The Institute of Mathematical Sciences, Chennai

Quarterly Report

January - March 2022

Highlights: research and events

Non-perturbative QCD, Lattice Gauge Theory, QGP

Confinement of color quantum number accounts for more than 99% mass of the visible universe yet we do not know its precise mechanism. What causes confinement? A strong suspicion in the community of researchers working in this field is that it is the topology of non-Abelian gauge theories that drives confinement. In our physical world the quark and gluon (gauge) degrees of freedom interact very strongly exchanging color forces. The presence of quarks influences the topological tunnelings in gauge theories and makes the identification of these fluctuations even more difficult. In our work by R. Larsen, Sayantan Sharma, E.Shuryak titled "Correlating confinement to topological fluctuations near the crossover transition in QCD" published as a Letter in Phys. Rev. D 105, L071501 (2022), we show, for the first time, that we can indeed isolate these topological hot-spots using the chirality or handedness of the light quarks. We used ab-initio lattice gauge theory techniques which require large supercomputers, to unravel the inner workings of the vacuum of strongly interacting gauge theories. We can now observe the rough landscape of this vacuum where the deep craters created due to the confining potential are the precise locations of intense topological activity, hinting at deeper connections between the two phenomena.

Workshop on Algorithms

The Theoretical Computer Science group at IMSc, hosted - "The Recent Trends in Algorithms workshop" from March 2-5, 2022.

It was conducted online consisting of 9 expository talks each 2 hours long. Please see the webpage: https://www.niser.ac.in/~aritra/RTA2022.html

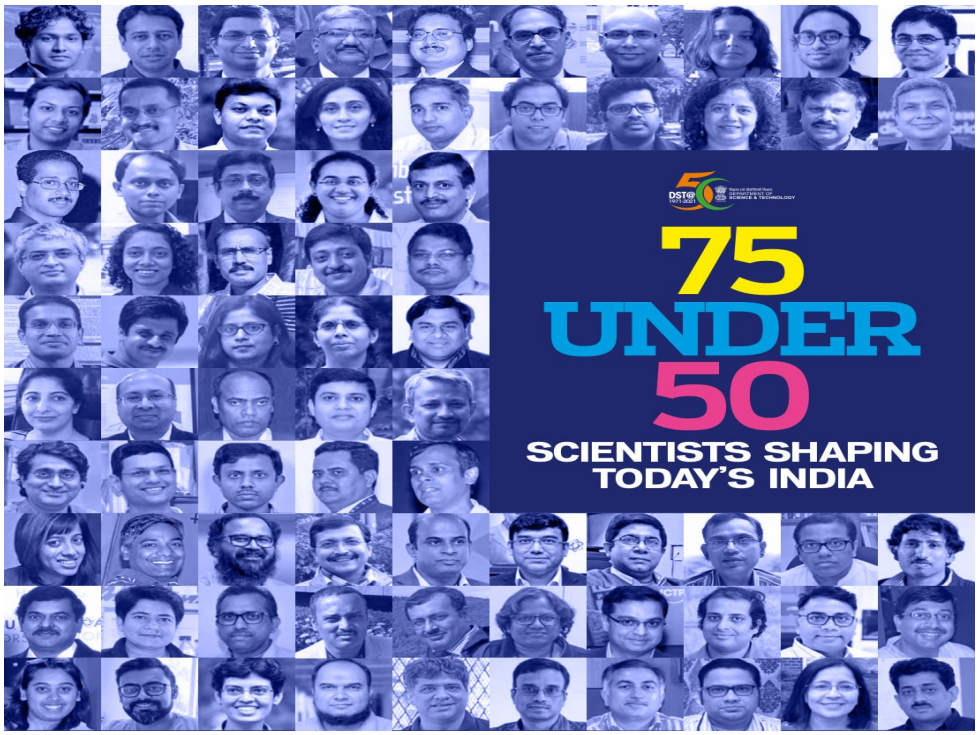
Participation in seminars and workshops

Nayana Mukherjee delivered a contributed talk, entitled "Effect of hunting cooperation on spatio-temporal pattern formation in prey-predator models" during the 13th Conference on Dynamical Systems Applied to Biology and Natural Sciences (DSABNS 2022), organized by the Mathematical and Theoretical Biology Group at the Basque Center for Applied Mathematics (BCAM) and held during February 8-11, 2022.

Dhiraj Hazra presented an invited talk titled 'One spectrum to cure them all' at the 40th meeting of the Astronomical Society of India held at IIT Roorkee between 25 to 29 March, 2022.

Awards and Honours

- Prof. Meena B. Mahajan was elected as a Fellow of the Indian Academy of Sciences, for the year 2022.
- Prof. Dishant M. Pancholi was elected as a Fellow of the Indian Academy of Sciences, for the year 2022.
- Prof. Amritanshu Prasad is recognized in the Book "75 under 50: Scientists Shaping Today's India" published by VigyanPrasar, Department of Science and Technology, Government of India.



IMSc Outreach

Azadi Ka Amrit Mahotsav

As a part of the 75th year of our country's independence we are organizing a series of lectures by distinguished scientists, to tell us about the scientific achievements in theoretical sciences from India. Following are the details of the talks organized during January-March 2022.

IMSc Distinguished Lectures

Title : Out of the Box Science - Some recent Inspiring Examples

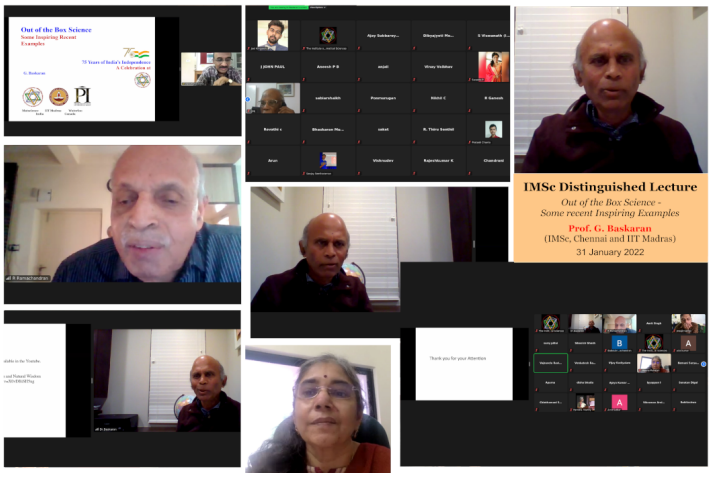
Speaker : Prof. G. Baskaran, IMSc, Chennai and IIT Madras

Date : 31 January 2022

Time : 11:30 - 12:30

Abstract : Traditionally science is practiced and nurtured by academics, research scholars, scientists, within scientific institutions, colleges, universities, laboratories, private institutes etc. There are some inspiring individuals, who practice or nurture science and young scientists, in some sense out of the box. Some cases are well known. Many are silently contributing, not worried about appreciation by the system. I will discuss some examples, from my personal knowledge. My list is only partial. In the wide world many inspiring examples exist.

URL : https://www.youtube.com/watch?v=11-L09ykiV8



Title : The Value of a Quiet Life: Muscle Stem Cells and Their Balancing Act in Tissue Repair

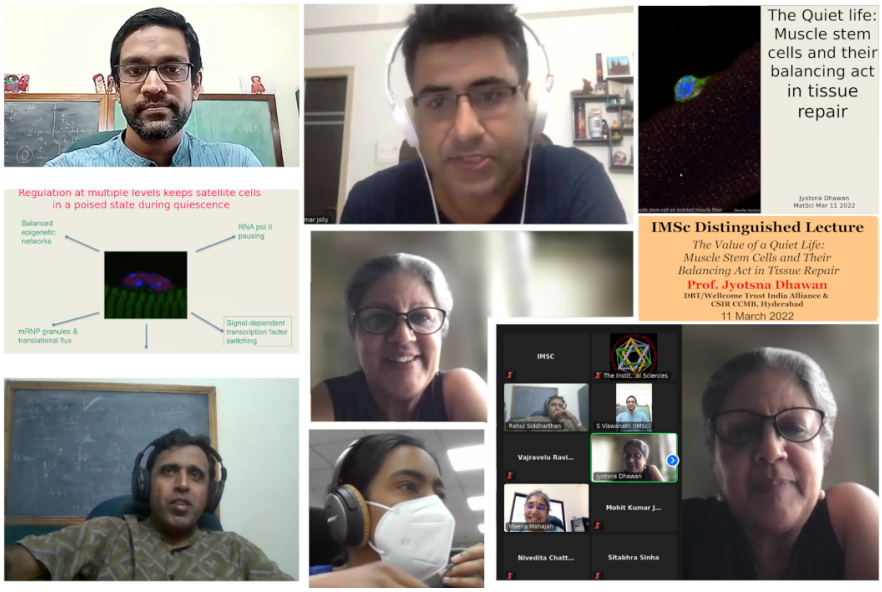
Speaker : Prof. Jyotsna Dhawan, DBT/Wellcome Trust India Alliance & CSIR CCMB, Hyderabad

Date : 11 March 2022

Time : 16:00 - 17:00

Abstract : While most of the drama of cell proliferation and movement happens during embryonic development, stem cells persist within adult tissues, in a dormant state, and contribute to tissue repair after damage. Earlier depicted as a hibernating state characterized by very low metabolic activity, cellular quiescence is now emerging as a balanced or poised state where both proliferation and specialization programs are held in check by active mechanisms. Skeletal muscle tissue provides an excellent model to understanding quiescence in stem cells, as muscle cells can be cultured in distinct cellular states, permitting comparisons of multiple developmental programs. I will speak about our work on defining and dissecting the molecular basis of quiescence, and locate this discussion in a context of the field of stem cell biology, and how this basic understanding may eventually lead to therapeutic avenues.

URL : https://www.youtube.com/watch?v=CB4ml75ame0



IMSc Heritage Lecture

Title : Snippets from History of Science in Ancient India

Speaker : Prof. T.R. Govindarajan, The Institute of Mathematical Sciences (IMSc), Chennai, India

Date : 25 February 2022

Time : 16:00 - 17:00

Venue : Ramanujan Auditorium, IMSc Chennai

Abstract : Science in ancient India was the story of several achievements and failures too. I will sketch a few of these in Astronomy, Mathematics and Archaeology. I will present some unsolved questions in our understanding too. I will end with some discussions on what we gave the outside world and what we learnt.

URL : https://youtu.be/grIA5AoAzmE

IMSc Popular Lecture

Title : How does the Sun shine? How do we know this?

Speaker : Prof. D. Indumathi, The Institute of Mathematical Sciences (IMSc), Chennai, India

Date : 16 February 2022

Time : 16:00 - 17:00

Venue : Ramanujan Auditorium, IMSc Chennai

Abstract : How the Sun (and other stars) shine has been the subject of interest to physicists, geologists and biologists. Here we tell the story of the Sun through the elementary particles called neutrinos. The talk is aimed at a general audience and is an attempt to show-case the on-going outreach and educational efforts of IMSc in this area.

URL : https://www.youtube.com/watch?v=dIdknBmL20o

Title : What can / should scientists do for mathematics and science education?

Speaker : Prof. R. Ramanujam, The Institute of Mathematical Sciences (IMSc), Chennai, India

Date : 28 February 2022

Time : 11:30 - 12:30

Venue : Ramanujan Auditorium, IMSc Chennai

Abstract : There is a vast gap between scientific research practices and science pedagogy in India, especially at undergraduate level. When it comes to school education, there is almost no point of intersection at all between teachers and scientists. This is even more stark when it comes to mathematics, where school or undergraduate mathematics bears little resemblance to the discipline of mathematics. In such a situation, is it possible at all for scientists and mathematicians to contribute meaningfully to school and college education? Does social responsibility entail any commitment in this direction? We suggest affirmative answers to both of these questions. This talk is part of National Science Day celebrations at IMSc.

URL : https://www.youtube.com/watch?v=5lfoPkXLksI

Title : The complexity of formal proofs

Speaker : Prof. Meena Mahajan, The Institute of Mathematical Sciences (IMSc), Chennai, India

Date : 14 March 2022

Time : 16:00 - 17:00

Venue : Ramanujan Auditorium, IMSc Chennai

Abstract : A proof of a statement convinces the person/entity addressed that the statement is true. Intuitively, a good proof is short, and easy to verify. A formal proof must convince an automated checking program (that may have limited resources). This talk discusses why we care about formal proofs, how we can design good formal proofs, and situations where we hit a wall. **URL :** https://www.youtube.com/watch?v=tUz7ubW367w

IMSc - 60 : Distinguished Lectures

As a part of the 60th anniversary of the foundation of our institute, we are organizing a series of lectures by scientists who have made fundamental contributions in their areas of research, as IMSc Diamond Jubilee Colloquium Series. This is aimed at keeping our graduate students updated with the latest and forefront research topics in the theoretical sciences and at the same time sharing the excitement of research in fundamental sciences with the common public. We had two colloquia by distinguished scientists, details of which are as follows:

Title : What is Control Theory in 2021? Can AI do Better?

Speaker : Prof. Olivier Pironneau, Université Pierre et Marie Curie, Laboratoire Jacques-Louis Lions and Honorary member of the French Académie des Sciences

Abstract : Until the twentieth century it was assumed that knowledge meant control. Automatic control came in the sixties for electronics with Bellman's dynamic programming and Kalman's filter and received a boost in the eighties with robust and H∞ control. Will artificial intelligence algorithms change the practice of control drastically? Parallel Optimal Control, which dates from the calculus of variations of Hadamard and the Pontryagin principle, is a more functional approach to the optimization of systems. It is heavily used for the design of mechanical devices like airplanes (optimal shape design) and the topological optimization of materials. Stochastic control remained up to now a mathematical field except for the rare semi-analytical solutions as in the case of linear quadratic control. It is now computationally feasible and its applications to finance for instance, though challenged by deep neural networks, are in daily use for risk assessment of bank's portfolios. Finally, perhaps the most mathematically demanding is the mean-field type control and its application to the Monge-Ampere problem. As this is a colloquium talk, the problems and the main results will be stated only, without assuming any prior knowledge of these sometimes difficult fields. Yet the talk is for a mathematically trained audience.

Date: Wednesday, 16th March 2022 at 5 PM

Venue : Ramanujan Auditorium,IMSc

URL : https://www.youtube.com/watch?v=JyB9Bb1aqUw

Title : Precision challenges in particle physics

Speaker : Prof. Dr. Sven-Olaf Moch, Institut für Theoretische Physik, Universität Hamburg

Abstract : We review the current state of precision predictions for the Large Hadron Collider LHC covering the aspects of perturbative corrections to hard scattering processes in quantum

chromodynamics at higher orders as well as our knowledge on fundamental parameters of the Standard Model such as the strong coupling constant and heavy quark masses. We illustrate how the precision of available experimental data challenges current theoretical predictions and discuss the mathematical requirements needed to advance the latter. We present an outlook and outline areas for future improvements.

Date : Friday, 25th March 2022 at 4 PM

Venue : Ramanujan Auditorium,IMSc

URL : https://www.youtube.com/watch?v=-3wJjE6Uxmw