

## **A Brief History of an Indian Initiative: ICTS-TIFR**

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### **Kok Khoo Phua and World Scientific**

In 1986, a high-energy physicist Kok Khoo Phua (affectionately called KK), and his wife Doreen Liu started the World Scientific publishing company. I was very happy that an Asian publishing house of the type envisioned by them had arrived on the scene to try and counter the monopoly over scientific publishing held by companies that were unaffordable in many institutions of higher learning in the developing world.

Over the years, World Scientific has grown into a major publishing house worldwide of scientific journals, books, and other educational publications. I was very happy to be associated with this enterprise and served on the editorial board of the International Journal of Modern Physics-A and Modern Physics Letters-A from inception. In the early years, I made many memorable visits to Singapore to discuss with KK and his staff and I was happy that they valued my suggestions and thoughts. On my part, I started publishing in World Scientific journals and encouraging others to do the same.

I arrived at the Tata Institute in Mumbai in 1982 from the University of Chicago. Among the many activities I joined in to improve our research and education, was organizing regular conferences and meetings. Those were the days when conference proceedings were popular, and KK was always generous about extending a helping hand. The World Scientific published the proceedings of several meetings organized by the Tata Institute. The first one was the proceedings of the 1986 Winter School on "Strings, Lattice Gauge Theory and High Energy Phenomenology", which also contains an original unpublished paper by Yoichiro Nambu, "Duality and Hydrodynamics". These notes were prepared for an undelivered

lecture at the Copenhagen High Energy Symposium, August 1970, and contain a detailed exposition of his ideas on string theory.

I was also happy to be invited to edit a World Scientific volume on the “Large N limit in Quantum Field Theory and Statistical Mechanics” with Edouard Brezin in 1991, and in 2005 a book of articles by leading scientists commemorating the three revolutionary 1905 papers of Albert Einstein. World Scientific also published in 1999, “A Quest for Symmetry”, which contains the selected works of Bunji Sakita edited by Keiji Kikkawa, Miguel Virasoro, and myself.

As a person, I always found KK to be very friendly and encouraging...bouncing off new ideas, impatient and in a kind of a hurry to reach his goals, only some of which I knew. He was also involved in organizing many scientific meetings in Singapore. My most memorable one was the conference to commemorate the 80<sup>th</sup> birthday of Murray Gell-Mann where his student Kenneth G. Wilson was also present and gave an amazing talk!

Time flies and KK is already 80! I would like to wish him many more wonderful and creative years.

In the following I will describe another Asian initiative, the International Centre for Theoretical Sciences (ICTS) of the Tata Institute of Fundamental Research (TIFR) in Bangalore, India, with which I was and am deeply involved.

## International Centre for Theoretical Sciences - Tata Institute of Fundamental Research

### A Brief history

#### The idea of [ICTS](#)

By the late 1990s, the subject of string theory was doing well in India with some influential contributions and a fair-sized community. It seemed like a good opportunity to organize the annual Strings meeting in India. There was good support towards this from the string theory community and we planned the meeting at TIFR in January of 2001. The initial funding was offered by Miguel Virasoro, then Director of ICTP Trieste, who remarked: "India deserves this". David Gross suggested that we 'get Stephen' and that gave enormous publicity to string theory and fundamental physics in India. [Strings 2001](#) was indeed a watershed moment for the subject in India.

After this meeting in Mumbai, Edward Witten was invited to deliver a lecture at the Indian Academy of Sciences in Bangalore. During the visit to Bangalore, he wanted to visit the campus of Infosys Technologies in Bangalore, 'a temple of modern India' in his words, rather than my suggestion to visit the Hoysala temples of Belur and Halebidu! The Infosys Campus was modern, and state of the art and it was a revelation to me that something like this was possible in India.

The idea of the ICTS was born in early 2001, after the successful organization of the Strings 2001 conference at TIFR Mumbai and a visit to the campus of Infosys Technologies 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 is possible in India. The combination of the highest quality science within a modern state-of-the-art campus, managed along modern management lines, inspired the basic idea of the Centre. However, ICTS was intended not to be just a string theory institute but one where all of 'science is one story'. The partitioning of science into different areas is historical and represents primarily a limitation of the human mind to process, comprehend and make sense out of so much disparate data. By the end of the last

century, it was already clear that physics, chemistry and biology form a hierarchy of complexity in the sense meant by Herbert Simon.

In February 2001, I drafted a proposal to Infosys Technologies for the creation of a “Center of Excellence in Theoretical Sciences”. It began with a critique of some aspects of the Indian science system and spelled out a vision for the Center, its faculty, visitor programs, students, location, management, and funding. However, I did not hear back from them and the idea also did not find much traction at TIFR.

In 2004, discussions with David Gross in Santa Barbara gave a concrete road map and impetus to the creation of the Centre. We usually sat on a bench outside his office as cigars were not allowed in the building! David emphasised that Government funding is crucial and should be the main source with private funding filling in some crucial gaps. We discussed the people in India who should be brought on board and be convinced about the Centre. Following up on this meeting it took about two years before I was able to make a presentation to the Governing Council of the Tata Institute in 2006 and with the strong support of C.N. R. Rao and K. Kasturirangan ICTS was approved in August 2007.

I was given the responsibility of serving as the first Director and was asked to find resources, search for a suitable place to locate the ICTS campus, begin the international programs, build up the faculty and the administration.

It felt like being thrown into the water without knowing how to swim! My colleague Avinash Dhar became convinced that ICTS was an important step forward for Indian science and joined in the effort. Sometime later we were joined by Uma Mahadevan Dasgupta, of the Indian Administrative Service on special duty at the Tata Institute, and by Mukesh Dodain who led the nascent administration at ICTS.

The ICTS began functioning from the Tata Institute in Mumbai holding its programs in institutions that willing to host them. Some of the early programs were held at the International Centre in Dona Paola in Goa, IUCAA-Pune, JNCASR-Bangalore and the Indian Institute of Science-Bangalore.

The governance structure of ICTS consists of a Management Board, a Program Committee and an [International Advisory Board](#) of distinguished experts to guide the ICTS on all aspects of its growth. Their advice and encouragement are invaluable. The first Board members consisted of Michael Atiyah, Manjul Bhargava, Roger Blandford, Edouard Brezin, Michael Green, David Gross (Chair), M.S. Narasimhan, TV Ramakrishnan, Subir Sachdev, Ashoke Sen, Katepalli Sreenivasan, Raman Sundaram and S.R.S. Varadhan.

It took about two years and considerable effort to find a suitable city in India to locate the ICTS campus. Bangalore became a preferred choice because it had the academic ecosystem to sustain ICTS given the presence of the Indian Institute of Science (IISc), the National Centre for Biological Sciences (NCBS) and the Centre for Applicable Mathematics (CAM) of TIFR, among others, and the fact that the State of Karnataka offered a piece of land in North Bangalore. Once the location was fixed the Centre and its budget were approved by the Atomic Energy Commission that was Chaired by Anil Kakodkar.

**ICTS missions: [Research](#), [Programs](#), and [Science Outreach](#)**

ICTS has a three-pronged mission. One mission is of course outstanding research and post-graduate education that is broadly organized into three main directions: complex systems that include statistical and condensed matter physics, fluid dynamics and turbulence, and physical biology; spacetime physics that includes gravitational wave astronomy, quantum gravity and string theory, and related areas; and mathematics that includes geometry, PDEs, probability theory, data assimilation, and computing. A strong PhD program has been instituted in all of these areas.

The other mission of the ICTS are its 'Programs' of various durations in time that bring together physicists, astronomers, cosmologists, mathematicians, biologists, students and researchers from all over the world, under one roof, for various lengths of time 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. These programs include discussion meetings and named lecture series in honour of S. Chandrasekhar (Physical Sciences), S. Ramanujan (Mathematical Sciences) and A. Turing

(Engineering and Biological Sciences). Special lectures like the Abdus Salam Memorial Lectures and the ICTS Distinguished Lectures are delivered by distinguished scientists as part of the third mission of ICTS which is Science Outreach. ICTS programs also enable a platform for new, important emerging areas of science, mathematics and engineering.

Using the resources of these two main missions, ICTS anchors a vibrant program of Science Outreach that interfaces with civic society. This includes public lectures by eminent visiting scientists. It is important to share our work with civic society: with students so they can get interested in science; with people who are not scientists to have them participate in this incredible journey of exploration of the natural world including ourselves. Outreach is important as we seek the support of civic society for curiosity-driven research.

ICTS organizes several science outreach activities. Kaapi and Kuriosity is a monthly Sunday lecture on an interesting science topic at the Nehru Planetarium in Bangalore; Math Circles is a national initiative at ICTS that identifies talented students and exposes them to the joy of doing mathematics at an early age; Einstein Lectures in partnership with institutions and colleges are delivered anywhere in India by distinguished scientists; Vishveshwara Lectures are delivered by leading scientists who are good communicators. The inaugural Lecture was delivered by Kip Thorne.

### **Moving from TIFR-Mumbai to the Bangalore campus**

In December 2009 ICTS organised its Inauguration Conference, “Science without Boundaries” and the “[Foundation Stone Ceremony](#)” at the Indian Institute of Science in Bangalore. This conference informed the Indian and international scientific community about the ICTS missions and its commitment to a modern and transparent governance structure. The idea of the ICTS was succinctly articulated by Michael Atiyah in his Foundation Stone remarks:

*“... Science has the noble aim of trying to understand the natural world in human terms : to make sense of what we see. This brief phrase encapsulates both theory and experiment. What we see, in the broad sense, covers experiment and making sense is the task of theory.*

*As the great French mathematician Henri Poincare said, science is no more a collection of facts than a house is a collection of bricks: it requires theory to hold it together.*

*Theory needs a framework in which to develop and, as a mathematician, I believe that mathematics provide that unifying framework. As Galileo said the book of nature is written in the language of mathematics. Galileo was thinking primarily of mechanics and astronomy but, increasingly since his time, mathematics has provided the essential underpinning of ever-widening branches of science. As soon as a science moves from the qualitative to the quantitative, mathematics becomes indispensable.*

*Not only does mathematics provide the technical tools that all sciences require but, by its very nature, it acts as a unifying principle, integrating the diverse aspects of nature into an organic whole.*

*I am sure that mathematics, in all its various aspects, will play an important part in the future activities of this Center. In the complex modern world with the enormous challenges that we face, from climate change to energy, from poverty to water shortages, science provide the bedrock on which we can build our future. I am sure that this Center will play its part in guiding both India and the wider world in the years ahead.”*

In 2010, ICTS moved to its temporary campus in IISc from where it planned and built its new campus, continued its programs and academic activities, began recruiting its first set of faculties, and welcomed its first students and postdocs. Several institutions in North Bangalore including IISc, NCBS, and CAM lent a helping hand in the various tasks faced by ICTS.

We consulted colleagues worldwide, studied many architectural designs of institutions in India and abroad including the Newton Institute in Cambridge, and worked closely with the architects (Venkataraman and Associates) to realise the Centre that we had envisaged, keeping in mind the famous saying, “We shape our buildings, thereafter they shape us”. The architecture, open spaces, and gardens contribute to an interactive academic atmosphere and a pleasant and comfortable stay on campus.

As the campus was being built ICTS organised most activities in Bangalore. Some early activities include a multi-disciplinary meeting on “Scientific Discovery through Intensive Data Exploration”, the “ICTP-ICTS joint School on Quantitative Biology”, “Random Matrix Theory and Applications”, “Winter School on Experimental Gravitational Wave Physics”, “Asian Winter School on Strings, Particles and Cosmology”, “Mathematical Perspectives on Clouds, Climate, and Tropical Meteorology”, Ramanujan Lectures by Andrej Majda, a major math outreach activity, “Mathematics of Planet Earth”, which included an exhibition on illustrating mathematics via simple hands-on models and a celebration of the Turing Centenary with a talk by Sydney Brenner, “The Architecture of Biological Complexity” and a discussion meeting, “On the Role of Theory in Biology”.

We moved into the campus on June 2015 even while the campus was being completed and the landscaping was being done. The Campus Inauguration event was a conference titled, “Science at ICTS” held on 20 June 2015, which also included a brilliant public lecture by Manjul Bhargava on “Poetry, Drumming, and Mathematics”.

By 2015 ICTS faculty had grown to consist of fifteen faculty members, and the graduate school and postdoctoral programs were in place. String 2015 was organized at ICTS in the Indian Institute of Science. The morning session on June 26<sup>th</sup> was held at the new ICTS campus and the afternoon session celebrated “100 Years of General Relativity”.

The lecture halls and auditorium have state-of-the-art audio-visual and recording facilities for ICTS events which are then made available on [YouTube](#). ICTS has a data centre (Turing Hall) that will eventually go up to 20,000 cores; it has an iconic library with an excellent collection; a guest house and residential facilities; a sports and wellness centre; and a computer centre and an efficient administration that serves the Centre well.

The main financial support for the Centre comes from the Govt of India as part of funding for the Tata Institute of Fundamental Research. Besides this, ICTS engages with private foundations and philanthropy. It has been able to secure grants from the Airbus Corporate Foundation, the Simons Foundation, and the Infosys Foundation. There is an active resource



development office that works with donors and 'Friends of the ICTS' worldwide. ICTS also brings out a regular [newsletter](#) that is widely circulated.

In July 2015 I stepped down as Director and handed over the baton to Rajesh Gopakumar. Under him the ICTS continues to grow and flourish in all its missions.

### **Activities at ICTS**

The quantum of Programs, Discussion Meetings, Named Lectures, and Science Outreach has grown many fold in the new campus. ICTS presently has twenty-three regular faculty members. It has added scientists working in probability and statistics, and theoretical computer science to its Mathematics unit.

In keeping with our vision that "science is one story" there are no subject departments at ICTS, only units that can interact with each other. ICTS faculty are domain experts in what they do, but their intellectual space is broader than their chosen field. This enables them to come together to solve problems that need diverse expertise. One example is the project to understand the mathematical foundations of the Indian monsoon – a weather system, which is very complicated and little understood, given India's proximity to the equator and its special geographical characteristics of being a peninsula with high mountains in the north.

The research quality and keen involvement of the ICTS faculty forms the bedrock for its various activities like schools, conferences, workshops, discussion meetings and the science outreach activities described earlier. Some of the best people in the world, across the landscape of science, social sciences and humanities, visit and spend varying lengths of time at the ICTS.

ICTS carries out joint activities with various other institutions worldwide. ICTS has held, in conjunction with ICTP-Trieste, ten instalments of a successful [Winter School in Quantitative Biology](#) alternating between Trieste and Bengaluru. ICTS is the Indian node of the very successful [Kavli Asian Winter School on Strings, Particles and Cosmology](#), which rotates

between China, Japan, Korea and India. ICTS also held a joint workshop with IMPA-Brazil and ICTP on [Smooth and Homogeneous Dynamics](#).

In January 2018, ICTS celebrated ten years of its existence by holding a major event "[The ICTS at Ten](#)". This was an opportunity to reflect on our journey since 2007, and to go ahead with renewed energy into the second decade. The theme of the meeting was "Celebrating the Unity of Science". Over the course of this meeting, speakers from around the world gave broad perspective talks across several different themes in the theoretical sciences: Astrophysics and Cosmology, String theory and Quantum Gravity, Mathematics, Theoretical Computer Science, Condensed Matter and Statistical Physics, Physical Biology. These areas reflected the profile of ICTS in 2018 as well as the directions that it would like to grow in the coming years.

The same year, ICTS had a [comprehensive review](#) undertaken by a distinguished international committee consisting of Beverly Berger, Curtis Callan (Chair), Bertrand Halperin, Kavita Ramanan, Itamar Procaccia, and Ashoke Sen. The committee concluded that *"ICTS is a powerful new asset for Indian science and science education. Much remains to be achieved, but a solid foundation for a future of great importance to Indian science and Indian society has been laid. ICTS has a unique multi-faceted mandate: to perform interdisciplinary research in theoretical science at the highest level across a broad intellectual frontier; to educate a new generation of PhD scientists in these disciplines; to facilitate the diffusion of frontier scientific developments and theoretical techniques across the Indian scientific enterprise through focused topical programs; to excite and inspire the public, especially the young who will be the scientists and technologists of India's future, through outreach programs. It is our assessment that ICTS, despite its youth as an institution, is doing an impressive job on all four fronts"*.

In May 2018, ICTS initiated the D. D. Kosambi Lectures devoted to the social sciences, the arts, and the humanities in honour of the first Professor of Mathematics at Tata Institute, who made pioneering contributions to the methods and study of ancient Indian history. The inaugural lecture was delivered by Pratap Bhanu Mehta. In February 2020, ICTS initiated the Madhava lectures devoted to the history of mathematics, science, and technology, in

honour of the great Indian mathematician of the Kerala School that invented rudiments of the Calculus. The inaugural lectures were delivered by P. P. Divakaran.

ICTS is involved in the Bengaluru Science and Technology ([BeST](#)) Cluster Initiative of the Govt. of India which is a collaborative ecosystem in which scientists, engineers, social scientists, and entrepreneurs working in academia, government labs, and industry, identify and collaborate towards solutions for some socially relevant problems. BeST has set up teams to be engaged in areas related to health, agriculture, urban transportation, climate, quantum science, materials, and jet engines.

During the Covid pandemic, the campus was closed for almost two years. ICTS activities shifted online. During these hard times ICTS created [Covid Resources](#) which has commentary on the COVID-19 data analysed by ICTS scientists, as well as links to useful online material.

### **The Future**

Since its inception, ICTS has achieved a fair measure of success in its three missions! Its programs have had a significant impact on Indian science; it is an international hub of science; its faculty (presently twenty-three members) has made widely recognised contributions and its science outreach has become a fixture for science enthusiasts in India.

ICTS is considered by many as one of the best institutions of its kind in the world. A distinguished visitor to ICTS from Caltech said his next travel destination was the ICTS of the North (IAS Princeton).

Going forward, a successful institution like ICTS should grow in size and expand the scope of its activities to serve a larger number of researchers and students. In this way it will become a greater national asset for India. Its present areas of research could be augmented to include, exploring areas of evolution, learning and cognition, artificial intelligence and computational mathematics to name a few. In another vein, progress in quantum science and mathematics will enable deeper insights into the workings of the quantum world and provide a paradigm shift in computing, sensitive devices and engineering, which can feed

back and enable us to make fundamental discoveries about the nature of the universe and life.

Further into the future, ICTS could include experimental science, engineering, social sciences and humanities, and strive to be a research university that integrates knowledge and human values. India a country of over a billion people trying to emerge from its inequitable past. It needs many, many such institutions of higher education and research!



ICTS Foundation Stone Laying Ceremony, 2009





ICTS under construction, April 2013



ICTS at Ten, January 2018



ICTS Campus now



ICTS Library



ICTS Data Centre