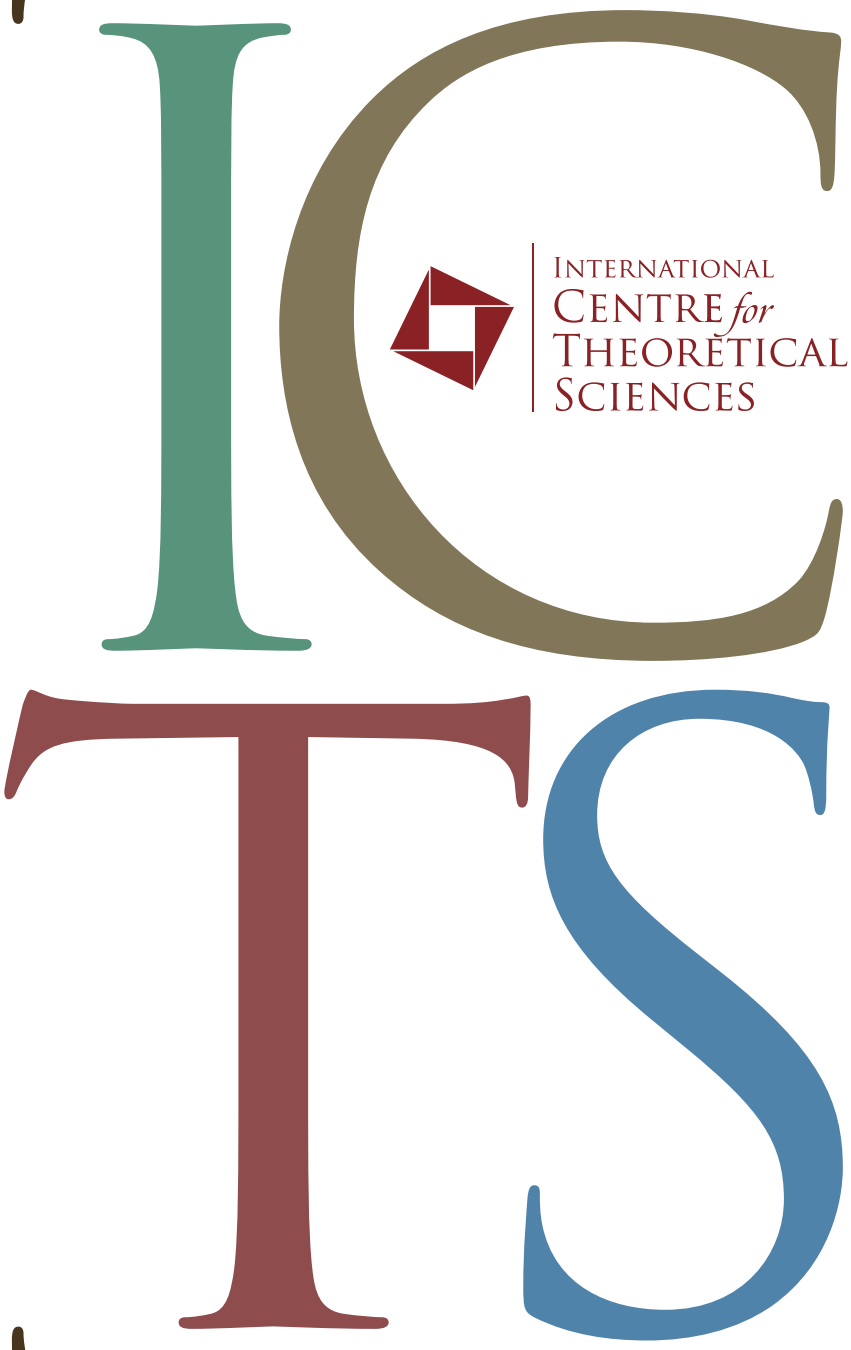


INTERNATIONAL CENTRE *for* THEORETICAL SCIENCES

We live in a world in which science, from mathematics through to biology and computer science, affects us all. By encouraging the full development of science across disciplines we help to shape the future.

–Michael Atiyah

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

CONTENTS

Brochure Editorial Team–Ananya Dasgupta, Parul Sehgal, Renu Singh
Design–Anisha Heble, Juny K Wilfred

I would describe ICTS with three words: Bold, Deliberate, Effective. Bold in its vision for its role in the Indian and international scientific community. Deliberate in its assessments of opportunity and in charting its path. Effective in supporting its faculty to achieve the full potential.
–Stan Whitcomb,
Caltech

FROM THE DIRECTOR'S DESK

"In our acquisition of knowledge of the universe (whether mathematical or otherwise) that which renovates the quest is nothing more or less than complete innocence ...
It alone can unite humility with boldness so as to allow us to penetrate to the heart of things ... "
Alexander Grothendieck (From *"Reaping and Sowing"*)

Grothendieck, in his wonderfully lyrical passage, had in mind the individual scientist and his or her, often, lonely quest. But I like to believe that, in essence, it also applies to the spirit of a scientific institution. What is it that gives a certain scientific environment that intangible zing which allows new paths to be charted, enables new breakthroughs ("to penetrate to the heart of things")? I like to believe that, beyond all the basic infrastructure, research support and other such essentials (not to underplay their importance), something more must be present in the air. And perhaps one element of this something is innocence.

As an institution in its childhood, at ICTS there is a notion of playfulness and, perhaps, naivety in our approach to all matters. We have a brand new campus like a new toy in the hands of our youthful faculty and students as well as enthusiastic admin staff - who are all eager to try new things, to do things differently. In short, to create a different ethos. After all, doing science is fun and we shouldn't lose sight of that (or horror, destroy it!) while we put in place institutional structures. It has been a real pleasure to work these last few years with all the members of the ICTS extended family in a spirit of camaraderie as we gradually made more and more of our campus functional and welcomed scientists to our first in-house programs.

And how fitting it was with this spirit when we learnt that seven of our family, including even a beginning graduate student, had participated in one of the most remarkable scientific discoveries in recent times - the

LIGO detection of gravitational waves emitted from the merger of a pair of giant black holes over a billion years ago. The vibrations from that event lingered long in the air at ICTS - we all partook a little from the thrill of gazing at the "*Universe in a New Light*". And for Diwali 2017, we delighted in the *Cosmic Fireworks* when news came of colliding neutron stars. When we brought Kip Thorne over to give our inaugural *Vishveshwara public lecture* in 2018, we were overwhelmed by the response - the event felt like a rock concert!

Our programs with their visitors (some from as far away as Chile or Colombia) rejuvenated us too with the scientific excitement they shared, whether it was about the second quantum revolution, machine learning, universality in sandpiles, understanding evolution quantitatively or observing the birth of the universe. With nearly thirty programs and discussion meetings having more than eighteen hundred participants (including around four hundred from abroad) in the last year, it was exhilarating to feel the energy of these activities course through the institute - the hubbub in the cafeteria at mealtimes, the small groups huddled around corridor blackboards or at our new coffee corner.

We began the second decade of ICTS with a stellar event celebrating the unity of science which featured talks by stalwarts in theoretical physics, mathematics, biology and theoretical computer science. It was a chance to look ahead to the areas where ICTS would like to grow in, while consolidating our strengths. We also aim to be hosting more of the Indian and world scientific community on our campus for one or other of our activities. Do come to ICTS and `Discover in India'. In addition to the grants from the Airbus and Simons foundations, we are also glad to receive strong support for our mission from the Infosys Foundation. Our flagship lecture series are now the *ICTS Infosys Chandrasekhar/ Ramanujan/Turing Lectures*. Emboldened by the success of our *Einstein lectures*, marking the centenary of general relativity, we had embarked in 2016 on "*Kaapi with Kuriosity*" - a science lecture series for schoolchildren

and the public in Bangalore city, in association with the Nehru Planetarium, by distinguished scientists in Bengaluru and program visitors. In summer 2019, we have launched a pilot "*Maths Circle*" in cooperation with NIAS-Bangalore for nurturing special talent in mathematics amongst 9th and 10th graders. Stay tuned for further developments.

Our Resource Development and Societal Engagement Wing aims to create more such partnerships between ICTS and the broader society we are embedded in. Through the "*Friends of ICTS*" program we invite everyone to get involved in our efforts and share the excitement of our journey. As we complete ten years, we are launching a drive to secure the future of ICTS by establishing an endowment, with an initial target of INR 20 Crores (approx. USD 3 million). I am confident that we can tap into the goodwill and appreciation of ICTS' unique mission to reach and surpass this target.

And as for our own researchers in the meanwhile, I am confident that their sense of play uniting "humility with boldness" will allow them to delve even deeper into the workings of the universe, in the years to come. Watch this page and share our journey.

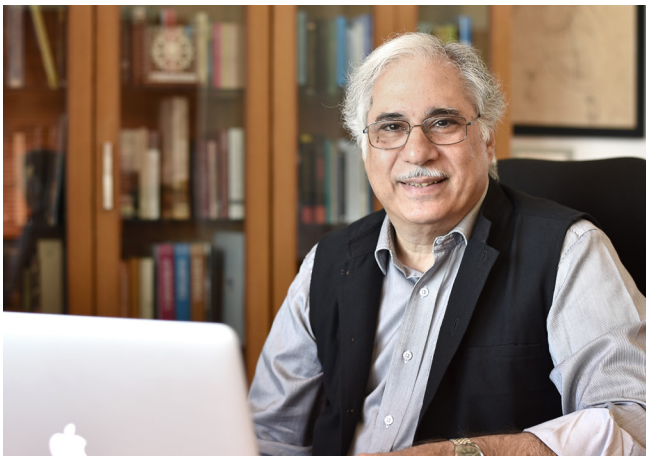
Rajesh Gopakumar
Centre Director, ICTS–TIFR
June 2019

THE ROAD TRAVELLED

The idea to create the ICTS was born in 2001, after the success of the Strings 2001 conference at TIFR Mumbai and a visit to the Infosys Campus in Bangalore. The former boosted our confidence based on our achievement in fundamental physics and the latter assured us that institutional infrastructure and management of the highest international quality was possible in India. The visit to the Infosys campus happened at the insistence of Edward Witten who was keen to visit the '*Temples of modern India*.' This combination of highest quality science within a modern state of the art campus, managed along modern thoughts inspired the basic idea of the ICTS. What made ICTS unique in India was that it was to be an international hub that would transform the ways of doing scientific research and advanced science education. I sent a proposal to Infosys Technologies but they were not ready to support this idea. In 2004, David Gross suggested that the core funding must come from the government and the way ahead.

The ICTS was approved by the TIFR Council in August 2007 to be a multi and interdisciplinary centre with 3 main goals -PROGRAMS that bring together physicists, astronomers, cosmologists, mathematicians, biologists, students and researchers from all over the world, under one roof, to work together to solve the most challenging questions posed by nature, to discover the underlying structures across the sciences and to strive for the unity of knowledge; In-house RESEARCH by highest quality faculty in the theoretical sciences; SCIENCE OUTREACH that stimulate and harness young minds of India and connects with members of the public who are interested in the latest scientific developments.

The next task was to create the Centre i.e. begin the programs and discussion meetings, find the government



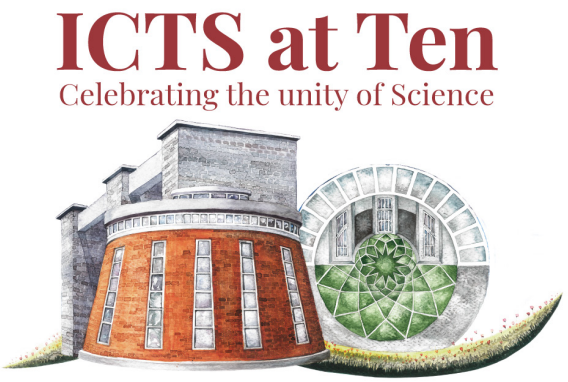
resources and land to build the campus, work with the architect for a design suitable for the ICTS mission, see through the execution of the architectural design, create a modern administrative support system, choose the research areas and attract outstanding faculty within each! This complex task involved a huge collective effort by members of TIFR (most notably Avinash Dhar), the Indian science community, and the Govt of India. Besides basic Govt support it was significant that ICTS received generous and crucial support from the Airbus Corporate Foundation, the Simons Foundation, the Infosys Science Foundation and the Infosys Foundation.

As it grew over the years, the Centre benefitted from the advice and blunt scrutiny of an International Advisory Board of eminent scientists, and the strong support and guidance of CNR Rao, K. Kasturirangan, H.R. Krishnamurthy, K. VijayRaghavan, Marie-Claire Certiat, Kris Gopalakrishnan, Andy Millis, Ardhendu Pathak and N. R. Narayana Murthy.

The new ICTS campus in Bangalore was inaugurated on 20 June 2015 and is now almost complete. In Rajesh Gopakumar, ICTS has got a very capable new Director since August 2015 who is taking the Centre forward with renewed vigour. During these past years ... *(CONT.)*

ICTS AT TEN

In January 2018, ICTS celebrated its 10th year with a celebratory scientific gathering. We heard broad perspective talks from a galaxy of distinguished researchers on subjects ranging from Quantum Gravity, Astrophysics, Statistical Physics And Physical Biology to Theoretical Computer Science and Mathematics. There was an associated public lecture by **Robbert Dijkgraaf**, followed by a panel discussion, on the theme of the "*Usefulness of Useless Knowledge*". *ICTS at Ten* was an opportunity for us to reflect on our journey thus far, plant the seeds for new initiatives and to pursue our dreams with renewed enthusiasm.



SPEAKERS

P. Ajith, *ICTS - TIFR*

Nima Arkani-Hamed, *IAS, Princeton*

Sanjeev Arora, *Princeton*

Leon Balents, *KITP, Santa Barbara*

Manjul Bhargava, *Princeton*

William Bialek, *Princeton*

Roger Blandford, *Stanford*

Sourav Chatterjee, *Stanford*

Jennifer Chayes, *Microsoft Research*

Abhishek Dhar, *ICTS - TIFR*

Surya Ganguli, *Stanford*

Rama Govindarajan, *ICTS - TIFR*

David Gross, *KITP, Santa Barbara*

Jonathon Howard, *Yale*

Shri Kulkarni, *Caltech*

Joel Moore, *UC Berkeley*

Mahan Mj, *TIFR, Mumbai*

Ramesh Narayan, *Harvard*

Christos Papadimitriou, *Columbia*

Suvrat Raju, *ICTS - TIFR*

Sriram Ramaswamy, *IISc, Bengaluru*

David Reitze, *Caltech*

Sankar Das Sarma, *University of Maryland*

Nathan Seiberg, *IAS, Princeton*

Ashoke Sen, *HRI, Allahabad*

Madhu Sudan, *Harvard*

Mriganka Sur, *MIT*

Mukund Thattai, *NCBS - TIFR*

Nisheeth Vishnoi, *EPFL, Lausanne*

(CONT.) ... ICTS has achieved some measure of success in its three missions. It is an international hub of science and its programs have had a significant impact on Indian science; its faculty has already made widely recognised contributions and its science outreach has become a fixture for science enthusiasts in Bangalore.

A successful institution like ICTS should grow unconstrained, expand the scope of its activities and continue to be an institution that integrates knowledge and human values. To this end ICTS will need the support of government, private foundations and all the people who care for '*truth*' and for an equitable future of humanity. (Read more at icts.res.in/about/history)

Spenta R. Wadia
Founding Director (Aug 2007–July 2015) and
Infosys Homi Bhabha Chair Professor, ICTS
Professor Emeritus, TIFR
June 2019

RESEARCH

The Centre is envisaged to have a high quality permanent faculty of modest size together with a large floating population comprising visitors, postdoctoral fellows and graduate students. The faculty members work in various areas of theoretical sciences. They carry out cutting-edge research, provide intellectual leadership and nurture a rich scientific culture. Their eminence attracts the brightest students and postdoctoral researchers as well as outstanding organizers and participants for the Centre's programs. ICTS also has a wide group of Associated Faculty, who are deeply involved in various activities of the Centre.

The in–house research 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, Condensed matter and Statistical Physics, Physical Biology and String Theory. There is a dedicated effort to establish a unit in Interdisciplinary/Exploratory mathematics. ICTS has also undertaken the process of building a vibrant mathematics and theoretical computer science group.

ASTROPHYSICAL RELATIVITY

This group pursues astrophysical applications of the general theory of relativity. In particular, the group is interested in different aspects of gravitational–wave physics and astronomy, including the modeling of the astrophysical sources of gravitational waves using analytical and numerical relativity, tests of general relativity using gravitational–wave observations, relativistic astrophysics, cosmology, high–performance computing, etc. The group is actively involved in the LIGO Scientific Collaboration and the Indian Initiative for Gravitational wave Observations, and has made direct contributions to deciphering the recent discovery of gravitational waves.

ICTS Faculty
P. Ajith ♦ *Gravitational-Wave Physics, Astrophysics*
Bala Iyer (Simons Visiting Professor) ♦ *Gravitational-Wave Physics, Analytical Relativity*

Postdocs
Apratim Ganguly, Haris M. K., Rahul Kashyap, Gayathri Raman

Associated Faculty
Rana Adhikari *(Caltech, USA)*, K. G. Arun *(CMI)*, Prayush Kumar (*Cornell University, USA)*, Tejaswi Venu Madhavan *(IAS, Princeton)*, B. S. Sathyaprakash *(Penn State University and Cardiff University),* Anand Sengupta *(IIT Gandhinagar)*, Prajval Shastry *(Retired from IIA, Bangalore)*

MATHEMATICS

The main idea of the mathematics unit in ICTS is to develop research that draws inspiration from and connects different mathematical disciplines and also to encourage collaborations with scientists in areas such as physics, biology, social sciences, earth sciences, computer science, and many others, thus making it an integral part of the scientific ecosystem within ICTS. Current research areas include dynamical systems, probability, nonlinear partial differential equations, geometry and mathematical physics.

ICTS Faculty
Amit Apte ♦ *Dynamical Systems, Data Assimilation*
Anirban Basak ♦ *Probability Theory*
Riddhipratim Basu ♦ *Probability Theory*
Rukmini Dey ♦ *Geometry, Mathematical Physics*
Pranav Pandit ♦ *Algebraic Geometry, Mathematical Physics*
Vishal Vasan ♦ *Partial Differential Equations, Nonlinear Waves and Fluid Mechanics*

Postdocs
Sumanto Chanda, Saibal Ganguly, Mohamed Saleem Lone, Varun Dilip Thakre, Shibi Vasudevan

Associated Faculty
Adway Mitra *(IIT Bhubaneswar),* Sujatha Ramdorai *(University of British Columbia, Canada)*

STATISTICAL PHYSICS, TURBULENCE, CONDENSED MATTER AND PHYSICAL BIOLOGY

This group pursues theory and applications of non-equilibrium statistical mechanics to a variety of systems including biological systems. Some of the areas of interest are - understanding heat transport in low-dimensional systems, non-equilibrium fluctuation theorems, turbulence, mechano-biological pattern formation in morphogenesis, frustrated magnetism, and topological insulators.

ICTS Faculty

Subhro Bhattacharjee ♦ *Condensed Matter Physics*
Chandan Dasgupta (Simons Visiting Professor) ♦ *Condensed Matter*
Abhishek Dhar ♦ *Statistical Physics*
Rama Govindrajan ♦ *Fluid Mechanics*
Vijay Kumar Krishnamurthy ♦ *Physical Biology*
Manas Kulkarni ♦ *Condensed Matter Physics*
Anupam Kundu ♦ *Statistical Physics*
Samriddhi Sankar Ray ♦ *Fluids and Turbulence*
Shashi Thutupalli (Joint Faculty - NCBS) ♦ *Physical Biology and Soft Condensed Matter Physics*

Postdocs

Adhip Agarwala, Amit Kumar Chatterjee, Arghya Das, Amit Dey, Pritha Dolai, Sangeeth Krishnan, Manoj Kumar, Priyanka Maity, Anish Mallick, Aabhaas Mallik, Sankaran Nampoothiri, Jason Ryan Picardo, Abhishod Prakash, Urbashi Satpathi, Jemseena V

Associated Faculty

Sumilan Banerjee *(IISc, Bangalore)*, Urna Basu *(RRI, Bangalore)*, Jérémie Bec *(CEMEF - MINES ParisTech, Sophia Antipolis)*, Debasish Chaudhuri *(IOP, Bhubaneswar)*, Bipin Kumar *(IITM, Pune)*, Amala Mahadevan *(Woods Hole Oceanographic Institution, USA)*, Nararyanan Menon *(University of Massachusetts, Amherst)*, Tapan Mishra *(IIT Guwahati)*, Vidyanand Nanjundiah *(CHG, Bangalore)*, Onuttom Narayan *(University of California, Santa Cruz)*, Arun Paramekanti *(University of Toronto, Canada)*, Thara Prabhakaran *(Indian Institute of Tropical Meteorology, Pune)*, Kabir Ramola *(TIFR, Hyderabad)*, Tridib Sadhu *(TIFR, Mumbai)*, Dario Vincenzi *(Nice Sophia Antipolis University, Nice)*

In just a few years, ICTS seems to have had tremendous impact on Indian science. The ICTS schools/programs in my own research area attract not only top international scientists but also some highly motivated and talented students. The ICTS discussion meetings are a novel alternate to the traditional conference format. I attended a cross-disciplinary discussion meeting a few years back which was one of the most stimulating and useful meetings in that area I have been to anywhere in the world.
–**Senthil Todadri,**
MIT

STRING THEORY AND QUANTUM GRAVITY

This group pursues various problems in black hole physics, the AdS/CFT correspondence and applications of this correspondence to some problems in condensed matter physics and cosmology, the conformal bootstrap, studies in Chern-Simons matter theories and higher-spin theories and beyond standard model physics.

ICTS Faculty

Avinash Dhar (Dean Emeritus and Visiting Professor) ♦ *String Theory, High Energy Physics*
Rajesh Gopakumar ♦ *Quantum Field Theory, String Theory*
R. Loganayagam ♦ *String Theory*
Suvrat Raju ♦ *String Theory, Cosmology*
Spenta R. Wadia (Infosys Homi Bhabha Chair Professor) ♦ *String Theory, Quantum Gravity and Statistical Mechanics*

Postdocs

Pinaki Banerjee, Bidisha Chakrabarty, Yogesh Dandekar, Sidharth G. Prabhu, Alexandre Serantes

Associated Faculty

Gautam Mandal *(TIFR, Mumbai)*, Shiroman Prakash *(Dayalbagh Educational Institute, Agra)*

> *We at the Simons Foundation are proud to provide financial support to the ICTS and I just want to tell you briefly why. Our job, our mission in the mathematics and physical sciences division of Simons Foundation is to foster excellence in the theoretical sciences radiating from mathematics. I think it's obvious to all of us that the outstanding high calibre of the members of ICTS, the focus that ICTS has in the connections between different areas of science and the key role it plays in forging links between scientists both across India and India with rest of the world, marks ICTS as one of the world's premier institutions in this area. One which is an honour and a privilege for the foundation to support.*
> –**Andy Millis,**
> Simons Foundation and Flatiron Institute

The ICTS is well–placed to play a leading role in theoretical physics, with a substantial international impact. In my own area of mathematical physics related to quantum fields and strings, many important contributions have been made by scientists working in India and I am sure that ICTS can play a major role in this field.
–Edward Witten,
IAS, Princeton

The ICTS is a fantastic addition to Bangalore's science landscape. Its defining role, to reach out both to scientists as well as to public, has helped bring existing institutions closer, and stimulated interactions which would not have otherwise happened.
–Mukund Thattai,
NCBS–TIFR, Bangalore


AdS=CFT

PROGRAMS

ICTS provides a platform for researchers working on diverse subjects to congregate during high-quality programs of varying durations. These highly interactive sessions endorse research areas that are especially contemporary, important and intellectually challenging. The programs contribute to transforming the way people approach research, venture into unexplored directions, nurture new frontiers of science and encourage collaborations. They also encourage the interaction between experimentalists and theorists.

ICTS long programs, with an embedded conference, have a large educational component. They aim to provide an introduction to current problems in an emerging research area. There is a fair balance of international and national participation. The lecturers are carefully chosen and are distinguished scientists. The participants are mainly graduate students, postdocs, and young faculty.

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 lecture series – *Chandrasekhar* (Physical Sciences), *Ramanujan* (Mathematics) and *Turing* (Biology, Computer Science and Engineering).

ICTS also organizes programs in collaboration with other international research institutes. Examples include the *`ICTP-ICTS Biology Program'* and the *`Asian Winter School in Strings, Particles and Cosmology'*.

A SAMPLE OF ICTS PROGRAMS

- **Cosmology - The Next Decade** ♦ 3–25 January 2019
- **The Theoretical Basis of Machine Learning (ML)** ♦ 27–29 December 2018
- **The 2nd Asia Pacific Workshop on Quantum Magnetism** ♦ 29 November–7 December 2018
- **AdS/CFT at 20 and Beyond** ♦ 21 May–2 June 2018
- **Summer School for Women in Mathematics and Statistics** ♦ 7–18 May 2018
- **ICTS–ICTP Winter School on Quantitative Systems Biology** ♦ 5–19 December 2017
- **Geometry, Groups and Dynamics** ♦ 6–24 November 2017
- **Extragalactic Relativistic Jets: Cause and Effect** ♦ 12–20 October 2017
- **Large Deviation Theory in Statistical Physics–Recent Advances and Future Challenges** ♦ 14 August–13 October 2017
- **Laser Plasma Accelerator** ♦ 6–17 March 2017
- **Modern Trends in Electron Transfer Chemistry: From Molecular Electronics to Devices** ♦28–29 January 2016
- **Mathematical Perspectives on Clouds, Climate, and Tropical Meteorology** ♦ 22–26 January 2013
- **The Role of Theory in Biology** ♦ 18 October 2012
- **Random Matrix Theory and Applications** ♦ 17 January 2012–1 February 2012
- **Scientific Discovery Through Intensive Data Exploration** ♦ 2–11 February 2011

A FEW ABDUS SALAM MEMORIAL LECTURES

- **Photochemical and Thermochemical Generation of Hydrogen by Water Splitting** ♦ **C. N. R. Rao** *(JNCASR, Bangalore)* ♦ 30 December 2016
- **Brain, Brawn and Behaviour** ♦ **K. VijayRaghavan** *(NCBS and Secretary, DBT, Ministry of Science and Technology)* ♦ 28 December 2015

ICTS is a unique institute which could serve as the major meeting point of scientists from India and outside India. I wish ICTS great success in its mission.

–Ashoke Sen,
HRI, Allahabad

A FEW INFOSYS-ICTS CHANDRASEKHAR LECTURES

- **Order, Disorder and Entropy** ♦ **Daan Frenkel** *(University of Cambridge)* ♦ 28 August 2018
- **Nature's Optics and our Understanding of Light** ♦ **Michael Berry** *(University of Bristol)* ♦ 11 June 2018
- **Quantum mechanics and the geometry of spacetime** ♦ **Juan Maldacena** *(IAS, Princeton)* ♦ 24 May 2018
- **Microscopic Stochastic Heat Engines Using Nonequilibrium Bacterial Reservoirs** ♦ **Ajay Sood** *(IISc, Bangalore)* ♦ 7, 8, 9 August 2017
- **Models of Cosmological Inflation** ♦ **John Ellis** *(King's College, London)* ♦ 7 June 2017

A FEW ICTS RAMANUJAN LECTURES

- **Some New Results On Rationality** ♦ **Claire Voisin** *(College de France)* ♦ 1 October 2018 ♦ *Infosys-ICTS Ramanujan lectures supported by Infosys Foundation*
- **Understanding Non-Equilibrium: Some Recent Advances and a Challenge for the Future** ♦ **Giovanni Jona-Lasinio** *(Sapienza University, Rome)* ♦ 3 November 2015
- **Locally Symmetric Spaces and Galois Representations** ♦ **Peter Scholze** *(University of Bonn)* ♦ 25 March 2014
- **Mathematical Perspectives on Clouds, Climates and Tropical Meteorology** ♦ **Andrew Majda** *(Courant Institute of Mathematical Sciences)* ♦ 22 January 2013
- **The Generalised Ramanujan Conjectures and Applications** ♦ **Peter Sarnak** *(Princeton University)* ♦ 21 May 2012

A FEW ICTS ALAN TURING LECTURES

- **Evolutionary Dynamics and Diversity in Large Populations** ♦ **Daniel S Fisher** *(Stanford University)* ♦ 8 March 2018 ♦ *Infosys-ICTS Alan Turing lectures supported by Infosys Foundation*
- **Complexity, Phase Transitions and Inference** ♦ **Cristopher Moore** *(Santa Fe Institute)* ♦ 28 June 2016
- **More Perfect than We Imagined: A Physicists View of Life** ♦ **William Bialek** *(Princeton University)* ♦ 4–6 January 2016

A FEW ICTS DISTINGUISHED LECTURES

- **Topological Quantum Matter, Entanglement** ♦ **Duncan Haldane** *(Princeton University and 2016 Nobel Laureate in Physics)* ♦ 11 January 2019
- **From Bits To Qubits: A Quantum Leap For Computers** ♦ **Susan Coppersmith** *(University Of Wisconsin-Madison)* ♦ 26 September 2018
- **Age of Networks** ♦ **Jennifer Tour Chayes** *(Microsoft Research New England)* ♦ 21 January 2015
- **Square Values of Mathematical Expressions, from Ancient Times to the Modern Day** ♦ **Manjul Bhargava** *(Princeton University)* ♦ 19 January 2015

A FEW HIGHLIGHTS FROM OUR PROGRAMS

THE UNIVERSE IN A NEW LIGHT

A day after the sensational discovery of gravitational waves was announced, on 13th February 2016, ICTS organized a day-long meeting to celebrate the occasion. The event consisted of talks aimed at a general scientific audience, and explained the origin of gravitational waves. We learnt about how they were detected, the things learnt and the new directions and possibilities that have now opened up. The event particularly brought out the Indian contribution to the discovery and its analysis starting from C.V. Vishveshwara's work about fifty years ago through to the present. The speakers included Bala Iyer, C. V. Vishveshwara, P. Ajith, K.G. Arun, Tarun Souradeep.

STRINGS 2015 AND 100 YEARS OF GENERAL RELATIVITY

The Strings conference, held every year since 1995, is the most important yearly meeting of string theorists from around the world. Strings 2015 – was hosted by ICTS-TIFR from June 22-26, 2015. It was the second time this meeting had been held in India after Strings 2001 in Mumbai. The final session of the meeting, on the afternoon of Friday the 26th of June, was a special celebratory session to commemorate a hundred years of general relativity. David Gross, Edward Witten, Peter Saulson, Francois Bouchet and Juan Maldacena presented talks surveying the accomplishments of general relativity over the last hundred years and looking towards the future. On 27 June – the day after the strings meeting – Ashoke Sen and Nima Arkani-Hamed participated in an interactive session with school and college students, fielding their questions on a range of subjects for over two hours. On the afternoon of the same day, Nathan Seiberg, Andy Strominger and Cumrun Vafa presented public talks at the Christ University Auditorium in central Bengaluru.

GAMES, EPIDEMICS AND BEHAVIOUR

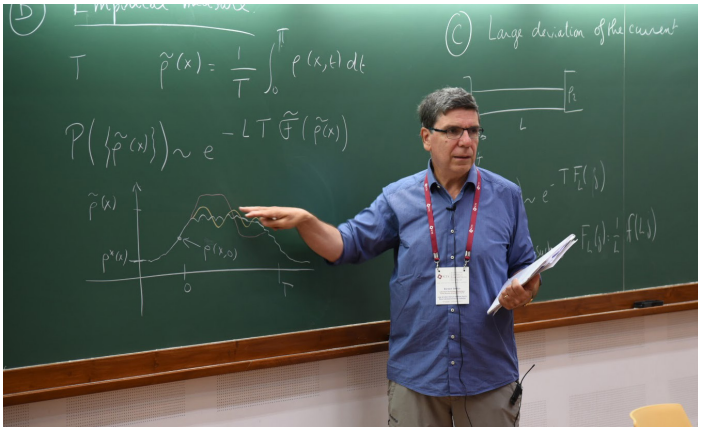
The discussion meeting was held during 27 June–1 July, 2016 and was the first ICTS meeting on theoretical computer science on our campus. The two main goals of this meeting were to explore the foundations of policy design for controlling epidemics, using a broad class of epidemic games on complex networks involving uncertainty in network information, temporal evolution and learning and to gain a better understanding of information flow that could assist in elucidating the complex mechanisms that underlie a variety of human dynamics and organizations giving rise to the ongoing Cambrian-style explosion in online social media. Cris Moore delivered the ICTS Turing Lectures on Complexity, Phase Transitions and Inference.

LARGE DEVIATION THEORY IN STATISTICAL PHYSICS – RECENT ADVANCES AND FUTURE CHALLENGES

The ICTS meeting on large deviations, organized from Aug 14-Oct 13 2017, was the longest program yet held at the ICTS main campus. Large deviation theory made its way into statistical physics as a mathematical framework for studying equilibrium systems, and is now increasingly used for studying nonequilibrium systems driven in steady states, quantum many-body systems, and disordered systems. This program on this exciting interdisciplinary topic brought together physicists and mathematicians working on large deviations to share their recent results, to engage in new collaborations, and to make progress on fundamental problems in statistical physics. There were three themes around which the program was planned – nonequilibrium large deviations, new frontiers of large deviation applications, large deviation simulations. As part of this program, Bernard Derrida delivered the Infosys-ICTS Chandrasekhar Lectures, titled '*Fluctuations and Large Deviations in Non-equilibrium Systems*'.

WINTER SCHOOL ON QUANTITATIVE SYSTEMS BIOLOGY

ICTS and the Abdus Salam International Centre for Theoretical Physics (ICTP), organize the annual Winter School on Quantitative Systems Biology (QSB), held alternately at Trieste and Bangalore. QSB2015 and 2017 were hosted at ICTS. The School is targeted towards young researchers, particularly those at the PhD and post-doctoral level with backgrounds in the physical and mathematical sciences and engineering, who are working in biology or hope to do so. QSB2015 was centered around bacteria, the simplest known forms of life. The focus was on the basics of cellular life and the principles thereof. The 2017 edition focused on biological evolution.



OUTREACH

We all recognize the ability of fundamental science to transform lives. The knowledge of it is priceless and unparalleled. It is important for experts working in various areas of science to share new exciting developments and discoveries with the entire community.

ICTS regularly organizes public lectures, given by eminent visitors. Public lectures bring exciting new developments in science to the general public and play an important role in engaging students and civic society at large on issues of modern science. In 2015, as part of the centenary celebration of Albert Einstein's General Theory of Relativity, the *Einstein Lectures* were introduced. Schools, colleges and other organizations can request ICTS for lectures anywhere in India. Another ICTS initiative is the *Kaapi with Kuriosity* lectures, organized in collaboration with the Jawaharlal Nehru Planetarium and other educational institutes of Bangalore.

ICTS is also the India node for '*Mathematics of Planet Earth*', a global initiative for mathematics programs and outreach. The proceedings of all ICTS activities are available on the website, on YouTube as well as DVDs and CDs.

A SAMPLE OF ICTS PUBLIC LECTURES

- **Deciphering the Workings of Molecules, Building Blocks of Life, with the Electron Microscope** ♦ **Joachim Frank** *(Columbia University and 2017 Nobel Laureate in Chemistry)* ♦ 1 November 2017
- **Whispers from Space: the Detection of Gravitational Waves from a Binary Black Hole Merger** ♦ **Stanley Whitcomb** *(Caltech)* ♦ 7 April 2016
- **Scaling of Electronic Devices – from the Vacuum Tube to a Single-Molecule Diode** ♦ **Latha Venkataraman** *(Columbia University)* ♦ 28 January 2016
- **Particles, Gravity and Strings** ♦ **Nima Arkani-Hamed** *(IAS, Princeton)*, **Ashoke Sen** *(HRI, Allahabad)*, **Nathan Seiberg** *(IAS, Princeton)*, **Andrew Strominger** *(Harvard University)*, **Cumrun Vafa** *(Harvard University)* ♦ 27 June 2015
- **Poetry, Drumming and Mathematics** ♦ **Manjul Bhargava** *(Princeton University)* ♦ 20 June 2015
- **The Architecture of Biological Complexity** ♦ **Sydney Brenner** *(Salk Institute of Biological Sciences, San Diego)* ♦ 18 October 2012
- **Structure and Randomness in the Prime Numbers** ♦ **Terence Tao** *(UCLA)* ♦ 23 February 2012
- **The Universe Unravelled – Cosmology, Gravitation, Elementary Particles** ♦ **Kip S. Thorne** *(Caltech)*, **Richard Bond** *(CITA)*, **James Peebles** *(Princeton University)*, **John Ellis** *(CERN)* ♦ 13 December 2011
- **The P vs NP problem- Efficient Computation and the Limits of Human Knowledge** ♦ **Avi Wigderson** *(IAS, Princeton)* ♦ 27 December 2009

ICTS VISHVESHWARA LECTURES

- **Observing the Birth of the Universe** ♦ **Lyman Page** *(Princeton University)* ♦ 22 January 2019
- **Exploring the Universe with Gravitational Waves – from the Big Bang to Black Holes** ♦ **Kip S. Thorne** *(Caltech and 2017 Nobel Laureate in Physics)* ♦ 11 January 2018

A SAMPLE OF KAAPI WITH KURIOSITY

- **Making Things, Doing Science** ♦ **Arvind Gupta** *(Children's Science Center, IUCAA - former)* ♦ 19 August 2018
- **The Discrete Charm of Geometry** ♦ **Alexander Bobenko** *(Technical University of Berlin)* ♦ 22 July 2018
- **How quantum physics democratised music: a meditation on physics and technology** ♦ **Michael Berry** *(University of Bristol)* ♦ 10 June 2018
- **Black Holes** ♦ **Ramesh Narayan** *(Harvard University and Smithsonian Astrophysical Observatory)* ♦ 21 January 2018
- **Great Triumphs and False Stories – A Brief History of Histories of Indic and European Science through the Ages** ♦ **Roddam Narasimha** *(JNCASR, Bangalore)* ♦ 8 October 2017
- **How Connected are You? An Introduction to Graph Theory and Network Science** ♦ **Hugo Touchette** *(National Institute for Theoretical Physics, Stellenbosch)* ♦ 17 September 2017
- **Fluids Everywhere – Flows on All Scales** ♦ **Julia Mary Yeomans** *(St. Hilda's College, University of Oxford)* ♦ 06 August 2017
- **ASTROSAT– A Multiwavelength View of the Universe** ♦ **S. Seetha** *(ISRO–HQ)* ♦ 11 June 2017
- **The Visions of Shamans and Saints – Dynamic Instabilities in Neuroscience** ♦ **Bard Ermentrout** *(University of Pittsburgh)* ♦ 14 May 2017
- **Work, Progress and Prosperity in the Time of Exponential Technologies** ♦ **Vijay Chandru** *(IISc, Bangalore)* ♦ 19 March 2017
- **My Life in Physics – From Quarks to Strings** ♦ **David Gross** *(KITP, Santa Barbara)* ♦ 14 January 2017
- **Insects as Architects – How Insects Engineer Their Ecosystems** ♦ **Sanjay Sane** *(NCBS–TIFR)* ♦ 11 December 2016
- **Vagaries of the Monsoon** ♦ **Sulochana Gadgil** *(IISc, Bangalore)* ♦ 26 November 2016
- **The Universe – Big and Small** ♦ **Ashoke Sen** *(HRI, Allahabad)* ♦ 23 October 2016

ICTS is shaping up nicely as a great interdisciplinary institute that was really lacking in India. It has already made its mark internationally by organizing high-quality conferences, workshops, summer schools and also hiring a group of talented young researchers across disciplines.

– Satya Majumdar,
LPTMS

ORGANISATION

ICTS is guided, nurtured and managed by three committees.

The *International Advisory Board*, chaired by David Gross, is unique in its existence among scientific institutions in India. It comprises distinguished people whose advice and guidance pertains to all aspects of ICTS. The ICTS Director submits a quarterly activity report to the Advisory Board.

The *Management Board*, chaired by the TIFR Director, oversees the overall administration and scientific direction of the Centre.

The *Program Committee* of ICTS consists of acknowledged leaders in different areas of theoretical sciences and interdisciplinary areas. Program proposals received by the Centre are circulated among its members for their views and advice.

INTERNATIONAL ADVISORY BOARD

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FORMER MEMBERS

Michael Atiyah
served as a member of the IAB from its inception till his passing away in January 2019.

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École normale supérieure, Paris

M. S. Narasimhan
CAM-TIFR

T.V. Ramakrishnan
Banaras Hindu University and *IISc*

K. R. Sreenivasan
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Raman Sundrum
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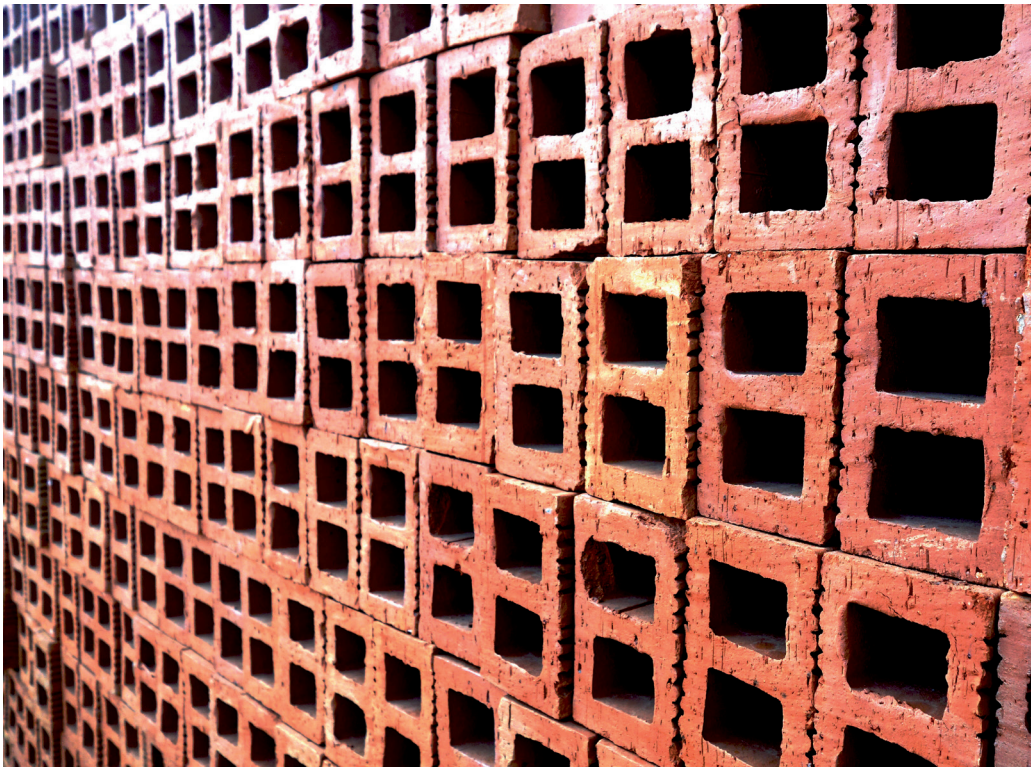

It has been a great honor and privilege to be a part of the International Advisory Board of the ICTS, and to watch the ICTS grow from a dream to reality.

I think the ICTS, through its numerous research activities, and through its varied lectures for scientists and the public, will play a vital role in advancing the science research culture of India.

–Manjul Bhargava,
Princeton University

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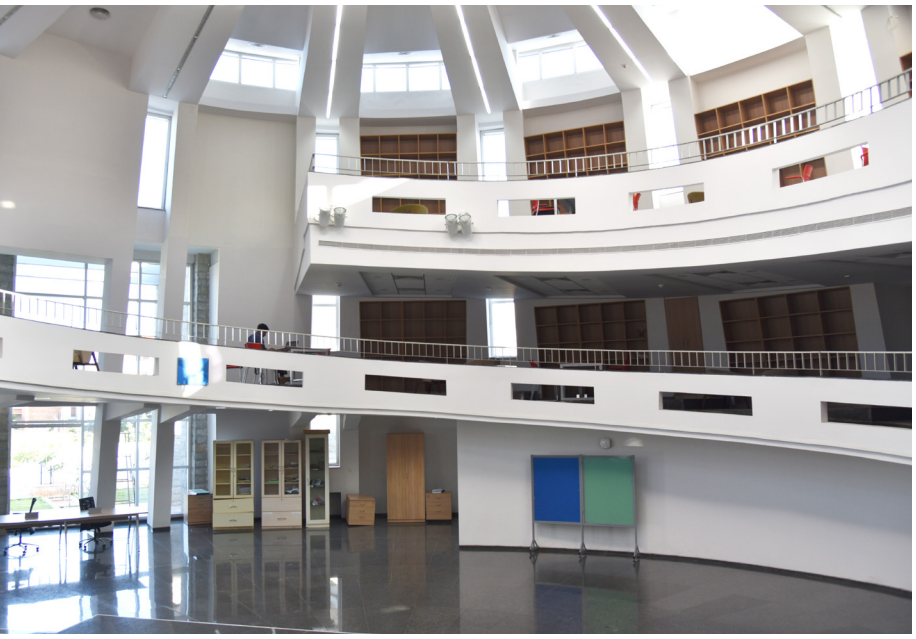
NCBS–TIFR and the Principal Scientific Adviser to the Govt. of India

CAMPUS

The new ICTS campus is spread over 78,000 square metres amidst the rustic surroundings of Hesaraghatta village in north Bangalore. The open corridors and foyers provide a conducive environment for research and learning. The campus is self-contained and includes academic housing and recreational facilities. It is equipped with a modern library, state-of-the-art computing and networking infrastructure, lecture halls with enough capacity for meetings with hundred plus participants, an auditorium, recreation spaces, childcare facilities and comfortable living quarters for staff and visitors.



It is wonderful to see the dreams we had of establishing a Centre for Theoretical Physics in India being realized. I am very impressed with the remarkable developments since the inauguration in 2009. Visiting the site I could see a beautiful facility where cutting edge theory is being pursued with dynamic leadership at the top, with an initial first-rate faculty – nothing can stop this from happening. For those of us who have tried to help from afar these developments make us proud.

–David Gross,
KITP, Santa Barbara

Indian Science has a long and proud history spanning many centuries and continuing to the present day. ICTS is an important node in helping with the continuation of this tradition and in serving as a meeting point for Indian scientists with the international scientific community.

–Cumrun Vafa,
Harvard University

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Website www.icts.res.in

ICTS International Centre for Theoretical Sciences
TATA INSTITUTE OF FUNDAMENTAL RESEARCH