper Tkacik

ORGANIZERS
Indranil Biswas, Rukmini Dey, Yakov Eliashberg, Rajesh Gopakumar, Mahan Mj and R. Thangadurai

DATES
1-22 December, 2014

VENUE
HRI, Allahabad and TIFR, Mumbai

ADVANCED SCHOOL AND DISCUSSION MEETING ON SYMPLECTIC GEOMETRY AND CONTACT TOPOLOGY

The field of symplectic and contact geometry and topology is currently an active area of mathematical research. It is intertwined with many areas of mathematics and mathematical physics, such as Hamiltonian Dynamics, Geometric Optics, Low-dimensional topology, Algebraic Geometry, the theory of integrable systems, and the mathematical theory of Mirror Symmetry to name a few. During the last three decades since the area emerged as a separate subject, many powerful methods have been discovered, such as the theory of holomorphic curves (introduced by M. Gromov in the mid-80's) leading to the creation of Gromov-Witten theory and Floer homology in its different flavors. As a result, several outstanding problems in Hamiltonian Dynamics, e.g. Arnold's and Weinstein's conjectures were solved, and a link to Mirror Symmetry was found. Organized in three parts, these subjects were the main focus of this program.

The preliminary school, held in HRI Allahabad, was aimed at bringing young faculty and postdocs up to gear. The resource persons for this component consisted of relatively senior faculty in India who work in nearby areas. The courses were easy-paced and assumed only a general background in Geometry and Topology. The Advanced School, held in TIFR, consisted of a number of intensive mini-courses given by international experts. The aim was to expose the participants to these new developments in the area.

SPEAKERS AND TALKS

Mahuya Datta	*Introduction to Symplectic Topology*
Dishant Pancholi	*Introduction to Contact Topology*
Rukmini Dey	*Quantization of symplectic manifolds*
Harish Seshadri	*Gromov Compactness*
Somnath Basu	*Introduction to Floer Theory*
Dheeraj Kulkarni	*Almost Holomorphic*
Sushmita Venugopalan	*Introduction to Gromov-Witten theory*
Dheeraj Kulkarni/Fran Pressas	*Lefschetz fibrations on symplectic/contact manifolds*
Rajesh Gopakumar	*A physics perspective on Mirror Symmetry and/or Gromov-Witten Invariants (1)*
Samik Basu	*Introduction to Madsen-Weiss Theore*
David Farris	*Introduction to Lagrangian Floer Homology*
Dusa Mcduff	*Introduction to Gromov-Witten theory*
Vincent Colin	-
Yasha Eliashberg	*Geometric methods in symplectic and contact topology*

Kenji Fukaya	*Introduction to Lagrangian Floer Theory*
Soren Galatius	*Topology of moduli spaces*
Sheel Ganatra	*Introduction to homological mirror symmetry*

ORGANIZERS
Mandar Deshmukh, Murali Kota

DATES
6-7 October, 2014

VENUE
Tata Institute of Fundamental Research, Mumbai

MASTERCLASS IN NANOSCALE PHYSICS AND DEVICES

The remarkable progress in semiconductor technology has enabled an amazing and rapidly expanding array of consumer products. However, it is becoming increasingly clear that in future information processing applications, synergistic innovations in materials and devices based on new physical principles will be a key to achieving new levels of performance. While desirable attributes of devices are high speed, high density, and low-voltage operation, device physics sets fundamental limits and forces trade-offs on the integration of all desirable attributes into one device element. The next generation of technologies will rely on the discoveries made by researchers working in the physical sciences.

The primary goal of the Masterclass was to present a pedagogical introduction to this rapidly growing field that can have a significant impact. The target participants were masters and PhD students in Physics, Materials Science and Electrical engineering, and junior faculty. The speakers at the Masterclass were pioneers in their respective areas of expertise and possess a clear vision about how scientific ideas at the present time can fashion revolutionary technologies of the future.

SPEAKERS AND TALKS

Murali Kota and Aniruddha Konar	*Quantum Effects in Nanodevices*
Victor Zhirnov	*Fundamental Limits of Charge Based Computing*
Nicola Marzari	*Electrical and thermal transport from first-principles*
Sadasivan (Sadas) Shankar	*Computational Materials Design*
R. Vijayaraghavan	*Superconducting quantum electrical circuits*
Subhasish Mitra	*Carbon Nanotube Robust Digital VLSI*
Manu Jaiswal	*Graphene: Physics and Devices*
Stuart Parkin	*The spin on electronics* (Public Lecture)
Erik Bakkers	*Towards light emission from hexagonal silicon*

ADVANCED INSTRUCTIONAL SCHOOL ON THEORETICAL AND NUMERICAL ASPECTS OF INVERSE PROBLEMS

ORGANIZERS
Venkateswaran Krishnan, Rakesh
Rakesh and M. Vanninathan

DATES
16-28 June, 2014

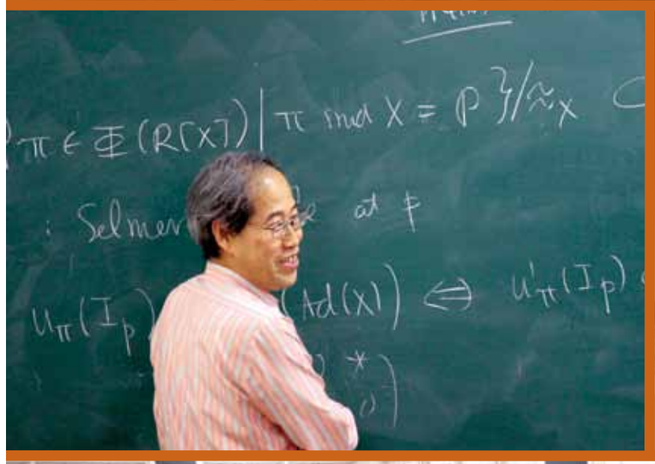
VENUE
Centre for Applicable Mathematics, TIFR, Bengaluru

In Inverse Problems the goal is to determine the properties of the interior of an object from the object response measured on the boundary, when the object is probed by electrical, acoustic or other means. Such problems arise in medical imaging, oil exploration, non-destructive testing and other fields. Determining the object properties corresponds to finding the non-constant coefficients of a partial differential equation (PDE) from the values, on the boundary of the region, of the solutions of the PDE. These problems may also be interpreted as the inversion of non-linear maps or transforms. The solution of these inverse problems requires harmonic analysis, PDE theory, numerical methods for PDEs, and custom designed inversion transforms and schemes.

SPEAKERS AND TALKS

M. Vanninathan	1. *Basics (Distribution theory)* 2. *Basics (Control Theory)*
Venky Krishnan	*Basics (Sobolev Spaces)*
Sreekar Vadlamani/ Amit Apte	*Basics (Statistical techniques)*
Rakesh	1. *Introduction to Inverse problems* 2. *Carleman estimates/Hyperbolic inverse problems*
Jan Boman	*Microlocal analysis of generalized Radon transform*
Gaik Ambartsoumian	*Generalized Radon transforms in tomography*
Yaroslav Kurylev	*Inverse problems in Riemannian and Lorentz geometry*
Bastian von Harrach	1. *Numerics Survey* 2. *Introduction to the numerical solution of inverse problems and shape detection in electrical impedance tomography*
Peter Kuchment	*Hybrid Imaging*
Cliff Nolan	*Inverse problems in seismic/radar imaging*
Kim Knudsen	*Numerical methods in inverse problems*
Venky Krishnan	*Calderon problem*







P-ADIC ASPECTS OF MODULAR FORMS

ORGANIZERS
Raghuram A, Baskar Balasubramanyan, Haruzo Hida and Jacques Tilouine

DATES
10-20 June, 2014

VENUE
IISER, Pune

This program focused on the p-adic aspects of modular forms and related topics. The program consisted of two components - an instructional workshop followed by a discussion meeting. There were several mini-courses in the workshop with focus on two broad themes. There were introductory lectures as well on p-adic families of automorphic forms with some modularity lifting applications in mind. Another set of lectures focused on the construction of p-adic L-functions in various situations and its applications.

The final part of the program was a three-day discussion meeting in which the state of current research in these topics was discussed.

SPEAKERS AND TALKS

Mini Courses

R. Sujatha	*p-adic families of modular forms*
Jacques Tilouine	*Families of Siegel modular forms and Galois representations*
Baskar Balasubramanyam	*Ordinary families for definite unitary groups*
David Geraghty	*Modularity lifting theorems for ordinary Galois representations*
Mladen Dimitrov	*p-adic L-functions for GL(2)*
Haruzo Hida	*Arithmetic of adjoint L-values*
Debargha Banerjee and A. Raghuram	*p-adic L-functions for GL(n)*

Advanced discussion meeting

Haruzo Hida	*Growth of Hecke fields*
Baskar Balasubramanyan	*Adjoint L-values and congruences of automorphic forms*
Olivier Fouquet	*Congruences and special values of L-functions*
Chandrakant Sharma	-
Giovanni Rosso	*Derivative of the symmetric square p-adic L-function via pull-back formula*
Riccardo Brasca	*Families of overconvergent modular forms over Shimura varieties without ordinary locus*
Denis Benois	-
Mahesh Kakde	*Higher rank congruences and geometric Iwasawa theory*
David Geraghty	-
Ming-Lun Hsieh	*Heegner point Euler system and p-adic L-functions*
Devika Sharma	*Locally indecomposable modular Galois representations with full residual image*

Fabian Januszewski	-
Eknath Ghate	*Reductions of Local Galois Representations via the LLC*
Tadashi Ochiai	*On the Iwasawa Main Conjecture for CM Hilbert cuspforms*
Mladen Dimitrov	*Albanese of Picard modular surfaces, and rational points*
Sudhanshu Shekhar	*Iwasawa theory and residual Galois representations*
Ashay Burungale	*On the non-triviality of Heegner points modulo p*
Jacques Tilouine	-

COSMOLOGY DAY

ORGANIZERS
Subhabrata Majumdar, Spenta Wadia

DATES
8 April, 2014

VENUE
ICTS-TIFR, Bengaluru

This was a one-day discussion meeting to discuss recent trends in Cosmology, covering topics in theory, observations and simulations. There have been several exciting developments recently – the BICEP2 results, the third round of results from the Planck satellite and the SDSS BOSS survey. The Standard Model of Cosmology and the paradigm of inflation have been established on solid ground and the time is ripe to go beyond it. The next generation of surveys are being planned. The Indian cosmology community is steadily getting involved in these worldwide cosmology missions. This meeting featured talks concerning a wide spectrum of contemporary topics. A brainstorming session on future prospects for growth of the Indian cosmology research within the global context was also held.

SPEAKERS AND TALKS

Tarun Souradeep	*Cosmology with CMB: the story thus far...*
L. Sriramkumar	*BICEP2 results and implications for the early universe*
Rishi Khatri	*After BICEP2*
Subha Majumdar	*After BICEP2: Connecting Inflation to LSS*
Koushik Dutta	*Open Inflation after BICEP2*
Aditya Rotti	*A new window into stochastic gravitational wave background*
Tapomoy Sarkar	*Cosmology using the post- reionization neutral IGM*

BANGALORE SCHOOL ON STATISTICAL PHYSICS - V

ORGANIZERS
Abhishek Dhar, Sanjib Sabhapandit

DATES
31 March-12 April, 2014

VENUE
Raman Research Institute, Bengaluru

This advanced level school was started in 2010 at the Raman Research Institute, Bangalore. The first four schools were held under the title RRI School on Statistical Physics. This school in 2014, the fifth of such schools held, was renamed as Bangalore School on Statistical Physics and was being jointly organized by RRI and ICTS.

Planned as a pedagogical school, this program was aimed at bridging the gap between masters-level courses and topics in statistical physics at the frontline of current research. It was intended for PhD students, post-doctoral fellows and interested faculty members at the college and university level.

SPEAKERS AND TALKS

Abhishek Dhar and Sanjib Sabhapandit	*Introduction to stochastic processes*
Jayanta Bhattacharjee	*Introduction to fluid dynamics and turbulence*
Sushanta Dattagupta	*Dissipative quantum systems*
Satya Majumdar	*Introduction to random matrix theory*
Kirone Mallick	*Bethe Ansatz: technique and applications*
Sumit Das	*Introduction to statistical field theory*

AUTOMORPHISMS OF AFFINE VARIETIES

ORGANIZERS
Rajendra Gurjar, A.J. Parameswaran

DATES
17-26 February, 2014

VENUE
Kerala School of Mathematics

Many striking results about the group of automorphisms of affine varieties have been proved in recent years. Similarly, several exciting open problems have been raised. The aim of this program was to bring together several experts in different aspects of the area of automorphism groups of affine varieties, viz. Locally Nilpotent Derivations, Rings of Invariants of finite and continuous Reductive Group Actions on C^n, Theory of Non-complete Algebraic Varieties, Applications of Brauer Groups, etc. There were five expository lectures each on these topics.

The expository talks informed the participants of different ways of attacking problems about automorphism groups of affine varieties, in particular affine space. Similarly, several open problems were also discussed. There were four expository talks every day for about five days. The second part of the program comprised a small research level discussion meeting to bring the participants up-to-date with current research in this area.

SPEAKERS AND TALKS

R.V. Gurjar and M. Miyanishi	*Non-Complete Algebraic Varieties*
L. Makar-Limanov and Kayo Masuda	*Locally Nilpotent Derivations*
A. J. Parameswaran	*On the Geometry Of Regular Maps From A Pure Quasi-Projective Surface To An Affine Curve*
Jugal Verma	*On a theorem of Rees about Pseudo-rational singularities*
S.M. Bhatwadekar	*Projective modules over the kernel of a locally nilpotent derivation on an affine space*
Neena Gupta	*On the affine threefold $x^my= F(x, z, t)$*
Jie-Tai Yu and V. Drensky	*Automorphisms of Polynomial Rings*
Kanel-Belov	*On The Zariski Topology Of Automorphism Groups Of Affine Spaces And Algebras*
Alok Maharana	*Complements of multi-sections on Hirzebruch surfaces*
Krishanu Dan	*Null Correlation Bundle on Projective Three Space*

SCHOOL AND DISCUSSION MEETING ON POPULATION GENETICS AND EVOLUTION

ORGANIZERS
Deepa Agashe, Kavita Jain

DATES
15-24 February, 2014

VENUE
IISc, Bengaluru

The aim of this school was to expose students and researchers from diverse backgrounds to the basics and the forefront of current research in population genetics. In addition to evolutionary biology students, students of mathematics, statistics, medicine, and physics who are interested in evolutionary theory were welcome. To equip students to think about issues in population genetics, there was a brief refresher course in mathematics, statistics, and basic biology including evolution and genetics. The remainder of the school introduced and developed an understanding of population genetics theory and its applications to interesting phenomena such as the evolution of sex and recombination, phenotypic plasticity, polyploidy, and human diversification. The program concluded with a short discussion meeting in which active researchers discussed their recent work on aspects of population genetics theory.

SPEAKERS AND TALKS

Kavita Jain	*Basic maths and statistics*
Amitabh Joshi	*Basic genetics*
Kavita Isvaran	*Mating systems*
Praveen Karanth	*Evolution I*
TNC Vidya	*Evolution II*
Mukund Thattai	*Molecular genetics*
Sandeep Krishna	*Models and simulations*
Brian Charlesworth	1. *DNA sequence variability and the coalescent* 2. *Linkage and selection* 3. *The effects of selection on variation and evolution*
Lindi M. Wahl	1. *Modeling adaptation (historical perspective)* *2.Mathematical approaches to modeling extinction probabilities* *3. Modeling experimental evolution*
Michael Whitlock	1. *Genetic load, mutation selection balance* 2. *Evolution in spatially structured populations*
Deborah Charlesworth	1. *Modeling evolution of mating systems* 2. *Evolution of sex chromosomes* 3. *Evolution of self-incompatibility*
Michael Desai	1. *Dynamics and population genetics of rapid adaptation* 2. *Pervasive selection and patterns of variation* 3. *Genome Dynamics in Experimental Evolution*
John Novembre	1. *Methods for the analysis of population structure and admixture* *2. Methods for demographic inference from genomic scale data* *3. Addressing challenges from next-generation sequencing*

Yuseob Kim	*Adaptive evolution in pathogen populations under complex demographic dynamics*
Guha Dharmarajan	*Disease dynamics in kin-structured populations*
Deepa Agashe	*Dealing with deleterious synonymous mutations*
Kavita Jain	*Adaptive walks and distribution of beneficial fitness effects*
Krushnamegh Kunte	*Molecular and population genetics of butterfly wing patterning*
Uma Ramakrishnan	*Population structure in real landscapes*
Hiroshi Akashi	*Codon usage bias in Drosophila: Population genetics and comparative genomics of near neutrality*
Vishwesha Guttal	*Evolution of collective movement*
Nisheeth Vishnoi	*Making evolution rigorous*
Narendra Dixit	*The evolutionary arms race between HIV and humans: can intervention tilt the balance?*
Farah Ishtiaq	*Native versus introduced haematozoan parasites of an island colonising host Zosterops lateralis: parasite loss or gain?*
K. Thangaraj	*Human origin, health and disease in India*
Bashisth Narayan Singh	*Population genetics of Drosophila ananassae*
Richard Gomulkiewicz	*Evolution and the establishment of new species*

INDIAN STATISTICAL PHYSICS COMMUNITY MEETING 2014

ORGANIZERS
Kavita Jain, Rahul Pandit, Samriddhi Sankar Ray and Sanjib Sabhapandit

DATES
1-3 February, 2014

VENUE
IISc, Bengaluru

This was the annual discussion meeting of the Indian statistical physics community which is attended by scientists, postdoctoral fellows, and graduate students, from across the country, working in the broad area of statistical physics. This meeting covered all the ten topics covered in the STATPHYS meetings.

SPEAKERS AND TALKS

Arijit Bhattacharyay	*An alternative approach to equilibrium of a mesoscopic system with spatial inhomogeneity*
Arul Lakshminarayan	*Number of real eigenvalues of products of random matrices*
Arvind Ayyer	*Exact results for a monomer-dimer model*
Prabodh Shukla	*Non-equilibrium random-field Ising model on a diluted triangular lattice*

Purusattam Ray	*Intermediate Phases in three dimensional Z(Sub N) spin models*
R. Rajesh	*Phase transitions in extended hard core lattice gas models*
Satyajit Banerjee	*Dynamic phases of the driven vortex state in superconductors: Jamming phenomena*
Subroto Mukerjee	*Size-dependent crossover scales in the thermalization on quantum systems*
Deepak Kumar	*Dynamics and growth of stripe patterns*
Apratim Chatterji	*Self-assembly of ordered cylindrical nano-structures: A theoretical investigation of experimental results*
B. V. R. Tata	*Entanglement effects on dynamics of dense thermo-responsive microgel suspensions*
Biswaroop Mukherjee	*Dual translocation path ways in smectic liquid crystals facilitated by molecular flexibility*
Narayanan Menon	*Structure of a crumpled object*
Ranjini Bandyopadhyay	*An ultrasound attenuation spectroscopy study of the aging behavior of soft glassy colloidal suspensions*
V Kumaran	*The hard-particle model for dense granular flows*
Yashodhan Hatwalne	*Morphologies of polymer crystallites*
K.P.N Murthy	*Work fluctuations and second law violation*
Nivedita Deo	*Matrix model with Penner interaction inspired by interacting RNA*
Punyabrata Pradhan	*Mass fluctuations in conserved-mass transport processes and gamma-like distributions*
Muktish Acharyya	*Dynamic-symmetry-breaking breathing and spreading transitions in ferromagnetic film irradiated by spherical electromagnetic wave*
Pragya Shukla	*Complex Systems with Goldstone condition: a statistical view-point*
Subir K. Das	*Hydrodynamic effects in kinetics of phase separation*
Anirban Sain	*Mechanics of cell division*
Apoorva Nagar	*mRNA translation: Traffic on decaying roads*
Sriram Ramaswamy	*Issues in the hydrodynamics of self-propelled systems – confinement and fluctuations*
Dibyendu Das	*Collective force generated by multiple biofilaments can exceed the sum of forces due to individual ones*
Mandar Inamdar	*Force generation by growing filaments and collectively migrating motors*
Kavita Jain	*Adaptation and extreme value theory*
Ravindra E. Amritkar	*Synchronization of nearly identical systems on complex networks*
Prasad Perlekar	*Clustering of inertial particles in rotating Rayleigh-Benard convection*

Rahul Pandit	*New exponents for heavy-particle trajectories in turbulent flows*
Samriddhi Sankar Ray	*Turbulence in fractal dimensions*
Smarajit Karmakar	*Static length scale in glass transition*
Sumedha	*On the behaviour of K-SAT on trees*
Varsha Banerjee	*Ground states of some complex spin systems using graph cuts*
Goutam Tripathy	*Collective motion in disordered ashing ratchets*
K. L. Sebastian	*Path integrals for anomalous diffusion*
Rajeev Kapri	*Hysteresis and nonequilibrium work theorem for DNA unzipping*
Sanjib Sabhapandit	*High energy tail of the velocity distribution of driven inelastic gases*
Sudipto Muhuri	*Phase segregation and transport in two species multi-lane system*
Pallab Basu	*Stochastic resetting, regime shifts and fat tailed distribution*
Manoj Gopalakrishnan	*Memory and correlations in a random walk model with internal states*
Mithun Mitra	*Role of delays in epigenetic landscapes*
P. K. Mohanty	*Biological networks: complexity and disease*
Neelima M. Gupte	*Synchronization on hierarchical lattices*
Ranjith Padinhateeri	*Statistical positioning of nucleosomes*
Sanjay Kumar	*Dynamical transition: hysteresis and scaling*
Mangal Chandra Mahato	*Particle motion in driven sinusoidal potentials*
Prabal Maiti	*Elasticity of DNA and various DNA nanostructures*
Deepak Dhar	*Modelling proportionate growth*
Supurna Sinha	*Statistical mechanics of bent twisted ribbons*
Debasish Chaudhuri	*Stochastic thermodynamics of active Brownian particles*

THE 8TH ASIAN WINTER SCHOOL ON STRINGS, PARTICLES AND COSMOLOGY

ORGANIZERS
Dileep Jatkar, Nakwoo Kim, Swapna Mahapatra, Anshuman Maharana, Subhabrata Majumdar, Jaemo Park, Suvrat Raju and Sandip Trivedi

DATES
9-18 January, 2014

VENUE
Puri

The Asian Winter School on Strings, Particles and Cosmology is organized annually in turn by Korea, Japan, China and India. The 8th meeting of this series was held in Puri, India, and was an ICTS program.

This was an advanced level school. While String Theory was the primary focus, it also aimed to provide a broader perspective emphasizing that String theory is a useful framework for the basic questions of Particle physics and Cosmology and for the study of strongly coupled systems. The school gave young researchers in Asia an opportunity to come together and learn about the latest important developments in the field from leading practitioners of the subject. The school was attended by advanced students, post-doctoral fellows and also active researchers.

SPEAKERS AND TALKS

Daniel Baumann	1. *Cosmology for String Theorists* 2. *Inflation in Effective Field Theory* 3. *Inflation in String Theory*
Seok Kim	*6 dimensional superconformal field theories*
Leonardo Senatore	*Cosmology*
Spenta Wadia	*Fermion-Boson Duality in 2+1 dim. large N Gauge Theories*
John Ellis	*The Standard Model and Beyond*
Subir Sachdev	*Quantum phase transitions in condensed matter*
Ashoke Sen	*Some issues in string perturbation theory*
Suvrat Raju	*Local operators, black hole interiors and the information paradox in AdS/CFT*
Tadashi Takayanagi	*Quantum Entanglement and Holography*
Rajesh Gopakumar	*Higher Spin Theories on AdS_3 and their CFT duals*
Gautam Mandal	*Introduction to Hawking radiation*
Tadashi Takayanagi	*Quantum Entanglement and Holography*

NONLINEAR FILTERING AND DATA ASSIMILATION

ORGANIZERS
Amit Apte, Christopher Jones and Sreekar Vadlamani

DATES
8-11 January, 2014

VENUE
ICTS-TIFR, Bengaluru

The application of the framework of filtering theory to the problem of data assimilation is currently considered an exciting area. Some of the emerging areas of research at the interface of these two fields are i) the adaption of filtering theoretical ideas, including those related to particle filters, for use in high or infinite dimensional systems, ii) the effects of nonlinearity on filtering, iii) the use of large quantities of data such as satellite data, iv) the development of new numerical techniques for addressing these problems.

The main aim of this discussion meeting was to bring together students and researchers in India working on probability, stochastic processes, and other related fields, in mathematics and engineering, to expose them to some of the exciting recent applications of nonlinear filtering theory to data assimilation problems. The invited speakers were either experts or working at the forefront of bringing these areas together. This meeting was supported by the "EADS Corporate Foundation International Teaching and Research Chair" entitled "Mathematics of Complex Systems" awarded to ICTS-TIFR and TIFR-CAM, Bangalore.

SPEAKERS AND TALKS

Rajeeva Karandikar	*Overview of nonlinear filtering*
Alberto Carrassi	*Data Assimilation in Geophysics - From Weather to Climate Prediction*
Dan Crisan	*Convergence of particle filters and relation to DA*
Sanjoy Mitter	*Overview of variational approach to nonlinear filtering*
Ramon van Handel	*Filtering in high dimension*
Sri Namachchivaya	*Stability, dimensional reduction and data assimilation in random dynamical systems*
Elaine Spiller	*Importance sampling*
Chris Jones	*Does the problem matter?*

ORGANIZERS
Kedar Damle, Indra Dasgupta, Manish Jain, H R Krishnamurthy, Tanusri Saha-Dasgupta and N.S. Vidhyadhiraja

DATES
6-17 January, 2014

VENUE
IISc, Bengaluru

STRONGLY CORRELATED SYSTEMS: FROM MODELS TO MATERIALS

The realistic description of materials with strong electron-electron interactions is one of the challenges of modern condensed matter physics. Such a realistic description on one hand requires non-perturbative many body approaches, and on the other hand requires model Hamiltonian with material specific details offered by density functional theory (DFT). Mastering these novel techniques requires a wide background, ranging from DFT to model building and non-perturbative many body approaches such as Quantum Monte Carlo. During the last few years a major breakthrough came with the development of the DFT+Dynamical Mean Field Theory (DFT+DMFT) method. In this approach, conventional ab-initio schemes based on DFT are combined with a modern many-body approach, the dynamical mean-field theory (DMFT). In the DMFT method the full many body problem of solid state physics is mapped onto a quantum impurity model related by a self-consistency condition and the resulting impurity model is solved using non-perturbative many body techniques.

The focus of this program was this circle of ideas. It was built around three Chandrasekhar lectures delivered by Antione Georges. In addition to these lectures there was a school, divided into two parts, and a discussion meeting, scheduled between the two parts of the school, in which recent theoretical and experimental results on strongly correlated materials were discussed by leading experts from India and abroad.

SPEAKERS AND TALKS

P. Blaha	1. *Basic concepts of bandstructure methods and the APW based methods* *2. WIEN2k: methods and features*
M. Harbola	*An Introduction to Density Functional Theory*
N Marzari	-
D Vanderbilt	*Wannier Functions*
Vijay Shenoy	*Review of many body field theory; Fermions in Synthetic Non-Abelian Gauge Fields*
D.D. Sarma	*Correlations and spectroscopy*
F. Aryasetiwan	*First-principles method for calculating the Hubbard U*
Markus Aichhorn	1. *Hunds coupling and magnetism in technetium and chromium oxides* *2. LDA+DMFT*
André-Marie Tremblay	1. *High-temperature superconductors: Where is the mystery?* *2. d-wave superconductivity in the one-band Hubbard model, the Cluster Dynamical-Mean-Field point of view*

A. Fujimori	*Self-energies in correlated metals SrVO3 and SrMoO3*
F. Aryasetiwan	*Electronic Structure of SrVO3 within GW+DMFT*
S. Biermann	*About empty states and Ab out U: New insights from combined GW and DMFT*
D.D. Sarma	*Probing buried interfaces*
M. Ferrero	*How bad metals turn good: spectroscopic signatures of resilient quasiparticles*
T.V. Ramakrishnan	*A Ginzburg Landau like Theory for Emergent d wave Superconductivity in the Cuprates*
M.Le Tacon	*Overview of recent results obtained in high temperature superconducting cuprates obtained by various x-ray scattering experiments*
Roser Valenti	*Correlations and pressure effects in Fe-based superconductors: A first principles investigation*
S. Ray	*Few interesting manifestations of metal-oxygen covalency in solid oxides*
S.R. Hassan	*Topological Phases in the Kitaev - Hubbard Model*
A. Millis	1. *Dynamical mean field theory of metal- insulator transitions in transition-metal perovskites in bulk and superlattice form* *2. An Introduction to Cluster DMFT*
T Prushke	-
P. Werner	1. *Extension of DMFT to nonequilibrium systems* *2. Hybridization-expansion-based CTQMC* *3. Analytic Continuation*
J W Freeland	-
Cedric Weber	*An implementation of dynamical mean field theory for nano-structures and molecules*
Arti Garg	*Doping a correlated band insulator: A new route to half-metallic behaviour*
A Georges	*Sum up on DMFT for the school*
T. Pruschke	*Quantum Impurity Solvers*
M. Ferrero	*Analytical /approximate Solvers; Action based solvers and tools*
F. Aryasetiwa	*The GW method*
S. Biermann	*The GW + DMFT Method*

ORGANIZERS
Rana Adhikari, Parameswaran Ajith, Bala Iyer, Sendhil Raja S and Tarun Souradeep

DATES
23-28 December, 2013

VENUE
Raja Ramanna Centre for Advanced Technology, Indore

ICTS WINTER SCHOOL ON EXPERIMENTAL GRAVITATIONAL-WAVE PHYSICS

A worldwide network of detectors is currently involved in an exciting experimental effort for the first direct detection of gravitational waves (GWs). There is also an ongoing proposal to build a GW detector, called LIGO-India, in India with significant international collaboration. Not only that GW astronomy will open up a fundamentally new observational window to the Universe, the experimental effort for GW detection has been driving precision measurement science for the last few decades.

The aim of the ICTS Winter School in Experimental GW Physics was to train students, young scientists and engineers on the instrumental science and technology for GW astronomy. The school featured intense series of lectures and hands-on sessions covering a number of topics including interferometry, highly stabilized lasers, control systems, etc

Peter R Saulson	1. *Overview of gravitational waves and detectors (Waves and sources)* *2. Interaction of waves and detectors* *3. Shot noise and Radiation Pressure noise (Classic view / Poisson fluctuations)* *4. Theory of Linear Systems (Basics); Vibration isolation (Passive systems)* *5. Thermal noise (Brownian noise, Zener damping, thermo-elastic noise)* *6. Optics of Fabry-Perot cavities (Plane wave picture, static response, audio frequency transfer functions)* *7. Control Systems (Basics (feedback))* *8. Details of current detectors (Specifications)* *9. Future detectors (Space)*
Rana Adhikari	*1. Overview of gravitational waves and detectors (Survey of past and present detectors)* *2. Shot noise and Radiation Pressure noise (Vacuum fluctuations/quantum noise propagation in interferometers)* *3. Theory of Linear Systems (Network synthesis method for electronics)* *4. Vibration isolation (Active platforms, limits of seismometers, issues with optical, magnetic, and electrostatic levitation)* *5. Thermal noise (Coatings, noise cancellation, generalized coordinates)* *6. Introduction to Finesse* *7. Optics of Fabry-Perot cavities (Higher order transverse modes, geometric stability, ray matrix approach to Gaussian beams)* *8. Optics of Fabry-Perot cavities (Matrix approach for interferometer fields)* *9. Control Systems (Feed-forward, adaptive FF, MIMO, optimal feedback, state-space methods, H-infinity)*

	10. Details of current detectors (Stories about current and past detectors) *11. Future detectors (ET)* *12. Future detectors (LIGO – III)*
Oliver Puncken	1. *The advanced LIGO pre-stabilized laser (PSL)* *2. Laser diagnostics and developmental tools* *3. Thermo-optical effects* *4. Stabilization of the PSL* *5. Installation and Integration of the PSL*

ORGANIZERS
Krishnendu Gongopadhyay, Rama Mishra and Madeti Prabhakar

DATES
10-20 December, 2013

VENUE
IISER, Mohali

ADVANCED SCHOOL AND DISCUSSION MEETING ON KNOT THEORY AND ITS APPLICATIONS

This program was centered around Knot theory and its applications to various disciplines of mathematics and other areas of science. Due to its applications in other disciplines, Knot theory has acquired an important place in terms of research globally. However, this area has not yet been strongly studied in India. The aim of this program to expose young researchers in India to this subject and enthuse them to work on knot theory.

There were two components of the program, an advanced school followed by a discussion meeting. The advanced school was mainly aimed at graduate students and young researchers working or wanting to work in knot theory and related areas. It was divided into six series of three lectures (one hour each) along with two tutorials on each topic adding up to 18 lecture hours and 12 tutorial hours. The topics included: Combinatorial Knot theory, Knot Quandles, Knot homologies, Surface knots, Knot theory and 3-manifolds, Knot invariants.

SPEAKERS AND TALKS

Rama Mishra	*Knot theory: An overview*
Louis Kauffman	*1. Reidemeister Moves, Bracket Polynomial, Alternating & Adequate Knots* *2. Virtual Knot Theory* *3. Khovanov Homology*
Jozef Przytycki	*1. Knots & distributive homology I: quandle colorings & weighted colorings* *2. Knots & distributive homology II: pre-simplicial & pre-cubic sets; geometric realization* *3. Knots & distributive homology III: (co)cycle invariants in co-dimension two embeddings* *4. Yang-Baxter homology: in search for a link between quandle & Khovanov homology of knots*
Slavik Jablan	*Unknotting number & knot distances*
Hideki Miyachi	-
Slavik Jablan	*The theory of pseudoknots*

Kapil Paranjape	*1. An algebraic approach to Braids* *2. Algebro-geometric interactions of braids*
Akio Kawauchi	*1. Knot theory for spatial graphs* *2. Unknotting notions on the spatial graphs* *3. Spatial graphs with degree one vertices attaching to a surface*
Seiichi Kamada	*1. Surface knots I: how to visualize 4-space, motion picture method & normal forms* *2. Chart description of surface braids*
Ayaka Shimizu	*The region crossing change on knot, link and spatial-graph diagrams*
Yoshiro Yaguchi	*Surface knots*
Abhijit Champanerkar	*1. Knots, Graphs and Khovanov Homology-I* *2. Knots, Graphs and Khovanov Homology-II* *3. Geometrically maximal knots*
Seiichi Kamada	1. *Surface knots II: Surface diagrams & invariants* 2. *Surface knots III: Braid form*
P. Ramadevi	*Chern-Simons theory and knot invariants*
V. G. Bardakov	-
Rama Mishra	*Some numerical knot invariants through polynomial knots*
Kanako Oshiro	*Linear Alexander quandle colorings; finite-fold cyclic covers of S3 branched over knots*
Kanji Morimoto	*On Heegaard splittings of knot exteriors with tunnel number degenerations*
Nafaa Chbili	*New obstructions for quasi alternating links*
Naoko Kamada	*Numerical invariants of twisted links*
Sree Krishna P.A.S	*Length of nth-shortest closed geodesic in a hyperbolic knot complement in S^3*
Mikami Hirasawa	*On Coxeter links associated to cycle graphs*
Benjamin Audoux	*Ribbon 2-tubes and automorphisms of reduced free groups*
Akio Kawauchi	*Component-conservative invertibility of links; Samsara 4-manifolds on 3-manifolds*
Makoto Sakuma	*The space of Kleinian groups generated by two parabolic transformations*
Takefumi Nosaka	*Bilinear-form invariants of Hurwitz equivalence classes*
Yeonhee Jang	*On Hempel distance of bridge splittings of links*
Jayanthan	*On double torus links*
Shantha Bhushan	*Understanding Proteins and Knot Theory*
Vikash Siwach	*Unknotting number of some knots*
Hitesh Raundel	*Path Components in the Space of Polynomial Knots*
Zodinmawia	*Superpolynomials Super-A-polynomials for Twist Knots*

ICTP-ICTS WINTER SCHOOL ON QUANTITATIVE SYSTEMS BIOLOGY

ORGANIZERS
Vijay Balasubramanian, Nagasuma Chandra, Sidhartha Goyal, Sanjay Jain, Matteo Marsili, Vidyanand Nanjundiah, Anirvan Sengupta, Mukund Thattai and Michele Vendruscolo

DATES
9-20 December, 2013

VENUE
IISc, Bengaluru

Biology is undergoing a revolution. Advances in experimental techniques are providing data of unprecedented quality and detail on the mechanisms that operate in living systems, at scales ranging from molecules and molecular networks, to organisms, populations and ecosystems. It is clear that new theoretical and mathematical approaches are required if we are to learn from this flood of data. In response to this need, a large number of researchers from mathematics, physics and engineering are growing interested in biological problems. However, biology presents high barriers to entry: the sheer breadth of biological phenomenology, the rapid progress of the field, and a language of scientific discourse often inaccessible to the outsider. The ICTP-ICTS Winter School in Quantitative Systems Biology 2013, targeted at participants with quantitative backgrounds, helped overcome these barriers.

By targeting young researchers, particularly those at the PhD and post-doctoral level with quantitative backgrounds, this school gave participants a broad introduction to open problems in modern biology, and provided pedagogical instruction on new quantitative approaches being used to address those problems. Lectures by internationally-recognized leaders in the field were supplemented by tutorials on basic topics, and hands-on sessions designed to extend the pedagogical material.

SPEAKERS AND TALKS

Mukund Thattai	*Prokaryotic genetic networks; Eukaryotic intracellular traffic networks*
Edward Cox	*Cell motion and cooperation*
Boris Shraiman	*Statistical genetics and evolution; A Physicist's View of Biology (Public Lecture)*
Fernando Quevedo	*Overview of Particle Physics after the Higgs Discovery (Abdus Salam Memorial Lectures)*
Robert Phillips	1. *A feeling for the numbers in Biology* *2. Napoleon is in equilibrium; Signaling and biology's greatest model*
Arthur Lander	1. *Pattern formation* *2. Control of Growth* *3. Special challenges of big data in biology*
M. Venkadesan	*How throwing made us human* (Colloquium)
Michele Vendruscolo	*Protein function and disfunction*
Antonio Celani	1. *Chemosensing* *2. Chemotaxis*

Eytan Domany	*Outcome prediction in Breast Cancer*
Anirvan Sengupta	*Model selection for large datasets*
Eytan Domany	1. *Dynamics of transcriptional response* 2. *Moving from Physics to Biology*

ORGANIZERS
Jeremie Bec,
Rahul Pandit and
Samriddhi Sankar Ray

DATES
14-18 October, 2013

VENUE
ICTS-TIFR, Bengaluru

TRANSPORT OF PARTICLES IN TURBULENT FLOWS: EXPERIMENTAL, COMPUTATIONAL AND THEORETICAL INVESTIGATIONS

Particle-laden turbulent flows are ubiquitous in nature, laboratories and modern industry: examples include the transport of aerosols and pollutants in the atmosphere, the advection of rain drops in clouds, the movement of swarms of micro-organisms like phytoplankton in the oceans, and fluid flows with colloids or polymer additives in laboratories or industries. It behooves us, therefore, to develop a detailed understanding of the physics of particle transport in turbulent flows. Research in this area has been growing apace on all fronts - experimental, computational, and theoretical. In particular, the transport, coalescence, and coagulation of particles, advected by turbulent flows, have attracted the attention of several groups. In addition to the complexity that arises from the turbulence of advecting flows, we have to confront the multiscale nature of particle-fluid interactions, for particle sizes can range from nanometre to centimetre scales; and these particles can often change the rheology of the underlying flow. To develop a good understanding of particle transport in such flows, we must adopt an interdisciplinary approach that combines ideas from physics, mathematics, and engineering and brings together computational, experimental, and theoretical studies. Advances in computational power and experimental techniques have led to several important results in this area. This meeting covered these exciting developments.

This discussion meeting was held as an ICTS-IISc joint program with support from the EADS Corporate Fondation Chair.

SPEAKERS AND TALKS

Massimo Cencini	*Clustering of swimming microorganisms in turbulent flow*
Giorgio Krstulovic	*Clustering, fronts, and heat transfer in turbulent suspensions of heavy particles*
Prasad Perlekar	*Spinodal decomposition in turbulent flows*
Shiva Kumar Malapaka	*Some Peculiar Statistical Properties Observed in DNS of Forced and Decaying 3D-MHD Turbulence*
Guido Boffetta	*Swimming of plankton in turbulence*
Ewe-Wei Saw	*Extreme relative velocities between droplets in turbulent airflow*

Rahul Pandit	*Particles in Turbulence: Time-dependent Correlation Functions and Persistence-time Statistics*
Rama Govindarajan	*Dynamics of particles in integrable vortical flow: possible bearing on cloud flows*
Croor Singh	*Attracting xed points for heavy particles in the vicinity of multiple vortices*
Ananyo Maitra	*Crawling solids*
Dhrubaditya Mitra	*Planetesimal formation by turbulence mediated collisions*
Dario Vincenzi	*Non-spherical particles in turbulent flows*
Srikanth Sastry	*Dynamical transition and memory in cyclically deformed* amorphous solids (SPECIAL SEMINAR)
Raymond Shaw	*Particle response to turbulent mixing in clouds*
Laurent Chevillard	*Orientation dynamics of small, triaxial-ellipsoidal particles in isotropic turbulence*
Mamadou Cisse	*Motion of large neutrally-buoyant particles in turbulence: analogy* with wall flow
Akshay Bhatnagar	*Persistence-time statistics in three-dimensional, homogeneous,* isotropic, fluid turbulence
Bernhard Mehlig	*Tumbling of axisymmetric particles in turbulent and random flows*
Colm Connaughton	*Inverse problems in droplet coagulation*
Anupam Gupta	*Statistical Properties of Inertial Particles in 2D, Homogeneous, Isotropic Fluid Turbulence*
Mysa Ravi Chaithanya	*Fluid-elastic interactions in heaving exible foil*
Francois Laenen	*Modelling inertial particles in turbulent flows by means of probability distributions*
Jeremie Bec	*Effective rates in dilute advection-reaction systems*

ORGANIZERS
Pallab Basu,
Suvrat Raju and
Spenta Wadia

DATES
22-23 September, 2013

VENUE
ICTS-TIFR, Bengaluru

THE INFORMATION PARADOX, ENTANGLEMENT AND BLACK HOLES

This meeting was held as part of the ICTS-IISc joint program to discuss recent progress on the black-hole information paradox, and the question of whether AdS/CFT can provide a useful description of the interior of black holes.

Long ago, Hawking found that the thermal radiation from black-holes appeared to be in conflict with the unitarity of quantum mechanics. It was believed, especially after the advent of the AdS/CFT correspondence that Hawking's calculation was not precise enough to provide a paradox, and that small effects in the CFT would reconcile Hawking radiation with unitarity.

Recently, there have been several claims, starting with the work of Mathur, and followed by the work of Marolf, Polchinski and others that this is impossible; rather unitarity implies that quantum effects modify the structure of the horizon of the black-hole.

hird one, we require that the operator identified as the "local field" depends on the microstate of the black-hole. The fourth one is difficult to reconcile with AdS/CFT or even energy-momentum conservation.

This meeting took stock of the claims and counter-claims in the literature. Broadly speaking, the following positions were articulated:

- Quantum effects modify the horizon structure, and the interior of a black-hole has a firewall, or that AdS/CFT does not describe the interior at all.
- Quantum effects modify the horizon structure, but the black-hole is described not by the smooth Schwarzschild geometry, but by various fuzzball solutions.
- Subtle non-local effects restore unitarity, so that the interior of the black-hole is in, some sense, a rewriting of the degrees of freedom that reside in the far-away radiation.
- Information loss really does occur in gravity.

SPEAKERS AND TALKS

Gautam Mandal	*Hawkings derivation of Black-hole entropy and Hawking radiation*
Sandip Trivedi	*The AMPS firewall and related topics*
Justin David	*Entanglement Entropy - (I)*
Aninda Sinha	*Entanglement Entropy (II)*
Suvrat Raju	*An infalling observer and the information paradox in AdS/CFT*
Dileep Jatkar	*Quantum error correction and the information paradox*

CHALLENGES IN GENOMICS AND COMPUTING: AN INAUGURAL UIUC-STRAND-ICTS-TIFR COMPGEN DISCUSSION MEETING

ORGANIZERS
Vijay Chandru,
Ravi K. Iyer, Gene Robinson,
R.K. Shyamasundar and
Spenta Wadia

DATES
22-24 July, 2013

VENUE
ICTS-TIFR, Bengaluru

Sequencing across species and across individuals is proceeding at a pace that far outstrips the capabilities of today's computer technologies. Indeed, while genomic data are quadrupling every year, the available computer power can at best double each year. Further, many algorithmic approaches in bioinformatics rely on direct comparisons of nucleotide sequences and optimization combined with statistical techniques and probabilistic models that do not scale to the massive data. To achieve the biological and consequent healthcare breakthroughs promised by advances in genome sequencing, new and disruptive computing technologies must be developed.

Breakthroughs can be envisaged by considering how features of genomic data can inspire new computational methods. Such innovations can occur only with an interdisciplinary team of computer engineers and scientists working closely with genomic biologists and bioinformatics specialists. It is a challenge to arrive at novel computational paradigms that shall have requisite innovative and scalable approaches for extracting small amount of relevant data from the big data, accurate algorithmic analyses and computational primitives supported by hardware-software co-design, and high-performance hierarchical storage.

This discussion meeting explored the following:

- Structure and features of Genomic data that can inspire new computational paradigms
- Mapping Genotype to Phenotype, Genotypic Determinants of Human Disease, Detection of Genomic Variation, Metagenomics
- Algorithmic scalability challenges.
- Deeper understanding of the data, integration of this knowledge into a domain-specific Computational platform
- Machine learning for Big data, computing on encrypted data
- Computational Test Bed and Managing Big data

The discussion meeting also arrived at a white paper calling for the creation of a center for Computing for Genomics and focused computing/biology groups to address each of the three target applications

(i) a configurable computing Test-bed (CompGen) with nodal interfaces at both Illinois and TIFR

(ii) inter-disciplinary programs to nurture and build quality human resources and

(iii) an industry consortium to develop application, hardware and software partnerships.

US-INDIA ADVANCED STUDIES INSTITUTE ON THERMALIZATION: FROM GLASSES TO BLACK HOLES

ORGANIZERS
Aparna Baskaran,
Bulbul Chakraborty,
Chandan Dasgupta,
Matthew Headrick,
Albion Lawrence,
Gautam Mandal,
Sanjib Sabhapandit and
Krishnendu Sengupta

DATES
10-21 June, 2013

VENUE
IISc Bengaluru

The study of thermalization has become an especially hot topic of research in the past several years, and there are multiple advanced workshops on the subject. However, these have been aimed at experts in the field. There is a clear need for an instructional program targeted at educating junior researchers across the disciplines including statistical mechanics, hard and soft condensed-matter physics, biophysics, nuclear physics, string theory, and quantum information theory. This program, in the format of a school, was aimed at promoting an intensive discussion of thermalization ranging from its conceptual foundations to modern-day applications in complex condensed matter systems, quantum information theory, and string theory.

The school was partitioned into the following six modules:

1. *Fundamentals of Classical Equilibration*
2. *Fluctuations and Nonequilibrium Thermodynamics*
3. *Broken Ergodicity and Glassy Dynamics*
4. *Quantum Information and Thermalization*
5. *Quantum Ergodicity and Quantum Quenches*
6. *Holography and Equilibration*

The primary pedagogical activities of the school were lectures, a subsequent tutorial, and lunch discussions among smaller groups. Each lecturer presented three lectures. Two of these were extended blackboard talks that gave the participants the basic tools of the theoretical framework at hand. A third talk was in the form of a short informal seminar that aimed to give a pedagogical presentation of the current research activities in the field, followed by a question-and-answer period of length comparable to the seminar itself.

SPEAKERS AND TALKS

Abhishek Dhar	*Fluctuations*
Amit Dutta	*Quantum quenches*

Henk van Beijeren	1. *Classical equilibration* *2. 1D Hydrodynamics* *3. KPZ equation*
Jorge Kurchan	*Glass Transitions*
Udo Seifert	*Stochastic thermodynamics*
Laurence Yaffe	*Non-Abelian plasma thermalization*
Alessandro Silva	*Quantum quenches*
Leticia Cugliandolo	*Coarsening and thermal quenches*
Anatoli Polkovnikov	*Quantum ergodicity*
Bulbul Chakraborty/ Chandan Dasgupta	*Falling out of Equilibrium Tutorial*
Patrick Hayden	*Quantum information and black holes*
Sumit Das	*Holography and Quantum Quenches*

NUMERICAL RELATIVITY

ORGANIZERS
P. Ajith, K. G. Arun,
Bala Iyer and Luis Lehner

DATES
10 June-5 July 2013

VENUE
ICTS-TIFR, Bengaluru

Numerical relativity deals with solving Einstein's field equations using supercomputers. Numerical relativity is an essential tool for the accurate modeling of a wide class of astrophysical phenomena, such as the collapse of massive stars (producing supernova explosions), merger of black holes or neutron stars (potentially producing gamma-ray bursts) and accreting black holes (in X-ray binaries or in galactic centers). Such high-energy astrophysical phenomena are prime targets for the upcoming gravitational-wave, electromagnetic and neutrino observatories.

This four-week long ICTS program included a summer school on numerical relativity and a workshop on three interface areas (analytical relativity and gravitational-wave astronomy, neutrino physics, and high-energy astrophysics) of numerical relativity. This program aspired to develop an active Indian research community in this emerging research frontier by training students in the area and linking Indian research groups working on related areas to international numerical-relativity groups.

SPEAKERS AND TALKS

Thomas Baumgarte	*Numerical relativity: Mathematical formulation*
Sascha Husa	*Introduction to theory and numerics of partial differential equations*
David Neilsen	*Introduction to numerical hydrodynamics*
Mark Hannam	*Advanced course in theory and numerics of partial differential equations*
Harald Pfeiffer	*Overview of current topics in numerical relativity*
B. S. Sathyaprakash	*Overview of current topics in gravitational-wave astronomy and astrophysics*
Bala Iyer	*PN convergence for spinning binaries*
B. S. Sathyaprakash	*Gravitational Astronomy: The Big Picture*
Harald Pfeiffer	*Spinning binaries in NR*
Masaru Shibata	*Coalescence and explosion of compact neutron star binaries*
(Manjari Bagchi Sarmistha Banik Christian Ott Arunava Mukherjee)	*Constraining EoS of neutron stars from the observations of neutron star mass: Status and prospects*
Christian Ott	*Modeling the Death of Massive Stars*
Brajesh Chandra Choudhar	*Upcoming neutrino experiments in the next decade*
Sovan Chakraborty	*Neutrinos from supernovae*

Bala Iyer	*From IndIGO to LIGO-India*
A. Gopakumar	*Some new work on spinning PN binaries*
Marc Favata	*Analytic approximation methods for gravitational-wave astronomy, GW memory*
Prateek Sharma	*Supermassive BH binaries, spin effects, etc*
Denis Pollney	*Cauchy-characteristic waveform extraction in NR*
P. Sreekumar	*Astrosat: Project and science*
Basudeb Dasgupta	*High-energy neutrino astronomy & synergy with GW astronomy*
Arunava Mukherjee	*GW generation mechanisms in neutron stars in X-ray binaries*
Harald Pfeiffer	*Numerical simulations of binary black holes*
Sukanta Bose	*Physics and astrophysics from networks of second-generation gravitational-wave detectors*

NCBS-ICTS MONSOON SCHOOL: PHYSICS OF LIFE

ORGANIZERS
Sandeep Krishna, Mukund Thattai and Madhusudhan Venkadesan

DATES
10-21 June, 2013

VENUE
NCBS, Bengaluru

The life sciences increasingly depend on quantitative measurements, multi-scale models and large datasets. The Monsoon School on the Physics of Life (i) Exposed undergraduate students from mathematics, physical sciences and engineering backgrounds to exciting problems in biology through research talks by biologists and physicists. Topics included: the structure and function of biomolecules; the organization of cells; the development of organisms from embryos to adults; the structure and function of the brain; populations and ecosystems; and aspects of evolution. (ii) Provided pedagogical instruction on a range of mathematical topics, so that students will be better prepared to enter PhD programs in computational biology, systems biology, biophysics, and related areas. Topics included: biophysics and soft-matter physics, ranging from aspects molecules to those of cells and tissues; information processing and decision making, at the level of cells or of the brain; stochastic processes in molecules or populations; dynamical systems models of genetic networks or biomechanical systems.

SPEAKERS

Pedagogical lectures
Madan Rao

Madhusudhan Venkadesan

Mukund Thattai

Sandeep Krishna

Shachi Gosavi

Research talks
Aswin Seshasayee

Deepa Agashe

Jayant Udgaonkar

M. K. Mathew

Sanjay Sane

Upinder Bhalla

PLANCK DAY

ORGANIZERS
Parameswaran Ajith, Archisman Ghosh

DATES
16 April, 2013

VENUE
ICTS-TIFR, Bengaluru

ICTS organized a one-day workshop to celebrate and discuss the recent results in Cosmology from the Planck mission. Planck is a space observatory of the European Space Agency and is designed to observe the anisotropies of the cosmic microwave background. Results from the first-year observation of Planck have been published recently. The workshop focused on various implications of these results on our understanding of the Universe. There were invited talks by eminent cosmologists.

SPEAKERS AND TALKS

Tarun Souradeep	*Cosmos revealed by Planck: Simplicity or Duplicity?*
Sanjit Mitra	*Extracting science from the Planck mission*
L. Sriramkumar	*Inflationary dynamics and non-Gaussianities: Planck and prospects*
Aditya Rotti	*Beyond the Isotropic Universe*
Shiv Sethi	*Constraints on massive and massless neutrinos*
Subha Majumdar	*SZ Cosmology with Planck*

ORGANIZERS
Darius Koester, Satyajit Mayor, John Mercer, Madan Rao and GV Shivashankar

DATES
15-26 April, 2013

VENUE
NCBS, Bengaluru

MECHANICAL MANIPULATIONS AND RESPONSES AT THE SCALE OF THE CELL AND BEYOND

This was a joint program of ICTS with NCBS and MechanoBiology Institute, Singapore.

The understanding of biological processes at a cellular and sub-cellular scale has made a big leap forward, thanks to the availability of new microscopy tools that enable sub-diffraction resolution and high-speed live cell / tissue imaging technologies that have made the advance from a qualitative to a quantitative description possible. Recently, the application of a wide variety of techniques to mechanically manipulate single molecules or multi-cellular cell composites has allowed scientists to begin addressing the question of how organisms react to controlled mechanical cues. This two-week long program introduced a scope of techniques to gain quantitative information of responses of the biological material (at all scales) to perturbations of a mechanical nature, and explored how the combination of theory and experiments would lead to a systematic deciphering of the physics of how living material engages with mechanical information. In addition, there was a short conference during the weekend between the two workshop weeks.

SPEAKERS AND TALKS

Dennis Discher	-
Maria Garcia-Parajo	*Effect of mechanical forces on the spatiotemporal organization of the beta2-integrin receptor LFA-1*
Cheng-han Yu	*Integrin-Matrix Clusters Form Podosomes in the Absence of Traction Forces*
Christoph Schmidt	*Tracking motor-protein and cytoskeletal dynamics with single-walled carbon nanotubes as stealth probes*
Roop Mallik	*Molecular and mechanical basis of organelle movement in cells*
P. Gayathri	*Mechanism of Plasmid Segregation by ParM, A Bacterial Actin*
Ravikrishnan Elangovan	*Development of magnetic tweezer for direct torque measurement on bacterial flagellar motor*
Sasha Bershadsky	-
Meghana Chayapathy	*Integrin adhesion drives the emergent polarization of active cytoskeletal stresses to pattern cell delamination*
Richard Treisman	*G-actin as a regulator of protein function*
Izabela Piechoka	*Expression and spatial organization of ICAM-1 molecules on the plasma membrane of endothelial cells under shear flow*
Pere Roca-Cusachs	*Rigidity sensing through regulation of integrin populations*

Dyche Mullins	*Mechanobiochemistry of Motile Actin Networks*
Daniel Fletcher	*Mechanical regulation of actin networks and the plasma membrane*
Andrew Clark	*Monitoring Actin Cortex Thicknessin Live Cells*
Ranjith Padinhateeri	*Dynamics of cytoskeletal filaments and force generation*
Wei Wei Luo	*Organization and dynamics of cytoplasmic actin networks*
Martin Lenz	*Disordered actomyosin contracts in unexpected ways*
Michael Murrel	*Contractility and Turnover in a Biomimetic CellCortex*
Darius Koester	*Reconstitution of Cortical Actin Dynamics Templating Membrane Organization*
Sven Vogel	*Actin Fragmentation (Turnover) and Lipid/Protein Diffusion Studied in Minimal Actin Cortices embrane-bound acto-myosin systems*
Christophe Lamaze	*Mechano-sensing and Mechano-signaling through Caveolae*
Nils Gauthier	*Membrane tension: a global physical signal that orchestrates cell functions*
Bidisha Sinha	*Understanding surface area regulation in cells*
Pramod Pullarkat	*Active mechanics and shape instabilities in axons*
Thomas van Zanten	*Nanophotonic approaches for spectroscopy and nanoscopy of cell membrane architecture*
Dave Odde	*Motor-clutch model for substrate stiffness sensing by living cells*
GV Shivashankar	*Nuclear mechanics & genome regulation*
John Mercer	*Actin- and myosin-Va-dependent cell-to-cell transfer of RNA*
Matthieu Piel	*Rounding up to divide or to move cell division and migration under confinement*
Guillaume Salbreux	-
Benoit Ladoux	*Emerging modes of collective cell behaviors under physical constraints*
Xavier Trepat	-
Thomas Lecuit	*Biomechanical control of tissue morphogenesis*
Maithreyi Narasimha	*Patterning transitions in cell behaviour during drosophiladorsal closure: The influence of Signals, Stresses Andgeometry*
Aparna Sherlekar	*Role of F-Bar Domain-containing Protein Syndapin in Plasma Membrane Polarity Formation during Drosophila Embryogenesis*
Sriram Ramaswamy	*Active hydrodynamics in the cell: nucleus, membrane and actin cortex*
Ronen Zaidel-Bar	*Molecular mechanisms regulating actomyosincontractility in C. elegans ovulation*

Mandar M. Inamdar	*Mechanical modeling of collective sheet migration*
Carl-Philipp Heisenberg	*Cell and tissue mechanics in zebrafish gastrulation*
Matteo Rauzi	*Embryo Scale Integration of Forces and Gene Patterns Controlling Tissue Morphogenesis*
Chaitanya Athale	*A mechano-chemical model of microtubule polarization in neuronal growth cone turning*
Madan Rao	-
Suvrajit Saha	*Cortical Acto-Myosin based active patterning machinery: Implications for the organization of cell surface molecules*

ORGANIZERS
Amit Apte, A. Jayaraman, Hann-Ming Juang, Amit Kesarkar, Ramchandra D Nair, Purnendranath Sen and Mahendra Verma

DATES
18-23 February, 2013

VENUE
National Atmospheric Research Laboratory (NARL), Gadanki, Andhra Pradesh

ADVANCED DYNAMICAL CORE MODELING FOR ATMOSPHERIC AND OCEANIC CIRCULATIONS

This program was organized as part of the activities related to the "Mathematics of Planet Earth 2013". The dynamics of geophysical phenomena are multi-scale in nature and the interaction between different scales makes the flow complex. Therefore, the system of coupled partial differential equations used in weather and climate models becomes complex which generally can only be solved numerically. The accuracy of the predictions obtained by numerical integration of these partial differential equations depends on model formulation, physical conservation principles, hypothesis and approximations used in their formulation and accuracy of numerical method used for the integration. The advanced dynamical core solvers used in atmospheric and oceanic general circulation models comprise designing of dynamical equations of conservations, latitudinal-longitudinal mesh, discretization method, temporal integration scheme, parallelization, integration on supercomputing platforms etc.

The challenges in the designing and development of advance dynamical core are to achieve required accuracy by their formulation and computational scalability while retaining required accuracy. The basic objective of this program was to bring together leading experts in the field to elucidate the challenges, practical considerations and opportunities and review the present state of understanding. In addition, another aim of this program was to encourage students and young researchers to take up advanced research problems related to dynamical core design.

SPEAKERS AND TALKS

Hann-Ming (Henry) Juang	*Advanced Dynamical Core Modeling for Atmosphere: current development and future plan*
Jimy Dudhia	*The global nonhydrostatic atmospheric model MPAS*
Todd D. Ringler	*Multi-scale climate modeling using geodesic grids techniques*

Jin Lee	*Global finite-volume non-hydrostatic Icosahedral Model*
U C Mohanty	*Meso-scale modeling of extreme weather events in tropics*
Dr G C Satyanarayana	*Formulation and discretization (Finite Difference/ Element) of Shallow Water equations over 2-D Sphere*
Bo-Wen Shen	*A View on the Predictability of Tropical Cyclogenesis with a Global Mesoscale Model*
U C Mohanty	*Meso-scale modeling of extreme weather events in tropics*
C V Srinivas	*Regional Atmospheric Modeling using WRF-ARW for seasonal scale monsoon and short-range tropical cyclones*
Mohan Kumar Das	*Cyclone Aila Moisture Effects on Heavy Rain*
A S Vasudeva Murthy	*Stability of partial differential equations of dynamical core*
Amit Apte	*Data Assimilation and Model Initialization*
S.K. Roy Bhowmik	*Data Assimilation and modeling efforts for operational forecasts in nowcast to medium range time scale at India Meteorological Department*
V Seshagiri Rao	*SEL: Dynamical weather forecasts for Space Launch Operations*
A Chandrasekher	*Semi implicit and semi Lagrangian methods*
Ramchandra Nair	*Advanced Numerical Methods for Atmospheric Modeling*
Todd Ringler	*Model for Prediction across scales- Ocean*
P. N. Vinaychandran	*High resolution Indian Ocean Modeling, Indian Ocean Modeling, problems & prospects*
P N Sen	*Discretization methods used in NWP: A Review*
S. Janaki Raman	*A variable resolution global spectral method with finely resolved tropics*
M Varalakshmi	*Formulation and discretization (Finite Volume) of Shallow Water equations over 2-D Sphere*
Jean Côté	*CMC–MRB Global Environmental Multiscale (GEM) Model*
V Balaji	*Flexible Modeling System GFDL*
Song-You Hong	*Global/Regional Integrated Modeling system (GRIMs)*
Anthony Thevenin	*OASIS3-MCT & Open-PALM: 2 open source codes couplers*
Mahendra Varma	*Physics of convective turbulence*
Bo-Wen Shen	*Scale Interactions of Tropical Waves and Tropical Cyclone Formation as Revealed by NASA Advanced Technologies*
A D Rao	*Simulation of coastal flooding due to storm surges using moving boundary treatment in the numerical model*

M. Midhun	*Application of Spectral Transform for discretization of Shallow Water equations over 2-D Sphere*
R Shankar	*Climate signals from Himalayan Glaciers and implications for climate models*
S Ramachandran	*Bio-geo-chemical, aerosol coupling in coupled models*
Jörn Behrens	*Numerical methods supporting the multi-scale character of ocean and atmosphere processes - lessons from modeling the 2004 Indian Ocean tsunami*
Amit P Kesarkar	*Dissipative Hamiltonian Dynamics and Climate Modeling*
Som Kumar Sharma	*Middle Atmospheric Climate Change over Indian Low Latitude Region: Modeling and Observations*
Jyoti Bhate	*Semi-Lagrangian Methods for discretization of Shallow Water equations over 2-D Sphere*
Rich Loft	*The Challenges of Massively Parallel Computing*
Ravi S Nanjundiah	*Parallel Computational Environments for modeling of atmospheric and oceanic flows*
Valentine Anantharaj	*HPC / Petascale computing, HPC, paradigm multi-core architecture, challenges in handling huge climate data*
V C V Rao	*Challenges in parallelization of atmospheric and oceanic models on Cluster of multicore systems with HPC Accelerators*
Rabindrakumar Nayak	*Numerical Investigation of Tidal and Residual Circulation in the Gulf of Khambhat and its surrounding on the West Coast of India*
Krishna Kishore Osuri	*Implementation of LDAS over India for Thunderstorm*
Sourav Mukherjee	*Dynamical core of the LMDZ weather model on GPGPU*
Jyoti Bhate	*Simulation of Diurnal Cycle of Convection and Rainfall in Global and Regional Models*
Radhika Kanase & P. S. Salvekar	*Understanding the Special features of cyclone Aila (2009) after landfall*
K B R R Hariprasad	*Numerical Simulation and Intercomparison of Boundary Layer Structure with six PBL schemes at a Tropical coastal site Kalpakkam with experimental observations*
Greeshma	*Numerical simulation of the Tropical Cyclone NILAM with WRF-ARW and comparison with meteorological tower and Doppler Weather Radar observations during landfall*
Venkat Ratnam	*Anthropogenic changes on the dynamics of the low latitude mesosphere: Observations and model simulations*
R. N. Ghodpage	*Mesospheric wave characteristic and there comparison with existing dynamical and photochemical models for OH emission over low latitude*
S P Gupta	*Role of electric field in producing turbulence in middle atmosphere*

D. P. Nade	*The Nocturnal Monthly and Latitudinal Variation in Characteristics of the Zonal Velocities of the Plasma Bubble over the Low Latitude (Kolhapur 16.42 o N, 74.2 o E, And 10.6o N dip Lat) Region*
Bhupendra Kumar Tiwari	*Effect of solar activity on galactic cosmic ray and global warming*
S. S. Nikte	*Study of Longitudinal and Latitudinal variations in the signal strength pattern of cosmic radio noise using riometers at southern and northern hemispheres*

CP VIOLATION IN ELEMENTARY PARTICLES AND COMPOSITE SYSTEMS

ORGANIZERS
B. P. Das, A. Dighe, S. Lamoreaux, N. Mahajan, R. Rangarajan, Bijaya Sahoo, Y. Sakemi, A. I. Sanda and A. D. Singh

DATES
7-23 February, 2013

VENUE
Mahabaleshwar

In the contemporary era of the Large Hadron Collider (LHC) in which physicists worldwide are hoping to find answers to many outstanding questions of particle physics, complementary attempts to look for new physics via non-accelerator probes are very significant. The field of CP violation is vast and is growing rapidly and independently in different research areas. It interconnects many areas such as particle, nuclear, atomic, molecular and solid state physics and involves experimental, theoretical and computational methods. This ICTS program on CP violation (PCPV 2013) brought together practitioners from such diverse fields as particle, nuclear and atomic physics, both experimental and theoretical, who have an interest in CP violation, on a single platform.

SPEAKERS AND TALKS

G. Castelo-Branco	*CP Violation in the Quark and the Lepton Sectors*
D. P. Roy	*Probing the Neutrino Mass Hierarchy and the CPV phase in the Foreseeable Future Experiments*
M. Nakahata	*Recent Results on Neutrino Oscillations and CP Violation Measurement in Neutrinos*
D. Budker	*Nuclear - Resonance Detection of Axion Induced Oscillating Electric Dipole Moments*
K. Jungmann	*Radium atoms to search for EDMs*
M. Bona	*Status of CKM in the light of recent results*
P. Paradisi	*CP and flavour violation in the charged leptonic sector*
G. Mohanty	*Experimental results on CP violation in the quark sector*
J. Hisano	*Neutron EDM in Physics beyond the Standard Model*
A. Soni	*Charming CP and all that*
A. Kundu	*Going beyond Mahabaleshwar: Search for CPT Violation*
G. Castelo-Branco	*Models of CP violation*

P. Geltenbort	*Ultra-Cold Neutrons and Searches for an Electric Dipole Moment*
P. Schmidt-Wellenburg	*Search for a neutron electric dipole moment a t PSI*
E. Shitani	*Nucleon EDM in lattice QCD*
T. Mibe	*Measurement of muon g - 2/EDM*
U.Yajnik	*Baryon asymmetry of the Universe and CP violation*
-	*CP violation results from BaBar*
A. Lytle	-
Ed Hinds	*Search for the electron EDM*
B. P. Das	*Theory of the Electric Dipole Moments of Atoms and Molecules*
A. V. Titov	*Study of T, P - nonconservation effects and hyperfine constants in diatomics and solids by the relativistic pseudo - potential/core - restoration method*
M. K. Nayak	*Theoretical studies of P & T violations in heavy polar molecules*
M. Abe	*Molecular orbital based calculations for the search of the electron EDM using the Coupled - Cluster method in the Dirac - Coulomb approximation*
M. Jung	*A robust limit for the EDM of the electron*
A. Petrov	*Hyperfine interaction in diatomics as a factor of influence on EDM experiments*
M. Chikamori	*The comagnetometer in 129 Xe active spin maser for EDM measurement*
S. Kanda	*Ultra cold Muon for J - PARC and muon (g - 2)/EDM experiment*
A. Vutha	*The electron EDM search using thorium monoxide*
T. Aoki	*Ultracold Rb - Sr atoms and FrSr molecules toward the search for an electron EDM*
Y. Ichikawa	*Experimental search for atomic EDM in 129 Xe at Tokyo Tech*
T. Fleig	*Electron Electric Dipole Moment P, T - Odd Constant for HfF + from Relativistic Correlated All - Electron Theory*
K. V. P. Lata	*Electric Dipole Moments of Some Closed-shell Atoms*

MATHEMATICAL PERSPECTIVES ON CLOUDS, CLIMATE, AND TROPICAL METEOROLOGY

ORGANIZERS
Amit Apte, G. S. Bhat, Andrew Majda, Ravi Nanjundiah, Roddam Narasimha, K. R. Sreenivasan, J. Srinivasan and Jai Sukhatme

DATES
22-26 January, 2013

VENUE
ICTS-TIFR, Bengaluru

This meeting was organized as part of the activities related to the "Mathematics of Planet Earth 2013".

The scientific themes of the Ramanujan Lectures delivered by Andrew Majda were modelling of wave phenomena in the tropics, study of convection and relations to clouds, and filtering or assimilation of chaotic signals in complex systems such as the atmosphere.

The discussion meeting, centred around these lectures, covered the following topics:

- Mathematical theory of tropical meteorology
- Observations and numerical simulations of these phenomena
- Role of clouds and convection in the tropics
- Prediction and data assimilation techniques

Convection in the tropics occurs across scales, from the scale of little eddies of a few mm or less to that of clouds to the planetary scale Walker and Hadley circulations. These scales continuously interact and exchange energy. Unlike in most other fluid mechanical phenomena, the energy transfer could be a two way process in the tropical atmosphere i.e. energy released at the small scales could drive the larger scales and there could be a cascade of energy from larger to smaller scales. These interactions are important for understanding tropical circulation and hence for predicting the weather/climate in the tropics.

One of the major features of the tropical atmosphere is the Madden Julian Oscillation (MJO) which occurs at the subseasonal (10-40 day) timescale. This is known to have a major impact on other tropical phenomena such as the Indian monsoon and the El-Nino Southern Oscillation (EnSO). The meeting focused on the mechanisms that govern these phenomena, new observations which will throw light on hitherto unknown aspects of these phenomena and also on modelling and simulating them using a hierarchy of models.

Filtering of chaotic systems, which is known as data assimilation in the context of earth sciences, is certainly very important for the study of tropical meteorology. In particular, the ocean-atmosphere interaction plays a key role in modulating the flow across different temporal and spatial scales, and assimilation of such signals is a major challenge. The meeting therefore included discussion on these topics and their relation to the other themes.

SPEAKERS AND TALKS

T N Krishnamurti	*Stratocumulus, Towering Cumulus during Undisturbed Weather and Heavy Orographic Rains with possible Geoengineering applications.*
D.R. Sikka	*Perspective Of Progress in Monsoon Meteorology and Prospects in the next two Decades*
Boualem Khouider	*Stochastic and Deterministic Models for Tropical Convection*
Samuel Stechmann	*Convective momentum transport and multiscale models*
R. Narasimha	*A review of recent laboratory and numerical simulations of cumulus cloud flows*
J. Srinivasan	*Thermodynamic Constraints on the ITCZ*
Ravi Nanjundiah	*Seasonal Prediction of Indian Monsoon: Role of Ocean-Atmosphere Coupling*
M. Rajeevan	*Vertical distribution of Clouds over the Indian Monsoon Region and its relationship with Cloud Radiative forcing and sea surface temperatures*
Arindam Chakraborty	*Medium-range Forecast Error: Air-sea Coupling, Clouds, and Scale of Meridional Propagation*
Andrew Majda	*Climate Science, Waves, and PDE's for the Tropics: Observations, Theory and Numerics.* ***(Ramanujan Lecture)***
Sulochana Gadgil	*Understanding the Indian monsoon and its variability*
Jai Sukhtame	*Moisture gradients and low-frequency variability in the tropics*
Olivier Pauluis	*Interactions between planetary scale flow and convection in an idealized Walker circulation*
Mitchell Moncrieff	*Tropical Convection in Global Context: The YOTC Project*
G. S. Bhat	*Clouds: Some observed features*
Andrew Majda	*Applied Math Perspectives on Stochastic Climate Models* ***(Ramanujan Lecture)***
Wojciech Grabowski	*Turbulence-microphysics interactions in boundary layer clouds*
Amit Apte	*Nonlinearity and stability in Lagrangian data assimilation*
Ibrahim Hoteit	*Sequential and Variational Assimilation for Predicting Loop Current in Gulf of Mexico: Toward Hybrid?*
Robert Breidenthal	*The peculiar behavior of stationary and accelerating vortices*
Andrew Majda	*Data Driven Methods for Complex Turbulent Systems (Ramanujan Lecture, ICTS Seminar Hall)*
D. Shankar	*Link between convection and meridional gradient of sea surface temperature in the Bay of Bengal*
John Harlim	*Test models for filtering and prediction of moisture-coupled tropical waves*

Nedjeljka Zagar	*Balance and tropical data assimilation*
Jörg Schumacher	*Moist Rayleigh-Benard convection in a conditionally unstable environment*
A. S. Vasudeva Murthy	*A linear sea breeze model relevant for the tropical regions*

ORGANIZERS
Roop Mallik, Dulal Panda, Krishanu Ray and Subhojit Roy

DATES
13-26 January 2013

VENUE
IIT, Mumbai and Mahabaleshwar

AXONAL TRANSPORT AND NEURODEGENERATIVE DISORDERS

Neurodegeneration, a broad symptom which arises out of several different dysfunctions, is prevalent in aging populations, and it mostly affects people after 50 years of age. There are both hereditary and sporadic cases. Alzheimer's, Parkinson's, Huntington's, Charcot Marie Tooth Type 2A (CMT2A), and a variety of different dementia are some examples. Recent research suggests that aberrant intracellular transport and mutations in the motor protein genes can induce such disorders in model organisms and humans. Recent reports also indicate that loss of mitochondrial transport, as well as the slow axonal transport, can induce dementia and neurofibrillary plaques in the brain. In view of these and other related developments, a large body of research has been launched world-wide to elucidate the connection between defective axonal transport and neurodegeneration. This ICTS program, jointly organized by faculties from TIFR, IIT Bombay and UC San Diego, highlighted this new area of research.

The program was organized in two parts:

(i) Advanced School January 13-19, 2013; Venue: IIT Bombay
(ii) Workshop January 20-26, 2013; Venue: The Club Mahabaleshwar

SPEAKERS AND TALKS

Scott Brady	1. *Neuron structure-function and historical research on axonal transport* *2. Regulation of fast axonal transport in health and disease* *3. Adult-Onset Neurodegeneration as Dysferopathies*
Bill Saxton	1. *Motor Proteins-biophysical characteristics and force generation mechanisms* *2. Direct observation of organelle transporting axons and questions about transport mechanisms* *3. Cytoplasmic streaming: how motors can move fluid*
Roop Mallik	1. *Biophysical Measurements of Motor function* *2. Force measurements on a single motor protein* *3. Tug of War: Motors fight it out inside a cell*
Dulal Panda	*Microtubule-form monomer to polymer and back*
Ranjith P	*Basics of Monte Carlo Simulations*

Gautam Menon	1. *Diffusion, Noise, and Brownian Motion: Concepts and Simple Estimates from Models relevant to Motors* *2. Simple Models for Axonal Transports*
Krishanu Ray	1. *Kinesin-2: A unique hetertrimeric motor* *2. Selective Axonal Transports by Kinesin-2*
Ambarish Kunwar	*Computational Techniques to Understand Single Motors*
Pramod Pullarkat	1. *Cellular force measurements* *2. Shape instabilities in axons*
Peter Hollenbeck	1. *Historical perspectives and current questions on axonal transport mechanisms and regulation* *2. Mitochondrial Transport, Metabolism and ROS Production in Disease Models* *3. Location and Organization of Features of the Mitochondrial Life Cycle in Neurons*
Peter Baas	1. *Microtubule organization in neurons, neuron development and disease* *2. Microtubule Polarity Orientation in Neurons: The Story behind the Story* *3. Microtubule-Severing Proteins in the Axon: Implications for Degeneration and Regeneration* *4. Mitotic Motors co-Regulate Microtubule Organization in Axons and Dendrites*
John Mercer	1. *Intracellular transport by (and other functions of) Myosins* *2. Myosin V at the synapse and in RNA transport between cells*
Subhojit Roy	1. *Human neurodegenerative neuropathology-the template for asking the right questions* *2. The Curious Case of the Soluble Protein: A new paradigm in axonal transport*
Anna Akhmanova	1. *Regulation of microtubule dynamics* *2. A zoo at the tip: a dynamic protein network controls the fate of microtubule ends*
Dulal Panda	*Unusual MAPs and Microtubule assembly in vivo*
Michel Steinmetz	*Molecular mechanisms of microtubule tip tracking*
Yishi Jin	1. *Genetic approaches to synapse formation* *2. From synapse formation to axonregeneration: tale of a kinase*
Sandhya Koushika	*Regulation of synaptic vesicle transport*

ORGANIZERS
Shiraz Minwalla, Sandip Trivedi

DATES
7-9 January, 2013

VENUE
TIFR, Mumbai

DISCUSSION MEETING: STRING THEORY

This three day discussion meeting on String theory focused on five areas.

- The exact counting of black hole entropy
- The black hole information paradox
- AdS/CMT
- Hydrodynamics and Gravity
- Higher Spin theories and their holographic duals.

There were sessions devoted to each of these topics. Each session consisted of a review talk followed by a moderated discussion.

SPEAKERS AND TALKS

Session I: Exact counting of Black hole entropy

Dileep Jatkar	*Review talk on exact counting of black hole microstates*
Justin David	*Discussion on exact counting of black hole microstates*

Session II: Black Hole information paradox

Kyriakos Papadodimas	*Review talk on the black hole information paradox*
Ashoke Sen	*Discussion on the information paradox*

Session III: AdS/CMT

Hong Liu	*Review talk on AdS/CMT*
Sandip Trivedi	*Discussion session on AdS/CMT*

Session IV: Hydrodynamics and gravity

Amos Yarom	*Review talk on Hydrodynamics and gravity*
Shiraz Minwalla	*Discussion session on Hydrodynamics and gravity*

SESSION V: Higher Spins

Xi Yin	*Review Talk on Higher Spins and Chern Simons*
Rajesh Gopakumar	*Discussion on Higher Spin theories*
Frederik Denef	*Review Talk on DeSitter space in higher spin theories*

MINI WINTER SCHOOL ON QUANTUM INFORMATION AND COMPUTATION

ORGANIZERS
Urbasi Sinha, Aninda Sinha

DATES
3-5 Jan, 2013

VENUE
ICTS-TIFR, Bengaluru

The aim of this school was to provide students and researchers an introduction to the field of quantum information, computation and communication. Topics that were covered included introduction to quantum information and computation, quantum algorithms, quantum error correction, NMR based quantum computing, solid state quantum computing, quantum optics and quantum photonics. The purpose was to provide young participants an idea about the wide scope of the rapidly expanding area of quantum computation science from leading international experts.

SPEAKERS AND TALKS

Barry Sanders	*Introduction to Quantum Information and Computing*
Stephen Lyon	*Electron Spin Qubits*
Ashwin Nayak	1. *Quantum Information Theory* 2. Quantum Algorithms and Complexity 3. Semi definite programming in Quantum Information
Barry Sanders	*Quantum Simulations*
Raymond Laflamme	1. *NMR Quantum Information Processing* *2. Quantum Error Correction*
Girish Agarwal	*Quantum Metrology*
Thomas Jennewein	*Quantum Communication and QKD*

RECENT TRENDS IN ERGODIC THEORY AND DYNAMICAL SYSTEMS

ORGANIZERS
Tarun Das, Ravi Rao

DATES
18-29 December, 2012

VENUE
Department of Mathematics, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara

'Dynamical Systems' is an exciting and very active field in mathematics that involves tools and techniques from many areas. A dynamical system can be obtained by iterating a function or letting evolve in time the solution of an equation. Even if the rule of evolution is deterministic, the long term behavior of the system is often chaotic. Different branches of 'Dynamical Systems', in particular 'Ergodic Theory', provide tools to quantify this chaotic behavior of the system and to predict it in average.

This program was planned in two parts: a seven-day workshop followed by four-day Discussion Meeting. The aim was to bring together on one platform experts from around the world who are actively working in various sub-disciplines of Dynamical Systems. An important aspect of the program was the emphasis put on making it accessible to younger participants.

SPEAKERS AND TALKS

Benjamin Weiss	*The Isomorphism Problem in Ergodic Theory - Recent Developments*
Amos Nevo	*Diophantine approximation, arithmetic groups and ergodic theory*
Jaydev Artherya	*Gap Distributions for the Golden L*
Vasili Bernik	*New connections between Dynamic Systems, Metric theory of Diophantine approximation and distribution of algebraic numbers*
Naoya Sumi	*Diffeomorphisms preserving hyperbolic SRB measures*
Kari Eloranta	*Sequences with long range exclusions*
Mythily Ramaswamy	*Control of Differential Equations*
Alexander Gorodnik	*Z^K - actions on nilmanifolds and Diophantine approximation*
Arnaldo Nogueria	*Classical homogeneous multidimensional continued fraction algorithms are ergodic*
Jon Aaronson	*Rational weak mixing in infinite measure spaces*
Barak Weiss	*Examples for the horocycle owon moduli spaces*
V. Kannan	*Coexistence of cycle lengths for linear operators*
Anish Ghosh	*Bounded orbits of flows on homogeneous spaces*
Francois Ledrappier	1. *Talk about Prof. Dani's work – 1* *2. Entropies and rigidities of compact manifolds*
Elon Lindenstrauss	1. *Talk about Prof. Dani's work – 2* *2. An effective proof of the Oppenheim Conjecture*
S. G. Dani	*Lattice subgroup actions and diophantine approximation with binary quadratic forms*

Riddhi Shah	*Embeddability of infinitely divisible probability measures on Lie groups*
Ravindra Kulkarni	*Inductive Construction of Representations of Finite Solvable Groups*
Kazuhiro Sakai	*Measure expansive diffeomorphisms*
Nimish Shah	*Equidistribution and counting on orbits of geometrically infinite hyperbolic groups*
Tom Ward	*Group automorphisms from a dynamical point of view*
Mahesh Nerurkar	-
Pralay Chatterjee	-
Vadim Kaimanovich	*Random graphs, stochastic homogenization and equivalence relations*
Tarun Das	*C^1 - generically continuum - wise expansive homoclinic classes are hyperbolic*

ORGANIZERS
Sudip Bhattacharyya, Subha Majumdar and Bhaswati Mookerjea

DATES
10-21 December, 2012

VENUE
TIFR, Mumbai

ASTRONOMICAL SURVEYS

This was a comprehensive program covering frontline research in multiple disciplines of astronomy, astrophysics and cosmology. The program was organized in two parts:

(i) Winter School on Astronomical and Cosmological Surveys, 10-17 December, 2012

(ii) Young Astrophysicists' Symposium, 19-21 December, 2012

The purpose of the school was to expose young Indian researchers to the underlying physics and data analysis issues in large scale observational surveys and subsequent use in addressing outstanding problems in astronomy and astrophysics. It helped to prepare the students to exploit the huge astronomical database that the different surveys and astronomy missions (for example VLT, Gemini, Subaru, XMM-Newton, Chandra, Spitzer, Herschel, ALMA, Astro-H, JWST, Suzaku, eROSITA, DES, LSST, Euclid, LOFT, ATHENA, Kepler etc.) have created.

The symposium was a confluence of primarily young and senior researchers across various disciplines of astrophysics to foster extensive interactions. It also gave young researches, especially those who are abroad, a feel of the institutional opportunities existing in India congenial for their further research career in India.

SPEAKERS AND TALKS

School

Sarbani Basu	*Stellar and Planet Search Surveys*
Varsha Kulkarni	*Surveys for ISM and IGM*
Ravi Sheth	*Galaxy Surveys*
Dipankar Bhattacharya	*Surveys for High Energy Astrophysics*
Alexandre Refregier	*Weak Lensing Surveys*
Subha Majumdar	*Cluster Surveys*

Symposium

R. Sheth	*Anisotropic Clustering and Nonlocal Bias*
S. Nadkarni-Ghosh	*Non-linear Density Velocity Relation from Phase Space Dynamics*
E. Bourbakhsh	*Groups of Galaxies in the Large Scale Astronomical Redshift Surveys*
A. Hasheminzadeh	*Fossil Galaxy Groups in the Millennium Simulation*
P. Tiwari	*Polarization Alignment in JVAS/CLASS Flat Spectrum Radio Surveys*
A. Gopakumar	*Astrophysical Aspects of Compact Binaries*
R. Basak	*Spectral Evolution in GRB Pulses*
R. Jain	*On the non-Gaussian imprints of primordial magnetic fields from inflation*
T.G. Sarkar	*Primordial Non-Gaussianity in the Ly alpha Forest*
A. Refregier	*Cosmology on a ball*
Y. Wadadekar	*Insights into Galaxy Evolution from Quantitative Morphology*
T. Roy Choudhury	*Constraints on Cosmological Reionization*
A. Roy	*Superbubble breakout and galactic winds from disk galaxies*
P.K. Rath	*Direction Dependent Power Spectrum and Its Effect on CMBR*
B. Paul	*Upcoming Indian Space Missions*
S. Bhattacharyya	*Relativistic Spectral Emission Lines from Accretion Discs of Neutron Stars*
S. Das	*CMB Lensing Research and Results: A Status Report*
R. Nair	*Probing Cosmic Acceleration with Multiple datasets*
R. Khatri	-
P. Natarajan	*Lensing by clusters: current status & future prospects*
A. More	*Lens Finding and Surveys*
A. Paranjape	*Excursion Set Peaks: A Self-consistent Model of Dark Halo Abundances and Clustering*
S. More	*From Galaxies to Cosmology*
S. Majumdar	*From Clusters to Cosmology – AGN Feedback*
E. Sefusatti	*Testing the initial conditions with the Large-Scale Structure of the Universe*
M. Musso	*Non-Gaussian Halo Statistics from Excursion Sets*
M. Shirasaki	*Cosmological Test with WL Minkowski Functionals*
P. Creminelli	*Symmetries of Primordial Perturbations*

ORGANIZERS
Arindam Ghosh,
Krishnendu Sengupta

DATES
16-18 December, 2012

VENUE
IISc, Bengaluru

MINI PROGRAM ON DIRAC MATERIAL AND QUANTUM COMPUTATION

The areas of quantum condensed matter physics and quantum information have made substantial theoretical and experimental progress in recent years. Some of such advances are discovery of materials such as graphene and topological insulators whose low energy quasiparticles obey effective Dirac equations, prediction of existence of Majorana fermions as effective low-energy quasiparticles of condensed matter systems, and theoretical and experimental progress in quantum computation.

This mini program, organized in the format of a school, was geared towards presenting the basic physics and current status of these topics to both graduate students and researchers from other sub-fields of condensed matter physics. The school had three pedagogical lectures by each of the four lecturers on graphene, topological insulators, non-Abelian quantum matter and quantum computation.

SPEAKERS AND TALKS

Mini Program

Krishnendu Sengupta	*Dirac physics in graphene: an introduction*
Steven M. Girvin	*Introduction to Circuit QED*
Joel Moore	1. *Topological insulators and other weakly - interacting topological phases* *2. Consequences of the Berry phase in solids: from topological phases to ferroelectrics, magnetoelectrics, and cuprates* *3. Topological phases arising from strong correlations*
Ady Stern	*Non - abelian anyons, Majorana fermions and topological quantum computation*

Discussion meeting

Steven M. Girvin Circuit	*QED: Wiring up Quantum Systems*
R. Vijayraghavan	*Evolution of the quantum wavefunction during measurement: From quantum jumps to feedback*
Roderich Moessner	*Topological and Flat Bands*
Ajay Sood	*Electronic topological transition from band to topological insulator under pressure in Sb2Se3*
Jim Eisenstein	*Condensate vs. Quasiparticle Transport in a Bilayer Quantum Hall Superfluid*
Sudhansu S. Mandal	*Possible Anti-Pfaffian Pairing of Composite Fermions at Filling Factor 3/8*
Sankar Das Sarma	*Advances in Graphene, Majorana Fermions, Quantum Computation* ***(Chandrasekhar Lecture)***

Joel Moore	*Approaching topological phases via numerics (DMRG) and topological field theories (of BF type)*
Zahid Hasan	*Topological Surface States in Topological Insulators, Superconductors and Beyond*
Ady Stern	*Fractionalizing Majorana Fermions: Non-abelian anyons on the edges of abelian quantum Hall states*
Diptiman Sen	*Transport at surfaces of topological insulators*
Subroto Mukerjee	*The chiral Mott phase of bosons in one dimensional optical lattices*
Michelle Simmons	*Quantum computing in silicon and the limits of silicon miniaturisation*
Charles Marcus	*A Fast Spin Qubit*
Sankar Das Sarma	*Majorana Fermions / Quantum computation* ***(Chandrasekhar Lecture)***
Rajdeep Sensarma	*Spectral Function in Bilayer Graphene: Quasiparticles and Plasmarons*
Amir Yacoby	*Correlated Electron Phenomena in Suspended Graphene*
Mandar Deshmukh	*Charge transport across tunable superlattice barriers in graphene*
Andrea Ferrari	*Graphene Interaction with Light*
Brijesh Kumar	*Quantum Ising Dynamics in the Rabi Lattice Model*
Sourin Das	*Correlation between dissipation and out of equilibrium noise in low dimensional mesoscopic systems*
Sankar Das Sarma	*Graphene/Topological insulators* ***(Chandrasekhar Lecture)***

ORGANIZERS
Hoshiyar Dhami,
Krishnendu Gongopadhyay,
Sanjay Pant and
Siddhartha Sarkar

DATES
3-16 December, 2012

VENUE
CEMS, Kumaun University,
Almora,
Uttarakhand

GROUPS, GEOMETRY AND DYNAMICS (GGD)

This program covered the areas of Geometry and Dynamics, which encompasses a large portion of Group Theory (finite or otherwise) in its proximity. The program was divided into two parts

(i) Advanced School, Dec 3 - 12, 2012

(ii) Discussion Meeting, Dec 13 - 16, 2012

The Advanced School was aimed mostly at young graduate and post-doctoral students. The Discussion Meeting led to the frontiers of current research and trends in the fields mentioned above.

SPEAKERS AND TALKS

Advanced School

C. S. Aravinda	*Crash course on Differential geometry and Lie groups*
Vikram Aithal	*Crash course on Covering space theory and fundamental groups*
Kashyap Rajeevsarathy	*Crash course on Hyperbolic plane geometry*
Pralay Chatterjee	*Lattices in Lie Groups*
Moira Chas	*The Goldman bracket on Fuchsian groups, String topology and three manifolds*
S. G. Dani	*An Introduction to Flows on Homogeneous Spaces*
Gareth Jones	*Beauville surfaces and groups*
Mahan Mj	*Recent Developments in Kleinian Groups*
Jose Seade	*Complex Kleinian Groups*
Anthony Weaver	*Discrete Groups and Riemann Surfaces*
Virginie Charette and Todd Drumm	*Lorentzian Geometry*
François Guéritaud	*The Geometry and Topology of Margulis Spacetimes*
John R. Parker	*An Invitation to Complex Hyperbolic Geometry*
Peter Shalen	*Quantitative Geometry of Hyperbolic 3-Manifolds*

Discussion Meeting

Jayadev Athreya	*Gap Distributions and Homogeneous Dynamics*
Valeriy Bardakov	*Groups of virtual links*
Kingshook Biswas	*On almost isometric extension of Moebius maps*
Waldemaar Barrera & J. P. Navarette	*Kulkarni Limit Set Of Subgroups Of $PSL(3, \Bbb{C})$*
Pallavi Dani	*Filling invariants: homological vs. homotopical*
Kealey Dias	*Bifurcations of Complex Polynomial Vector Fields in C*
Gopal Datt	*Transcendental dynamics: escaping sets and composite functions*
Allan Edmonds	*Introduction to Haken n-Manifolds*
Fred Gardiner	*An extension of Slodkowski's holomorphic extension theorem*
Subhojoy Gupta	*Projective structures, grafting and Teichmüller rays*
William Harvey	*Discrete groups and the geometry of manifolds*
Quitzeh Morales Meléndez	*Noncommutative signature (and fixed points)*
Tarakanta Nayak	*Omitted values and Herman rings of small periods*
Olivier Sargent	*Values of linear maps on quadratic surfaces*
Siddhartha Sarkar	*On p-groups of Gorenstein-Kulkarni Type*
Ser P. Tan	*Coxeter group actions on C^4 preserving quartic varieties: Dynamics and Identities*

ORGANIZERS
Sheetal Dharmatti,
Raju K. George, Utpal Manna,
A.K. Nandakumaran and M.P. Rajan

DATES
3-20 December, 2012

VENUE
IISER, Thiruvananthapuram

WINTER SCHOOL ON STOCHASTIC ANALYSIS AND CONTROL OF FLUID FLOW

Stochastic analysis and control of fluid flow problems have seen great mathematical advancement over past two decades. A vast number of physical and engineering systems are encompassed under various flow governing equations. Various applications lie in defense related problems, important one is aero-hydrodynamic drag reduction in aerial, surface and undersea vehicles. Other applications are in atmospheric and ocean data assimilation, plasma fusion and energy-environmental problems.

The school's aim was to make students and researchers across various organizations, working in fluid flow problems, well acquainted with the basic and advanced topics in control of partial differential equations (PDEs) arising from fluid dynamics with special emphasis on Navier-Stokes equations in both deterministic and stochastic settings. The winter school also comprised a one-day discussion meeting where a number of Indian senior experts presented their recent work related to the theme of the school.

SPEAKERS AND TALKS

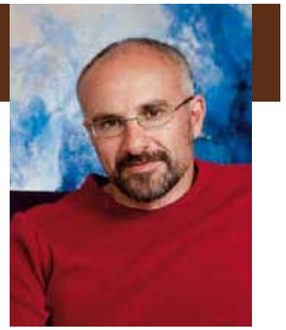
Barbara Ruediger	*Stochastic Integration & SDEs*
A.K. Nandakumaran	*An Introduction to deterministic optimal control and controllability*
Adi Adimurthi	1. *Basics of functional analysis, Sobolev spaces, embedding theorems, Lax Milgram theorem* 2. *Introduction to the semigroup theory*
A.J. Shaiju	*Deterministic viscosity solutions*
Mrinal Ghosh	*Controlled diffusion processes*
Suresh K	*Stochastic viscosity solutions*
Sivaguru S. Sritharan	1. *Introduction to deterministic and stochastic Navier-Stokes equations* 2. *Stochastic Navier-Stokes equations – solvability control*
Jean-Pierre Raymond	*Deterministic control in fluids*
P. Sundar	*Invariant measures and ergodicity for stochastic Navier-Stokes equations*
Bartosz Protas	*Applications of optimization and control methods in fluid mechanics*
Zdzislaw Brzezniak	*Landau-Lifshitz-Gilbert equations*
S.S. Ravindran	*Numerical Methods for Navier-Stokes Equations - Model Reduction, Control and Random Inputs*
Marco Romito	*Invariant measures and ergodicity for stochastic Navier-Stokes equations*

ICTS hosts a series of events that bring world class scientists and researchers to deliver lectures and engage in scientific discussion. The ICTS lecture series are often organized in conjunction with a discussion meeting. The three named lecture series – the Subrahmanyan Chandrasekhar lectures for Physical sciences, the Srinivasa Ramanujan for Mathematics and the Turing lectures for biology, computer science and engineering – have already made a very positive impact on the scientific landscape. Apart from these, Distinguished Lectures and the Abdus Salam Memorial Lectures are also organized.

LECTURE SERIES

SUBRAHMANYAN CHANDRASEKHAR LECTURE SERIES

STRONGLY CORRELATED SYSTEMS: FROM MODELS TO MATERIALS



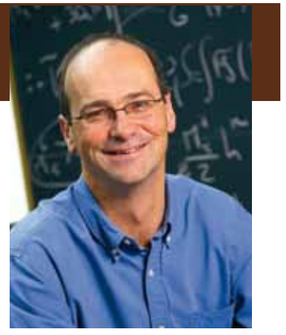
ANTOINE GEORGES
Professor of Collège de France and at Ecole Polytechnique
DATES
10, 11, 13 January 2014
VENUE
IISc, Bengaluru

LECTURE 1
Quantum Matter from Hot Superconductors to Cold Atoms.

LECTURE 2
Understanding and Controlling Materials with Strong Electronic Correlations: Recent Advances from Dynamical Mean-Field Theory.

LECTURE 3
Ultra-Cold Atoms meet Mesoscopics and Thermoelectrics.

NEW DIALOGUES: ENTANGLEMENT, HOLOGRAPHY AND RENORMALIZATION



ROBERT MYERS
Perimeter Institute for Theoretical Physics, Canada
DATES
10 December 2014
VENUE
ICTS-TIFR, Bengaluru

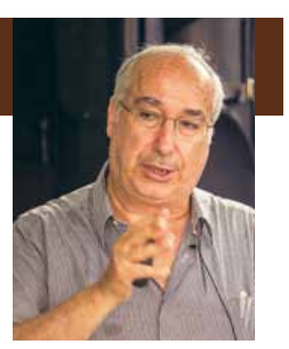
In science, we often see new advances and insights emerging from the intersection of different ideas coming from what appeared to be disconnected research areas. The theme of the colloquium was an ongoing collision between the three ideas listed in the title which has been generating interesting new insights into a variety of fields, eg, condensed matter physics, quantum field theory and even quantum gravity. Myers gave an introduction to each of these three ideas separately and then discussed the intersections that have been generating new insights in recent years.

QUANTUM ENTANGLEMENT IN MACROSCOPIC MATTER

T. SENTHIL
Department of Physics, Massachusetts Institute of Technology
DATES
13, 14, 15 January 2015
VENUE
IISc, Bengaluru

A powerful organizing principle to describe and distinguish phases of macroscopic matter is provided by the concepts of broken symmetry and long range order. Modern work in quantum condensed matter physics has however revealed the inadequacy of these concepts in capturing the essence of many different phenomena. A different set of concepts - centered around the notion of quantum entanglement on a macroscopic scale - is proving to be crucial in describing these phenomena. In these lectures, Senthil reviewed the physics of quantum matter characterized by interesting long range quantum entanglement rather than just by long range order. He described specific examples like quantum spin liquid phases in magnetism, non-Fermi liquid metals, and unconventional quantum phase transitions.

THE NONLINEAR PHYSICS OF DISORDERED SYSTEMS: FROM AMORPHOUS SOLIDS TO COMPLEX FLOWS



ITAMAR PROCACCIA
The Weizmann Institute of Science
DATES
6, 7, 8 April 2015
VENUE
ICTS-TIFR, Bengaluru

In a series of three lectures, Itamar Procaccia presented ideas and methods to advance the physics of strong disorder. As usual in nonlinear physics one rarely can employ standard methods - nonlinear systems require specialized thinking to provide useful progress. Nevertheless some generic techniques like scaling on the one hand and bifurcation theory on the other can find powerful ramifications in the explored issues.

LECTURE 1
Micro Big-Bangs and Quantized Vortex Dynamics in Turbulent Quantum Fluids
This lecture was about the study of small-scale turbulence in quantum liquids like low-temperature 4He and 3He by referring to some exciting new experiments. There was focus on the dynamics of the density of quantum singularities, propose new equations of motion for this density, and apply the results to explain the experiments.

LECTURE 2

Plasticity and Material Failure in Amorphous Solids

Procaccia explained the nature of plasticity in glasses (amorphous solids) in contradistinction to plasticity in crystalline solids. Armed with this understanding he focused on one of the catastrophic modes of failure of amorphous solids, i.e. shear banding. He also showed how to estimate the yield strain and the angle of the shear band from microscopic theory.

LECTURE 1

Cross Magneto-Mechanical Effects in Amorphous Solids with Magnetic Degrees of Freedom

Metallic glasses with magnetic components exhibit fascinating cross-effects between mechanical and magnetic responses. Magnetostriction and Barkhausen Noise are just a few of these effects. Procaccia described microscopic models of magnetic glasses and a theory to explain some of the interesting effects that are typical to such systems.

SRINIVASA RAMANUJAN LECTURE SERIES

MATHEMATICAL PERSPECTIVES ON CLOUDS, CLIMATE, AND TROPICAL METEOROLOGY

ANDREW J. MAJDA
Morse Professor of Arts and Science
Dept. of Maths and Courant
Institute, New York University, USA

DATES
22, 23, 24 January 2013

VENUE
ICTS-TIFR, Bengaluru

LECTURE 1

Climate Science, Waves, and PDE's for the Tropics: Observations, Theory, and Numerics

Geophysical flows are a rich source of novel problems for applied mathematics and the contemporary theory of partial differential equations. The reason for this is that many physically important geophysical flows involve complex nonlinear interaction over multi-scales in both time and space so developing simplified reduced models which are simpler yet capture key physical phenomena is of central importance. In mid-latitudes, the fact that the rotational Coriolis terms are bounded away from zero leads to a strict temporal frequency scale separation between slow potential vorticity dynamics and fast gravity waves; this physical fact leads to new theorems justifying the quasi-geostrophic mid-latitude dynamics even with general unbalanced initial data for both rapidly rotating shallow water equations and completely stratified flows.

At the equator, the tangential projection of the Coriolis force from rotation vanishes identically so that there is no longer a time scale separation between potential vortical flows and gravity waves. This has profound consequences physically that allow the tropics to behave as a waveguide with extremely warm surface temperatures. The resulting behavior profoundly influences longer term mid-latitude weather prediction and climate change through hurricanes, monsoons, El Nino, and global teleconnections with the mid-latitude atmosphere. How this happens through detailed physical mechanisms is one of the most important contemporary problems in the atmosphere-ocean science community with a central role played by nonlinear interactive heating involving the interaction of clouds, moisture, and convection. The variable coefficient degeneracy of the Coriolis term at the equator alluded to earlier leads to both important new physical effects as well as fascinating new mathematical phenomena and PDE's. In this equatorial context, new multi-scale reduced dynamical PDE models are even relatively recent in origin.

After a brief discussion of the observational record as background, this lecturer surveyed the remarkable new hyperbolic systems that have emerged recently in applications

including their physical properties, applied mathematical and rigorous mathematical theory. These last topics include novel relaxation limits for climate models with active moisture and new singular limits for hyperbolic PDE's with variable coefficients.

LECTURE 2

Applied Math Perspectives on Stochastic Climate Models

We are entering a new era of Stochastic Climate Modeling. Such an approach is needed for several reasons: 1) to model crucial poorly represented processes in contemporary comprehensive computer models such as intermittent organized tropical convention in the atmosphere and mesoscale/submesoscale eddies in the ocean; 2) to quantify uncertainty in intermediate and long rang forecasts where both uncertainty in initial data and forcing play a role 3) to represent unresolved stochastic backscatter from small scales to large scales in midlatitude dynamics. The lecture had three parts which illustrated how contemporary applied mathematics contributes novel stochastic ideas and potentially practical algorithms for these important problems. The use of judicious simplified but complex mathematical models for turbulent dynamical systems was emphasized throughout the lecture.

LECTURE 3

Data Driven Methods for Complex Turbulent Systems

An important contemporary research topic is the development of physics constrained data driven methods for complex, large-dimensional turbulent systems such as the equations for climate change science. Three new approaches to various aspects of this topic are emphasized here: 1) the systematic development of physics constrained quadratic regression models with memory for low frequency components of complex systems; 2) Novel dynamic stochastic superresolution algorithms for real time filtering of turbulent systems; 3) New nonlinear Laplacian Spectral Analysis (NLSA) algorithms for large dimensional time series which capture both intermittency and low frequency variability unlike conventional EOF or principal component analysis. Examples included dynamic stochastic superresolution (DSS) for the mesoscale eddy heat flux from coarse satellite altimetry measurements and low frequency and intermittent modes in SST form 800 year runs of CCM.

LOCALLY SYMMETRIC SPACES, AND GALOIS REPRESENTATIONS

PETER SCHOLZE
The University of Bonn, Germany
DATES
25-28 March 2014
VENUE
TIFR, Mumbai

One of the most studied objects in mathematics is the modular curve, given as the locally symmetric space which is the quotient of 2-dimensional hyperbolic space by congruence subgroups of SL_2(Z). In particular, it is naturally the home of modular forms. It also has an algebraic structure as the moduli space of elliptic curves, and this algebraic structure implies that one can attach number-theoretic objects, such as Galois representations, to modular forms. The simplest generalization of the modular curve are the Bianchi manifolds, introduced in 1892 by the Italian differential geometer Luigi Bianchi, which are quotients of 3-dimensional hyperbolic space by congruence subgroups of SL_2(O_F), where F is an imaginary-quadratic field. Although these are just real manifolds, which do not admit an algebraic structure, it has been speculated already around 1970 that their singular homology, including the large torsion subgroup, knows about Galois representations. The aim of the lecture series was to first explain this conjecture and its higher-dimensional generalizations, and the recent work resolving this conjecture.

AUTOMORPHIC FORMS AND GALOIS REPRESENTATIONS

CHANDRASHEKHAR KHARE
University of California Los Angeles
DATES
3, 5, 7 November 2014
VENUE
TIFR, Mumbai

Modular forms are holomorphic functions on the upper half plane which have a high degree of symmetry. Galois Theory studies permutation symmetries of roots of polynomial equations defined over the rationals. There is a close and occult connection between these two completely different symmetries. This lecture series explored this connection, putting special emphasis on the case when the group of symmetries of the roots of the polynomial is the group of two by two invertible matrices over a finite field.

LECTURE 1

Modular forms and Galois representations

This was a broad overview of the connection between Galois groups and modular

forms, and reciprocity laws in this context which links the two. One such law is Serre's modularity conjecture which has the particular consequence that there is a unique, irreducible, odd motive of rank 2 over the rationals, of weight 12 and with good reduction everywhere. It arises from the Ramanujan Delta-function.

LECTURE 2

Automorphy lifting theorems

This lecture talked about a technique used in the proof of Serre's modularity conjecture. This technique, called modularity/automorphy lifting, was developed by Wiles in his proof of Fermat's Last Theorem. It allows one to go "backwards" from a Galois representation to a modular form. (The "forward" direction from modular forms to Galois representations was known earlier by the work of Eichler, Shimura, Deligne and Serre.) It's likely to be a key tool in any attack on higher dimensional analogs of Serre's conjecture.

LECTURE 3

Dimensions of deformation rings and generic unobstructedness

This lecture focused on the deformation rings of Galois representations as defined by Barry Mazur. Their spectra are moduli spaces of Galois representations. These moduli spaces provide a context for the study of a classical conjecture of Leopoldt. Khare indicated how automorphy lifting techniques give rather complete information about these moduli spaces in the self-dual case, while in the non-self-dual case, the corresponding moduli spaces are still shrouded in mystery. It is the latter case which is relevant to Leopoldt's conjecture which postulates a dimension formula for these spaces.

ALAN TURING LECTURE SERIES

OVERCOMING COMPUTATIONAL INTRACTABILITY IN UNSUPERVISED LEARNING

SANJEEV ARORA
Princeton University

DATES
7 January 2015

VENUE
IISc, Bengaluru

Given today's data deluge, unsupervised learning i.e. learning with unlabeled data is becoming increasingly important. Most natural problems in this domain e.g. for models such as mixture models, HMMs, graphical models, topic models and sparse coding/dictionary learning, deep learning are NP-hard. Therefore researchers in practice use either heuristics or convex relaxations with no concrete approximation bounds. Several non-convex heuristics work well in practice, which is also a mystery. The talk described a sequence of recent results whereby rigorous approaches leading to polynomial running time are possible for several problems in unsupervised learning. The proof of polynomial running time usually relies upon nondegeneracy assumptions on the data and the model parameters, and often also on stochastic properties of the data (average-case analysis). Some of these new algorithms are very efficient and practical. E.g. for topic modeling.

THE CONTEXTUAL BANDITS PROBLEM: A NEW, FAST, AND SIMPLE ALGORITHM

ROBERT SCHAPIRE
Microsoft Research and
Princeton University

DATES
7 January 2015

VENUE
IISc, Bengaluru

In the contextual bandits learning problem, the learner must repeatedly decide which action to take in response to an observed context, and is then permitted to observe the received reward, but only for the chosen action. The goal is to learn through experience to behave nearly as well as the best policy (or decision rule) in some possibly very large space of candidate policies. We assume that the learner can only access this policy space using an oracle for solving empirical cost-sensitive classification problems; in practice, most off-the-shelf classification algorithms could be used for this purpose. In this very

general setting, a new, fast, and simple algorithm that achieves a regret guarantee that is statistically optimal was presented. Moreover, this algorithm makes very modest use of the oracle, which it calls far less than once per round, on average. These properties suggest this may be the most practical contextual bandits algorithm among all existing approaches that are provably effective for general policy classes. This is joint work with Alekh Agarwal, Daniel Hsu, Satyen Kale, John Langford and Lihong Li.

VERSATILITY OF SINGULAR VALUE DECOMPOSITION

RAVI KANNAN
Microsoft Research
DATES
7 January 2015
VENUE
IISc, Bengaluru

Singular Value Decomposition (SVD) is a basic tool to deal with matrix data and has traditionally been applied in a variety of fields. In the modern setting, matrix sizes have increased, but improved sampling based algorithms are still effective. Besides, many new applications of SVD to Gaussian Mixtures, Nearest Neighbors, Topic Modeling etc. have been developed. Combined with a simple device of thresholding, SVD is useful on a new bunch of problems. The talk discussed from first principles some recent developments.

DISTINGUISHED LECTURES

THE UNIVERSE BEFORE THE HOT BIG BANG

VALERY RUBAKOV
Moscow State University, Russia
DATES
24 November 2014
VENUE
IISc, Bengaluru

It has been known for a long time that the Universe went through the hot Big Bang stage, with extraordinarily high temperatures of matter and extremely rapid expansion of space. It is less known that existing observational data strongly suggest that the hot Big Bang stage was not the first one, but was preceded by yet another epoch with completely different and unusual – properties. The best guess for that early epoch is cosmic inflation, but alternative theories are not yet ruled out. It is reassuring that future cosmological observations will most likely be capable of unveiling the nature of the earliest epoch and physics that governed the Universe at that time.

SQUARE VALUES OF MATHEMATICAL EXPRESSIONS, FROM ANCIENT TIMES TO THE MODERN DAY

MANJUL BHARGAVA
Princeton University
DATES
19 January 2015
VENUE
TIFR, Mumbai

Understanding whether (and how often) a mathematical expression takes a square value is a problem that has fascinated mathematicians since antiquity. In this lecture a survey of this problem, starting from its independent origins in many cultures in ancient times to some of the major advances of the modern day was described. How the problem closely relates to the very active and exciting area of modern mathematics known as “arithmetic geometry” and how the ideas of this subject have revolutionized cryptography and coding theory was also explained.

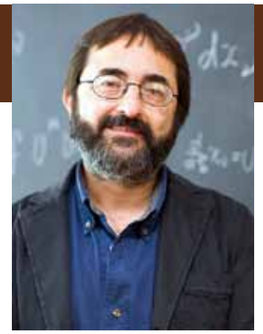
AGE OF NETWORKS

JENNIFER TOUR CHAYES
Microsoft Research New England &
Microsoft Research New York City
DATES
21 January 2015
VENUE
ICTS-TIFR, Bengaluru

Everywhere we turn these days, we find that networks can be used to describe relevant interactions. In the high tech world, we see the Internet, the World Wide Web, mobile phone networks, and a variety of online social networks. In economics, we are increasingly experiencing both the positive and negative effects of a global networked economy. In epidemiology, we find disease spreading over our ever growing social networks, complicated by mutation of the disease agents. In biomedical research, we are beginning to understand the structure of gene regulatory networks, with the prospect of using this understanding to manage many human diseases. In this talk, Jennifer Chayes looked quite generally at some of the models we are using to describe these networks, processes we are studying on the networks, algorithms we have devised for the networks, and finally, methods we are developing to indirectly infer network structure from measured data. She discussed in some detail particular applications to cancer genomics, applying network algorithms to suggest possible drug targets for certain kinds of cancer.

ABDUS SALAM MEMORIAL LECTURES

OVERVIEW OF PARTICLE PHYSICS AFTER THE HIGGS DISCOVERY



FERNANDO QUEVEDO
University of Cambridge, UK and
Director, ICTP
DATES
10 December 2013
VENUE
IISc, Bengaluru

The discovery of the Higgs boson has been one of the greatest scientific achievements of fundamental science in decades, establishing the validity of the Standard Model of particle physics beyond reasonable doubt. It has also led to very strong constraints on what new physics may exist beyond the Standard Model and is starting to put doubts on sacred principles of physics such as naturalness. An overview was presented on what avenues are left available to go beyond the Standard Model and address its main open questions such as dark energy and dark matter. A brief account was presented on Abdus Salam's vision regarding fundamental physics and science policy.

COMPLEXITY AND SIMPLICITY IN BIOLOGICAL SYSTEMS

RAMAKRISHNA RAMASWAMY
Vice Chancellor,
University of Hyderabad
DATES
21 November 2014
VENUE
IISc, Bengaluru

It is generally recognized that biological systems are complex - indeed they need to be complex, given the multiplicity of functions that they need to perform. The opposite of this profound truth (which as Niels Bohr alerted us to, may well be another profound truth) is that there can indeed be simplicity in biology as well. Some aspect of this potential simplicity was captured in the astonishing hypothesis of Francis Crick, that living organisms and all their actions, responses and even emotions are essentially the results of the complex reactions and interactions in collections of a vast number of fairly simple molecules.

OUTREACH

PUBLIC LECTURES

THE SPIN ON ELECTRONICS

STUART PARKIN
IBM Fellow and Director Max Planck Institute for Microstructure Physics
DATES
7 October 2014
VENUE
TIFR, Mumbai

The charge on an electron is commonly used in conventional electronics, unlike the spin degree of freedom. Using the spin is revolutionizing computing and storage.

STRINGS AND THE MAGIC OF EXTRA DIMENSIONS

CUMRUN VAFA
Harvard University
DATES
5 June 2013
VENUE
IISc, Bengaluru

The extra dimensions of string theory which were originally viewed as a source of embarrassment for the theory, have proven to be instrumental in resolving a number of puzzles associated with 3+1 dimensional physics. Vafa discussed examples of this in the context of black holes, gauge theory and particle phenomenology.

A PHYSICISTS VIEW OF BIOLOGY

BORIS SHRAIMAN
Kavli Institute for Theoretical Physics, University of California, Santa Barbara
DATES
13 December 2013
VENUE
IISc, Bengaluru

The interface of Biology and Physics is an exciting and rapidly developing frontier of science. The lecture drew examples from the study of animal development and the study of evolution – two of the fundamental problems of Biology – to illustrate the sometimes unexpected ways in which concepts, ideas and approaches of Theoretical Physics come to fore in the quest to understand the rich world of biological phenomena.

QUANTUM REALITY

SANKAR DAS SARMA
University of Maryland, USA
DATES
12 December 2012
VENUE
IISc, Bengaluru

Quantum mechanics, the underlying microscopic theory of our existence governing the behavior of the physical world, is the crowning success of human intellect. It is astonishingly successful-- no experiment contradicts the predictions of the theory, and the theory has been explicitly verified to be correct to a precision better than 1 part in a trillion. In the past 60 years, developments of quantum theory have led to the modern technology that has revolutionized the world through applications such as transistors, lasers, integrated circuits, and magnetic discs. Despite this great success we really do not understand the quantum theory in an intuitive manner because quantum laws are so radically different from the classical laws of physics. The dichotomy that the modern world is quantum, but the precise meaning of the quantum remains elusive, disturbed the stalwarts of physics such as Einstein, Schrodinger, and Feynman, and continues to baffle physicists even today. This lecture explored this curious state of affairs, highlighting the numerous quantum based ideas and applications which underpin our modern world and the sublime strangeness of the theory which completely eludes our intuition. Connection was made to some of the most exciting recent developments such as quantum computation which is bridging the gap between the 'weird' microscopic laws of the quantum world and some real life problems in our everyday world such as code breaking and database search.

SCHOOL TALKS

RAHUL ROY (IISc)
The Amazing nano world
Parikrma Foundation
7 February 2015

SIVA ATHERYA (ISI)
Workshop on problem solving in Mathematics
Parikrma Foundation
17 September 2014

SIVA ATHERYA (ISI)
Workshop on problem solving in Mathematics
Hesaraghatta School
17 September 2014

ARAVINDA (TIFR-CAM)
Some snippets from Euclidean Geometry
Hesaraghatta School
2 August 2014

ARAVINDA (TIFR-CAM)
Some snippets from Euclidean Geometry
Parikrma Foundation
7 November 2014

MUKUND THATTAI (NCBS)
Patterns in Biology
Parikrma Foundation
7 August 2014

COLLEGE WORKSHOPS

SREEKAR VADLAMANI (TIFR-CAM)
Probability and Statistics
ICTS seminar room
7 March 2015

ARVIND (IISc, Maths)
Counting and Tiling
Jain University
9 August 2014

BALA IYER (ICTS-TIFR)
What is Einstein's General Relativity?
Jain University
13 September 2014

Video Session

SAMRIDDHI SANKAR RAY (ICTS-TIFR)
Alfred Leitner – Liquid Helium II the Superfluid
https://www.youtube.com/watch?v=sKOlfR5OcB4
23 August 2014

MATHEMATICS OF PLANET EARTH 2013

ICTS was a partner in Mathematics of Planet Earth 2013 (MPE 2013), a global initiative for mathematics programs and outreach. MPE 2013 was aimed at encouraging research and education in identifying and communicating the role of mathematics in solving fundamental questions about Earth.

As part of this program, ICTS organized an exhibition from November 22-December 1, 2013, at the Visvesvaraya Industrial & Technological Museum (VITM) Bangalore. The exhibition was planned in collaboration with the TIFR Centre for Applicable Mathematics (CAM), VITM, and the National Council for Science Museums (NCSM). Inaugurated by Roddam Narasimha, the exhibition was designed and executed by a joint team from these organizations along with the Srishti School of Art, Design and Technology, Bangalore. The inaugural function was attended by principals and faculties from various colleges, students from local colleges, research institutes, design schools, academicians from various research institutes and several science enthusiasts.

The exhibition saw over 32,000 visitors in the span of ten days. It was also extensively covered by the media.

The focus of MPE 2013 was divided into four broad categories – a planet to discover, a planet supporting life, a planet organized by humans, and a planet at risk. The interactive exhibition, designed to make visitors feel at ease with mathematical ideas, involved models and visual information that most effectively express the vision of this initiative. The exhibition aspired to illustrate to the visitors the varied answers to the question that many of us have: what is mathematics useful for? There were more than 30 different exhibits. As part of the MPE-2013 exhibition, ICTS also conducted outreach activities in the form of interactive sessions involving mathematical discussions and experiments for children, youth, and teachers.

Prior to the exhibition, ICTS conducted four awareness workshops for undergraduates to guide them to prepare the exhibits for the exhibition. We encouraged them to form groups in different parts of India to discuss and help in making the exhibition operational.

CONCLAVE ON SCIENCE EDUCATION

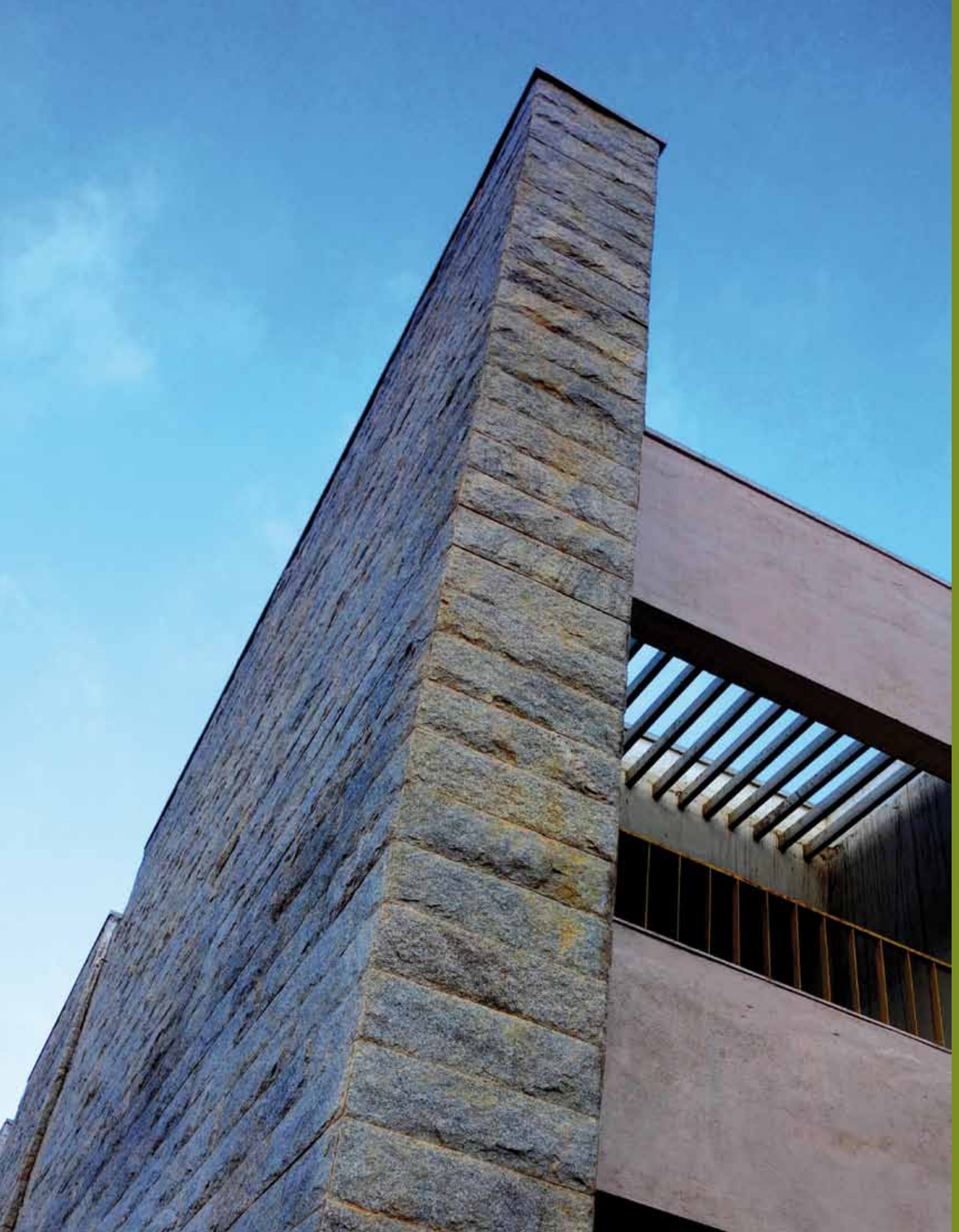
A science education conclave, jointly organized by ICTS and the Observer Research Foundation Mumbai, was held at the Faculty Hall of the Indian Institute of Science on November 21, 2014. The conclave discussed urgent reforms in science education and was attended by prominent members from academia and industry. Prof. T. V. Ramakrishnan of the Indian Institute of Science and BHU, Varanasi, chaired the discussion. Teachers from various colleges in Bangalore attended the conclave.

The first science conclave, held in Mumbai in July 2014, was presided over by Prof. C.N.R. Rao and attended by key stakeholders in science education. This initiative seeks to gather inputs from experts and the wider public to build consensus on the issue, and, to understand how each institution or individual can contribute to implementing the changes, and present the recommendations to the government for implementation. Online discussions are also underway on this topic which is of national importance.

OPEN DAY

Every year the Indian Institute of Science opens its gates to the public on Open Day, giving everyone access to the labs and research work. Departments organize experiments, lectures, quizzes aimed at various audiences – school, college students and also parents. ICTS also participates in this event.

This year Open Day was held on 28th February 2015. Post-docs, graduate students and project trainees organized the entire event. Different exhibits like metronome, steam engine, Fractals-MPE exhibit and various other exhibits demonstrating basic scientific principles were on display. Among other things, ICTS also had a Game zone where various interactive games like a Black Hole game, a walk a function game, were organized. There was also an audio-visual display about ICTS faculty as well as one on the general properties of the black hole. More than 350 students from across Bangalore visited ICTS on Open Day.



CAMPUS

The new ICTS campus is located in Hessarghatta, north Bengaluru, and spread over 78,000 square metres. The campus is planned to be self-contained and includes academic, housing and recreational facilities for more than 150 academic members, including 75 visitors. The architectural design provides space for maximum academic interactions. It contains lecture halls with enough capacity for meetings with hundred plus participants, an auditorium, recreation spaces and comfortable living quarters for staff and visitors. There will also be healthcare and childcare for members and visitors.

The firm of Venkatramanan and Associates from Bengaluru has created the architectural plan of the new campus, in close consultation with the academic members of ICTS and the project management group from the Department of Atomic Energy (DAE), Government of India. The vital task of managing the construction project and associated processes is being executed by a team of engineers from the Directorate of Construction, Services & Estate Management (DCSEM) of the DAE.

B.N.R.Prasanna, project engineer (BW) of DCSEM has played a key role in the supervision of the project. The agency responsible for the construction is JMC Projects (India) Ltd.

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Scientific Officer
Web Administrator

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Project Scientific Officer (till June 2015)

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AWARDS AND HONORS

P. AJITH

- Head of the Max Planck Partner Group in Astrophysical Relativity and Gravitational-Wave Astronomy at ICTS-TIFR (2015-2018)
- Associateship of the Indian Academy of Sciences (2014-2017)
- Ramanujan Fellowship from the Department of Science and Technology (2013-2018)

ABHISHEK DHAR

- Indo-Israeli grant, 2014-2017
- ANR (French National Research Agency) grant, 2015-2020.

RAJESH GOPAKUMAR

- TWAS Prize in Physical Sciences, 2013
- G. D. Birla Award for Scientific Research, 2013
- Elected Fellow of the National Academy of Sciences, India (NASI), 2014
- J. C. Bose Fellowship of the DST, Govt. of India, 2015

ANUPAM KUNDU

- Feinberg Fellowship from the Weizmann institute

BALA IYER

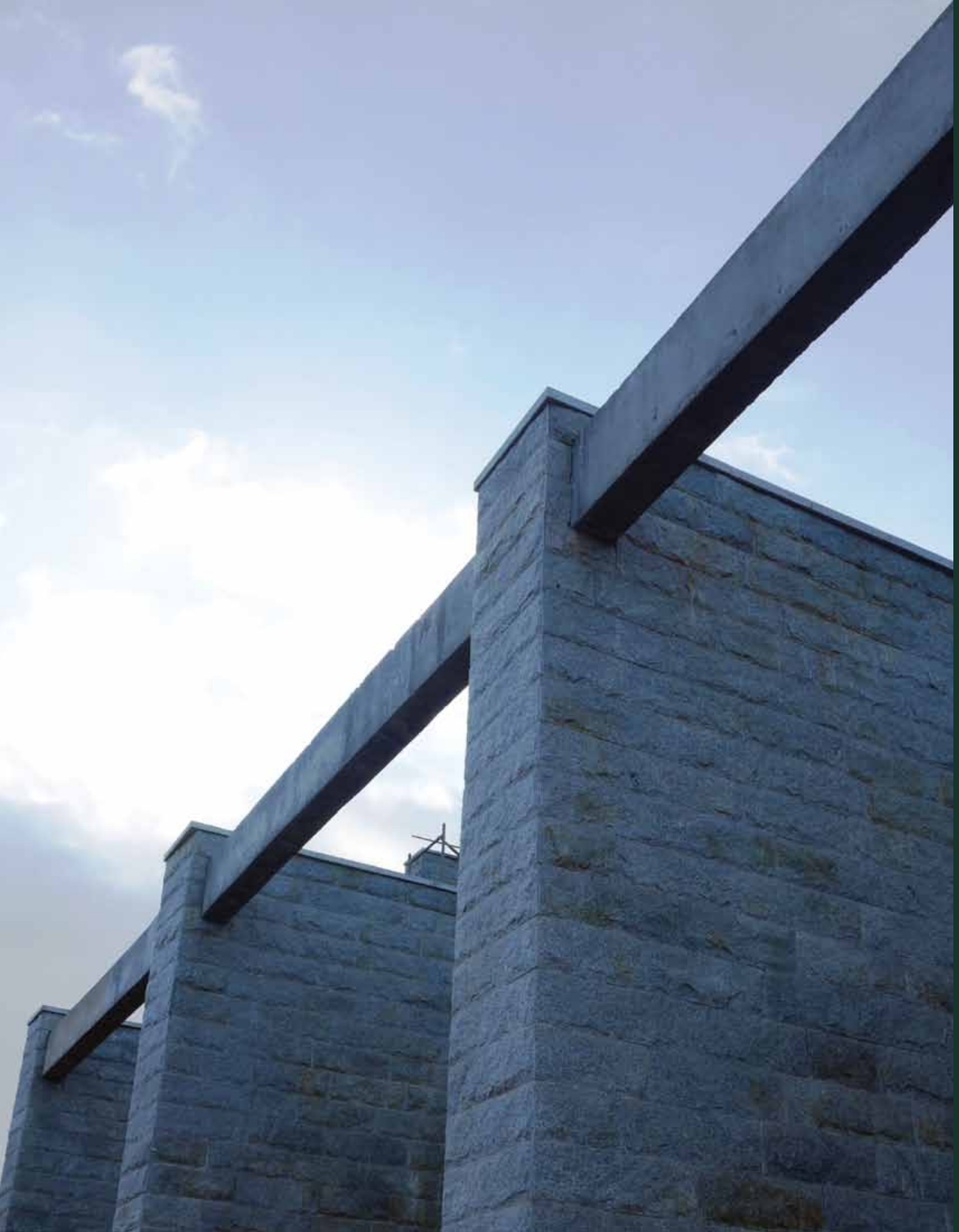
- Fellowship of the International Society of General Relativity and Gravitation (2013)
- Vaidya-Raychaudhuri Endowment Award of IAGRG (2015)
- Beller Lecturership for APS April 2015 meeting

SUVRAT RAJU

- INSA Young Scientist Medal, 2013
- NASI Young Scientist Platinum Jubilee Award, 2013

SPENTA R. WADIA

- J.C. Bose National Fellow, Dept of Science and Technology, Govt of India 2006-2011; 2011-present



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