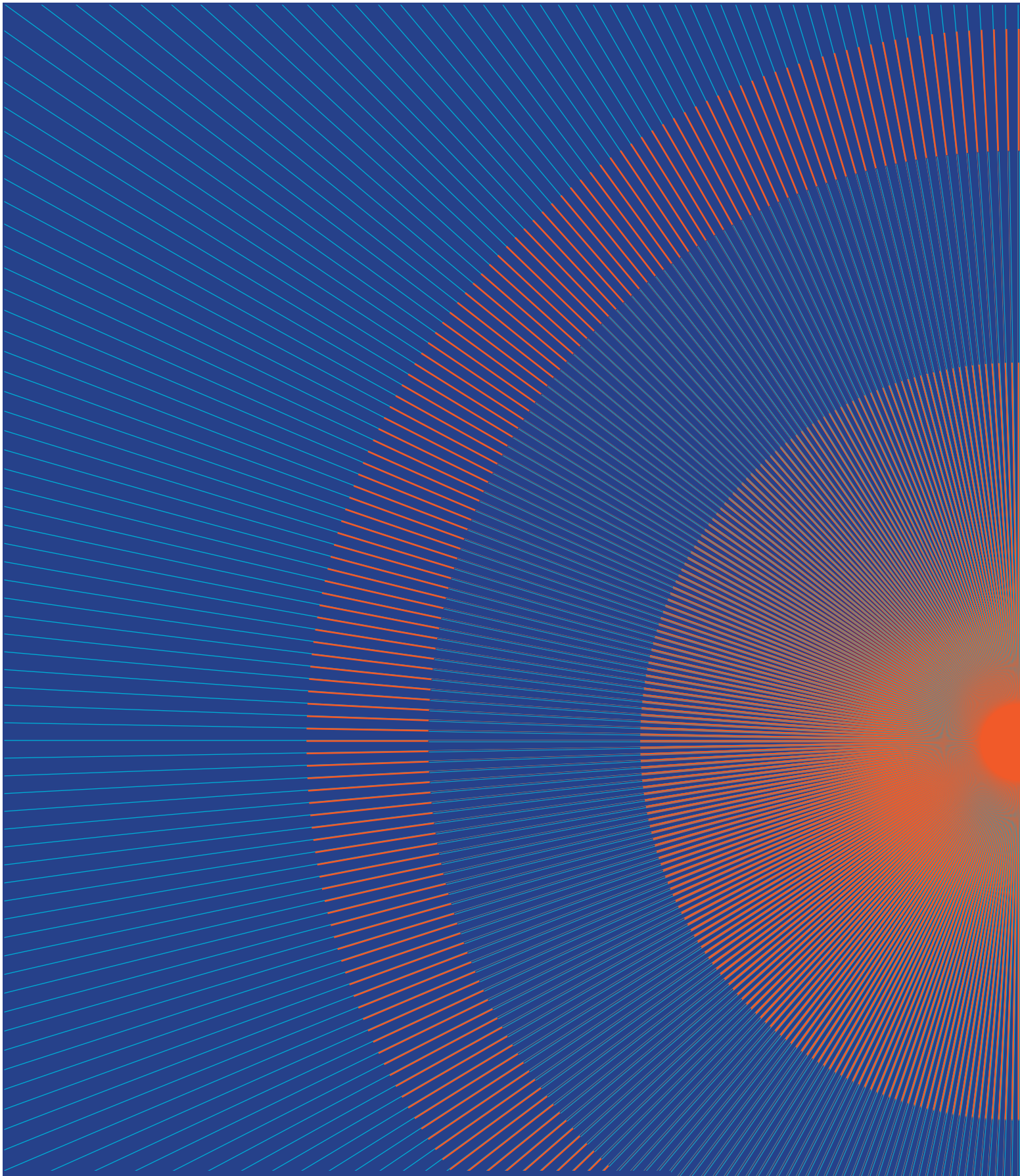
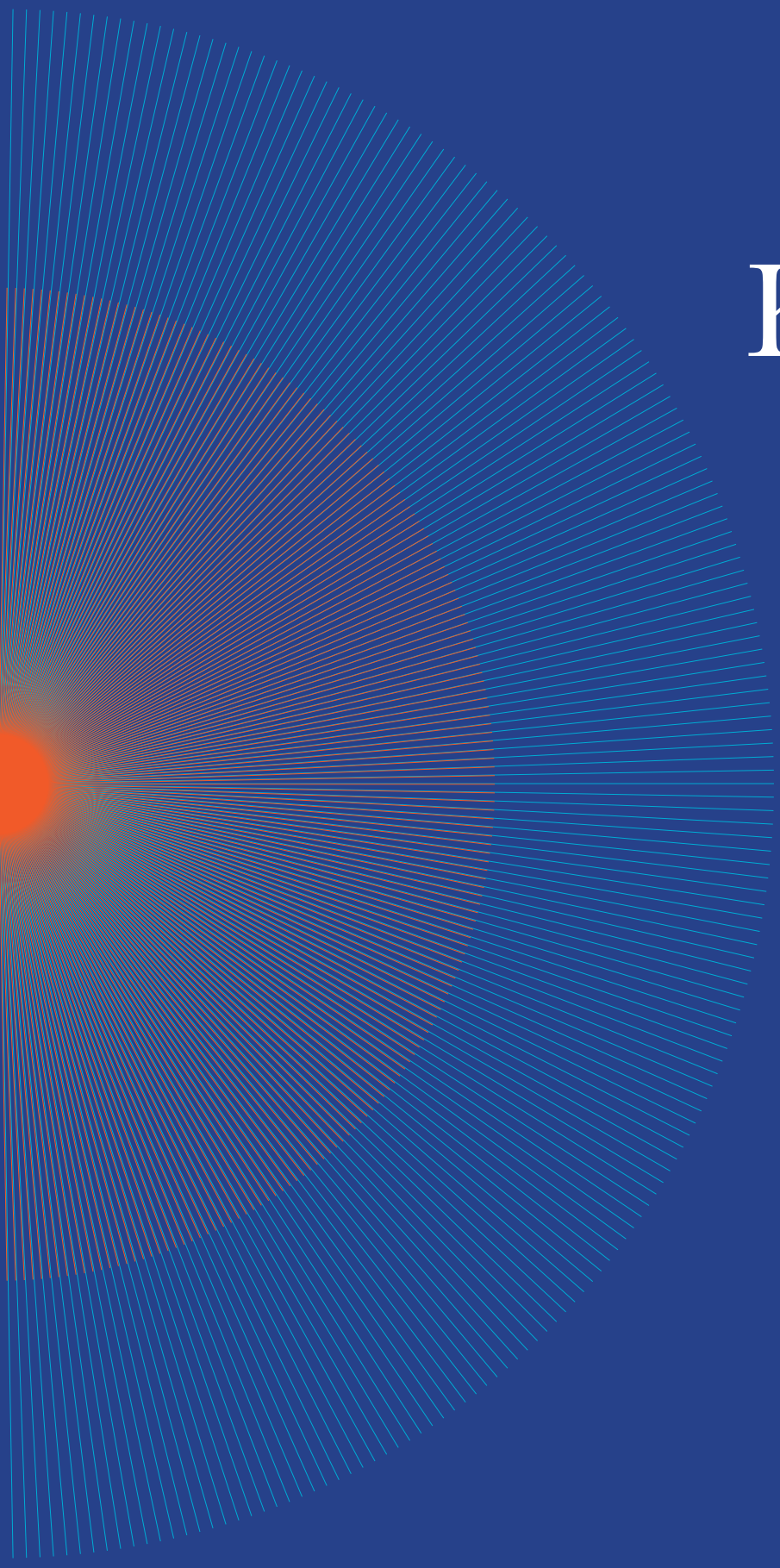
KERNEL

IISc 2014-15

INDIAN INSTITUTE OF SCIENCE



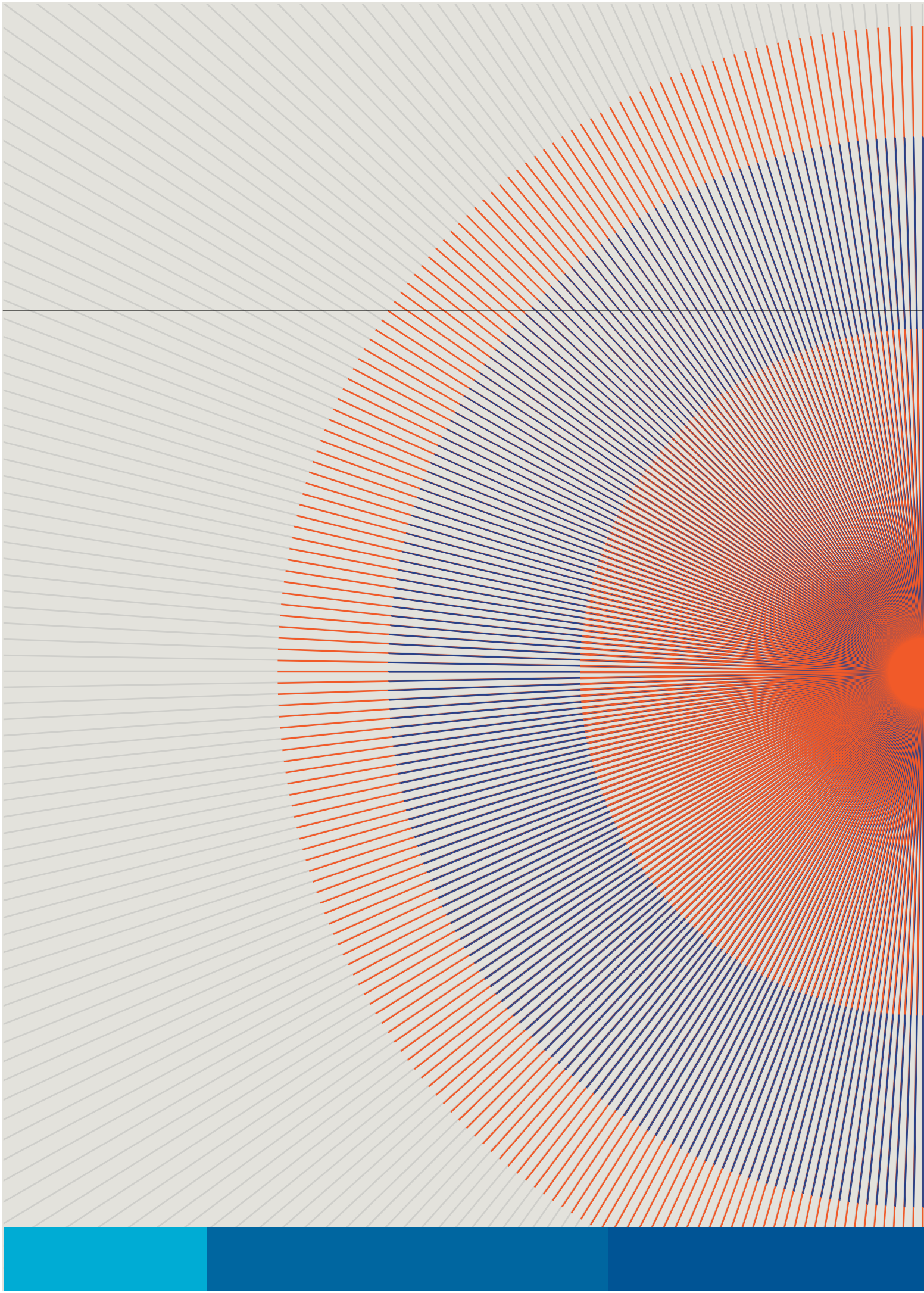
In everyday usage, the word *kernel* refers to the central or the most important part of something. In science and technology, *kernel* has several connotations in fields as diverse as biology, computer science and mathematics. For instance, in computer science, the *kernel* is a fundamental, essential part of a computer operating system, providing basic services for all other parts of the operating system. Similarly, in biology, the word is used to denote the softer, usually edible part of a nut, seed, or fruit stone contained within its shell.



KERNEL

IISc 2014-15

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान



CONTENTS

FROM THE DIRECTOR

The Indian Institute of Science (IISc, or just "The Institute") was established in 1909 by a visionary partnership between the industrialist Jamsetji Nusserwanji Tata, the Maharaja of Mysore, and the Government of India. Over the 106 years since its establishment, IISc has become the premier institute for advanced scientific and technological research and education in India. Since its inception, the Institute has laid balanced emphasis on the pursuit of basic knowledge in science and engineering, as well as on the application of its research findings for industrial and societal benefit. In the words of its founder, J N Tata, the objectives of the Institute are "to provide for advanced instruction and to conduct original investigations in all branches of knowledge as are likely to promote the material and industrial welfare of India."

The Institute has introduced many innovations in teaching and research. As of date, IISc has a highly qualified and internationally acclaimed faculty numbering about 500, and a student strength of almost 4000. The traditional degree programmes have been the ME, MTech, MDes, MMgt, MSc (Engg), and the PhD degrees. In 1990, the Institute introduced the very popular Integrated PhD programme (to which students are admitted after a three year BSc) in biological, physical, chemical, and mathematical sciences. In 2011, the Institute introduced a four-year undergraduate program in which, apart from their course and laboratory work, the students are exposed to research in the laboratories of the Institute. In addition to establishing these teaching programs, the Institute has taken several initiatives in promoting emerging and interdisciplinary areas, in developing active and close collaboration with research institutions worldwide, and in enabling enhanced interactions with industry through knowledge sharing, translational research, and technology transfer.

During the Centenary celebrations in 2009, the Institute acquired a second campus of 1500 acres in the emerging Science City promoted by the State of Karnataka in Challakere, in the district of Chitradurga. This campus will be the location for large projects (such as in renewable energy and climate change), extension laboratories, and a skill development centre. A school-level science teachers training program is already underway in IISc's Talent Development Centre, and has been supported by the Government of Karnataka. More than 6000 science teachers have been trained, and the centre has recently been designated as a Centre of Excellence under the Madan Mohan Malaviya National Program on Teachers and Teaching.

The Institute continues to receive major research support from national and international sources, public and private, and strives to have strong international connections in the form of collaborative research programs. The Office of International Relations (OIR) has facilitated agreements with several universities and R&D institutions worldwide. A newly established Office of Development and Alumni Affairs (ODAA) will strengthen engagement with alumni all over the world, and will enable the Institute to tap various non-government sources for supporting infrastructure development and some new initiatives.

In recent years, the Institute has created new avenues for dissemination of knowledge to society. The IISc Press was established during the Institute's centenary year, and has published several monographs and lecture notes in a co-publishing agreement with international publishers. Efforts have been underway to regularly release information to the public about significant scientific and technical progress at the Institute; this also aims to promote scientific temper in the society.

This is the first issue of Kernel, a magazine format document that accompanies the IISc Annual Report for the year 2014-15, and provides some highlights of the past year. Some notable landmarks for the year 2014-15 were: (1) A visit by the Honourable Prime Minister of India, Mr. Narendra Modi; (2) The graduation of students from the first batch of IISc's new undergraduate program; (3) The installation and commissioning of the fastest supercomputer in the country in IISc's Supercomputer Education and Research Centre. These events, and several achievements and milestones are highlighted in this document.

As I complete my first year as Director of this unique institution, I recall the visionary leadership of the former Director Prof. P Balaram, and the Associate Director Prof. N Balakrishnan who were at the helm of the Institute for almost a decade, and I place on record my personal gratitude to the Chairman and the Members of the Council of the Institute for their valuable guidance.

Anurag Kumar
Director, IISc
September 2015

WHEN THE PRIME MINISTER CAME CALLING

A PHOTO DIARY OF PRIME MINISTER MODI'S VISIT

On 18 February 2015, Prime Minister Shri Narendra Modi visited the Indian Institute of Science (IISc). During his visit, he unveiled the foundation stone of the new Centre for Brain Research (CBR) and rededicated the Centre for Nano Science and Engineering (CeNSE) to the nation. He also witnessed the signing of an MoU between the Oil and Natural Gas Corporation Limited (ONGC) and the Super Wave Technology Pvt. Ltd. (SWTPL), a company started by researchers from the Institute under the Faculty Entrepreneurship Programme (FEP) of IISc.

Prime Minister Shri Narendra Modi interacting with students from IISc

Congratulations on an excellent effort,
for always keeping alive in themselves,
the immortal essence of
excellent guru-disciple tradition,
for generations,
with single target, of the welfare of human beings.
And to touch the new horizons of development,
scientifically, with the help of science,
and with the help of excellent research in science.
Completing 100 years,
this is a tapobhumi.
I salute to this tapobhumi!
I salute to all tapaswis!

The Prime Minister's message for the Institute in the Visitors' Book during his visit

Foundation stone of the new Centre for Brain Research being unveiled by the Prime Minister

The Prime Minister at the Centre for Nano Science and Engineering

Prime Minister Shri Narendra Modi witnesses the MoU signing between ONGC and Super Wave Technology Pvt. Ltd. (SWTPL), a company started by researchers from the Institute

THE GOVERNING COUNCIL

P Rama Rao
Chairman of the Council
Former Vice Chancellor
University of Hyderabad, Hyderabad
(Nom. GoI)

S N Agarwal
Chairman
Bhoruka Power Corporation Ltd., Bangalore
(Nom. Court)

Satyanarayan Mohanty
Secretary, MHRD
Dept. of Higher Education, GoI,
New Delhi (Nom. GoI)

V S Ramamurthy
Director
National Institute of Advanced Studies, Bangalore
(Nom. Court)

S P Goyal
Joint Secretary (TEL), MHRD,
Dept. of Higher Education, GoI
New Delhi (Nom. GoI)

S N Puri
Vice Chancellor,
Central Agricultural University, Imphal
(Rep. Indian Universities)

Bharat Lal Meena
Pr. Secretary to GoK
Higher Edu. Dept.,
Bangalore (Nom. GoK)

Harish Padh
Vice Chancellor
Sardar Patel University, Vallabh Vidhyanagar
(Rep. Indian Universities)

I S N Prasad
Pr. Secretary to GoK
Dept. of Finance
Bangalore (Nom. GoK)

Avinash S Pant
Chairman
AICTE, New Delhi
(Rep. AICTE)

A N Singh
Managing Trustee
Sir Dorabji Tata Trust, Mumbai
(Nom. Tata Trusts)

P S Ahuja
Director General
CSIR, New Delhi
(Rep. CSIR)

J J Irani
Director
Tata Sons Limited, Mumbai
(Nom. Tata Trusts)

Anurag Kumar
Director (Ex-officio)

S K Joshi
Former Director General
CSIR, Gurgaon
(Rep. UGC)

M Narasimha Murty
Dean, Engineering Faculty (Ex-officio)

Murli Manohar Joshi
Member of Parliament (Lok Sabha)
New Delhi (Rep. Parliament)

T N Guru Row
Dean, Science Faculty (Ex-officio)

Suresh C Angadi
Member of Parliament (Lok Sabha)
New Delhi (Rep. Parliament)

V Rajarajan
Registrar (Ex-officio Secretary)

Ashok S Ganguly
Member of Parliament (Rajya Sabha)
New Delhi
(Rep. Parliament)

DEPUTY DIRECTORS

Starting this year, the Indian Institute of Science (IISc) will have two Deputy Directors to lead the Institute in many of its endeavours

S RAMAKRISHNAN

DEPUTY DIRECTOR (PLANNING AND INFRASTRUCTURE)

An eminent chemist, S Ramakrishan is a Professor in the Department of Inorganic and Physical Chemistry. He received his PhD from the University of Massachusetts, Amherst. After a two-year postdoctoral stint at the Corporate Research Laboratory of Exxon Research and Engineering Company at Annandale, New Jersey, he joined the Department of Inorganic and Physical Chemistry in 1990 at IISc. Before taking up the Deputy Directorship of the Institute, he served as the Chairperson of Division of Chemical Sciences.

Ramakrishnan's research interests are in the areas of highly branched polymers, self-assembled polymerizable systems and conformational control in synthetic polymers. His research accomplishments have won him several honours, including the Shanti Swarup Bhatnagar Prize, DAE Outstanding Young Researcher Award, JC Bose Fellowship and Distinguished Alumnus Award from IIT Bombay. He currently serves as an Associate Editor of Chemical Communications, one of the flagship journals of the Royal Society of Chemistry and is also on the Editorial Board of Macromolecules (ACS) and Polymer Chemistry (RSC).

JAYANT M MODAK

DEPUTY DIRECTOR (FINANCE AND ADMINISTRATION)

Jayant M Modak is a Professor in the Department of Chemical Engineering. He obtained his PhD from Purdue University, Indiana. After a one-year stint at the University of California-Irvine as a postdoctoral fellow, he joined IISc in 1989. Here, he initiated a research programme in the area of bioprocess engineering with an emphasis of modeling, optimization and control of fermentation processes and advanced oxidation technologies for waste-water treatment.

Modak has served as the Chief Executive, Society of Innovation and Development and as the Chairperson of the Office of Intellectual Property & Technology Licensing (formerly known as the Intellectual Property Cell) at IISc. He has also served as an Independent Director on the Board of Mangalore Refineries and Petrochemicals Limited. Modak is a Fellow of Indian National Academy of Engineering and National Academy of Sciences, Allahabad. He is a recipient of P C Ray and Amar Dye Chem award of Indian Institute of Chemical Engineers, C V Raman Award of Karnataka State and Biotech Process Development Award of the Department of Biotechnology, India.

DIVISIONS

The Institute comprises six Academic Divisions:

BIOLOGICAL SCIENCES

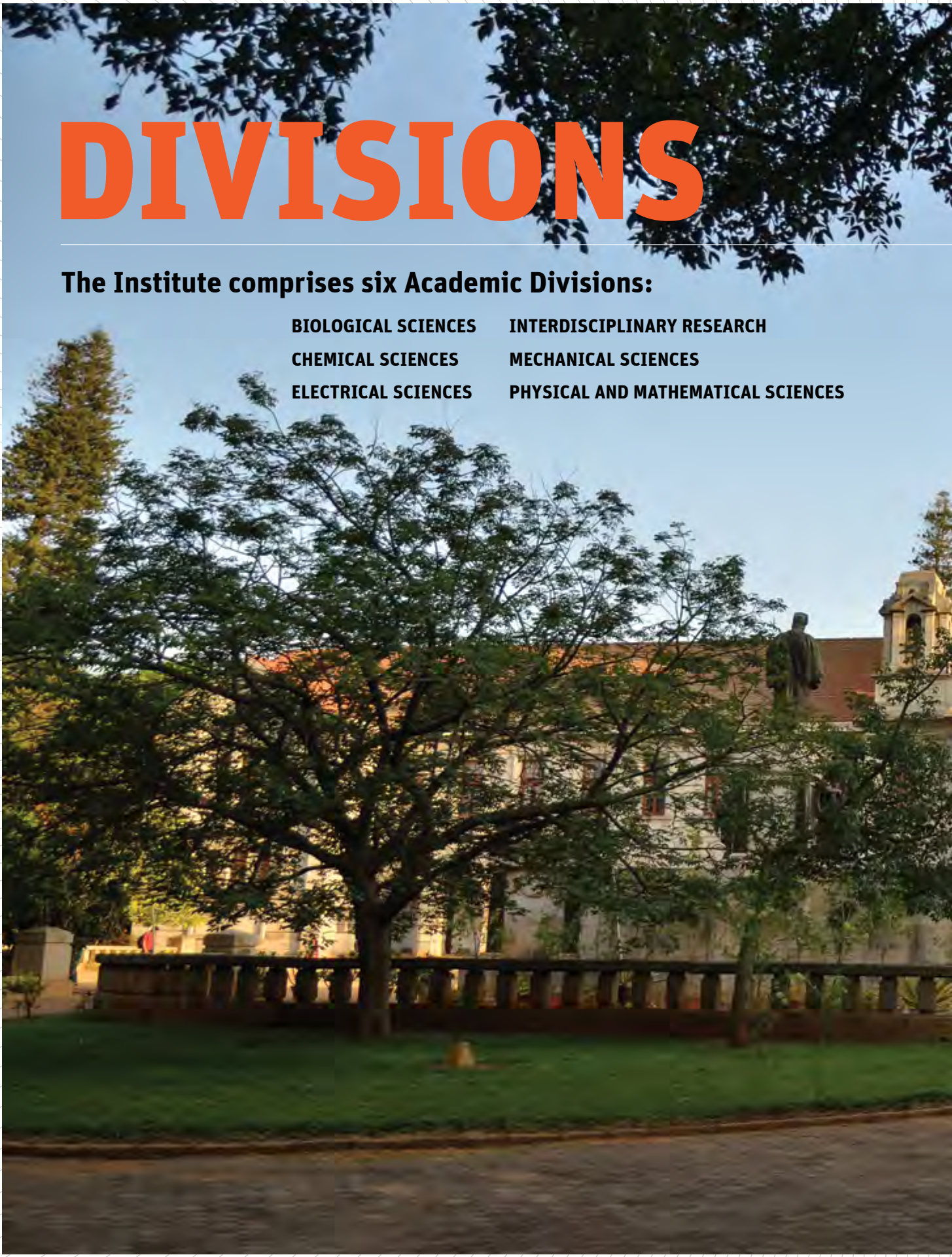
CHEMICAL SCIENCES

ELECTRICAL SCIENCES

INTERDISCIPLINARY RESEARCH

MECHANICAL SCIENCES

PHYSICAL AND MATHEMATICAL SCIENCES



This section offers a glimpse into the composition of and the research carried out in all the six Divisions. It includes the core areas and themes of research pursued by faculty members in each of them as well as snapshots of some of the recent research emerging from these Divisions. It also captures stellar accomplishments of select research groups during 2014-15.

BIOCHEMISTRY
ESTD: 1921 | CHAIR: PROF. C JAYABASKARAN

CENTRE FOR ECOLOGICAL SCIENCES
ESTD: 1983 | CHAIR: PROF. RENEE M BORGES

MICROBIOLOGY & CELL BIOLOGY
ESTD: 1941 | CHAIR: PROF. UMESH VARSHNEY

CENTRE FOR INFECTIOUS DISEASES RESEARCH
ESTD: 2014 | CHAIR: PROF. DIPANKAR NANDI

CENTRE FOR NEUROSCIENCE
ESTD: 2009 | CHAIR: PROF. VIJAYALAKSHMI RAVINDRANATH

MOLECULAR BIOPHYSICS UNIT
ESTD: 1971 | CHAIR: PROF. RAGHAVAN VARADARAJAN

CENTRAL ANIMAL FACILITY
ESTD: 1971 | CHAIR: PROF. KUMARAVEL SOMASUNDARAM

MOLECULAR REPRODUCTION, DEVELOPMENT & GENETICS
ESTD: 1989 | CHAIR: PROF. PATURU KONDAIAH

DIVISION OF BIOLOGICAL SCIENCES

Chairman: **Prof. D Narasimha Rao**

77 Faculty members

28 Fellows of Science Academies in India

379 PhD students

74 Integrated PhD students

49 PhD students graduated in 2014-15

DIVISION OF BIOLOGICAL SCIENCES

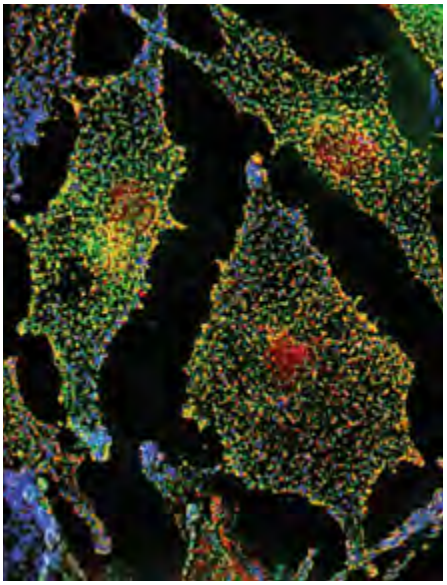
Core Research Areas

The Division of Biological Sciences forges important links between basic science and innovative research. It is committed to enhancing frontline studies in almost all aspects of modern biology: Neuroscience in Health and Disease, Infectious Disease, Structural Biology, Oncology, DNA Repair and Genomic Stability, Systems Biology and Bioinformatics, Immunology, Enzymology, Reproductive and Developmental Biology, Diverse Ecological Studies and so on.

Themes

Investigators in the Division focus on numerous processes central to the understanding of life, emphasizing on areas with considerable translational potential, namely, Cognition and Neuronal Reprogramming, Infectious Diseases, Drug and Molecular Design, Diagnostics and Therapeutics in Cancer, Gene Targeting, Genetic Disorders and Genetic Diversity.

Snapshots of Achievements in 2014-15

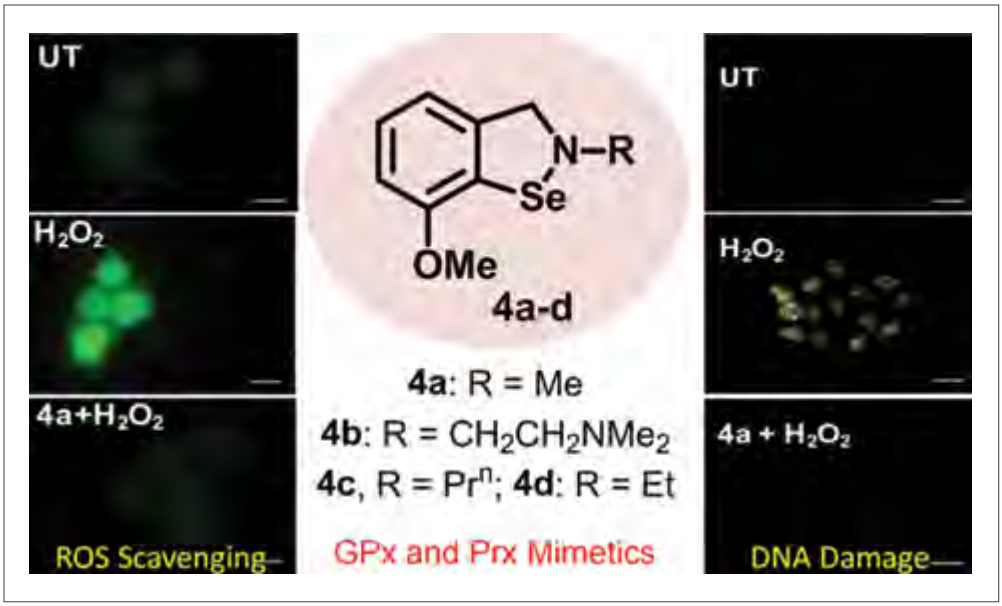


STX13 regulates cargo transport to melanosomes

(Jani RA et al., ***Journal of Cell Science,*** 2015)

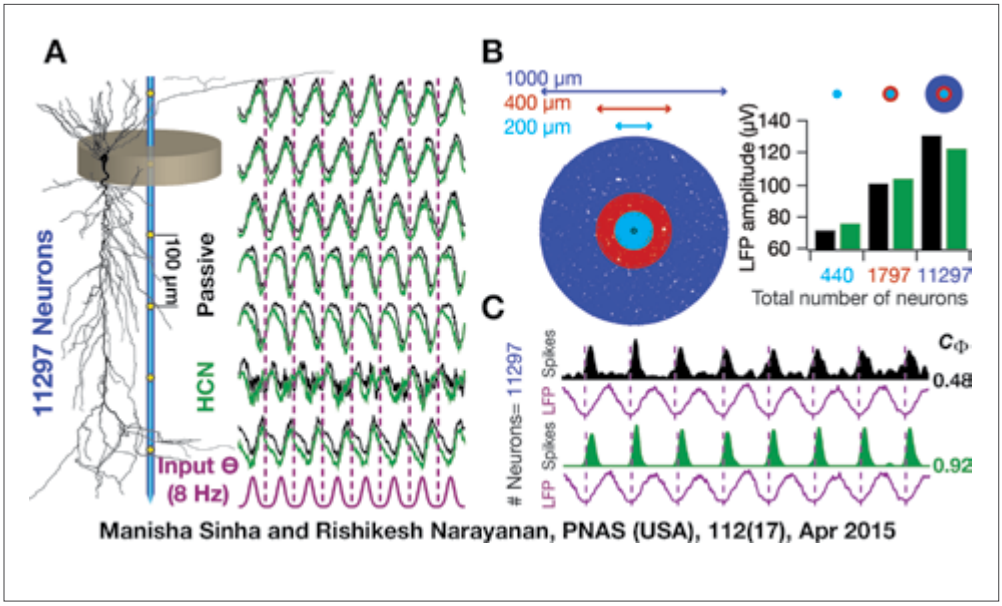
Dectin-1 and WNT signaling pathway intercept Toll-like receptor-induced inflammatory signature

(Trinath J and Holla S et al., ***Molecular and Cellular Biology,*** 2014)



Isoselenazoles: Artificial antioxidants use Glutathione (GSH) and Thioredoxin (Trx) to scavenge cellular peroxides and prevent oxidative stress mediated DNA damage

(Bhowmick D et al., ***Angewandte Chemie International Edition English,*** 2015, **Highlights:** Wirth T, ***Angewandte Chemie International Edition English,*** 2015)



The presence of hyperpolarization-activated cyclic-nucleotide-gated non-specific (HCN) channels in neurons alter the phase (A) of local field potentials (LFP) without significant alterations to the amplitude, for computations performed with different numbers of neurons (B). These channels also significantly contribute to enhancement of spike phase coherence (C)

(Sinha M and Narayanan R, ***Proceedings of the National Academy of Sciences,*** USA, 2015)

V NAGARAJA | **Professor, Department of Microbiology and Cell Biology**
S RAMAKUMAR | **Professor, Department of Physics**

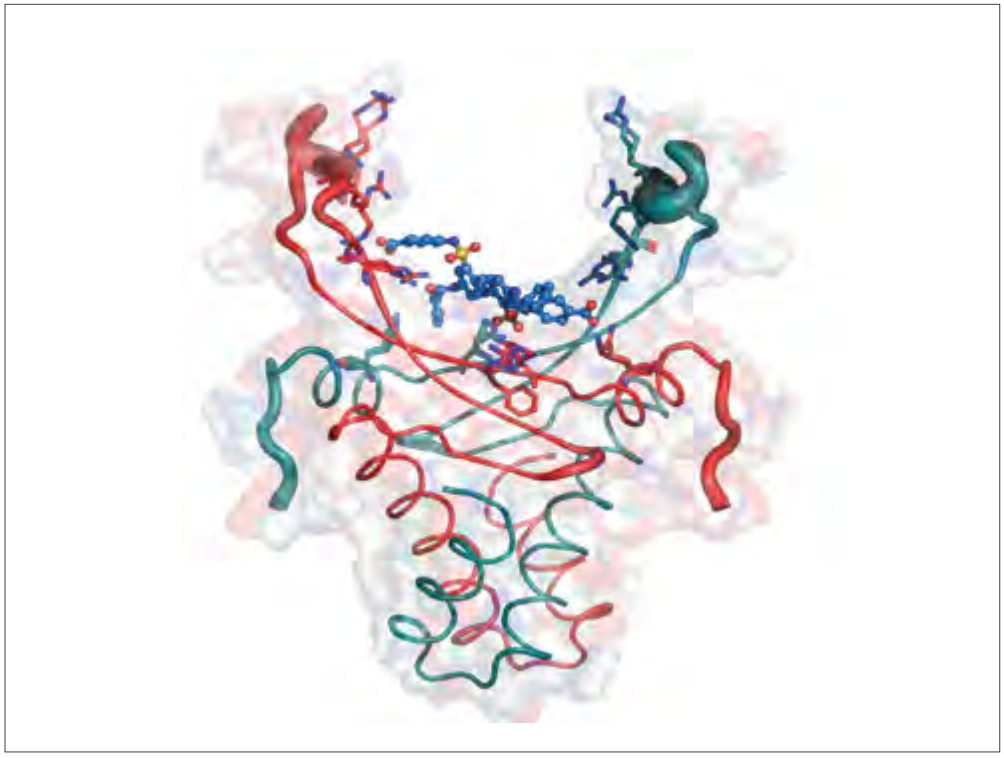
COMBATING TUBERCULOSIS

Mycobacterium tuberculosis is an ancient pathogen that causes the disease tuberculosis (TB), infecting millions of people every year; the disease has a very high rate of mortality and morbidity. The TB challenge has only grown with the emergence of drug-resistant strains of this bacterium. To combat the disease caused by these drug-resistant strains, researchers across the world are employing diverse strategies, including finding new drug molecules.

Nagaraja, a molecular biologist has been trying to understand the organism's key biological processes which are essential for its growth and survival. Now in collaboration with Ramakumar, a physicist, he is using an interdisciplinary approach to investigate how a TB causing bacterium's DNA in the chromosome is compacted, coiled or unwound by enzymes and DNA binding proteins.

Nagaraja's and Ramakumar's labs have carried out structural and functional studies of one such DNA organizing protein *HU*, essential for the survival of the pathogen. They believe that knocking out this protein's function would kill the TB-causing bacterium. So far the progress achieved by using this approach has been impressive—they have successfully cloned, expressed and purified the *HU* protein. This collaboration has also led to the deciphering of the three-dimensional structure

of this protein and the identification of small molecules that bind to the key pocket in the protein. In addition, they have shown that these molecules inhibit the protein, decompact the chromosome and affect the bacterial growth. This is the first time that proteins of this class from any organism have been targeted for inhibition.



HU from *Mycobacterium tuberculosis* bound to Stilbene derivative inhibitor

Prof. Nagaraja and Prof. Ramakumar with their teams

SATHEES C RAGHAVAN | Associate Professor, Department of Biochemistry

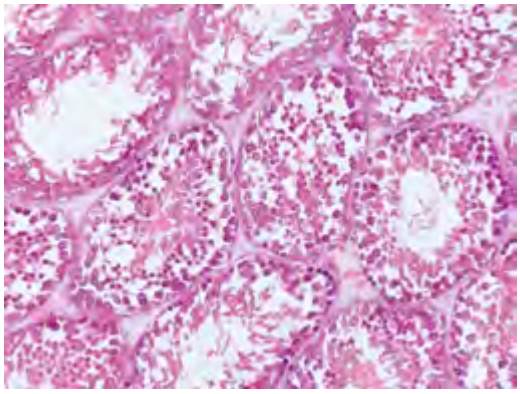
STUDYING DNA REPAIR, GENOMIC INSTABILITY AND CANCER THERAPEUTICS

Sathees C Raghavan and his group work in the field of DNA repair, chromosomal translocations, altered DNA forms, the biochemistry of antibody diversity generation and cancer therapeutics. Recently, they have designed, synthesized and identified a novel inhibitor SCR7 of Ligase IV, an enzyme involved in the final sealing of DNA double-strand breaks during NHEJ (a key DNA repair pathway). SCR7 exhibited anti-tumour activities in most cancers and its usage improves the efficacy of existing cancer therapeutic modalities by bringing down their effective dose. In the past year, this molecule has gained worldwide attention by helping improve precision and efficiency of genome editing technology.

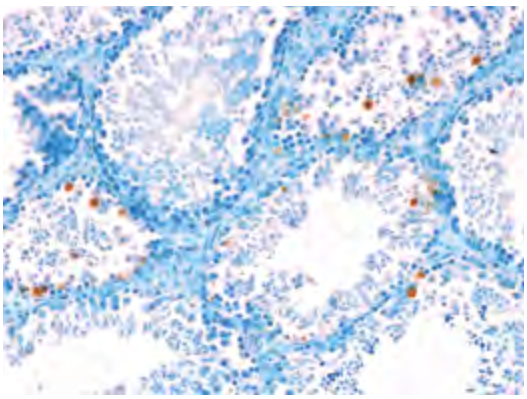
Another area of research that interests Raghavan's team is how the integrity of the genome is threatened. Among the threats to genome integrity are hazardous environmental factors like pesticides used extensively in agriculture.

Pesticides have been known to damage DNA in many ways. Raghavan's team studies a commonly used organochlorine pesticide, endosulfan (ES). ES, like several other pesticides, has been banned in many countries because it is detrimental to human health. However, little is known about how it causes genotoxicity. Using mouse as a model system, Raghavan and his group have demonstrated

that ES exposure affects the physiology and cellular architecture of various organs. They found that it was particularly damaging to mice testes. The testicular damage ES caused was shown to be both qualitative and quantitative in nature. It affected spermatogenesis, reducing quantity and vigour of sperm, thus leading to male infertility. The results of this study also indicate that ES is more detrimental to males than females.



Histological analyses of Endosulfan treated mice testes showing depleted seminiferous tubules



Testicular cell death in Endosulfan treated testes seen as brown spots

Prof. Raghavan with his team

INORGANIC AND PHYSICAL CHEMISTRY
ESTD: 1909 | CHAIR: PROF. S UMAPATHY

ORGANIC CHEMISTRY
ESTD: 1911 | CHAIR: PROF. N JAYARAMAN

SOLID STATE AND STRUCTURAL CHEMISTRY UNIT
ESTD: 1976 | CHAIR: PROF. S YASHONATH

MATERIALS RESEARCH CENTRE
ESTD: 1978 | CHAIR: PROF. A M UMARJI

NMR RESEARCH CENTRE
ESTD: 1977 | CHAIR: PROF. S VASUDEVAN

DIVISION OF CHEMICAL SCIENCES

Chairman: **Prof. P K Das**

58 Faculty members

25 Fellows of Science Academies in India

261 PhD students

75 Integrated PhD students

44 PhD students graduated in 2014-15

DIVISION OF CHEMICAL SCIENCES

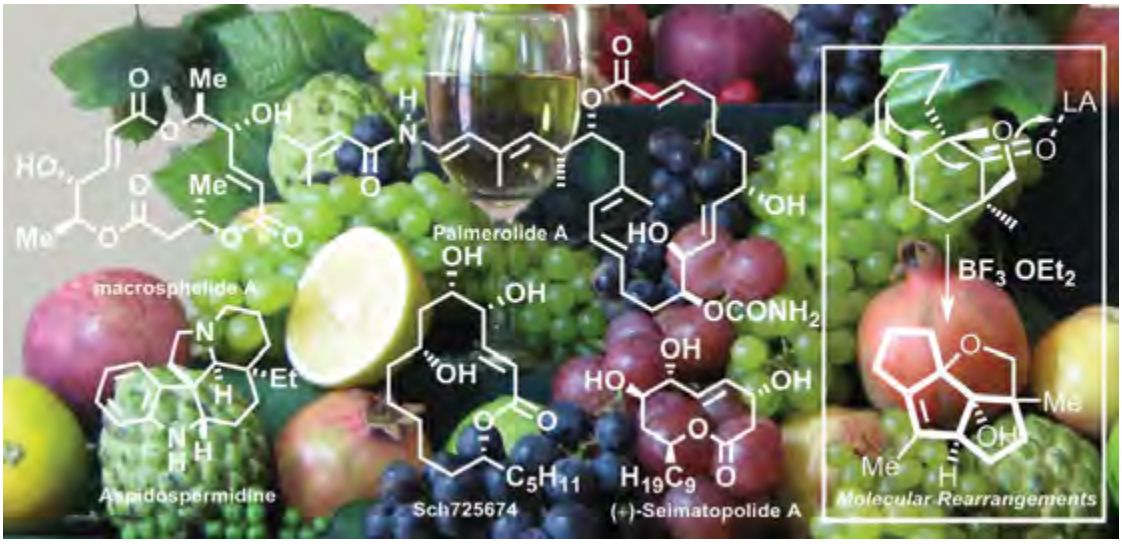
Core Research Areas

The Division of Chemical Sciences hosts some of the oldest departments in the Institute. The Department of Applied Chemistry, which was established in 1909, soon separated into the Department of Inorganic and Physical Chemistry and the Department of Organic Chemistry. Three more departments were added later. The faculty of the Division works on all contemporary topics in chemistry, such as Chemical Synthesis, Drug Design, Chemical Biology, Materials Chemistry, Surface Science, Nanochemistry, Molecular Spectroscopy, Ultrafast Chemical Dynamics, Computational and Theoretical Chemistry, Solid State Chemistry and Nuclear Magnetic Resonance.

Impact

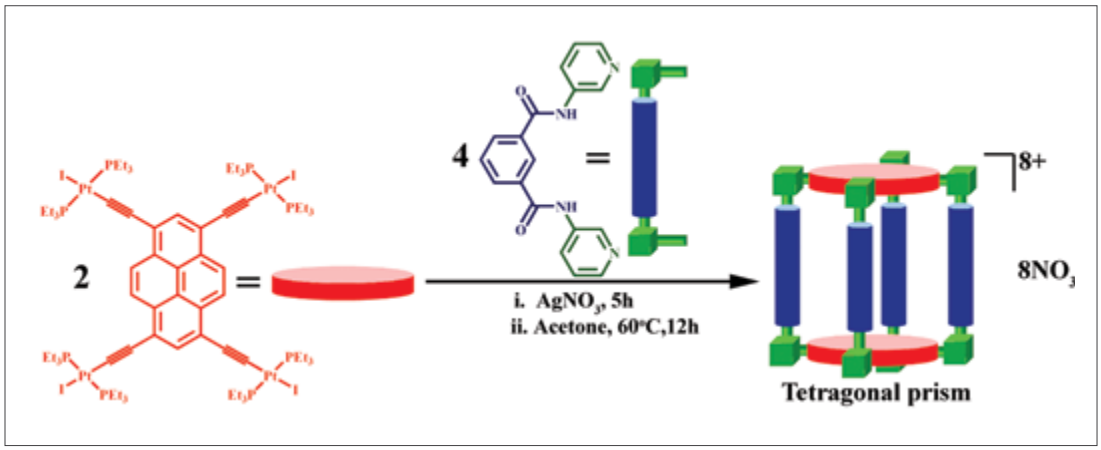
Departments from the Chemical Sciences Division have consistently figured among the top 50 chemistry departments in world ranking of universities during the past decade, a clear recognition of the globally-competitive research efforts of its faculty. Several members of the Division work on major initiatives of the DST, DRDO, DAE etc.; in addition, faculty collaborate with major international companies such as Boeing, Unilever and GE, and national companies such as Reddy's Labs, Balmer Lawrie and ICI.

Snapshots of Achievements in 2014-15

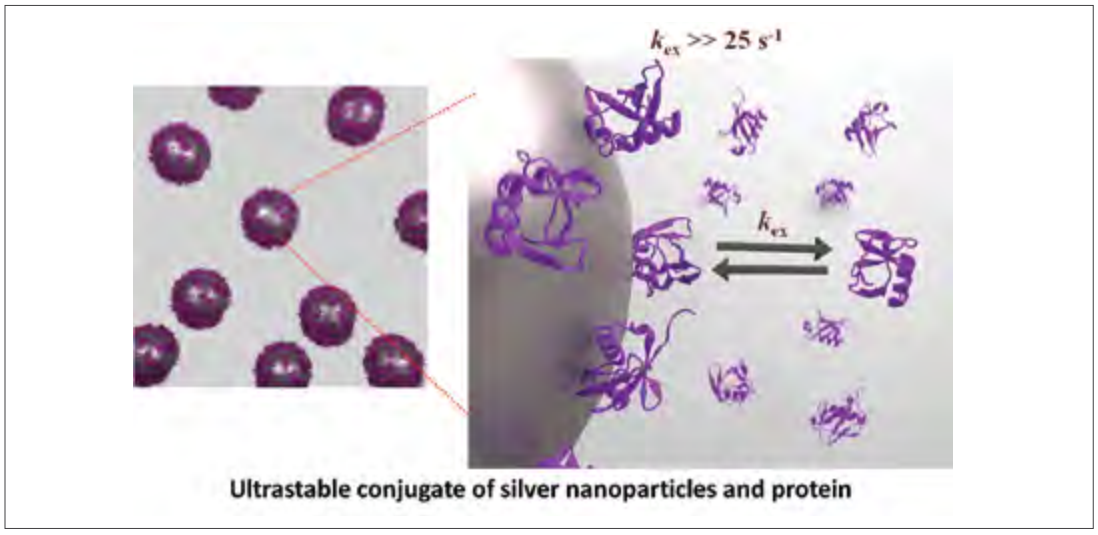


Molecular Complexity: Creating complex molecular structures in the laboratory using simple organic transformations is of immense significance in drug discovery. Prof. K R Prasad and co-workers recently reported the synthesis of structurally complex di- and tri-quinanes, which are

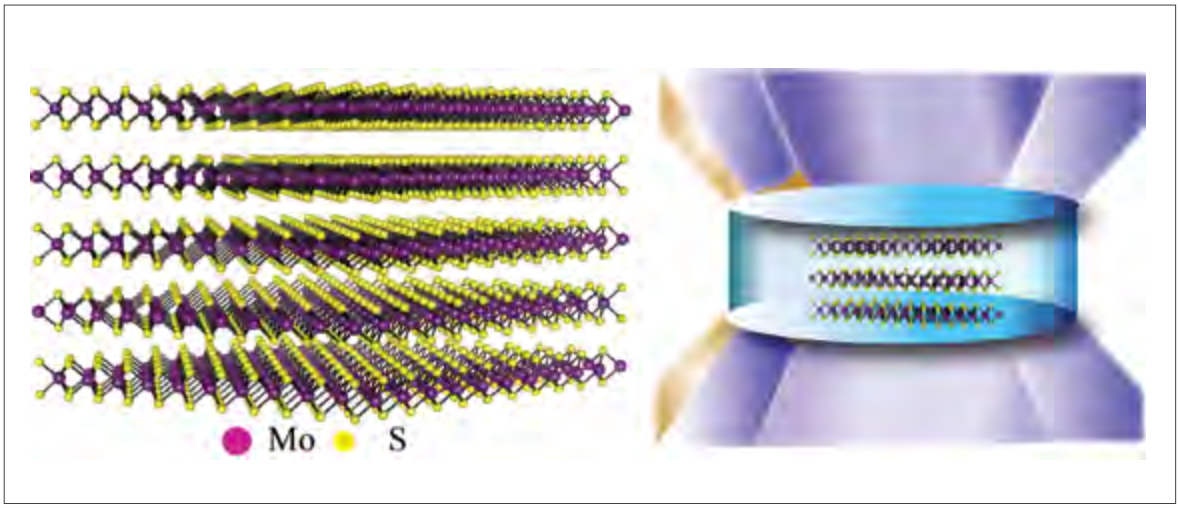
key constituents in a number of natural products, using clever Lewis acid-mediated tandem ring contraction rearrangement sequences. The naturally occurring molecules portrayed in the picture were synthesized in his laboratory using a chiral pool of tartaric acid/lactic acid/furyl carbinol, which in turn is sourced from grapes/wine, apple, etc.



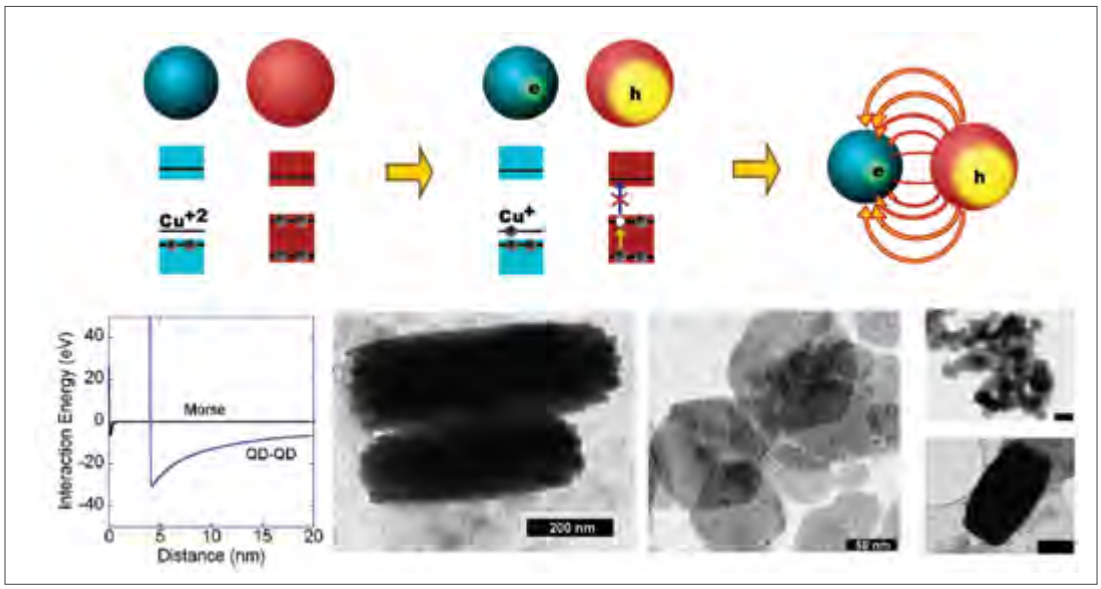
Caged Molecular Complexes for Sensing Explosives: Prof. P S Mukherjee's group has demonstrated that molecular prisms bearing an extended π-conjugation are both electron-rich as well as luminescent. Such macrocycle-cage structures, therefore, exhibit fluorescence quenching in solution when exposed to poly-nitrated compounds like picric acid (PA). The high degree of specificity towards PA in comparison to other electron-deficient nitro-aromatic explosives makes them promising candidates for selective sensing of PA at the ppb level.



Origins of Anti-Microbial Activity of Ag-nanoparticles: Using advanced NMR spectroscopic techniques, Prof. H S Atreya's group has unravelled the mechanism of interaction between silver nanoparticles and the protein, ubiquitin (Ubq). A dynamic association/dissociation process is believed to assist prolonged stabilization of silver nanoparticles, which is believed to be important for their well-known antimicrobial properties.



Pressure-Induced Semiconductor-to-Metal Transition: Theoretical simulations by Prof. Abhishek Singh's group has shown for the first time a completely reversible semiconductor-to-metal transition in bilayer molybdenum disulphide as a function of applied pressure. This phenomenon was shown to occur in all the semiconducting transition-metal dichalcogenides (TMDs), implying that the band gap can be tuned reversibly by applying a pressure of the order of few GPa. This prediction was recently confirmed by an experimental group from UT Austin using high-pressure experiments in diamond anvil cell. This observation opens up new possibilities for the utilization of TMDs as pressure sensors and straintronic devices.



Artificial Atoms: Prof. Anshu Pandey's group has recently succeeded in building semiconductor quantum dots that behave like "artificial atoms" and can react with each other. These "compounds" exhibit unusual structural diversity. Their odd properties such as size, periodicity and stoichiometry, in absence of a well-defined valence state, could challenge some of the fundamental chemical concepts.

GAUTAM DESIRAJU | Professor, Solid State and Structural Chemistry Unit

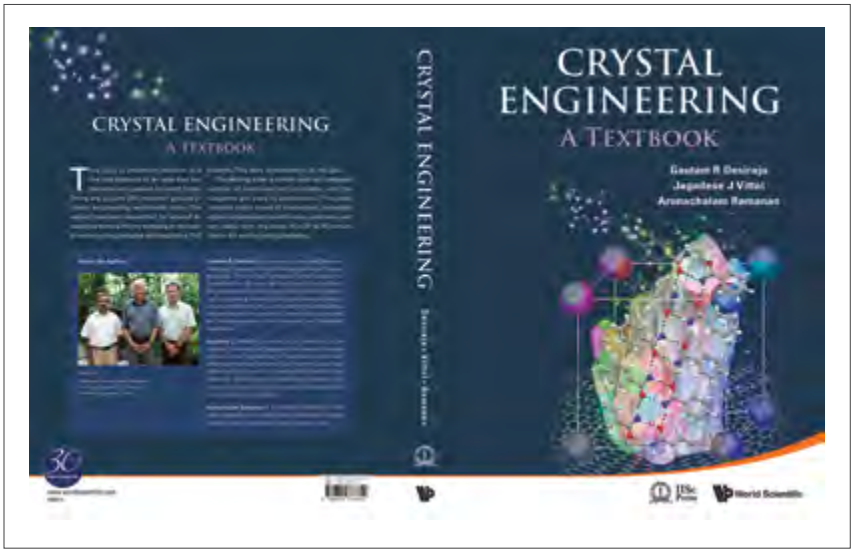
A PIONEER IN CRYSTAL ENGINEERING

Gautam Radhakrishna Desiraju, one of India's most eminent chemists, joined the Indian Institute of Science in 2009 after 30 years at the University of Hyderabad. It was he who, in his 1989 book, coined the term "crystal engineering", which he defined as the understanding of intermolecular interactions in the context of crystal packing and using it to design new solids with desired physical and chemical properties.

He is also associated with terms such as "weak hydrogen bond" and "supramolecular synthon", now an integral part of a crystallographer's lexicon, and is one of the most highly cited Indian scientists.

He was president of the International Union of Crystallography from 2011 to 2014 and is currently a member of the editorial advisory boards of *Angewandte Chemie, Journal of the American Chemical Society and Chemical Communications*.

In their research, Desiraju's group uses a technique called nanoindentation, in collaboration with U Ramamurty of the Department of Materials Engineering, to understand the mechanical behaviour of organic crystals and to correlate it with the properties of the molecules in these crystals. With this tool, they have studied the properties of the active pharmaceutical ingredient (API) felodipine and also engineered the hardness of an important API, omeprazole. Recently, they have also identified



Front and back cover pages of Desiraju's textbook, co-authored by Jagadese Vittal and Arunachalam Ramanan

the structural features that enable organic crystals such as N-benzylideneaniline to be highly flexible.

Dual mechanical properties in an organic crystal, namely pressure induced elastic mechanical bending and temperature induced crystal splitting, have been established for the first time by Desiraju's research team. A combinatorial crystal synthesis approach has been explored to design ternary (three component) molecular solids that constitute the crystal structure landscape. This concept of a supramolecular combinatorial library can be profitably extended to the crystallization process, with supramolecular synthons being the constituents of such a library.

Desiraju's lab has also successfully improved the physical and chemical properties of the diuretic drug hydrochlorothiazide using various other compounds with which it can form crystals.

Prof. Desiraju with his team

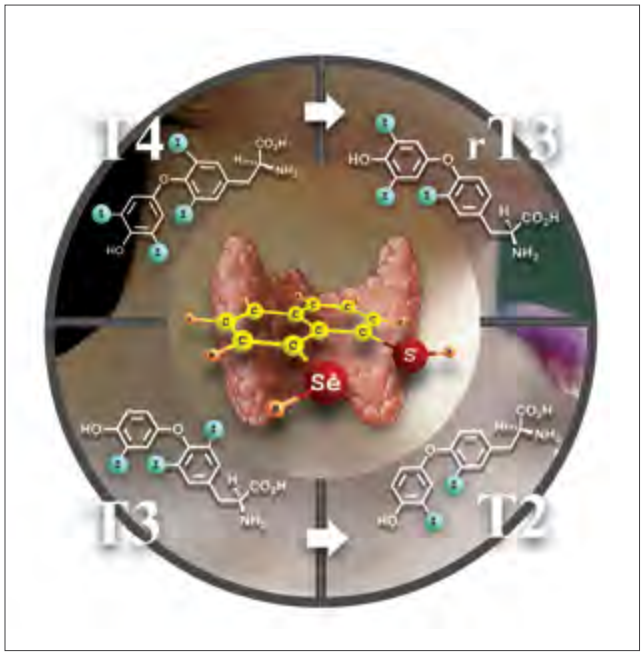
G MUGESH | Professor, Department of Inorganic and Physical Chemistry

HELPING DEVELOP NEW DRUGS

G Mugesh's laboratory works on developing new therapeutic agents to battle diverse diseases. For instance, cancer, renal disease, and neurodegenerative disorders such as Alzheimer's and Parkinson's are all associated with reactive oxygen species (ROS)—chemically reactive molecules containing oxygen that are important in cell signaling—and oxidative stress. Oxidative stress is an imbalance between the production of free radicals (highly reactive and short-lived molecules) and the ability of the body to neutralize their harmful effects through antioxidants. Mugesh's group has developed compounds that efficiently mimic antioxidant enzymes and combat oxidative stress without affecting the cellular antioxidant systems. These include several biocompatible selenium compounds and nanomaterials, which exhibit remarkable antioxidant activity and protect human cells against ROS-mediated damage. The new compounds are being evaluated to determine whether they can inhibit the aggregation of amyloid peptides, a biomarker of Alzheimer's disease, and whether they can prevent the inactivation of eNOS, an enzyme essential for a healthy cardiovascular system.

Mugesh's group has received worldwide attention for their seminal contributions in understanding the mechanism of thyroid hormone action. This understanding will help in designing and synthesizing novel compounds that can control thyroid levels through regioselective deiodination—the selective removal of an iodine atom from a molecule.

As abnormal thyroid levels have adverse effects in different disease conditions, such as hypoxia, myocardial infarction, neuronal ischemia, tissue injury and cancer, the novel compounds developed in his laboratory are candidates for further drug discovery studies.



Enzyme mimetic deiodination of thyroid hormones

Besides authoring more than 115 research papers in international peer reviewed journals, Mugesh is also on the editorial boards of many international journals. He has received several awards such as the Shanti Swarup Bhatnagar Prize and the Ramanna and Swarnajayanti Fellowships from the Government of India. Mugesh has also been elected as a Fellow of the National Academy of Sciences, India, and the Indian Academy of Sciences.

Prof. Mugesh with his team

COMPUTER SCIENCE AND AUTOMATION
ESTD: 1969 | CHAIR: PROF. JAYANT HARITSA

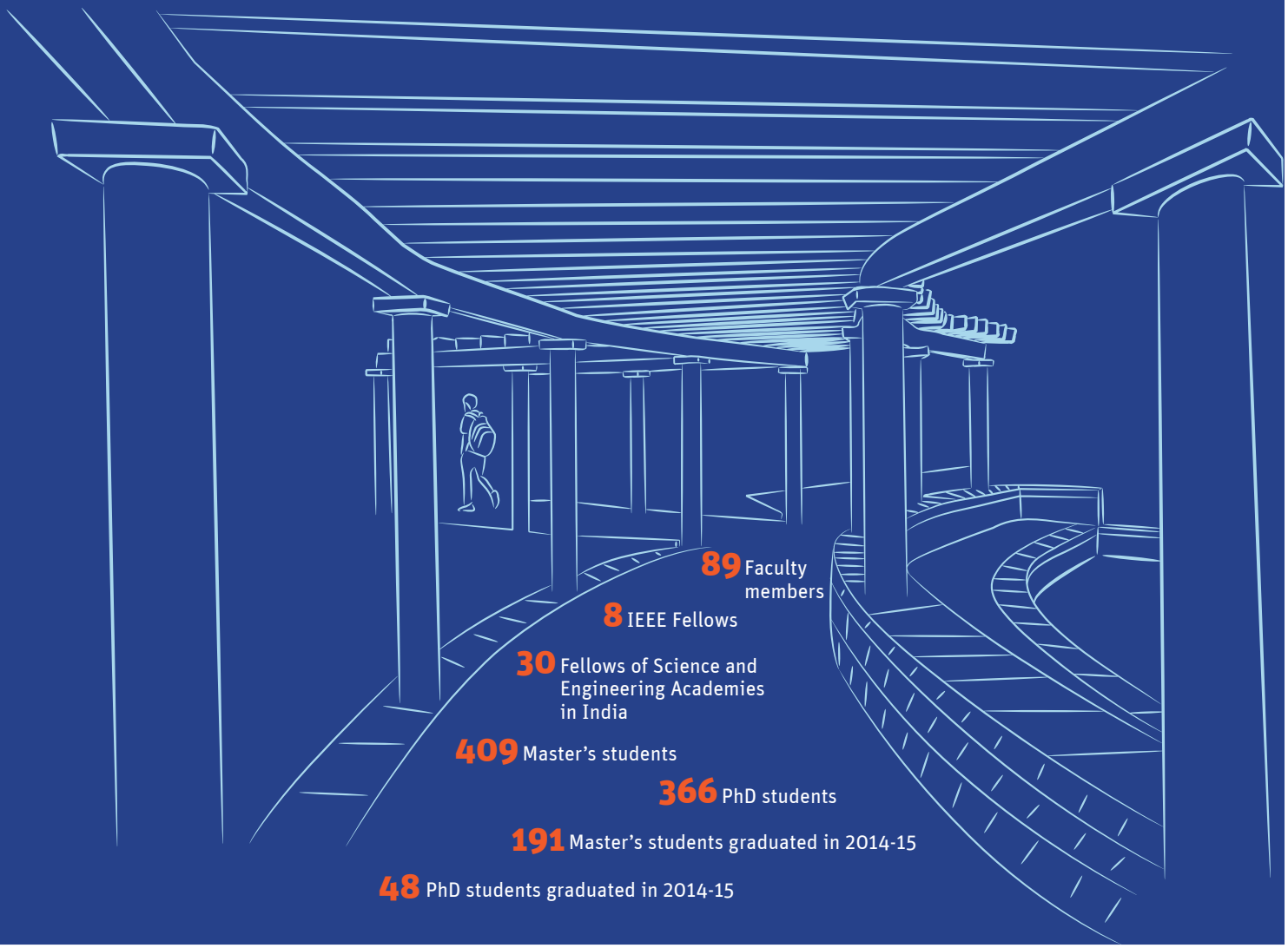
ELECTRICAL ENGINEERING
ESTD: 1911 | CHAIR: PROF. A G RAMAKRISHNAN

ELECTRICAL COMMUNICATION ENGINEERING
ESTD: 1946 | CHAIR: PROF. K V S HARI

ELECTRONIC SYSTEMS ENGINEERING
ESTD: 1974 | CHAIR: PROF. JOY KURI

DIVISION OF ELECTRICAL SCIENCES

Chairman: **Prof. Y Narahari**



89 Faculty members

8 IEEE Fellows

30 Fellows of Science and Engineering Academies in India

409 Master's students

366 PhD students

191 Master's students graduated in 2014-15

48 PhD students graduated in 2014-15

DIVISION OF ELECTRICAL SCIENCES

Core Research Areas

Rigorous innovation is the hallmark of the Division of Electrical Sciences. Even while working on high impact artefacts, the Division is assiduously seeking fundamental advances in the following areas: Signal Processing, Communications, Networks, Microelectronics and Devices, Theoretical Computer Science, Computer Systems and Software, Artificial Intelligence and Machine Learning, Power Engineering, Image Processing, and Computer Vision.

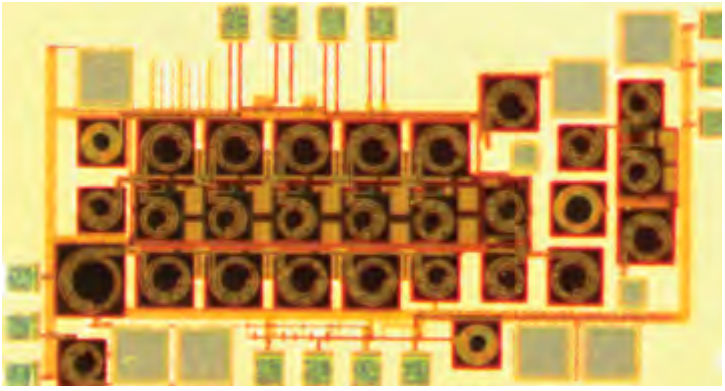
Themes

A feature of the Division's R&D activities is its focus on contemporary, interdisciplinary themes: Big Data Analytics, Internet of Things, 5G Technologies, Devices for Healthcare, Electronics for Strategic Sector, Network Science, Cybersecurity, and Multicore Computing.

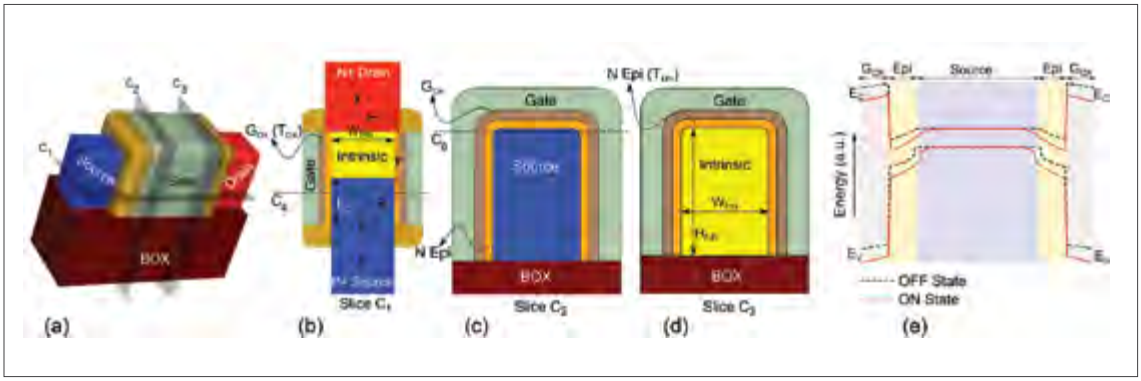
Impact

The work is splendidly aligned with major national initiatives such as Digital India, Make in India, and Smart Cities and is poised to impact major national programs under DRDO, DeITY, and DST. The Division is also actively engaged in collaborative R&D with global industrial research labs. Major collaborative programs with Tata Consulting Services, General Electric Research, Hewlett Packard, Texas Instruments, and Cisco are on the cards.

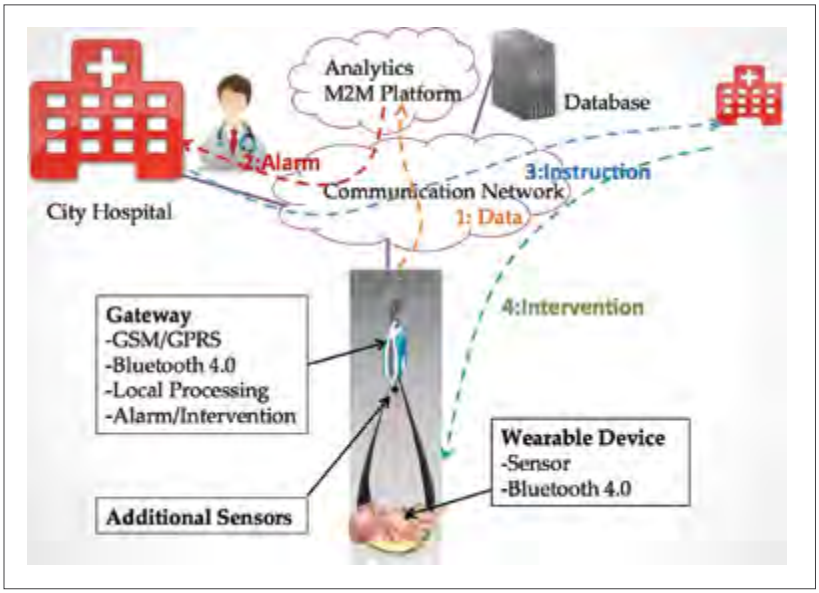
Snapshots of Acheivements in 2014-15



Strengthening Self-Reliance in Strategic Sector: A novel 2-20 GHz CMOS Wideband RF Amplifier developed by Dr. Gaurab Banerjee and team. This strategic component is cost effective and performs better than imported ones. The technology is being transferred to a company soon.



Sub-10nm CMOS Technology: A novel Fin Tunnel FET Device developed by Dr. Mayank Srivastava and team. This has recently been patented and is poised to transform sub-10 nm node CMOS technologies.



IoT Innovation for Healthcare: A remote monitoring system for new-borns developed by Prof. Bharadwaj Amrutur and team.

Printed Books to Braille Texts: Several hundred Braille texts have been created from printed books (using Tamil OCR). This innovation developed by Prof. A G Ramakrishnan and team is currently used by hundreds of visually challenged students. It has bagged the Manthan award in 2014 and Gandhian Young Technological Innovation Award in 2015.

A CHOCKALINGAM | **Professor, Department of Electrical Communication Engineering**
B SUNDAR RAJAN | **Professor, Department of Electrical Communication Engineering**

RESEARCH IN LARGE-SCALE MIMO SYSTEMS

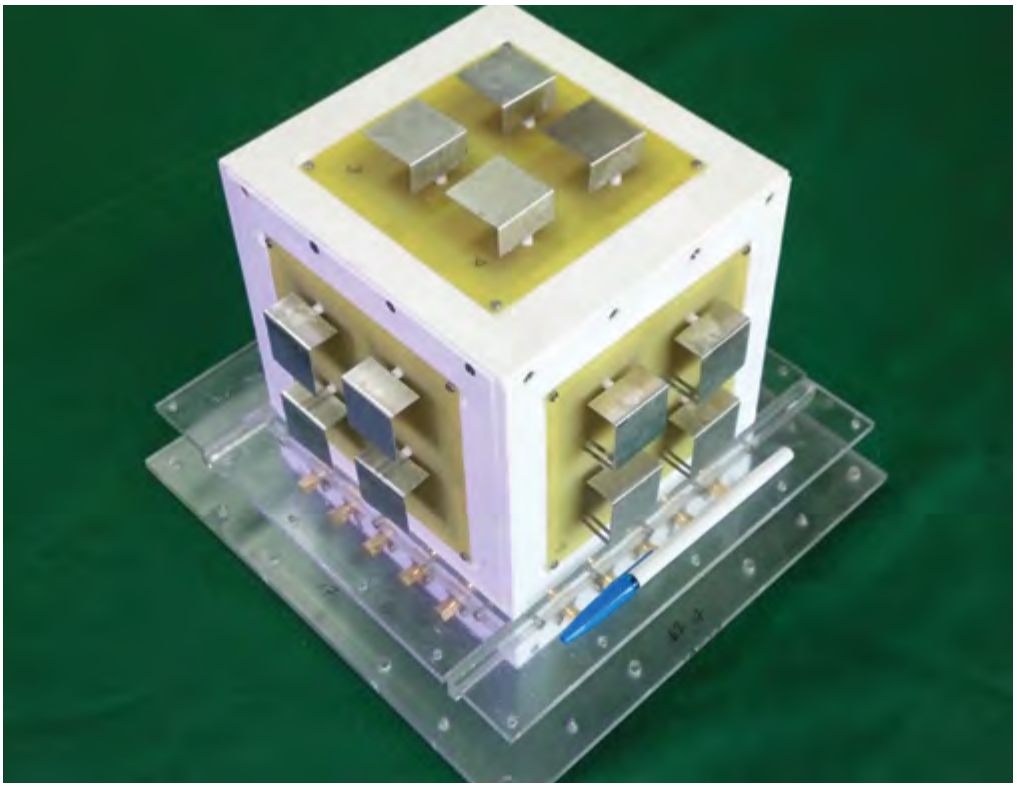
Multi-antenna wireless communication has become immensely popular because of its unique advantage of achieving increased data rate (without increasing bandwidth) and link reliability. Large-scale multiple-input multiple-output (MIMO) systems with tens to hundreds of antennas are being considered for 5G wireless standards.

Chockalingam and Sundar Rajan's labs have made pioneering contributions in the area of large-scale MIMO systems (now popularly called Massive MIMO systems). They have developed near-optimal low-complexity receiver algorithms that break the optimum receiver complexity barrier encountered in large dimensions.

These algorithms are rooted in artificial intelligence and machine learning; algorithms based on local search and meta heuristics (tabu search, for example), belief propagation/message passing and Monte Carlo sampling methods. Ingenious ideas in these proposed algorithms with carefully balanced performance and complexity were instrumental in the success of these algorithms for signal detection in large-scale MIMO systems. This collaborative research by these two electronics communication engineers resulted in the early development of the field of large-scale MIMO systems. They also have several US patents granted in this area.

More recently, recognizing the value and importance of translating their research output into practice, Chockalingam and Sundar Rajan, jointly with DRDO and partners from industry, have developed a large-scale MIMO system that uses 16 transmit antennas and 20 receive antennas in the 2.5 GHz band. The basic design and implementation approach for this system are based on their patents on large-scale MIMO.

Chockalingam and Sundar Rajan have also authored a book titled 'Large MIMO Systems', published by Cambridge University Press in 2014. It is the first book to take an in-depth look into large MIMO systems with tens to hundreds of antennas. A Chinese edition of this book is being planned by the publisher.



A 20-Antenna MIMO Cube

VIJAY NATARAJAN | Associate Professor, Department of Computer Science and Automation

VISUALIZING DATA

Scientific data such as those arising from imaging devices and computational experiments in science and engineering disciplines is increasingly becoming larger in size and richer in its features. A deeper understanding of such data plays a fundamental role in the discovery of knowledge.

In their research, Natarajan and his team employ an approach called feature-directed data visualization where the data is first processed to obtain abstract representations, which in turn can be visualized for interactive exploration.

They have demonstrated the effectiveness of such feature-directed and knowledge-assisted visualization methods to data from various disciplines like weather and climate science, molecular biology, and cosmology.

One problem that has received Natarjan's special attention is the study of the role of symmetry in understanding the structure as well as the physical properties of both natural and man-made objects. His lab has modeled the problem of symmetry identification for the first time in a novel feature-aware manner, where the symmetric repeats are restricted to features of interest in the data. They have also designed computationally efficient algorithms to identify symmetric regions within volumetric data that may arise from 3D imaging devices or from simulations. The automatic detection of symmetry is a computationally challenging problem because it necessitates a search over all possible regions within the volume and a search over all possible symmetries. Moreover,

real life data sets never exhibit perfect symmetry. This introduces additional challenges in determining symmetry in an approximate sense as well as in handling noise and in identifying missing parts within symmetric regions in the data.

Visualization of the dodecahedral symmetric structure of the human adenovirus. The symmetric patterns were computed automatically from cryo-electron microscopy data and used to highlight interesting features in a visualization

Natarajan and his team have shown that symmetry information helps enhance traditional visualization methods. They have also demonstrated applications to query-driven exploration of feature-rich data where displaying the entire data is neither efficient nor useful. They believe that their methods for symmetry detection will open new frontiers in analyzing structural similarity of scientific data.

Prof. Natarajan with his team

CENTRE FOR CONTEMPORARY STUDIES
ESTD: 2004 | CHAIR: PROF. R GADAGKAR

CENTRE FOR NANOSCIENCE AND ENGINEERING
ESTD: 2010 | CHAIR: PROF. RUDRA PRATAP

MANAGEMENT STUDIES
ESTD: 1985 | CHAIR: PROF. M H BALASUBRAHMANYA

INTERDISCIPLINARY CENTRE FOR ENERGY RESEARCH
ESTD: 2012 | CONVENER: PROF. K CHATTOPADHYAY

INTERDISCIPLINARY CENTRE FOR WATER RESEARCH
ESTD: 2015 | CONVENER: PROF. P MAJUMDAR

ROBERT BOSCH CENTRE FOR CYBER PHYSICAL SYSTEMS
ESTD: 2011 | CHAIR: PROF. S ASOKAN

SUPERCOMPUTER EDUCATION AND RESEARCH CENTRE
ESTD: 1990 | CHAIR: PROF. R GOVINDARAJAN

CENTRE FOR BIOSYSTEMS SCIENCE AND ENGINEERING
ESTD: 2015 | CO-CHAIR: PROF. G ANANTHASURESH
PROF. SANDHYA VISWESWARAIAH

CENTRE FOR INFRASTRUCTURE, SUSTAINABLE TRANSPORTATION AND URBAN PLANNING
ESTD: 2009 | CHAIR: PROF. J M CHANDRA KISHEN

DIVISION OF INTERDISCIPLINARY RESEARCH

Chairman: **Prof. Govindan Rangarajan**

29 Faculty members

141 PhD students

95 Master's students

6 PhD students graduated in 2014-15

30 Master's students graduated in 2014-15

DIVISION OF INTERDISCIPLINARY RESEARCH

Core Research Areas

Interdisciplinarity is the characteristic feature of the research carried out in this Division. Specific research areas are: Bioengineering, Urban Infrastructure and Transportation, Nanoscale Materials, Nano Devices and Systems, Economics, Finance, Human Resource Management, Marketing, Optimization, Public Policy, Energy, Water, Internet of Things, Distributed Sensing, Computer Systems, Computational Science and Bioinformatics.

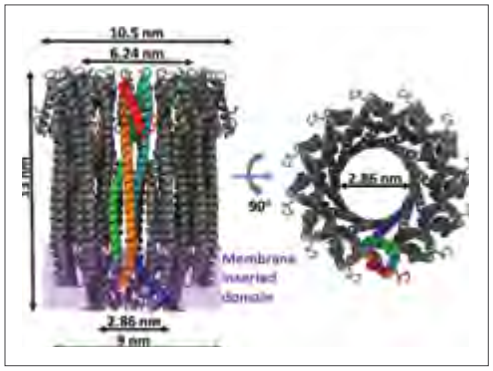
Themes

Interdisciplinary research has emerged as a crucial part of the research landscape in recent years. By breaking down departmental barriers, interdisciplinary research facilitates novel breakthroughs that may not be possible within the confines of a particular discipline. The Division of Interdisciplinary Research has a wide range of Departments/Centres with the common theme of a strong interdisciplinary focus.

Impact

Research in the Division directly addresses the burning issues facing the country such as energy, water and infrastructure. Moreover, basic and translational research in Nano-science and -Engineering, Bioengineering, Computational Science and Cyber Physical Systems have not only advanced the frontiers of science and engineering but have also provided the tools and materials required to solve some of the national issues listed above. The nanofabrication and characterization facilities and the supercomputing centre are of international standards and are widely used by researchers and students from across India. The recently established National Supercomputing Mission (where IISc provides the academic leadership) will have a transformative effect on the field of supercomputing research in India. The Indo-US SERIIUS project (coordinated by IISc) has had a significant impact on high-end energy research in both India and the USA.

Snapshots of Acheivements in 2014-15



The structure of the ClyA pore as determined by X-ray crystallography

Molecular Mechanisms of Action of Pore-Forming Toxins: Pore forming toxins are produced by pathogenic bacteria and punch holes in cell membranes, thereby killing the cell. Research led by Prof. Sandhya Visweswaraiah has shown which region of the ClyA toxin is important for pore formation, and molecular dynamics simulations have revealed the molecular details that underlie pore formation and membrane interaction. Deleting 12 amino acids at the C terminus of the toxin reduces its activity and ability to form pores.

Technology Driven Solutions for Urban Floods: This work by Prof. Pradeep Mujumdar's research group aims to leapfrog from the current, poorly managed response to urban floods to a highly efficient, automated, human-computer interaction, and sensor technology-driven end-to-end management, thus overcoming the institutional constraints to a significant extent. An innovative use of sensor and communication technologies coupled with state-of-the-art hydrologic models and Geographic Information Systems is demonstrated on a pilot scale for operational decisions.

Measuring Arterial Pressure: A Fiber Bragg Grating (FBG) pulse recorder which uses a novel technique for accurately acquiring arterial pressure pulse waveforms was developed by Prof. S. Asokan's research group. This project won the Gandhian Young Technological Innovation Award in 2015.

JAYANT HARITSA | Professor, Supercomputer Education and Research Centre and Department of Computer Science and Automation

DEVELOPING ROBUST DATABASE MANAGEMENT SYSTEMS

Database management systems constitute the behind-the-scenes backbone of today's information-rich society, providing a congenial environment for handling enterprise data during its entire life cycle. A compelling instance of their grassroots impact is the centralized database created by the Government of India, under the Aadhaar card programme, for hosting the humongous corpus of personalized identification information collected from the Indian population.

With the impending advent of the Big Data world, where data is expected to be the engine driving virtually all aspects of human endeavour, the role of database systems will soon assume ubiquitous proportions.

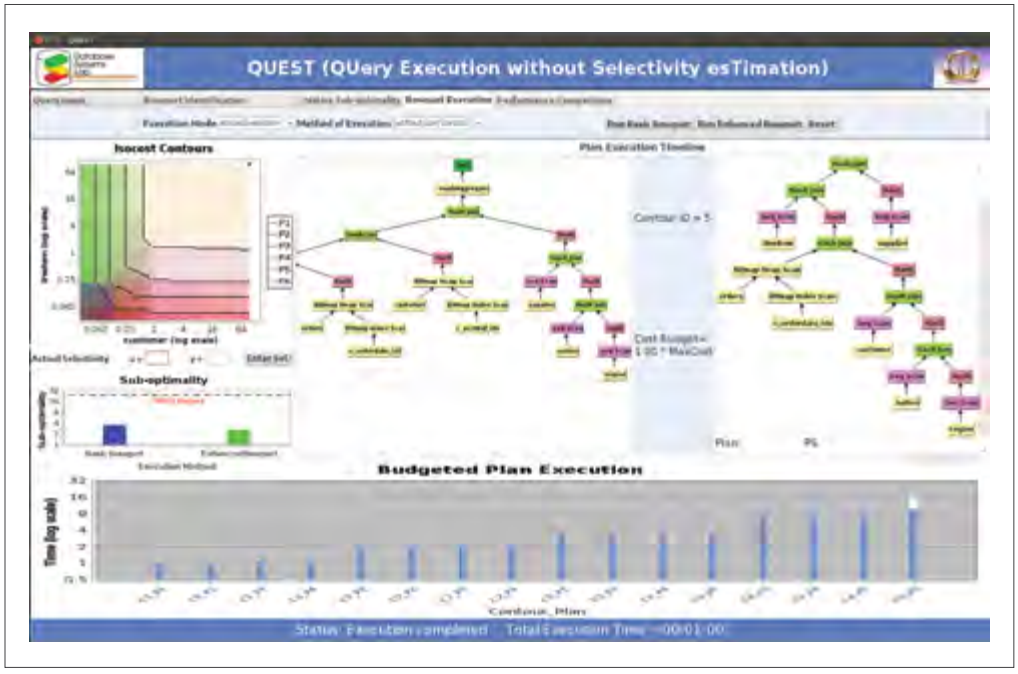
A potent and unique feature of database systems is their organic support for declarative user queries, where the user only specifies the search objectives, and the system is responsible for identifying an efficient means to achieve these ends. In practice, however, it is often belatedly realized after the query execution is completed, that a poor choice of strategy had been made. Therefore, a highly desirable, but equally elusive target for several decades has been the provision of performance guarantees on the specific means chosen by the system.

Jayant Haritsa leads the Database Systems Lab (DSL) at the Institute which has, over the past two years, solved this classical problem by designing a radically different query execution mechanism called plan bouquets. This game-changing approach delivers, for the first time, proven and

competitive performance guarantees. Moreover, it does so even in complex situations where contemporary commercial systems suffer significant degradation in their operational quality.

In a nutshell, DSL has developed the first-ever provably robust query processing technique, thereby fulfilling a dire and long-felt need of the global information management community. Major database vendors are currently exploring integration of these far-reaching ideas in their products.

A prototype implementation of the plan bouquet mechanism received the Best Software award at VLDB 2014, a premier international database research conference. Haritsa also won the prestigious Infosys Science Foundation Award in 2014 for his research contributions.



Basic Bouquet Execution

Prof. Haritsa with his team

RUDRA PRATAP | Professor, Centre For Nano Science And Engineering (CeNSE)

HOW NANOENGINEERING IS CHANGING OUR WORLD

Rudra Pratap studies structures that are so small that they have properties very different from those in the macro-world. The current focus of his group is to understand the dynamics of micro and nanoscale mechanical structures, such as beams, plates, membranes etc, commonly used in Microelectromechanical Systems (MEMS) and Nanoelectromechanical Systems (NEMS) devices.

Because of their size, these mechanical structures have very high natural frequencies (ranging from a few KHz to a few GHz). At such frequencies, it is important to understand certain phenomena that are very different at macroscales. One such example is the mechanism of energy dissipation. Its understanding at nanoscales will help in realizing devices with incredibly sharp resonant peaks never achieved before in mechanical devices.

Pratap's lab is studying mechanisms of damping in MEMS/NEMS devices and developing dynamic sensors that find applications in acoustics, ultrasonics, inertial navigation and medical diagnostics.

With the help of collaborators, Pratap's group is vigorously pursuing research in controlled electromigration for material transport at nanoscales. They have invented a new technology called Electrolithography, capable of nanoscale patterning and pattern transfers on any substrate using an inexpensive patented process. They now aim to develop this technology for commercial use.

Pratap's team is also interested in exploring the world of tiny transducers that insects use. In collaboration with insect biologists, they are seeking to understand the design of transducers involved in cricket song production. They have developed a model of singing field crickets that reveals how natural selection has ensured that different cricket species have evolved distinct frequency bands using an elegant scaling law for their wing design (crickets produce songs by rubbing their wings against each other). This finding may find use in designing new MEMS speakers.

Top left: A field cricket

Top Right: The harp, a resonator embedded in the wing that acts as a loudspeaker

Left: Set of micro teeth that form a file on the underside of one edge of the harp, responsible for converting low frequency wing stridulation into a high frequency impulse train that excites the harp

Prof. Pratap with his team

AEROSPACE ENGINEERING
ESTD: 1942 | CHAIR: PROF. DEBASISH GHOSE

CHEMICAL ENGINEERING
ESTD: 1943 | CHAIR: PROF. GANAPATHY AYAPPA

MECHANICAL ENGINEERING
ESTD: 1945 | CHAIR: PROF. PRADIP DUTTA

MATERIALS ENGINEERING
ESTD: 1945 | CHAIR: PROF. T A ABINANDANAN

CIVIL ENGINEERING
ESTD: 1950 | CHAIR: PROF. M SUDHAKAR RAO

CENTRE FOR PRODUCT DESIGN AND MANUFACTURING
ESTD: 1998 | CHAIR: PROF. AMARESH CHAKRABARTI

CENTRE FOR ATMOSPHERIC AND OCEANIC SCIENCES
ESTD: 1982 | CHAIR: PROF. RAVI S NANJUNDIAH

DIVECHA CENTRE FOR CLIMATE CHANGE
ESTD: 2009 | CHAIR: PROF. J SRINIVASAN

CENTRE FOR SUSTAINABLE TECHNOLOGIES
ESTD: 1974 | CHAIR: PROF. H N CHANAKYA

CENTRE FOR EARTH SCIENCES
ESTD: 2007 | CHAIR: PROF. D NAGESH KUMAR

DIVISION OF MECHANICAL SCIENCES

Chairman: **Prof. Vikram Jayaram**

128 Faculty members

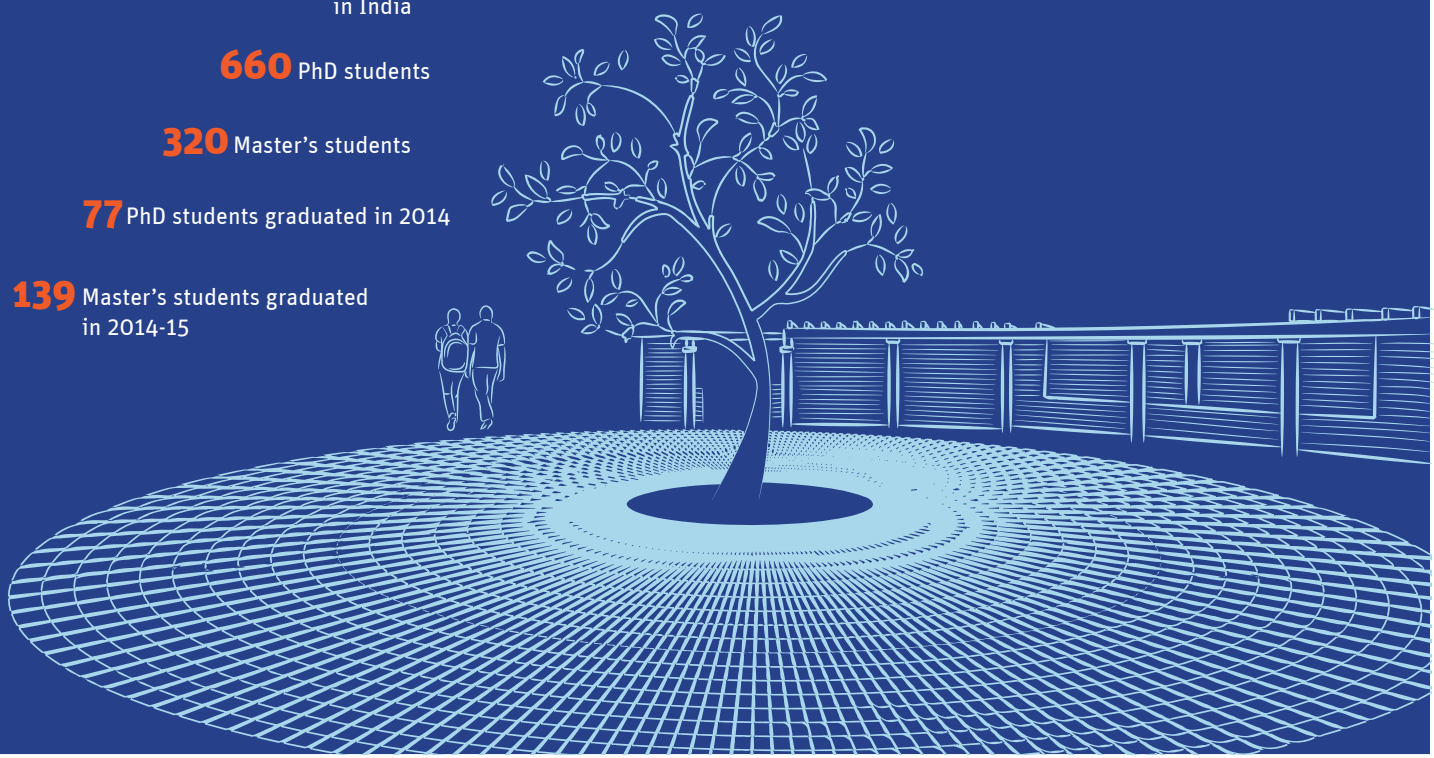
22 Fellows of Science and Engineering Academies in India

660 PhD students

320 Master's students

77 PhD students graduated in 2014

139 Master's students graduated in 2014-15



DIVISION OF MECHANICAL SCIENCES

This is the largest Division, both in terms of faculty members as well as student strength.

A drone with a nanomist generator for pesticide and nutrient delivery

Research in aerospace and related disciplines have led to strong programmes in structural health monitoring, green energetic materials as rocket propellants, fluid mechanics of bodies landing on water and the identification of a new type of hovering motion as well as the design and development of fixed wing nano air vehicles as part of India's Micro Air Vehicle programme.

Environmentally friendly *in-situ* printing for flexible electronics, patterned conducting, new catalysts for enhanced photo-electro-oxidation and synthetic natural gas production comprise some of the activities in chemical engineering. Bio- and health-related research are carried out in multiple locations and focus on issues as diverse as mathematical modeling of treatments for hepatitis C, microcapsules for drug delivery, turbulent flow in microchannels to simulate flow in blood vessels and an endoscopic simulator for the upper gastrointestinal tract. Energy research focuses on new polymeric photovoltaics, flow batteries that complement solar and wind sources, low temperature combustors as hybrid heating sources for solar thermal power, gel-adsorption systems that use waste/solar heat for refrigeration, potable water and efficient stoves and driers which have been disseminated in their thousands in rural areas of Karnataka and Madhya Pradesh

The broad field of materials encompasses new high-temperature structural alloys, lead-free piezoelectric materials, modeling of semi-solid forging, fracture in metallic glass and modeling of processes such as iron-making and reactive densification of ceramics.

The role of zinc in the biomechanics of substrate boring by fig wasps

The broad field of civil engineering has been revolutionized in recent times through cutting edge technologies such as ultrasonic and laser-based displacement measurements. Sustainable development forms much of the focus in areas such as low carbon building materials, gas production in landfills, solid waste management, contaminant transport, sustainable transportation systems, the use of remote sensing data to predict crop yields, and development of an equitable model of urban water distribution. Industrial mine waste has been shown to be a sand substitute and demonstrated through the construction of a two storeyed building. Studies into forest cover that revealed over-reporting forest area and under-reporting forest loss were widely reported and discussed in Parliament. Anaerobic digesters have been developed as bio-refineries that can generate value added by-products and treat waste water. Affordable sanitation technology packages, at a nominal cost of Rs. 11000 each, have been developed for both rural and urban areas.

A 20 kW solar power plant on the roof of the JRD Tata Memorial Library to power part of the Central Office at IISc

Studies on Earth systems focus on atmospheric/ocean dynamics as well as climate change. The topics include: the influence of seasonal variability of anoxic condition and its influence on fish production in the Arabian Sea; the role of Indian Monsoon in controlling the effect of anthropogenic emission on the seasonal variation of air-CO_2 over Bangalore; the ages and

magnitudes of pre-2004 tsunamis inferred from Andaman and Nicobar islands; studies into droughts that stem from El Nino and non El Nino causes and the role of aerosols in determining climatic variations. Interestingly, modeling has shown that geoengineering to mitigate warming can have adverse consequence of reducing water resources and crop yields in India.

A mould for rapid construction of fuel efficient ASTRA domestic stove

Design research encompasses theory, product sustainability, digital human modeling, thermal comfort and tools for CAE. A significant finding in design for disassembly was the significantly higher ergonomic hazards associated with manual disassembly in informal sectors vis-à-vis those in formal sectors. A questioning based method for automated knowledge acquisition has been developed along with a computer-assisted procedure for accurate anatomical landmark identification from MRI data.

Advanced Facility for Microscopy and Microanalysis

This central facility houses a number of imaging and spectroscopy systems including atomic resolution electron microscopes with electron and x-ray spectroscopy, ion beam machining, x-ray tomography and atomic force microscopy and has more than 200 registered users.

KAMANIO CHATTOPADHYAY | **Professor, Department of Materials Engineering**
DEBIPROSAD ROY MAHAPATRA | **Professor, Department of Aerospace Engineering**

DESIGN INSPIRED BY NATURE

Kamonio Chattopadhyay, a materials engineer who has done pioneering work in the field of crystal structures, and Debiprosad Roy Mahapatra, an aeronautical engineer who works on engineering mechanics, were brought together by a mutual interest in designing futuristic materials inspired by nature.

By a process of trial and error over millions of years, natural selection has shaped evolutionary traits that help animals and plants survive, often in adverse environmental conditions. One such example is the shell of the mollusk. Many of these marine animals live in the deep seas and have to withstand enormous pressure. How these animals protect themselves from stress and fracture was a question that intrigued Chandrasekhar Tiwary— a former PhD student with Chattopadhyay—when he stumbled upon them as he took a stroll on a beach in Pondicherry.

Chattopadhyay and Mahapatra decided to investigate this question with Tiwary and his new postdoctoral advisor, Pulickel Ajayan, a Professor at Rice University in the US.

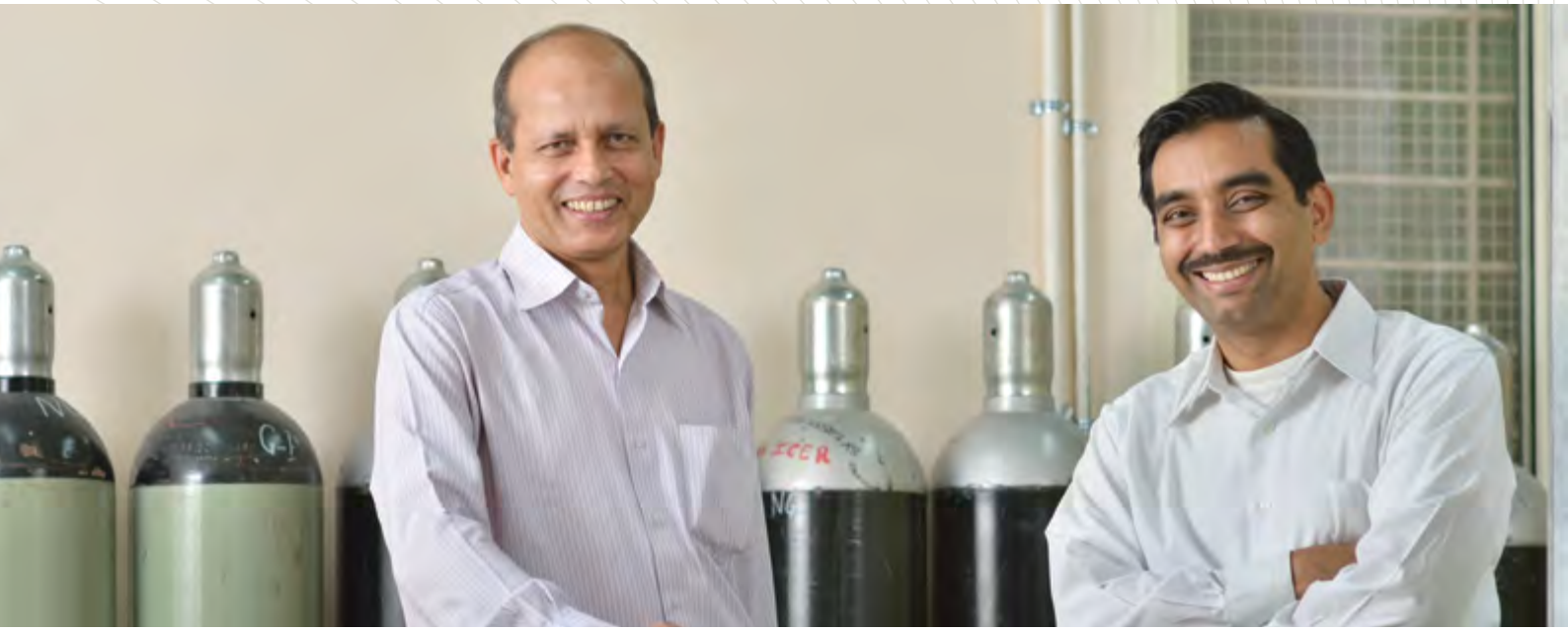
With the help of mechanics theory and experiments, they found that these animals secrete shells with an optimal thickness to deal with their marine lifestyle. Also, they have complex shapes that enable them to transfer stress from the outer surface to particular locations of geometric concentrations.

At great pressures deep in the sea, this design of the outer shell allows the soft-bodied animal inside to survive because even if there is a fracture, it occurs in these sturdy parts. Their hypothesis was confirmed by mechanical tests performed on models created using 3D printing.

Besides helping us understand how nature has driven the evolution of life forms, this study could have a wide range of implications in many diverse fields, from designing aircrafts that are safer and more damage tolerant to constructing buildings that protect against environmental calamities. Chattopadhyay and Mahapatra hope that their findings, along with information emerging from other such studies, could help us design and engineer a new generation of materials.

The other team members

PRADIP DUTTA | **Professor, Department of Mechanical Engineering**
PRAMOD KUMAR | **Professor, Department of Mechanical Engineering**



TOWARDS CLEANER, CHEAPER AND MORE EFFICIENT POWER GENERATION

Today's thermal power plants use steam to carry heat away from the source and turn a turbine to generate power. However, one could generate more power if, instead of steam, supercritical carbon dioxide (S-CO_2) is used. The term "supercritical" describes the state of carbon dioxide above its critical temperature of 31°C and critical pressure of 73 atmospheres, making it twice as dense as steam.

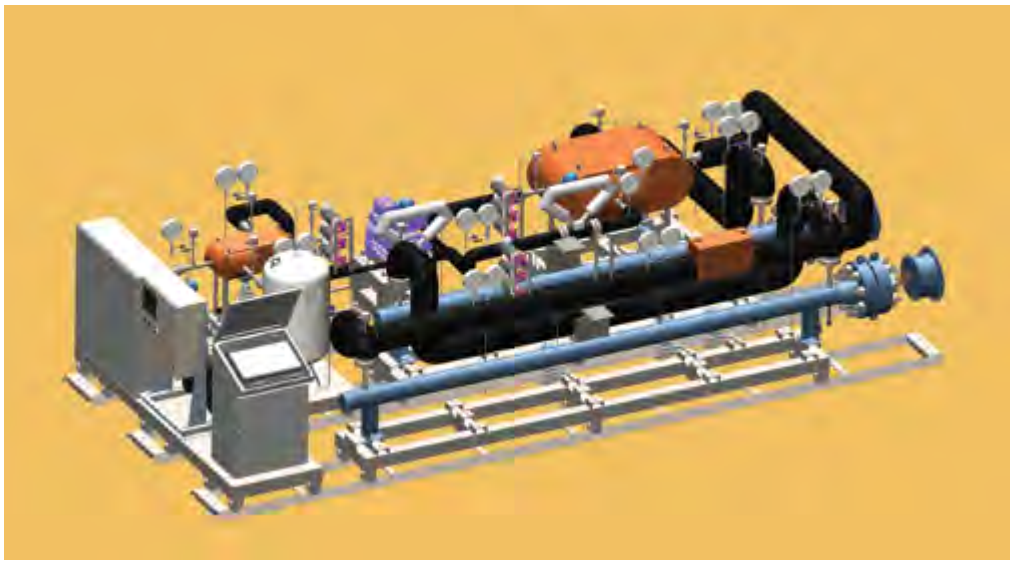
The efficiency of energy conversion could also be significantly increased by as much as 50 percent or more if S-CO_2 is operated in a closed loop Brayton cycle. Besides increasing power generation and making the process more efficient, there are other advantages of using this new technology. Smaller turbines and power blocks can make the power plant cheaper, while higher efficiency would significantly reduce CO_2 emissions for fossil fuel based plants. Moreover, if the power plant used solar or nuclear heat source, it would mean higher capacity at lower operating costs.

In order to help make this technology a reality, a research group led jointly by Pramod Kumar and Pradip Dutta is setting up the world's first S-CO_2 based solar thermal test loop at laboratory scale at the Interdisciplinary Centre for Energy Research in the Institute.

This test loop is designed to generate the necessary data for future development of scaled up S-CO_2 power plants. But this would require overcoming several technological challenges– developing critical components such as the turbine, compressor and heat exchangers that can work at the desired pressure and temperature ranges, and using materials that can withstand these conditions.

In spite of these challenges, the group has made tremendous progress over the past three years. They have developed optimized thermodynamic cycle designs, heat transfer and fluid flow codes for designing the test loop, critical components such as compact heat exchangers and solar receivers, and state-of-the-art instrumentation along with loop control sequence algorithm.

This effort is part of an Indo-US project, which has already been identified as a possible national initiative for the next generation of solar thermal power plants. This gives India an opportunity to become a world leader in this technology and fulfill a major objective of the National Solar Mission which emphasizes indigenous manufacturing.



A Model of the S-CO_2 Test Loop Facility at ICER

Prof. Dutta and Prof. Kumar with their teams

KUSALA RAJENDRAN | Professor, Centre for Earth Sciences

EARTHQUAKE MECHANISMS, RECURRENCE AND HAZARD EVALUATION

The Himalaya, formed by the India-Eurasia collision about 40 million years ago, is the northern boundary of the Indian subcontinent, and Burma-Andaman arc is its eastern boundary. Both of these are active tectonic boundaries which have made parts of the Indian subcontinent exceptionally vulnerable to earthquakes and resultant hazards like tsunamis.

Kusala Rajendran's research seeks to further our knowledge on how earthquakes are generated along the plate boundary systems and to develop source and recurrence models, leading to more effective earthquake and tsunami preparedness and hazard mitigation. Her investigations have led to several recent publications in leading international journals.

Rajendran's ongoing projects, many of them in collaboration with C P Rajendran, a Professor at the Jawaharlal Nehru Centre for Advanced Scientific Research, are helping develop a better database for earthquake hazard models for the central Himalaya region. Based on archaeological and historical data as well as geological proxies, she and her team have dated the last great earthquake in this region at around 700 years ago. Only a few months before the high-magnitude earthquake that hit Nepal, her seismo-tectonic models predicted a large strain build up and a renewal time

of about 600 years, meaning that this segment of the Himalaya was due for the next big earthquake. Rajendran's research also suggests that the Nepal earthquake in 2015 ruptured only about 150 km length of the fault, leaving adjoining segments ready for future earthquakes.

One of her research projects, funded by Indian National Centre for Ocean Information Services (INCOIS), aims to build earthquake source models for the Andaman-Sumatra plate boundary and the Indian Ocean earthquakes and also developing tsunami cycles. Studies by Rajendran's team along the Andaman and Nicobar Islands and the east coast of India suggest that tsunamis had occurred there in the past with an approximate interval of 500 years. These observations together with the numerical models for coastal inundation provide inputs for the Indian Tsunami Early Warning System at INCOIS.

During a field work at Port Blair, the Andaman Islands, with collaborator CP Rajendran. The field work was part of post-2004 earthquake surveys for mapping ground deformation features.

At Sidhababa Cave, Nepal, during field work with students and collaborator. The field work was to determine whether there was any damage within the cave due to ground shaking after the 2015 earthquake.

Prof. Rajendran with her team

CENTRE FOR HIGH ENERGY PHYSICS
ESTD: 2004 | CHAIR: PROF. B ANANTHANARAYAN

CENTRE FOR CRYOGENIC TECHNOLOGY
ESTD: 1971 | CHAIR: PROF. V VENKATARAMAN

INSTRUMENTATION AND APPLIED PHYSICS
ESTD: 1996 | CHAIR: PROF. K RAJANNA

MATHEMATICS
ESTD: 1956 | CHAIR: PROF. G MISHRA

PHYSICS
ESTD: 1933 | CHAIR: PROF. V VENKATARAMAN

DIVISION OF PHYSICAL AND MATHEMATICAL SCIENCES

Chairman: **Prof. Rahul Pandit**

86 Faculty members

16 Fellows of Science Academies in India

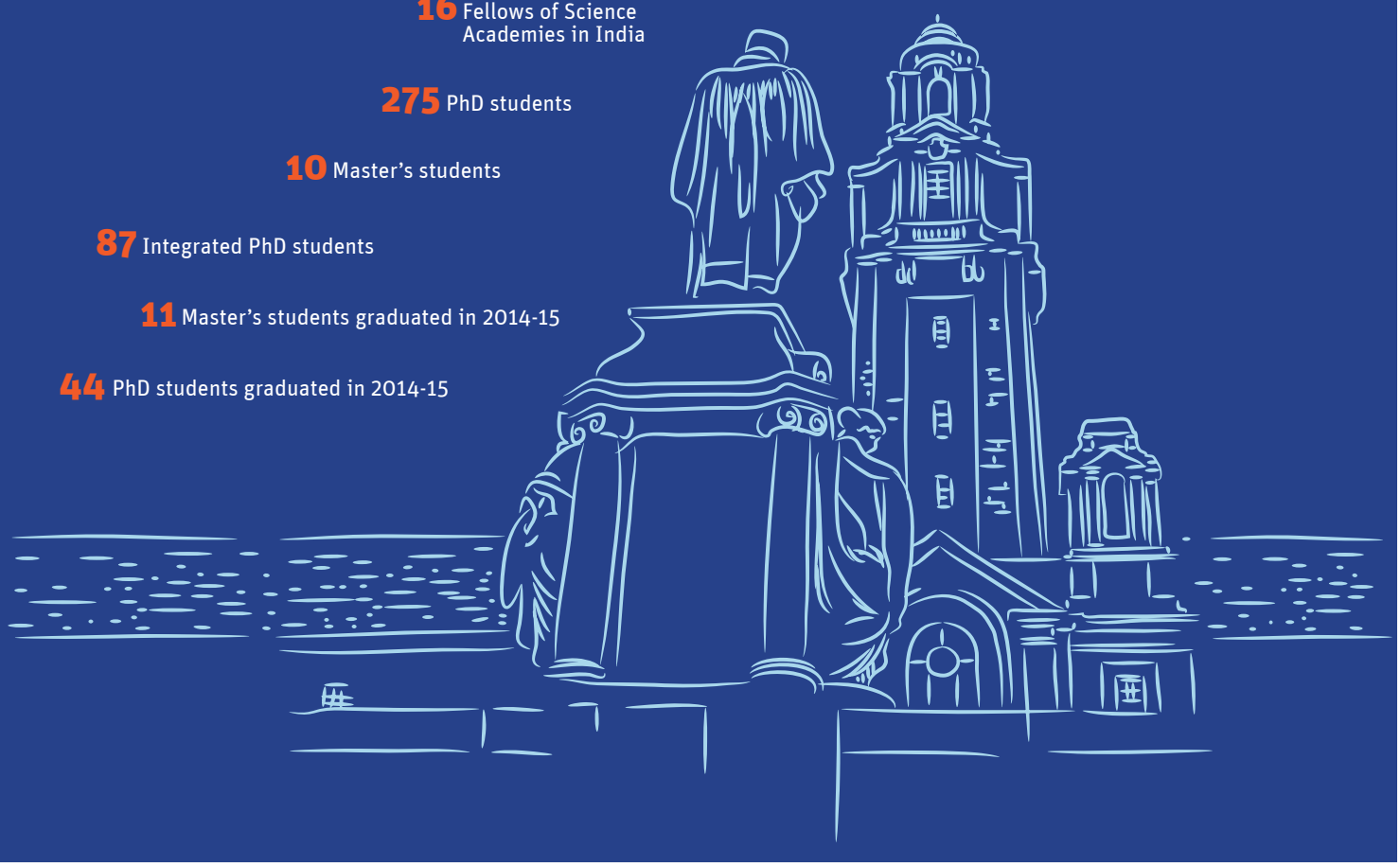
275 PhD students

10 Master's students

87 Integrated PhD students

11 Master's students graduated in 2014-15

44 PhD students graduated in 2014-15



DIVISION OF PHYSICAL AND MATHEMATICAL SCIENCES

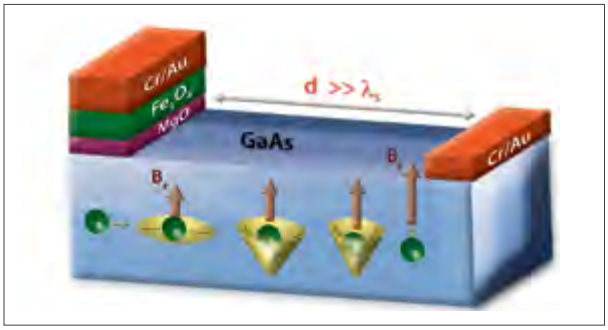
Core Research Areas

Research in the Division covers a wide variety of areas in the physical sciences, including fundamental investigations in String Theory, Particle Phenomenology, Field Theory, Condensed Matter Physics, both theoretical and experimental, Soft-Matter and Complex Systems, Biology-Inspired Physics, Bio-molecular Structure and Biophysics, Atomic and Optical Physics, Astronomy and Astrophysics, and cutting-edge Applied-Physics research including MEMS-based and Fibre-Optic Sensors, Multifunctional materials such as graphene and carbon nanotubes, Super-Resolution Fluorescence Microscopy, Nano-Scale Imaging, Optics and Microfluidics, and Energy- and Health-Monitoring Instrumentation, and Cryogenic Technology. Research in Mathematics covers major areas, both pure and applied, including Probability, Partial Differential Equations, Analysis, Geometry, Topology, Algebra, Algebraic Geometry, and Analytic Number Theory.

Funding and Impact

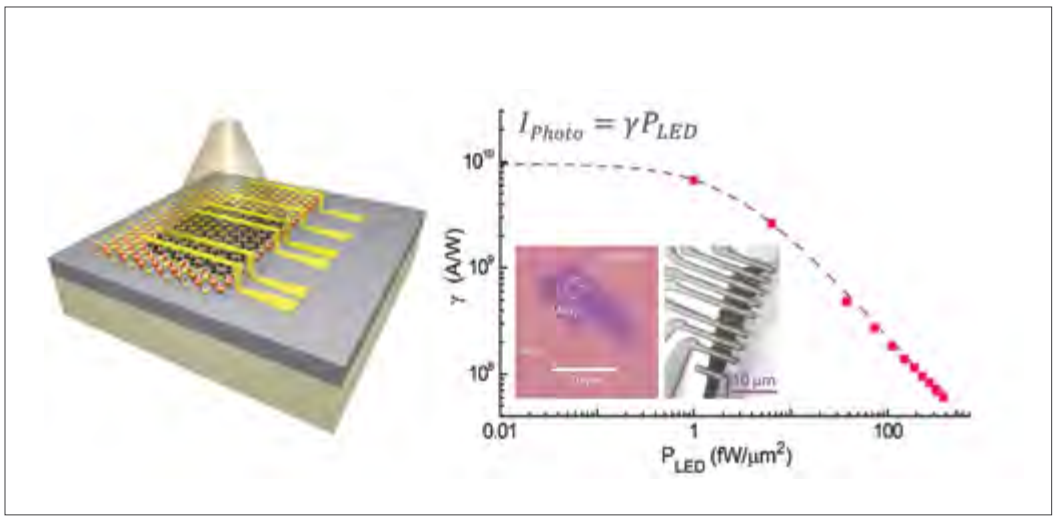
The Departments in this Division are supported by grants from major governmental agencies and ministries such as the Department of Science and Technology, the Council for Scientific and Industrial Research, Defence Research and Development Organization, Ministry of Communication and Information Technology, Indian Space Research Organization, and the University Grants Commission. The departments in this Division have awarded the largest number of Physics PhDs in India and have played a leading role in training researchers in the country. Illustrious alumni include Dr. R Chidambaram, Principal Scientific Advisor to the Government of India, and Mr. A S Kiran Kumar, Chairman of ISRO. Important books have been written by faculty members in this Division on a variety of subjects including Solar Dynamos, Circuit Techniques for Non-Crystalline Semiconductors, Fluorescence Microscopy, and Atomic Physics.

Snapshots of Acheivements in 2014-15



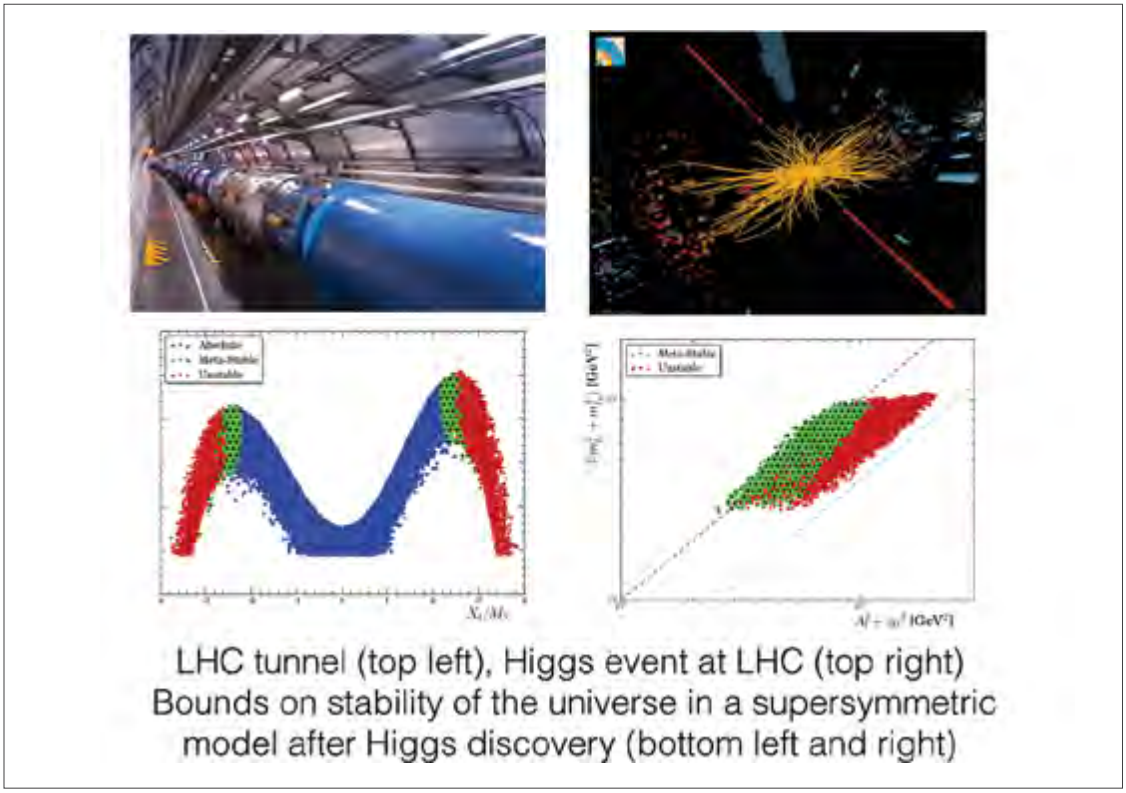
Room-Temperature Spintronics: Electrical spin injection from an oxide magnetic material Fe_3O_4, into GaAs, with the help of a tunnel barrier MgO at room temperature has been established by

the group of Prof. P S Anil Kumar, which creates a platform for the development of room-temperature, oxide-based spintronic devices.



Prof. A Ghosh and co-workers have developed a Graphene/MoS_2 hybrid based highly sensitive photodetector with a responsivity of 1010 A/W, which is about 10 billion times more than that of the silicon photodetectors available in the market today.

In the area of Optics and Microfluidics Instrumentation (OMI), automated, portable, open-platform-technology-based point-of-care (POC) testing devices and instruments have been developed by Prof. S S Gorthi's group. These novel devices have been used for the diagnosis of sickle-cell anemia, spherocytosis, and malaria. A common reader has been designed to diagnose all these diseases; a replaceable, microfluidic-lab-on-chip (MLOC) cartridge needs to be inserted into the instrument to perform the test.

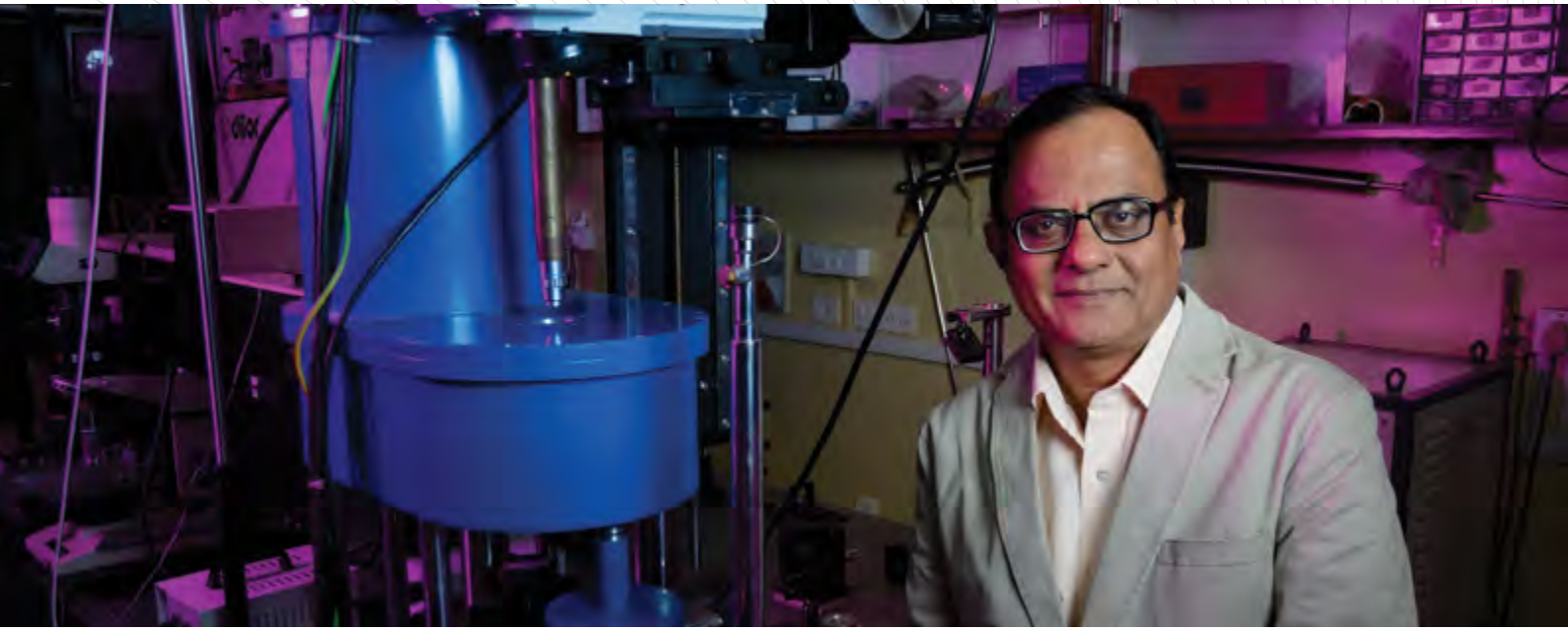


LHC tunnel (top left), Higgs event at LHC (top right)
Bounds on stability of the universe in a supersymmetric model after Higgs discovery (bottom left and right)

Several theoretical studies have been devoted to the new and exciting results that have been emerging from the Large Hadron Collider (LHC) in CERN.

In the broad area of probability theory and, more specifically, in the zeros of random functions and eigenvalues of random matrices, a conjecture of Thomas Lam about the limiting direction of a random walk in the affine root system A^n has been proved.

AJAY SOOD | Professor, Department of Physics



GLASS, GRAPHENE AND COLLECTIVE BEHAVIOUR

In recognition of his significant contributions to diverse areas of physics, Ajay Sood was recently elected as a Fellow of The Royal Society, the most prestigious scientific body in the world.

Much like his previous work, Sood's recent research—ranging from flocking behavior to the formation of glass—reflects the diversity and the interdisciplinary nature of his interests.

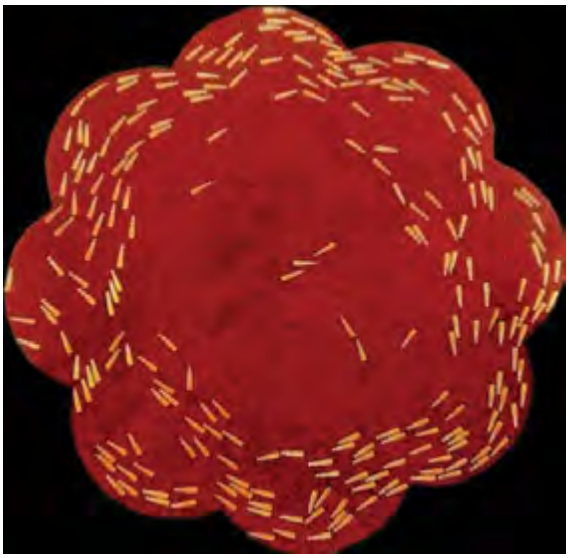
Flocking is a collective motion of self-propelled entities, an example of how complex group behavior can emerge from simple rules followed by individuals with no central coordination. Sood and his group are studying this phenomenon using small metal spheres and brass bits. This study would help in understanding how organisms like microbes, ants, birds, etc aggregate and move together; this, in turn, may also help in evolving more effective protocols in managing crowds and traffic which are also self-organizing phenomena.

Towards ultrafast optoelectronic applications of graphene, Sood's experiments on optical pumps—terahertz probes—using femtosecond laser pulses have provided insights into the microscopic behaviour of photoexcited electronic carriers in graphene. The dominant processes contributing to the photo-conductivity have been delineated for the first time in a quantitative way.

Sood's team has also developed a new sensitive and accurate platform for biosensors using nanomaterials like graphene and etched Fibre Bragg Grating (eFBG) in collaboration with S Asokan, a Professor at the Department of Instrumentation and Applied Physics. This has been used to detect

C-reactive protein (CRP), a biomarker to indicate inflammation in the body. The CRP detection has been carried out by monitoring the shift in Bragg wavelength of an eFBG.

In close collaboration with R Ganapathy, a Professor at the Jawaharlal Nehru Centre for Advanced Scientific Research, Sood's team is also addressing a long-standing unsolved problem of how glass is formed using colloidal systems and experimental probes of confocal microscopy and holographic optical tweezers.



Flocking in active granular media

Prof. Sood with his team

ABHA MISRA | Assistant Professor, Department of Instrumentation and Applied Physics

REARRANGING CARBON ATOMS FOR A BETTER WORLD

Heading a very productive research group, many recognitions have already come Abha Misra's way. She is a recipient of the Indian National Science Academy Medal for Young Scientists and an Associate of the Indian Academy of Sciences and the National Academy of Sciences, India. Her research revolves around carbon, especially two of its more distinct, but related forms graphene and carbon nanotubes.

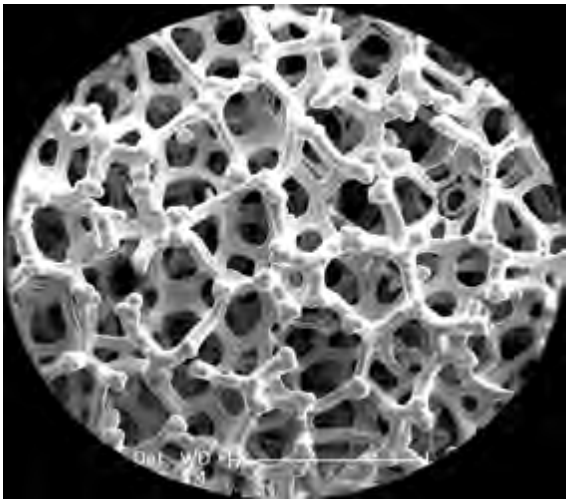
In graphene, carbon atoms are present at the vertices of a hexagon, not unlike a honeycomb, and arranged in sheets, merely one atom thick. This structure bestows upon it extraordinary electrical, thermal, mechanical and optical properties. Graphene is also an ideal sensing material because of its high surface area.

By combining a compound of graphene with hydrogen and tuning its energy band gap, Misra's lab has designed a device that detects infrared light with high sensitivity.

Misra's team has also found a way to enhance the generation of photocurrent—current produced when light is incident upon it—in a form of few layer graphene (FLG) by combining it with semiconducting nanowires in an arrangement that harvests energy more efficiently.

Another interesting property of FLG is that it responds differently to a flame along two different directions. This has allowed Misra's team to design a graphene-based flame sensor with a smart flame detection algorithm.

Carbon nanotubes (CNTs), by contrast, are long, hollow structures with graphene walls. CNTs can be used to detect gases such as ammonia, sulphur-dioxide, and hydrogen sulphide even in very low concentrations through unique charge-exchange phenomena. Misra's group has exploited this property to develop a prototype of a gas-sensing alarm system applicable in gas and oil industries as well in detecting LPG leakage.



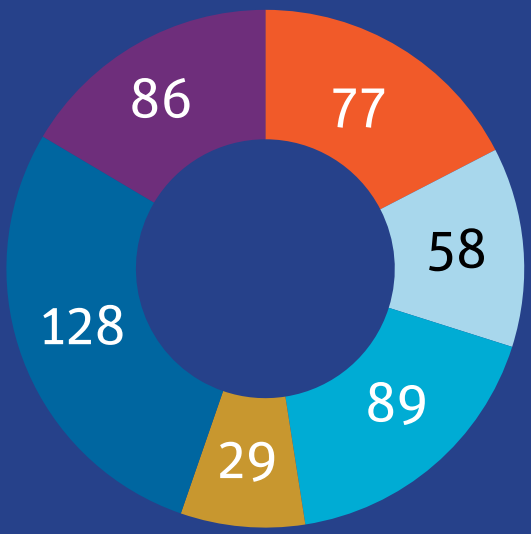
Graphene foam for impact absorption

A unique surface interaction between CNT in bundles leads to novel applications such as impact-absorbing macroscopic foam, bulk actuators, and sensing devices – chemical, photo and mechanical. Misra and her team have also shown that the strength of a fluid-filled CNT foam can be tuned using a magnetic field which could then be used for making artificial joints and shock absorbers by mimicking the biological systems.

Prof. Misra with her team

IISc IN NUMBERS

FACULTY MEMBERS



- Biological Sciences
- Chemical Sciences
- Electrical Sciences
- Mechanical Sciences
- Interdisciplinary Research
- Physical & Mathematical Sciences

Total: 467

FELLOWSHIPS

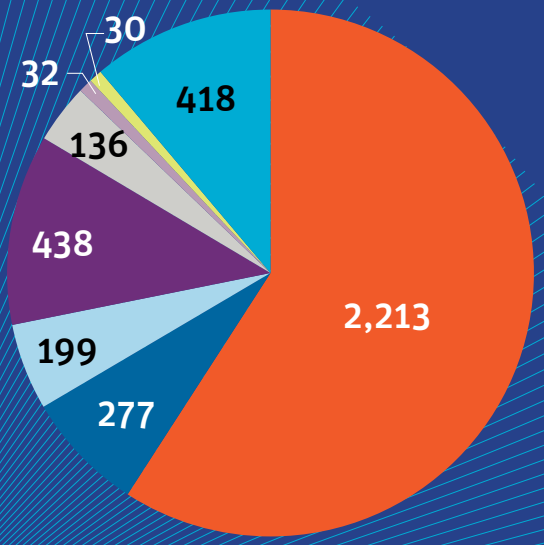
Indian Academy of Sciences (IASc)	80
Indian National Science Academy (INSA)	67
National Academy of Sciences, India (NASI)	53
Indian National Academy of Engineering (INAE)	39

The Royal Society	1
National Academy of Sciences, USA	1
Royal Aeronautical Society	1
American Ceramic Society	1
American Society of Mechanical Engineers	4
Institute of Electrical and Electronics Engineers (IEEE)	8
The World Academy of Sciences (TWAS)	20

AWARDS

Padma Awards	6
Infosys Prize	2
Shanti Swarup Bhatnagar Prize	51
JC Bose Fellowship	56
DST – Swarnajayanti Fellowship	27
Wellcome Trust – DBT Fellowship	25

STUDENTS ON ROLL (2014-15)

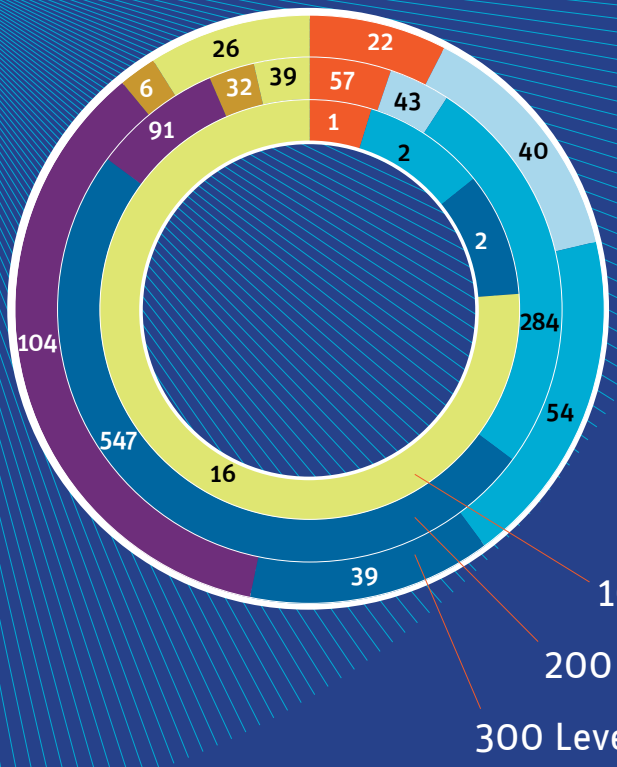


- PhD
- Int PhD
- MSc (Engg)
- ME
- MTech
- MDes
- MMgt
- BSc (Research)

Total: 3,743

International Students: 50

COURSES (2014-15)



- Biological Sciences
- Chemical Sciences
- Electrical Sciences
- Mechanical Sciences
- Interdisciplinary Research
- Physical & Mathematical Sciences
- Undergraduate

Total: 1,408

OUR FUTURE

Meet the researchers who became part of the Indian Institute of Science (IISc) in 2014-15

PARTHA PRATIM TALUKDAR | Assistant Professor, Supercomputer Education and Research Centre

Pratha Talukdar is from Guwahati, Assam. He completed his Bachelors degree from BITS, Pilani. He received his PhD from the University of Pennsylvania, USA and completed his postdoctoral work on the Never Ending Language Learning (NELL) project at the Machine Learning Department in Carnegie Mellon University, USA. His current research is focused on automatically harvesting knowledge from Web-scale datasets. He draws upon the areas of Machine Learning, Big Data analysis, and Natural Language Processing to address the challenges in his field.

BHAVANA KANUKURTHI | Assistant Professor, Department of Computer Science and Automation

Bhavana Kanukurthi has a PhD from Boston University, USA, and she completed her postdoctoral work at UCLA, USA. Her current research focuses on building cryptographic primitives which provide strong security guarantees even under powerful adversarial settings. Her work is highly relevant in today's world where data storage and computation is increasingly moving to the Cloud. In addition to this, Kanukruthi's research explores questions such as: Can we guarantee privacy of data while running some computations on it? Can we guarantee security even if the data we store depends on the cryptographic key intended to secure it? Can we provide these security guarantees while minimizing the possible overhead – in storage size, computation time and communication costs.

PRASANTA KUMAR GHOSH | Assistant Professor, Department of Electrical Engineering

Prasanta Kumar Ghosh has a Master's degree in engineering from IISc and a PhD from the University of Southern California, Los Angeles, USA. He worked as a research scientist at the IBM Research Lab, New Delhi and was a DST-INSPIRE faculty at IISc previously. His current research interests include understanding human speech communication and building engineering models for speech technology solutions. Some of the key research questions he examines are: how do humans co-ordinate the motion of different speech articulators including tongue, lips, jaw, velum and glottal vibration seamlessly to produce natural sounding speech? Can we find out the coordinated movements of articulators from a given speech acoustics? He is also interested in understanding human speech perception and its relation to speech production.

TANMOY DAS | Assistant Professor, Department of Physics

Tanmoy Das received his PhD from Northeastern University, Boston, USA and pursued his postdoctoral work at Los Alamos National Laboratory. He also carried out research at the Graphene Research Center at the National University of Singapore for a year, before joining IISc. His current work focuses primarily on the theoretical study and numerical simulation of condensed matter physics.

ARPITA PATRA | Assistant Professor, Department of Computer Science and Automation

Arpita Patra grew up in West Bengal where she did her early education including her B Tech. She got her Master's at IIT Madras where she also pursued her PhD thesis research in cryptography, the mathematical science of secrets. Her postdoctoral research in cryptography and distributed computing took her to the University of Bristol (UK), ETH Zurich (Switzerland) and Aarhus University (Denmark). While she does not have a fixed agenda for her research at IISc, she has identified a number of topics in cryptography that will keep her engaged for the next few years.

SUSHOBHAN AVASTHI | Assistant Professor, Centre for Nano Science and Engineering

Sushobhan Avasthi grew up in Lucknow. He graduated in Electrical Engineering from IIT Kanpur and did postgraduation from Princeton University. His PhD research, also at Princeton, was on organic/silicon heterojunction solar cells. He continued his work in this field as a postdoctoral fellow at the Princeton Institute of Science and Technology of Materials (PRISM). His current research interests include the study of novel materials like perovskites, metal-oxides, metal-oxynitrides, and metal-oxide thin-film transistors for solar cell applications.

PARIMAL PARAG | Assistant Professor, Department of Electrical Communication Engineering

Parimal Parag hails from Munger in Bihar. He received his B Tech and M Tech from IIT Madras. After his PhD from Texas A&M University, he worked as a senior systems engineer at ASSIA Inc. Parag's research focuses on network theory, applied probability, optimization methods, and in their applications to distributed systems; he is also interested in the areas of applied statistics, game theory, queueing theory, information theory, and combinatorics.

OUR FUTURE

BIPLOB BHATTACHERJEE | Assistant Professor, Centre for High Energy Physics

Biplob Bhattacherjee obtained his PhD in particle physics from Calcutta University. After his postdoctoral research at the Tata Institute of Fundamental Research, he was associated with Kavli IPMU, University of Tokyo, Japan for three years. His research covers theoretical aspects of high energy particle physics with a primary focus on the phenomenology beyond the standard model and their collider signatures in the context of the Large Hadron Collider and the proposed International Linear Collider.

PRERNA SHARMA | Assistant Professor, Department of Physics

Prerna Sharma completed her early education in Jaipur and spent her teenage years and beyond in Delhi. She has a PhD in Physics on the measurements of interactions and dynamics that occur at interfaces from the Tata Institute of Fundamental Research, Mumbai. Her postdoctoral work at Brandeis University, Massachusetts, USA, was on self-assembly of colloidal rafts in membranes. Her current research interests include studying fundamental aspects of colloids, polymers and membranes.

MAHAVIR SINGH | Assistant Professor, Molecular Biophysics Unit

After obtaining a Master's degree from the Delhi University, Mahavir Singh received his PhD in Biochemistry from the Max-Planck Institute, Germany where he studied how the major tumor suppressor protein pRb interacts with its cellular and viral proteins partners. During his postdoctoral work at the University of California, Los Angeles, USA he got interested in understanding the structure and functions of non-coding RNAs and their interactions with proteins in ribonucleoprotein complexes. His research now investigates the role of non-coding RNAs in telomere length maintenance and gene regulation.

SUPRADEEPA V R | Assistant Professor, Centre for Nano Science and Engineering

Supradeepa hails from Bangalore and has a PhD in Electrical and Computer Engineering from Purdue University, USA. He worked at OFS Laboratories, Somerset, New Jersey, with the fiber lasers and amplifiers group before joining IISc. He is currently interested in studying nonlinear optical phenomena in low power integrated devices to high power lasers and systems and engineering them for practical applications.

DIGBIJOY N NATH | Assistant Professor, Centre for Nano Science and Engineering)

Digbijoy Nath grew up in Golaghat, Assam. He received his PhD from Ohio State University, USA where he worked on gallium nitride materials epitaxy and devices and continued there to pursue his postdoctoral research on 2D layered materials. His current research focuses on devices for deep UV applications, high speed transistors and novel semiconductor devices made from gallium nitride which continue to fascinate him.

CHANDRAMANI KISHORE SINGH | Assistant Professor, Department of Electronic Systems Engineering

Chandramani Singh grew up in Bharthui Garh, a village in Siwan district of Bihar. He has a PhD from IISc for his work on resource management in cellular and mobile opportunistic networks. He did his postdoctoral work on fair and efficient medium access in ad hoc networks jointly with TREC (a joint research team of INRIA Rocquencourt and ENS de Paris in France) and University of Illinois, USA. His current research interests include modeling and analysis of communication networks using control, optimization and game-theoretic techniques.

VIJAY A SETHURAMAN | Assistant Professor, Department of Materials Engineering

An electrochemical engineer by training, Vijay Sethuram graduated from the Central Electrochemical Research Institute, Karaikudi. He has a PhD in chemical engineering from the University of South Carolina, USA, and completed his postdoctoral work from the Lawrence Berkeley National Laboratory, USA. He worked at the School of Engineering at Brown University for four years before joining IISc in 2014, where he is in the process of setting up facilities to fabricate and test lithium-ion batteries.

HIMANSHU TYAGI | Assistant Professor, Department of Electrical Communication Engineering

Himanshu Tyagi grew up in Delhi and pursued a dual degree in Electrical Engineering from IIT Delhi. He received a PhD in Electrical and Computer Engineering from the University of Maryland, USA, and completed his postdoctoral work at the Information Theory and Applications Center at the University of California (San Diego), USA. At present, his research interests lie in the application of information theory in communication, computer science, statistical learning and control.

OUR FUTURE

SRIDHARAN DEVARAJAN | Assistant Professor, Centre for Neuroscience

Sridharan Devarajan grew up in Chennai and obtained his Bachelors and Masters degrees in Engineering from IIT Madras. He then moved to Stanford University, where he completed his PhD and postdoctoral work in neuroscience. His research now focuses on understanding how cognitive phenomena, such as attention and decision-making, emerge from elementary neural computations in the human brain. His work combines neuroimaging (fMRI, dMRI, EEG) and neurostimulation (tMS, tES) technologies and seeks to identify key theoretical and computational principles by which neural processes of the brain shape behavior.

KAUSIK MAJUMDAR | Assistant Professor, Electrical Communication Engineering

Kausik Majumdar received his PhD from IISc. His primary research interest lies in the physics of novel material systems and their applications to optoelectronic and nanoelectronic devices, from experimental as well as theoretical points of view. He is also interested in 2D valleytronics – how electron/hole spin couples with valley degree of freedom and how individual valley population can be controlled through external stimulation – as well as in the tunneling of electrons through ultra-thin ferroelectric and multiferroic materials, and their applications in novel memories.

GURUNATH GURRALA | Assistant Professor, Electrical Engineering

Gurunath Gurrala has a PhD from IISc and did his postdoctoral work at Texas A&M University, USA. At IISc, he works on the development of parallel algorithms for faster-than-real-time simulation of large power systems which enable predictions of blackouts and development of mitigation strategies in real-time before a catastrophic failure of the power grid happens.

ADITYA GOPALAN | Assistant Professor, Department of Electrical Communication Engineering

Aditya Gopalan has a PhD in Electrical Engineering from the University of Texas, USA where he worked on the design and analysis of effective wireless scheduling algorithms. He completed his postdoctoral work from Technion in Israel. His research interests span over networks, algorithms, control and learning. He is also interested in the study of decision making and optimization under uncertainty, which finds concrete application in several modern day autonomous systems such as Internet recommender systems, personalized search, automated trading, robotic control, etc.


EQUIPMENT DEVELOPMENT
INLINE CHARACTERISATION

OUR WELL-WISHERS

The Indian Institute of Science (IISc) continues to benefit from generous endowments made by its benefactors

PRATIKSHA TRUST

Pratiksha Trust donated Rs. 225 crores to set up a new Centre for Brain Research at IISc. The Trust was set-up by Kris Gopalakrishnan, the co-founder of Infosys, along with his wife, Sudha Gopalakrishnan, and their daughter.

The Trust has also established three new chairs at the Institute for research in the areas of computational neuroscience, machine learning, data science and neuromorphic engineering. The first of these three Chairs, the K Vaidyanathan Distinguished Chair, will be occupied by Shihab Shamma, Professor, Institute of Systems Research at the University of Maryland. The Chair is named after Sudha Gopalakrishnan's father.

"The Centre for Brain Reseach will focus on ageing and age-related disorders like Parkinson's, dementia and Alzheimer's"

– Kris Gopalakrishnan

Prime Minister Shri Narendra Modi interacting with Kris and Sudha Gopalakrishnan during the unveiling of the foundation stone of the Centre for Brain Research at IISc. Anurag Kumar and Vijayalakshmi Ravindranath look on.

ROBERT BOSCH FOUNDATION

The Robert Bosch Foundation is providing Rs. 11 crores every year for 10 years to the Robert Bosch Centre for Cyber Physical Systems, established in 2011. Scientists at this interdisciplinary Centre focus on using advances in sensing, communication and data analytics technologies to address key challenges in water, healthcare and energy sectors.

ARJUN DIVECHA & GRANTHAM FOUNDATION

Arjun and Diana Divecha, along with the Grantham Foundation for the Protection of the Environment, founded by Jeremy Grantham, had jointly donated USD 3 million to establish the Divecha Centre for Climate Change in 2009. This year they have extended their funding for another five years. Researchers at the Centre study climate science and critical issues related to climate change. Arjun Divecha is the Chairman and Investment Director at Grantham, Mayo, Van Otterloo & Co.

"I think the Centre (Divecha Centre for Climate Change) has evolved quite nicely"

– Arjun Divecha

TATA TRUSTS

The Tata Trusts have awarded a grant of Rs 75 crores to the Centre for Neuroscience, spread over five years, to study the mechanisms underlying the Alzheimer's disease and to evolve methods for early diagnosis and effective treatment for this brain disorder. This research will be championed by the faculty members at the Centre for Neuroscience led by its Chairperson, Vijayalakshmi Ravindranath.

INFOSYS FOUNDATION

The Infosys Foundation granted a corpus of Rs 20 crores to endow Visiting Chair Professorships in Mathematics and Physics. The grant is aimed at bringing distinguished scientists in these broad areas to IISc in order to catalyze cutting-edge research and initiate long-term collaborations. Chairperson of the Foundation and IISc alumna Sudha Murthy personally handed over the grant statement to the respective departments at IISc. The Foundation has also provided an additional grant of Rs. 1.20 crores to initiate the process of appointing the Chair Professors.

"If we want to enrich our students, we need to expose them to the best in the world"

– Sudha Murthy

OUR SECOND HOME

The Indian Institute of Science (IISc) now has a second home. This new campus will help India's premier scientific institute to continue to flourish for the next few decades

Back in the winter of 2008, during the centenary celebrations of IISc, the then Chief Minister of Karnataka, BS Yeddyurappa, announced that the state would provide land to Institute for a second campus. Following this announcement, IISc was able to acquire 1500 acres of land near Challakere in Chitradurga district 225 kms from its Bangalore campus in what is being developed as a Science and Technology city. IISc's new neighbours here include national R&D institutions like DRDO, BARC and ISRO.

While the campus now already has uninterrupted power supply, two check dams are being built to harvest rainwater. When the dams are completed, it will be home to two large lakes. Soon, drinking water will also be supplied from Vani Vilasa Sagara Dam under a state government plan.

Even as the infrastructure is being put in place, a few research activities have started or are on the anvil, including projects on solar power, climate research and sustainable technologies. One initiative, however, has not only taken roots, but has also become the face of the Challakere campus – The Talent Development Centre (TDC).

A visit by the former President Abdul Kalam to the Talent Development Centre

Workshop employing local talent to build equipment for the labs

TDC, formally inaugurated in 2011, trains high school and PUC teachers in science and mathematics. With generous support from the State Government, more than 6500 teachers have already gone through this 10-day boot camp that involves lectures and hands-on training in various disciplines. The success of this initiative under the leadership of its Convenor, MS Hegde, CSIR Emeritus Scientist from the Solid State and Structural Chemistry Unit, has attracted the attention of educators and law makers. TDC will soon become the first teachers training centre under the Pandit Madan Mohan Malaviya National Mission for Teachers Training of the Ministry of Human Resources Development. As part of this Mission, TDC will also train undergraduate science and mathematics teachers.

Land-use Master Plan for the new campus

The Chair of the Challakere Empowered Committee that is overseeing the development of its infrastructure, BN Raghunandan, also a Professor in the Department of Aerospace Engineering, believes that the acquisition and the development of land for the new campus is a visionary move that will benefit science in India in the next few decades. “Such large stretches of unfettered land is unlikely to be found in the future,” he adds.

A NEW BLOOM

This July saw the graduation of the first batch of students from a unique four-year undergraduate programme started by the Indian Institute of Science (IISc) in 2011

"The training in the undergraduate programme at IISc has made me more open to new ideas, helped me appreciate the importance of several research areas. And it made me a well-rounded person," says Neha Kondekar, one the students from the first batch of young men and women who graduated this year.

The programme has been popular since its inception in 2011. Of the more than 10,000 students who apply every year to this sought-after programme, only 120 are chosen. The chosen ones are taught by faculty members who are experts in their fields of research. And the labs where students do their experiments are among the best in the world.

Until their third semester, when students choose their majors, they take compulsory foundational courses in all the sciences, besides engineering courses. They also study humanities for six semesters. This interdisciplinary approach helps them see the interconnectedness of different fields of study and also discover their own interests. After their third semester, students major in any one of the following subjects: physics, chemistry, biology, mathematics, environmental science, and materials science. The seventh and eighth semesters are devoted entirely to research projects which they do under the guidance of one of the faculty members.

Not unexpectedly, these students have excelled in academics. At least 20% of the students have secured a CGPA (Cumulative Grade Point Average) of 7 or more out of 8. They have been selected by reputed national and international organizations and universities for their summer and final projects. Of the students who have just graduated, a few of them like Neha Kondekar have joined PhD programmes in some of the best universities in the world, while many others are continuing at IISc for another year, after which they will have a Master's degree.

The undergraduate students at IISc have made a mark outside the classroom too. Since 2013-14, they have been organizing Pravega, an annual science-tech-cultural fest. They also bring out an annual magazine called *Quarks* that showcases their multifaceted talents.

The undergraduate programme started as an experiment, exactly one hundred years after India's premier research institution admitted its first students back in 1911. Needless to say, this experiment has yielded remarkably satisfying results.

WINDOWS TO THE WORLD

The Indian Institute of Science (IISc) strives to connect with the outside world through several offices and centres which are dedicated to this endeavour

The Centre for Scientific and Industrial Consultancy

The Centre for Scientific and Industrial Consultancy (CSIC) was established in 1975 as a platform to bring together academia and industry. Its goal is to promote indigenous technology and contribute towards making the nation self-reliant in its technological needs.

Society for Innovation and Development

The Society for Innovation and Development (SID), founded in 1991, serves as a channel to take innovations in science and technology developed at IISc to society. It provides industry and business access to the vast intellectual and infrastructural resources at IISc.

Office of Intellectual Property & Technology Licensing

The Office of Intellectual Property and Technology Licensing (OIPTeL), formerly known as the Intellectual Property Cell, was set up in 2004 with the aim of protecting and maintaining the intellectual property of IISc. The Cell has now evolved into a one-stop window for all IP-related issues in the Institute. It also seeks to create awareness among researchers in IISc about the importance and relevance of intellectual property rights.

Alumni Association

The IISc Alumni Association (IIScAA), established in 1976, is an active organization on campus; its many activities include organizing the Science Forum Lectures, Knowledge Exchange Programme and the Global Alumni Conference. It also gives away the Distinguished Alumnus Award to the illustrious sons and daughters of the Institute.

The Office of Development and Alumni Affairs

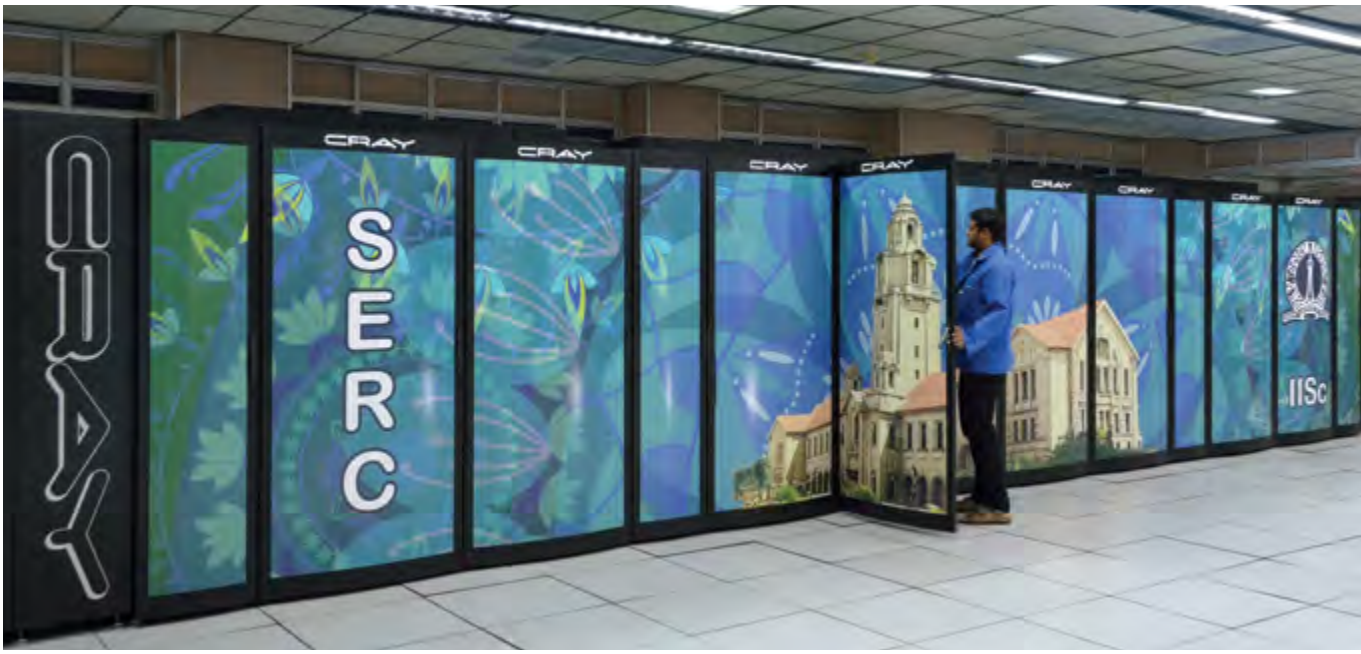
A few months ago, IISc established the Office of Development and Alumni Affairs (ODAA) to build a vibrant ecosystem of industry partners, individuals and alumni who seek to support its development. By working closely with the Institute's faculty members and administration, ODAA identifies specific programmes and garners funding from industry, alumni and private donors for these initiatives. These programmes include industry-sponsored Corporate Social Responsibility projects, infrastructure development at IISc's campuses, both in Bangalore and Challakere, and projects for student and faculty professional development. ODAA also focuses on developing mechanisms to process gifts, and maintain accountability and compliance standards for funding sources.

The alumni networking portal

In addition, ODAA actively provides support for alumni-related activities and engagement programmes at the Institute. As part of its new initiatives, ODAA has launched an exclusive alumni networking portal (www.alumni.iisc.ernet.in) to help alumni to re-connect with each other and with the Institute. The response from alumni to this initiative has been overwhelmingly positive. So far, more than 1600 alumni have registered at the portal, many of whom have already contributed to the Institute's various projects.

SAHASRAT

INDIA'S FIRST PETASCALE SYSTEM



Meet the latest acquisition of the Supercomputer Education and Research Centre (SERC) at the Indian Institute of Science (IISc)

Some stars die dramatically in massive explosions called supernovae. Prateek Sharma, an astrophysicist from the Department of Physics, is interested in how multiple supernovae going off in a small volume, sometimes almost simultaneously, affects the interstellar medium around it (and how the medium in turn influences the birth of new stars). To understand this phenomenon, he runs complex simulations by exploding virtual stars in a patch of interstellar medium on IISc's newest supercomputer a Cray XC40 christened Sahasrat.

"It is no ordinary machine," says N Balakrishnan, former Chair of SERC and former Associate Director of IISc, about Sahasrat, India's fastest supercomputer. The speed of a supercomputer is measured as the number of floating-point operations it performs per second (or just FLOPS). Sahasrat has a peak performance of 1,320 TeraFLOPS (1,320 x 10^{12} FLOPS) – hence the name Sahasrat – and a sustained performance of over 900 TeraFLOPS.

Not surprisingly, Sahasrat's architecture is complex and its design, intricate. Its basic unit is a replaceable blade; each blade is made up of four nodes; each node in turn has 24 cores; 16 such blades are assembled on a chassis; three chassis units comprise a rack, of which there are 8. In all, this workhorse has 33,000 cores. "Each node can have its own software and operating system. In that sense, each node is an independent computing system," explains J Lakshmi, a principal research scientist at the Centre.

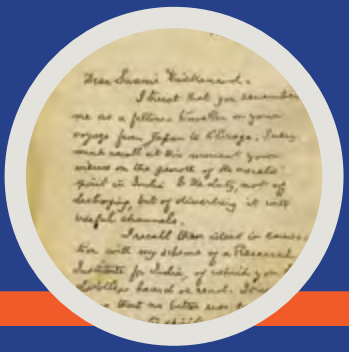
Sahasrat has Intel's Haswell processors at its heart, delivering its computing power. Another crucial factor that influences its performance is how the different nodes in the machine "talk" to each other—called network topology. Sahasrat has a topology named Dragonfly with an Aries Network-on-Chip (NoC). But the hardware alone does not determine a supercomputer's performance; it also needs the appropriate software environment to exploit its architecture. Sahasrat comes with a specialized, complete Cray software stack. With one eye on the future, SERC has also ensured that Sahasrat has two accelerator-based cluster systems, one having graphics processing units and the other having Intel's Many Integrated Cores (MIC).

Though it was installed only a few months ago, Sahasrat has a utilization of more than 80%. According to SERC's Chair, R Govindarajan, at least three research groups on campus have been able to utilize the capabilities of the machine as a large High Performance Computing (HPC) system. "It has been very well received," an understated Lakshmi adds with a smile.

ORIGINS

Swami Vivekananda inspired J N Tata to set up an institute of higher learning when they met aboard a ship in

1893



Letter from J N Tata to Swami Vivekananda, recalling their meeting, written in

1898

Lord Curzon, the Viceroy of India, actively helped in establishing IISc until he left India in

1905

The first Director of IISc, Morris Travers, arrived in India in

1906

The Foundation Stone was laid by the Maharaja of Mysore in

1911

The first batch of 24 students with faculty and staff in

1912

J N Tata, founder and benefactor, created an endowment to establish an institute of higher learning in

1898

The Maharaja of Mysore, Krishnaraja Wodiyar IV, and his mother offered land for setting up the Institute in

1901

Construction of the Main Building started in

1908

The Vesting Order to establish IISc was passed in

1909

After several delays, the Main Building was completed in

c. 1918

The memorial to Tata unveiled by the Maharaja of Mysore in

1922

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