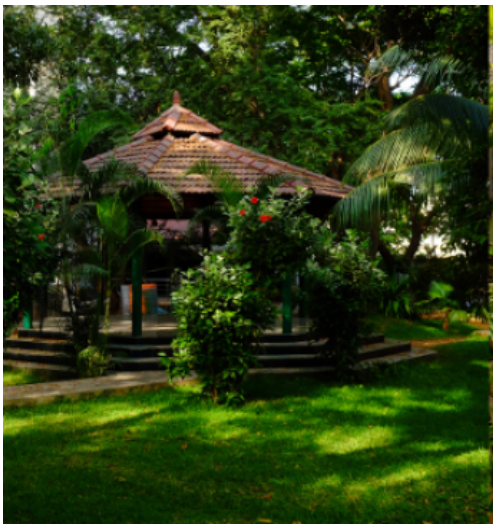
The Institute of Mathematical Sciences, Chennai

DAE-Report

April - December 2020



A. Executive Summary:

1. The document provides our academic and research activities for the period April-December 2020 including the research programs, workshops/seminars organised, outreach activities etc. Also it provides the information about awards and honours which our faculty received during the report period. A list of publications is also provided.
2. Our research highlights include several workshops and seminars organised during the report period.
3. Outreach activities highlights include our regular enrichment workshops, summer camps for school students, college students and teachers in addition to area specific outreach activities.
4. There were about 134 publications including arxiv papers during the reporting period.

1. The Institute

The Institute of Mathematical Sciences (IMSc), is an autonomous institute funded by the Government of India, through the Department of Atomic Energy. Its members work primarily in the areas of Computational Biology, Mathematics, Theoretical Physics and Theoretical Computer Science. The Institute is an autonomous body governed by a Governing Board and an Executive Council. Academic personnel of the Institute are designated as Faculty, Post-Doctoral Fellows and Junior Research Fellows. The academic programmes are ably supported by an administrative set-up. The Director is assisted by the Faculty in academic matters and by the Registrar in administrative matters.

The Institute has a faculty strength of 54 during the current year, with 40 of them at the professor level. The Institute has 144 Junior Research Fellows, 42 Post Doctoral Fellows, 35 members of scientific, administrative and Accounts staff. Also there are 41 project staff at various levels.

The Institute has an excellent scientific library and computing environment with a dedicated high speed network. The Institute has adequate infrastructure to host several national and international conferences, workshops and instructional schools which it does regularly. This includes the state of the art, 200 seater 'Ramanujan Auditorium' in our campus.

2. Teaching Programmes

IMSc has prestigious PhD and integrated PhD programs. Students are selected at the graduate and postgraduate level each year through an all India joint entrance screening test followed by an interview. They undergo two years (typically) of rigorous course-work, and after successful completion of which they join doctoral thesis work under the supervision of a faculty member. The qualified thesis work is submitted to the 'Homi Bhabha National Institute', which is a deemed University of which IMSc is a part, for award of PhD degrees.

3. Research Highlights

Algebra

The IMSc Algebraic Combinatorics Seminar has been running successfully online since April 2020. Weekly talks are given by the world's leading experts in Algebraic Combinatorics as well as by IMSc's own faculty, postdoctoral fellows and students. These seminars have helped expose our researchers to the latest developments in the area, and have improved our visibility in the community.

Algorithms and Data Structures

We proved the W[1]-hardness of the KONIG EDGE DELETION problem, which was a long standing open problem in the field of parameterized complexity for over 7 years. We also show that a variant of this problem, called KONIG EDGE DELETION DISJOINT FROM MATCHING, is fixed-parameter tractable. We study a generalization of the DIRECTED FEEDBACK VERTEX SET problem. Our results include a $O(2^{k \log k})$ algorithm for the problem, and a $O(2^{k \log k})$ algorithm for some special cases of the problem, which matches the best known algorithm for DIRECTED FEEDBACK VERTEX SET.

These results are an improvement over a previous paper in literature. We study the complexity of recognizing the class of k-Clique Extendible Orderable (abbr. k-CEO) graphs. These graphs are a generalization of the well-known comparability graphs, for which there is a polynomial time recognition algorithm. In fact, comparability graphs are exactly the 2-CEO graphs. 3-CEO graphs also arise as the neighborhood of a vertex in a visibility graph. We show that recognition of these graphs is NP-hard for each $k \geq 3$. This resolves an open problem posed by Spinrad on the complexity of the recognition of 3-CEO graphs. A previous result in literature showed that one can find a maximum clique in k-CEO graphs in time $O(n^k)$. We show that, under some complexity assumptions, that one cannot find a maximum clique in these graphs in time faster than $O(n^k)$, proving that the result is tight.

Astrophysics and Cosmology

Magnetars are magnetically powered neutron star with a very high value of the surface magnetic field. In their quiescent state, magnetars emit persistent X-rays, but no radio pulsations. However, there are a handful of magnetars that enter into a radio active state for some time when they emit radio pulsations. These radio active states are often accompanied by X-ray bursts. We are running a program with the upgraded Giant Metrewave Radio Telescope (Kodad, Pune) to search radio pulsations from newly discovered magnetars or when x-ray bursts or radio pulsations are reported by other telescopes at different frequencies.

We are the first to detect the low-frequency radio waves from the magnetar Swift J1818.0-1607 after the high-frequency radio pulsations were reported by other groups. We also searched for radio pulsations from two other magnetars, SGR J1935+2154 and SGR 1830-0645. We did not detect any radio pulsations from these two sources which agreed with independent searches by other radio telescopes at other radio frequencies. Our imaging study provided an upper limit of radio brightness of these two sources.

Four astronomer's telegram have been published so far from this campaign.

In [73], Dhiraj Kumar Hazra in collaboration with Paoletti, Finelli and Smoot introduced a new model of reionization that allows us to combine cosmological and astrophysical data in a conservative approach to provide best possible constraints.

<https://inspirehep.net/literature/1727849>

Automorphic Forms and Nonlinear Differential Equations:

We associate generalized Ramanujan type relations and non-linear differential equations to triangle groups and prove that a subset of these satisfy the Painlevé property.

Triangle Groups: Automorphic Forms and Nonlinear Differential Equations

SIGMA 16 (2020) 102 • e-Print: 2004.06035 [nlin.SI]

Discrete-Time Quantum Walks Algorithm

In a collaborative work involving researchers from IMSc and Joint Quantum Institute, University of Maryland, we have demonstrated the circuit-based implementation of a discrete-time quantum walk in position space on a five-qubit trapped-ion quantum processor. Using the same framework, by encoding the space of walker positions in particular multi-qubit states and by programming the system to operate with different quantum walk parameters, experimental realization of Dirac cellular automaton with tunable mass parameter was demonstrated. The quantum walk circuits and position state mapping we have reported scale favorably to a larger model and physical systems, allowing the implementation of any algorithm based on discrete-time quantum walks algorithm and the dynamics associated with the discretized version of the Dirac equation. This work was published in Nature communication [77].

Huerta Alderete C., *Shivani Singh*, Nguyen, Nhung H., Zhu, Daiwei, Balu, Radhakrishnan, Monroe, Christopher, *Chandrashekar, C. M. *, & Linke, Norbert M. (2020). Quantum walks and Dirac cellular automata on a programmable trapped-ion quantum computer. *Nat Commun* *11, *3720 (2020). https://doi.org/10.1038/s41467-020-17519-4

Epidemiological model for India: INDSCI-SIM

Gautam Menon, Sitabhra Sinha, Pinaki Chauduri and Dhiraj Kumar Hazra from IMSc in collaboration with scientists from Pune University (Pune) IISc (Bengaluru) and BITS-Pilani (Goa) have been working on the development of INDSCi-SIM model, which is a detailed, India-specific, epidemiological model for analysing the spread of COVID-19 in India, with parameters based on clinical studies and demographic data, including age stratification, migration, contact matrix information. Using this model, it is possible to compare the effects of multiple non-pharmaceutical interventions – including different types of lock-downs, quarantines and expanded testing – in altering the trajectory of the pandemic. Finally, the model can be used to forecast the requirements that will be placed on the health care system, including requirements for hospital beds and for critical care. The INDSCI-SIM code can simulate disease progression at arbitrary granularity (country/states/districts) and an online dashboard can be used by local administrators to plan their interventions. The model has been successfully incorporated into the resource planning and interventions by some local governments (e.g. Pune, Karnataka). We have been publishing regular reports which are available online 'indscicov.in/indscisim', and a manuscript is now in preparation.

https://indscicov.in/for-scientists-healthcare-professionals/mathematical-modelling/indscisim/

Sitabhra Sinha of IMSc was part of the Public Health Working Group set up by the Ministry of Health & Family Welfare, Government of India in March this year under Union Secretary (H) to review the evolving scenario of COVID19 and guide public health response to the same. He has been evaluating the epidemiological situation of the COVID19 pandemic in India from March, and our work has been featured in the electronic and print media prominently from that time.

Sinha S. (2020) Epidemiological Dynamics of the COVID-19 Pandemic in India: An Interim Assessment. In STATISTICS AND APPLICATIONS (Vol. 18, No.1, pp. 333–350) https://ssca.org.in/media/21_18_1_2020_SA_SSinha_Uq5HK22.pdf

Extreme active matter at high densities

In a collaborative work[96] involving researchers from IMSc, NCBS and ICTS, we have shown that extreme activity in biological systems or synthetic active matter, in the form of persistent motion, leads to a fascinating manifestation of the physics of glass, jamming, plasticity and turbulence, in a new state of driven classical matter, which has been published in Nature Communications .

In this work, we have demonstrated that by tuning the persistence time, it is possible to explore the crossover between glass physics, where the dynamics proceeds by density relaxation, and jamming-yielding physics, where the dynamics is controlled by stress buildup and release via macroscopic flows.

Mandal, R., Bhuyan, P. J., Chaudhuri, P., Dasgupta, C., & Rao, M. (2020). Extreme active matter at high densities. In NATURE COMMUNICATIONS (Vol. 11, Issue 1). NATURE PUBLISHING GROUP. https://doi.org/10.1038/s41467-020-16130-x

Flow of Polycrystalline Softmatter

In a collaborative work involving researchers from IMSc and IIT-B, we have reported how the flow of polycrystalline soft matter in channels exhibits a rich interplay between grain sizes and confining lengthscales, leading to novel spatiotemporal heterogeneities, with large variation in the phenomenology as the width of the channel is varied.

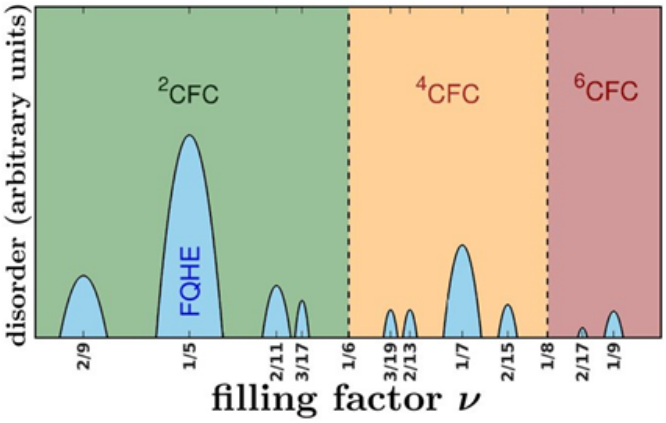
This work [121], published in Physical Review Letters, should spur more work on understanding how the morphology of polycrystalline matter responds to external drive, specially in the context of rheological applications.

Sarkar, T., Chaudhuri, P., & Sain, A. (2020). Poiseuille Flow of Soft Polycrystals in 2D Rough Channels. In PHYSICAL REVIEW LETTERS (Vol. 124, Issue 15). AMER PHYSICAL SOC. https://doi.org/10.1103/PhysRevLett.124.158003

Fractional quantum Hall effect:

The fractional quantum Hall effect (FQHE) forms a paradigm in our understanding of strongly-correlated quantum many-body systems. The FQHE in the lowest Landau level (LLL) is well-understood in a unified manner using the framework of composite fermions. However, such a unified description of FQHE states in the second LL (SLL) has been lacking. We propose that a unified description of FQHE states in the SLL can be obtained using the parton construction. We elucidate in detail that parton wave functions capture all the FQH states observed in the SLL [11, 12].

In the publication titled ``Interplay between fractional quantum Hall liquid and crystal phases at low filling" [10] , we revisit the issue of the nature of the ground state at low filling factors by studying the competition between the fractional quantum Hall effect (FQHE) liquid and the Wigner crystal phases. Our calculations suggest that rather than forming a full-fledged crystal immediately below filling factor 1/6, the system finds it advantageous to remain in the FQHE liquid phase while creating strong short-range crystalline correlations. In particular, we predict that the ground state at filling factor 1/7 is an FQHE liquid.



Ajit Balram

https://twitter.com/IMScChennai/status/1296351081220341760

https://twitter.com/IMScChennai/status/1293042206329245697

Multidisciplinary Research

Chandrani Kumari, Gautam Menon and Rahul Siddharthan were part of a multidisciplinary team, with doctors at Apollo Hospitals and biomedical researchers at IIT Madras, that studied the role of circulating progenitor cells in predicting vasoplegia, which is associated with ICU morbidity and organ failure. This work was published in PLOS ONE https://doi.org/10.1371/journal.pone.0242375

Media coverage appeared in 'The Hindu', November 2020 : https://www.thehindu.com/sci-tech/science/pilot-study-finds-potential-signal-indicative-of-loss-of-tone-in-blood-vessels-after-cardiac-surgery/article33201645.ece

Pilot study finds potential signal indicative of loss of tone in blood vessels after cardiac surgery (Source: THE HINDU, SCIENCE NOVEMBER 28, 2020)

Photo credit: Vital Hil

The researchers noted a weakening of possible repair mechanisms of blood vessels in patients who showed clinically significant vasoplegia.

Vasoplegia, where "vaso" refers to blood vessels and "plegia" stands for paralysis, is a condition where the patient exhibits a low blood pressure, even in the presence of normal or

increased output of blood from the heart. When this occurs as a complication of cardiopulmonary bypass surgery, there is a chance that it can lead to multiple organ failure and even death. Now, a diverse group of researchers including clinicians, computational biologists and biotechnologists have come together to study how this may be predicted early on based on clinical observations, so that effective treatment may be given.

Chandrani Kumari, Rahul Siddharthan, Gautam Menon et al

https://twitter.com/IMScChennai/status/1333285582693224450

Potential inhibitors for COVID-19

Our work with NISER on finding potential inhibitors for COVID-19 which has been listed here:

Coverage in:

Dinamalar Pattam: தாவரங்களில் கோவிட் 19 மருந்து!

<https://www.imsc.res.in/~asamal/doc/Pattam_Molecules.pdf>

Times of India: NISER study identifies plant compound that may cure Covid

<https://timesofindia.indiatimes.com/city/bhubaneswar/bhubaneswar-niser-study-identifies-plant-compound-that-may-cure-covid/articleshow/77816379.cms?>

Prameya News: Scientists from NISER, IMSc identify phytochemicals 'potential drug candidates' for COVID-19 treatment

<http://www.prameyanews.com/scientists-from-niser-imsc-identify-phytochemicals-potential-drug-candidates-for-covid-19-treatment/>

Quantum Matter

Our recent work on Iron oxychalcogenide materials as part of a multinational research enterprise with 20 experimentalists and 3 theorists is now accepted for publication in Nature Partner Journal: Quantum Matter.

Here, we have conducted an exhaustive range of experiments and extensive theoretical analysis to demonstrate a rare, novel, hidden spin-quadrupolar (or a liquid crystal-like spin nematic state of matter) in a Mott insulator. This has numerous implications for understanding the physics of these exotic materials, many of which are high temperature

superconductors. It now seems that an electronic nematic phase, either orbital or spin-driven, influences the superconductivity, which emerges in its direct proximity.

Reference: arXiv.org: cond-mat:1708.01693.

To appear in Nature Partner Journal: Quantum Matter.

https://www.nature.com/nature-research/open-access/nature-partner-journals

Quantum Precision Thermometry

In our work [107] entitled, "Quantum precision thermometry with weak measurements" [authored by A. K. Pati, C. Mukhopadhyay, S. Chakraborty, and S. Ghosh, Phys. Rev. A, vol. 102, pp. 012204 (July, 2020)], we proposed an alternative method to measure the temperature of a bath using the weak measurement scheme with a finite-dimensional probe.

The precision offered by the present scheme not only shows similar qualitative features as the usual quantum-Fisher-information-based thermometric protocols, but also allows for flexibility over setting the optimal thermometric window through the judicious choice of post-selection measurements.

Soft plus Virtual(SV) and next to SV

We have worked on formulating a framework to study soft plus virtual (SV) and next to SV (NSV) contributions to inclusive as well as differential distributions for the production of colorless state in hadron colliders.

We studied the perturbative structure of threshold enhanced logarithms in the coefficient functions of deep inelastic scattering (DIS) and semi-inclusive e^+e^- annihilation (SI) processes and Drell Yan and Higgs productions and we setup a framework to sum them up to all orders in perturbation theory.

Threshold logarithms show up as the distributions from the soft plus virtual (SV) and as logarithms log(1-z) from next to SV (NSV) contributions.

We used the Sudakov differential and the renormalisation group equations along with the factorisation properties of parton level cross sections to obtain the resummed result that predicts SV as well as next to SV contributions to all orders in strong coupling constant. In Mellin N space, we resumed the large logarithms of N keeping 1/N corrections.

String Theory

In two papers[25, 26], we showed how co-dimension two defects in gauge theories can be embedded into string theory using fractional D-branes. This is part of the geometric engineering programme in which physical properties are encoded in (stringy) geometry. The string theoretic framework should allow us to better understand and explore the physics of defects.

Surface defects from fractional branes. Part I

JHEP 07 (2020) Article number 051 • e-Print: 2005.02050 [hep-th]

Surface defects from fractional branes. Part II

JHEP 08 (2020) Article number 058, • e-Print: 2005.03701 [hep-th]

In addition to the above research highlights, following are some of the tweets on the research activities of IMSc:

1. **Dhiraj Hazra**

https://twitter.com/IMScChennai/status/1295216282208538624

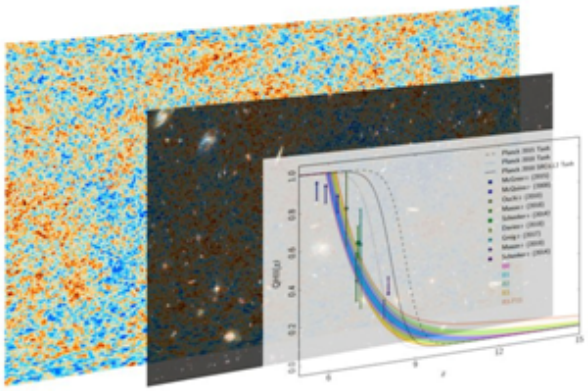
"Space telescope can reveal fine details of the primordial Universe by mapping millions of galaxies after its launch in 2022" - Dhirajhazra@IMScChennai et. al. publish a study showing #EuclidMission @ESA_Euclid

A tweet about the article 'Constraints on features in the inflationary potential from future Euclid data' , by Ivan Debono, Dhiraj Kumar Hazra, Arman Shafieloo, George F Smoot, Alexei A Starobinsky, published in 'Monthly Notices of the Royal Astronomical Society, Volume 496, Issue 3, August 2020, Pages 3448–3468, https://doi.org/10.1093/mnras/staa1765

https://twitter.com/IMScChennai/status/1294241548209553408

"Our universe is less opaque!" - Dhirajhazra@IMScChennai et. al. , present a unified scenario for the history of reionization that indicates our Universe is more transparent to #CMBphotons

Another tweet about the article, 'Joining Bits and Pieces of Reionization History', by Dhiraj Kumar Hazra, Daniela Paoletti, Fabio Finelli, and George F. Smoot, published in Phys. Rev. Lett. 125, 071301, August 2020.



https://twitter.com/IMScChennai/status/1276473880694030337

Dhirajhazra@IMScChennai with Xingangchen01 @ HarvardITC - “study bias between # confirmed and actual cases in #CoVid19 pandemic: , results project the number of actual infections, provide guidance on test volumes and derive infection fatality rate (~0.48%)”

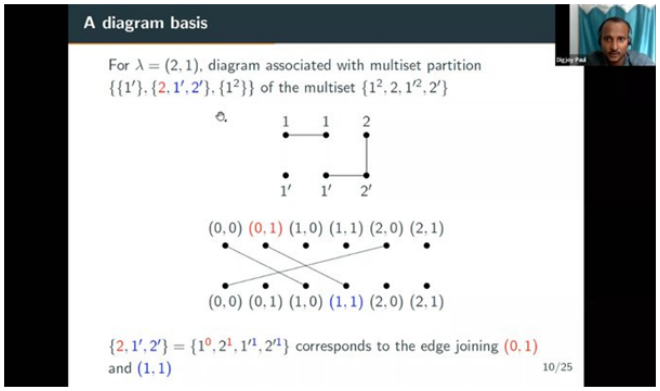
A tweet about the preprint, ‘Understanding the Bias between the Number of Confirmed Cases and Actual Number of Infections in the COVID-19 Pandemic’, by Xingang Chen, Dhiraj Kumar Hazra

Doi: https://medrxiv.org/content/10.1101/2020.06.22.20137208v1

Thesis Defense related tweets:

2. **Digjoy Paul**

https://twitter.com/IMScChennai/status/1313358385996197888



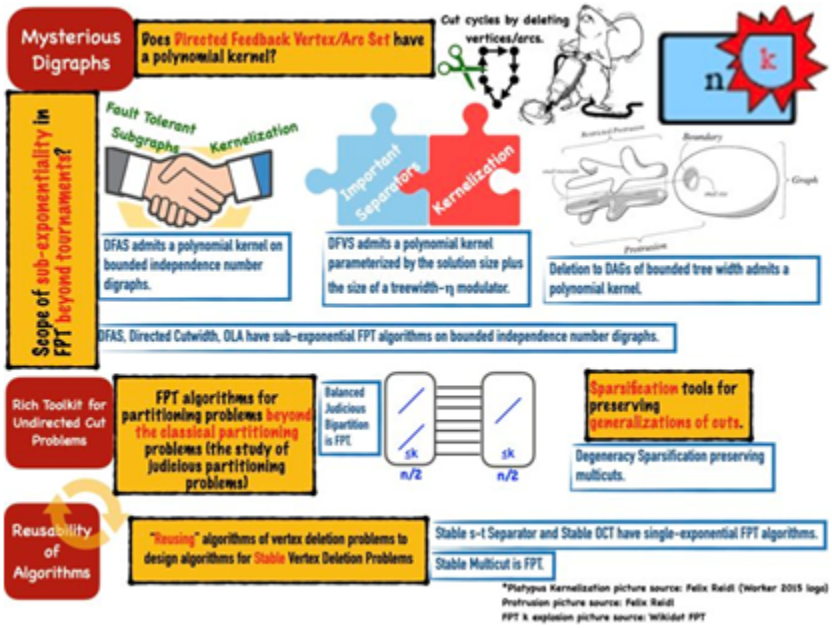
Digjoy Paul @IMScChennai successfully defended his PhD thesis "The Multiset Partitions Algebra" on 2nd Oct 2020. Congrats Dr. Digjoy!

3. **Roohani Sharma**

https://twitter.com/IMScChennai/status/1293533380940685312

Roohani Sharma @IMScChennai, is defending her thesis titled 'Advancing the Algorithmic Tool-kit for Parameterized Cut Problems' on her new results in the field of #GraphAlgorithms and #ParameterizedComplexity.

Join on Aug13 @ 12:00 : https://bluejeans.com/544145125/3911?src=join_info

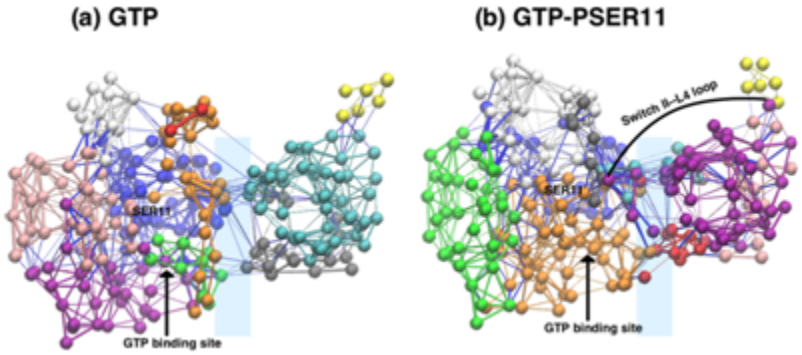


4. **Devanand T**

https://twitter.com/IMScChennai/status/1282549882239082497

Devanand_t @IMScChennai defended his PhD thesis "Allosteric effects in protein dynamics and their interactions with membranes" on 24 June 2020 about Allostery propagation in Rap:Raf protein complex. Congrats Dr. Devanand!

https://link.springer.com/article/10.1007/s00232-019-00072-7



4. Participation in conferences

Our institute had a quite a few selected talks at the recently concluded XXIV DAE-BRNS symposium on High Energy physics at NISER Bhubaneswar through online mode (14-18th December), the largest of its kind in our country.

There were 5 presentations by students and post-docs from our group and one invited plenary talk by Sayantan Sharma of IMSc, titled "Recent theoretical developments on QCD matter at finite temperature and density".

Meena Mahajan of IMSc Participated in 15th Computer Science in Russia Symposium (CSR) held at Online during Jun 29 – Jul 3, 2020. (originally planned at Ekaterinburg, Russia);

Participated in 23rd International Conference on Theory and Applications of Satisfiability Testing (SAT) held online during Jul 6 – Jul 8, 2020. (originally planned at Alghero, Italy);

Participated in 35th Annual ACM/IEEE Symposium on Logic in Computer Science (LICS) held online during Jul 8 – Jul 11, 2020. (originally planned at Saarbr¨ucken, Germany);

Participated in ACM-W India Grad Cohort held at Virtual meeting online during Jul 24 – Jul 26, 2020. Keynote speaker in one session, panelist in one panel discussion;

Participated in 35th Computational Complexity Conference held online during Jul 28 – Jul 30, 2020. (originally planned at Saarbr¨ucken, Germany);

Participated in Workshop on Matrix Rigidity held at online (originally scheduled at BITS Goa) during Dec 13 – Dec 14, 2020; and

Participated in 40th Foundations of Software Technology and Theoretical Computer Science (FSTTCS) Conference held online (originally scheduled at BITS Goa) during Dec 15 – Dec 17, 2020.

K.N. Raghavan of IMSc Participated in the 'Eleventh Summer Training Programme in Mathematics' held at RIASM, University of Madras during May 16, 2019 – May 21, 2020. Conducted six lecture + tutorial sessions (of three hours each) during this period

5. Highlights of Outreach Activities

The Institute has conducted various Conferences and workshops in addition to regular seminars during the academic year 2020-21; During this period, many of our academic colloquia and seminars series by speakers from all over the world are announced on social media and online links are open to attend.

In particular 'Algebraic Combinatorics series' and 'Computational Biology series' were announced like this.

The list of outreach activities includes the following:-

Annular Solar Eclipse: 21 June 2020

An Annular Solar Eclipse (ASE) was visible on the morning of 21 June 2020 in India, with the annular track passing through Punjab, Haryana and Uttarakhand. Solar eclipses are of huge public interest and provide an exceptional opportunity to promote science and scientific temper among the people, as well as challenge the myths surrounding the topic. The mass campaigns during past solar eclipses in India are unique in their range and reach.

Given the global CoViD-19 pandemic, we provided information about the eclipse in various regional languages through our social media handles and website and encouraged the public to observe the eclipse safely from their homes.

https://www.imsc.res.in/outreach/ASE2020/

From Learning to Doing -- Release of online material for ‘Madras Day’, 22 August 2020

Our poster series "From Learning to Doing: Science, Education and Public Service in Chennai" was curated for IMSc's Science at the Sabha 2019. The series of 12 posters highlights some of Chennai's traditions in science, mathematics, education, and public service, together with the people and institutions that helped to shape them. To mark ‘Madras day’ (founding of the city of Madras) on 22nd August, this series was made available online through our social media channels and website.

https://www.imsc.res.in/outreach/ChennaiScience2019/

Facets: 12 - 15 October 2020

Facets is the Institutes's outreach program for advanced undergraduate and postgraduate students of mathematics. This program is intended for mathematics students to interact with professional mathematicians working in various fields. This year, the program was conducted online. The talks are also now available on our YouTube channel.

https://www.youtube.com/watch?v=wPIKouOnEpE&list=PLhkiT_RYTEU05LSptj3DP0o4sguX3kMQA

Organizers: Sushmita V, Varuni P

Moderators: Sushmita V, Manikandan Sambasivam, Soumya Dey, Varuni P

Speakers: Amritanshu Prasad, Dhiraj Kumar Hazra, Anirban Mukhopadhyay, Meena Mahajan

Vigyan Pratibha Teachers workshop (Tamil) : 23-24 December 2020

Vigyan Pratibha is a Government of India program to nurture talent in Science and Mathematics among VIII - X students. As a regional center for the program, we are organizing a teachers workshop to introduce the program to local teachers highlighting the material that has been recently made available in Tamil.

Organizers: K.N. Raghavan, Manikandan Sambasivam, Varuni P

Speakers: Manikandan Sambasivam, Niruj Mohan Ramanujam (ASI-POEC), R.

Ramanujam, Subashri V, Uthra Dorairajan (D G Vaishnav College), Varuni P

6. List of Publications:

1. Agrawal, Akanksha, Fomin, F. V., Lokshtanov, D., Saurabh, S., & Tale, P. (2020). PATH CONTRACTION FASTER THAN 2^n. In *SIAM JOURNAL ON DISCRETE MATHEMATICS* (Vol. 34, Issue 2, pp. 1302–1325). SIAM PUBLICATIONS. https://doi.org/10.1137/19M1259638

2. Agrawal, Akanksha, Gupta, S., Jain, P., & Krithika, R. (2020). Quadratic vertex kernel for split vertex deletion. In *THEORETICAL COMPUTER SCIENCE* (Vol. 833, pp. 164–172). ELSEVIER. https://doi.org/10.1016/j.tcs.2020.06.001

3. Agrawal, Akanksha, Jain, P., Kanesh, L., & Saurabh, S. (2020). Parameterized Complexity of Conflict-Free Matchings and Paths. In *ALGORITHMICA* (Vol. 82, Issue 7, pp. 1939–1965). SPRINGER. https://doi.org/10.1007/s00453-020-00681-y

4. Agrawal, Akanksha, Lokshtanov, D., Misra, P., Saurabh, S., & Zehavi, M. (2020). Polylogarithmic Approximation Algorithms for Weighted-F-deletion Problems. In *ACM TRANSACTIONS ON ALGORITHMS* (Vol. 16, Issue 4). ASSOC COMPUTING MACHINERY. https://doi.org/10.1145/3389338

5. Agrawal, Akanksha, Panolan, F., Saurabh, S., & Zehavi, M. (n.d.). Simultaneous Feedback Edge Set: A Parameterized Perspective. In *ALGORITHMICA*. SPRINGER. https://doi.org/10.1007/s00453-020-00773-9

6. Agrawal, Ankit, Ganai, N., Sengupta, S., & Menon, G., I. (2020). Nonequilibrium Biophysical Processes Influence the Large-Scale Architecture of the Cell Nucleus. In *BIOPHYSICAL JOURNAL* (Vol. 118, Issue 9, pp. 2229–2244). CELL PRESS. https://doi.org/10.1016/j.bpj.2019.11.017

7. Ahmed, T., Banerjee, P., Chakraborty, A., Dhani, P. K., & Ravindran, V. (2020). Form factors with two operator insertions and the principle of maximal transcendentality. In *PHYSICAL REVIEW D* (Vol. 102, Issue 6). AMER PHYSICAL SOC. https://doi.org/10.1103/PhysRevD.102.061701

8. Ahmed, Taushif, Ajjath, A.H., Mukherjee, Pooja, Ravindran, V., Sankar, Aparna (2020). Soft-virtual correction and threshold resummation for n-colorless particles to fourth order in QCD: Part II
arXiv: 2010.02980 [hep-ph]

9. Ahmed, Taushif, Ajjath, A.H., Mukherjee, Pooja, Ravindran, V., & Surabhi Tiwari (2020). Soft-virtual correction and threshold resummation for n-colorless particles to fourth order in QCD: Part I
arXiv: 2010.02979 [hep-ph]

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In short the Institute is contributing significantly and extensively to the DAE mandate for supporting basic sciences in the areas of Computational Biology, Mathematics, Theoretical Physics and Theoretical Computer Science.