THE INSTITUTE OF MATHEMATICAL SCIENCES

C. I. T. Campus, Taramani,

Chennai - 600 113.

ANNUAL REPORT

Apr 2021 - Mar 2022

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Foreword

I am very pleased to present the annual report of the Institute for the year 2021-2022 and put forth the distinctive achievements of its members during the year along with a perspective for the future.

During the period April 2021 - March 2022, there were 146 students pursuing their PhD and 49 scholars pursuing their post-doctoral programme at IMSc. A total of 26 students were awarded PhD degree, 9 students have submitted their PhD thesis, 5 students were awarded MSc by Research degree, and a student has submitted his MSc thesis.
Research productivity of the members of the Institute has been excellent throughout the year. Several high quality publications have been reported in national and international journals, and some research work carried out has also been presented in international conferences.

During 2021-2022, a total of 35 lecture courses were conducted at the Institute. The Institute also organized or co-sponsored several workshops and conferences. These were all held online due to the ongoing pandemic.
For instance, “Special Lecture Public Talks (Conducted at IMSc as Webinar) on Cancer : Reducing Risk, Early Detection and Treatment”, ’Steps towards Life: Chemistry’, ’Recent Developments in the Mathematics of Neural Nets’, ’The hadronic vacuum polarization from lattice QCD: contributions to the muon anomalous magnetic moment and to the running of electroweak couplings’, Mini-symposium on ‘Looking back, looking forward’, on the ‘Science of COVID19’, & ’Workshop on Algorithms’ are to name a few.
The list also includes conferences like, ’The first Asian-Oceanian CWM ambassador meeting’, ’Annual Meeting of the International Pulsar Timing Array’, ’Conference on applications of Macdonald polynomials’, ’Topological aspects of strong correlations and gauge theories’, ’Modular forms - an online conference’, ’Teachers’ Enrichment Workshop on Complex Analysis and Number Theory’, and ’Workshop for CACM India Region Special Issue’ during this year.
This year the Institute of Mathematical Sciences (IMSc),Chennai, is celebrating its 60th anniversary (**IMSC60**) combined with Azadi Ka Amrit Mahotsav (**AKAM**) - 75th anniversary of India’s independence. As part of these, the institute has organised several popular scientific talks, distinguished lectures, public outreach programmes and educational initiatives including *IMSc Distinguished Lectures* - ’Physical Sciences: Synergy with Mathematics’, ’Equity and Inclusion in Science: Role that individuals, institutions and society can play’, ’Online Bipartite Matching and Adwords’, ’Out of the Box Science - Some recent Inspiring Examples’, ’The Value of a Quiet Life: Muscle Stem Cells and Their Balancing Act in Tissue Repair’, ’What is Control Theory in 2021? Can AI do Better?’, ’Precision challenges in particle physics’, *IMSc Heritage Lectures* - ’Snippets from History of Science in Ancient India’, *IMSc Popular Lectures* - ’Lecture on the Nobel Prize in Physiology or Medicine 2021 : Sensing Heat and Pressure’, ’Lecture on The Nobel Prize in Physics 2021 : Physics of complex systems: dis-ordered materials and the earth’s climate, ’Playing games during a pandemic: Mathematical modeling for public health’, ’Coping with Intractability Using Parameters’, ’How does the Sun shine? How do we know this?’, ’What can / should scientists do for mathematics and science education?’, ’The Complexity of Formal Proofs’ are to be mentioned during this year.

A number of research collaborations between other institutions, are in progress in tune with the theme of the proposal both national and international, and research groups of IMSc. Among these, we mention a few. 'Arecibo 327 MHz Drift Pulsar Survey (AO327) is an international effort to discover pulsars and transients using the Arecibo radio telescope (USA). IMSc is an international research laboratory for the Indo-French Program in Mathematics. As part of the ongoing Max Planck Partner Group in Mathematical Biology, IMSc has been collaborating with MPIMIS Leizig on the study of biological networks. As part of the SPARC project, IMSc has been organising seminars jointly with the University of Bordeaux and IIT Madras.

We are proud to note the awards and honors bestowed on our faculty for their contributions: S. Gun was Elected standing committee member of the Asia-Pacific association for women in Mathematics, for 2021, by the Asia-Pacific association for women in Mathematics under the auspices of CWM, IMU. Vijay Kodiyalam was awarded V. Ramaswamy Aiyer Memorial Award Lecture, for 2021, by the Indian Mathematical Society. Meena B. Mahajan was elected FASc, Fellow of the Indian Academy of Sciences, effective from 2022, by the IAS. Sitabhra Sinha was awarded P. C. Mahalanobis National Award for the year 2021, for 2021, by the Government of India's Ministry of Statistics Programme Implementation. Saket Saurabh was awarded Shanti Swarup Bhatnagar Prize for Science and Technology(SSB) in 2021, for his contributions in Mathematical Sciences, by the Council of Scientific and Industrial Research, Government of India. Dishant M. Pancholi was elected as a Fellow of the Indian Academy of Sciences, for the year 2022. Amritanshu Prasad was recognized in the Book '75 under 50: Scientists Shaping Today's India' published by VigyanPrasar, Department of Science and Technology, Government of India.

This report was compiled through the efforts of the IMSc Annual Report Committee consisting of Drs. S. Viswanath, Shrihari Gopalakrishna, Vikram Sharma, Areejit Samal, Sayantan Sharma, Paul Pandian and Usha Devi. I owe my gratitude to all of them.

June, 2022 **V. Ravindran**

Contents

Chapter 1

The Institute

1.1 Governing Board

Thiru. **K. Ponmudy**,
Hon'ble Minister for Higher Education,
Government of Tamil Nadu, Fort St.George, Chennai
(**Chairman**)

Dr. **K.N. Vyas**,
Chairman, AEC & Secretary to Government of India,
Department of Atomic Energy, CSM Marg, Mumbai
(**Co-Chairman**)

Prof. **Mustansir Barma**,
Former Director, TIFR,
Professor Emeritus, TIFR Centre for
Interdisciplinary Sciences (TCIS),
Hyderabad
(**Member**)

Prof. **Amitava Raychaudhuri**,
Former Director, HRI,
Sir Tarak Nath Palit Professor of Physics
Professor Emeritus, University of Calcutta,
Kolkata
(**Member**)

Prof. **S. Gowri**,
Vice-Chancellor, University of Madras,
Chepauk, Chennai
(**Member**)

Prof. **Sudhanshu Jha**,
Former Director, TIFR,
402, Vigyanshila, Juhu-Versova Link Road,
Seven Bungalows,
Andheri(W), Mumbai
(**Member**)

Smt. **Sushma Taishete**, CSS,
Joint Secretary (R&D) to Govt. of India,
Department of Atomic Energy,
CSM Marg, Mumbai
(**Member**)

Ms. **Richa Bagla**, IAS,
Joint Secretary (Finance) to Govt. of India,
Department of Atomic Energy,
CSM Marg, Mumbai
(**Member**)

Dr. **D. Karthikeyan**, IAS,
Principal Secretary to Govt., Higher
Education Department,
Secretariat, Fort St.George, Chennai
(**Member**)

Prof. **V. Ravindran**,
Director, Institute of Mathematical Sciences,
CIT Campus, Taramani, Chennai
(**Member Secretary**)

1.2 Executive Council

Dr. **K.N. Vyas**,
Chairman, AEC, & Secretary to Government of India,
Department of Atomic Energy, CSM Marg, Mumbai
(**Chairman**)

Prof. **Mustansir Barma**,
Former Director, TIFR,
Professor Emeritus, TIFR Centre for Interdisciplinary Sciences (TCIS),
Hyderabad
(**Member**)

Prof. **Amitava Raychaudhuri**,
Former Director, HRI,
Sir Tarak Nath Palit Professor of Physics,
Professor Emeritus, University of Calcutta,
Kolkata
(**Member**)

Prof. **Manindra Agrawal**,
Department of Computer Sciences and Engineering,
Indian Institute of Technology, Kanpur
(**Member**)

Smt. **Sushma Taishete**, CSS,
Joint Secretary (R&D) to Govt. of India,
Department of Atomic Energy,
CSM Marg, Mumbai
(**Member**)

Smt. **Richa Bagla**,IAS
Joint Secretary(Finance) to Govt. of India,
Department of Atomic Energy, Mumbai
(**Member**)

Dr. **D. Karthikeyan**, IAS
Principal Secretary to Government, Higher Education Department,
Secretariat, Fort St.George, Chennai
(**Member**)

Prof. **V. Ravindran**,
Director,
The Institute of Mathematical Sciences, Chennai
(**Member Secretary**)

1.2.1 Profiles of Governing Board and Executive Council Members

Thiru **K. Ponmudy**, Hon‘ble Minister for Higher Education, Government of Tamilnadu, Chennai
(**Chairman**, *Governing Board*)

Dr. K. N. Vyas, Chairman, Atomic Energy Commission & Secretary to Govt. of India, Department of Atomic Energy, CSM Marg, Mumbai
(**Co-Chairman**, *Governing Board* & **Chairman**, *Executive Council*)
Dr. Kamlesh Nilkanth Vyas is a Mechanical Engineering graduate from MS University, Vadodara. After completion of the training in the 22nd Batch of the BARC Training School in 1979, he joined Fuel Design Development Section of Reactor Engineering Division of BARC. Dr. Vyas has worked for design & analysis of nuclear reactor fuels. He was also responsible for design & development of a novel fuel for strategic applications. He has worked extensively in thermal hydraulics and stress analysis of critical reactor core components. Dr. Vyas, as an engineer, has played a key role for completion of strategic projects. Dr. Vyas has also participated in design & analysis of the Test Blanket Module planned to be installed in ITER, France.
Dr. Vyas has been conferred several awards, which include Indian Nuclear Society Outstanding Service Award 2011, Homi Bhabha Science and Technology Award 2006, DAE Awards in the years 2007, 2008, 2012 and 2013. He is also a Fellow of the Indian National Academy of Engineers.
Dr. K. N. Vyas was Director, Bhabha Atomic Research Centre, before he has taken over the charge of Secretary, Department of Atomic Energy and Chairman, Atomic Energy Commission on 20.09.2018.

Prof. Mustansir Barma Former Director, TIFR, Professor Emeritus,TIFR Center for interdisciplinary Science, Hyderabad
(**Member**, *Governing Board & Executive Council*)
Prof. Barma was a faculty member at TIFR Mumbai and was Director, TIFR Mumbai. For his contributions to physics Prof. Barma has received numerous awards, including the Bhatnagar prize and the “S.N. Bose Birth Centenary Award”. Prof. Barma is member of many national and international science academies including the Indian National Science Academy. For his contributions he was awarded “Padma Shri” by Government of India.

Prof. Amitava Raychaudhuri Former Director, Sir Tarak Nath Palit Professor of Physics, Professor Emeritus, University of Calcutta, Kolkata.
(**Member**, *Governing Board & Executive Council*)
Prof. Raychaudhuri has held numerous academic positions in India and abroad. He was the 'Sir Tarak Nath Palit Professor' at Calcutta University, and he was Director HRI, Allahabad. For his research contributions in physics, Prof. Raychaudhuri has received several awards, including the 'Bhatnagar Prize' and the 'J.C. Bose fellowship'. He is member of several science academies, including the Indian National Science Academy. Prof. Raychaudhuri was conferred the honour of International Alumnus of the Year by the University of Maryland.

Prof. Sudhanshu Jha, Former Director, TIFR,
402, Vigyanshila, Juhu-Versova Link Road, Seven Bungalows, Andheri (W) Mumbai.
(**Member**, *Governing Board*)
Prof. Sudhanshu Jha was faculty member at TIFR, Mumbai and is a former Director, TIFR, Mumbai. For his contributions in physics, Prof. Jha has received many awards including the 'Bhatnagar Prize' and the 'S.N. Bose Medal'. He is a member of several national and international academies, including the Indian National Science Academy and the Third World Academy of Sciences.

Prof. **Manindra Agrawal**,
Department of Computer Sciences and Engineering,
Indian Institute of Technology, Kanpur
(**Member**, *Executive Council*)

Prof. Manindra Agrawal is a professor at the Department of Computer Science and Engineering and the Deputy Director at the Indian Institute of Technology, Kanpur. He was also the recipient of the first Infosys Prize for Mathematics and the Shanti Swarup Bhatnagar Award in Mathematical Sciences in 2003. He has been honored with Padma Shri in 2013.

Prof. V. Ravindran, Director, IMSc Chennai
(**Member Secretary**, *Governing Board & Executive Council*)
Prof. V. Ravindran was a faculty member at Harish-Chandra Research Institute, Allahabad, prior to joining IMSc as a faculty member. His research interests are in theoretical high energy physics and in the perturbative structure of quantum field theories. He is Fellow of Indian Academy of Science (IAS) since 2012, and Fellow of Indian National Science Academy (INSA) since 2019.

Prof. **S. Gowri**, Vice-Chancellor, University of Madras, Chennai
(**Member**, *Governing Board*)
He has previously been the First Registrar of Anna University of Technology Chennai and Chairman, Faculty of Mechanical Engineering of Anna University of Technology Chennai.
He is the recipient of the National award for Outstanding Academic 2011 honoured by the Indian Society for Technical Education, New Delhi in 2012.
He has contributed to SWAYAM MOOCS and DTH of the Central Government. He is also the channel coordinator of DAKSH HD Channel, an educational channel of the MHRD.

Smt. Sushma Taishete, CSS, Joint Secretary (R & D), Department of Atomic Energy, CSM Marg, Mumbai.
(**Member**, *Governing Board & Executive Council*)

Ms. Richa Bagla, IAS
Joint Secretary(Finance) to Govt. of India,
Department of Atomic Energy, Mumbai
(**Member**, *Governing Board & Executive Council*)

Dr. **D. Karthikeyan**, IAS
Principal Secretary to Government,
Secretariat, Higher Education Dept., Government of Tamilnadu, Chennai
(**Member**, *Governing Board & Executive Council*)

1.2.2 Director's Advisory Committees

Annual Report Committee

Shrihari Gopalakrishna	Chair
Viswanath, S.	
Vikram Sharma	
Areejit Samal	
Sayantan Sharma	
Paul Pandian	(Librarian)

Alumni Committee

Indrava Roy	Chair
Meena Mahajan	
Pinaki Chaudhuri	
Paul Pandian	
Raveendra Reddy, B.	

Computer Media & Web Committee

Pinaki Chaudhuri	Chair
Rahul Siddharthan	
Satyavani Vemparala	
Sanoli Gun	
Sayantan Sharma	
Dhiraj Kumar Hazra	
Sushmita Gupta	
Raveendra Reddy, B.	SO'F'(Systems)
A student representative	(nominated by the Chair)

Events & Outreach Committee

Areejit Samal	Chair
Raghavan, K.N.	
Venkatesh Raman	
Viswanath, S.	
Rahul Siddharthan	
Ajit C Balram	
Sushmita Venugopalan	
Varuni Prabhakar	Research Associate

Internal Complaints Committee (Gender Bias Redressal)

Sushmita Venugopalan	Chair
Subramanian, C.R.	
Vinayalatha, S.	Registrar
Indra, R.	Administrative Officer

Geetha, V.	(External Member)
A Student Representative	(Nominated by the Chair)

Grievance Redressal Committee

Meena Mahajan	Chair
Anirban Mukhopadhyay	
Sanatan Digal	
Sujay Ashok	

Guest House Advisory Committee

Saket Saurabh	Chair
Syed R. Hassan	
Roji Pius	
Anup B Dixit	
Vinayalatha, S.	Registrar
A Student Representative	(Nominated by the Chair)

HBNI Coordinators Committee

Amritanshu Prasad	Dean, Student Affairs
Satyavani Vemparala	Dean, Physical Sciences
Sanatan Digal	Associate Dean, Physical Sciences
Vijay Kodiyalam	Dean, Mathematical Sciences
Sitabhra Sinha	Dean, Life Sciences

Hostel Faculty Counselor Committee

(This Committee will also serve as the Anti-Ragging Committee)

Indumathi, D.	Chair
Syed R. Hassan	
Prakash Saivasan	
Anup B Dixit	

Housing & Up-Keep Committee

Syed R. Hassan	Chair
Pinaki Chaudhuri	
Sayantan Sharma	
Vinayalatha	Registrar
Indra, R.	Administrative Officer

Library Committee

Amritanshu Prasad	Chair
Sitabhra Sinha	
Anirban Mukhopadhyay	
Manjari Bagchi	
Chandrashekar, C.M.	
Prakash Saivasan	

Paul Pandian	(Librarian)
Sathish Kumar, V.	SRF, (Mathematics)

National Science Day Committee

Sayantan Sharma	Chair
Ravindran, V.	
Prakash Saivasan	
Sushmita Venugopalan	

Official Language Implementation Committee

Ravindran, V.	Chair
Srinivas, K.	
Saket Saurabh	
Nita Sinha	
Vinayalatha, S.	Registrar
A Student Representative	(nominated by the Chair)

PDF Committees

Sanoli Gun & **Dishant Pancholi**	Mathematics
Dhiraj Kumar Hazra	Physics (HEP)
Sibasish Ghosh & **Sitabhra Sinha** &	
Ajit C. Balram	Physics (LEP)
Venkatesh Raman	TCS
Rahul Siddharthan	CB

Right To Information Act [RTI] Committee

Raghavan, K.N.	Appellate Authority
Vinayalatha , S.	Public Information Officer

Space Planning & Allocation Committee

Ravindran, V.	Chair
Indumathi, D.	
Syed R. Hassan	
Subramanian, C.R.	
Chandrashekar, C.M.	
Vinayalatha, S.	Registrar

Institute Seminar Day

Sayantan Sharma
Sushmita Venugopalan
Prakash Saivasan
Anup B Dixit

Tender Committee

Syed R. Hassan
Ajit C Balram
Sushmita Gupta

Sports/GYM Committee

Vikram Sharma
Manjari Bagchi
Sundar, S.
Student Members :

Rakesh Netha (*Cricket*)	**Anupam Sarkar**(*Badminton*)
Tanmoy Sengupta (*Foot ball*)	**A Student Representative** (*Table Tennis*)

Science at the Sabha Committee

Rahul Siddharthan	Chair
Viswanath, S.	
Dhiraj Kumar Hazra	
Vinayalatha , S.	Registrar

Approval Coordinators Committee

Shrihari Gopalakrishna	Physics
Srinivas, K.	Mathematics
Meena Mahajan	TCS
Rahul Siddharthan	CB

Colloquium & Seminar Committee

Nemani, V.S.	Physics
Anup B Dixit	Mathematics
Prakash Saivasan	TCS

Summer Research Programme Committee

Venkatesh Raman	TCS
Pinaki Chaudhuri	Physics
Dishant Pancholi	Mathematics

Associateship Programme Committee

Ravindran, V.	Chair
Venkatesh Raman	TCS
Sanoli Gun &	
Dishant Pancholi	Mathematics
Sujay Ashok	Physics
Rahul Siddharthan	CB

Academic Coordinators Committee

Sujay Ashok	Physics
Anup B. Dixit	Mathematics
Subramanian, C.R.	TCS
Rahul Siddharthan	CB

JEST/NBHM/JGEEBILS Coordinators Committee

Sanoli Gun	Mathematics(NBHM)
Vikram Sharma	TCS(JEST)
Ajit C Balaram	Physics(JEST)
Areejit Samal	CB(JGEEBILS)

Group Conveners Committee

Raghavan, K.N.	- Mathematics
Venkatesh Raman	- TCS
Rahul Siddharthan	- CB
Syed R. Hassan	- LEP
Dhiraj Kumar Hazra	- HEP

Infrastructure Committee

Syed R. Hassan	- Chair
Saket Saurabh	
Vinayalatha, S.	Registrar
Mohan, S.	Scientific Officer E (Electrical)
Sundar, M.	Scientific Officer D(Civil)

1.3 Faculty

Computational Biology

Name	*Userid*
Choubey, Sandeep	sandeep
Menon, Gautam I.	menon
Samal, Areejit	asamal
Siddharthan, Rahul	rsidd
Sinha, Sitabhra	sitabhra

Mathematics

Name	*Userid*
Chakraborty, Partha Sarathi	parthac
Chatterjee, Pralay	pralay

Dixit, Anup Biswanath	anupdixit
Gun, Sanoli	sanoli
Iyer, Jaya N.	jniyer
Kodiyalam, Vijay	vijay
Mohari, Anilesh	anilesh
Mukhopadhyay, Anirban	anirban
Pancholi, Dishant Mayurbhai	dishant
Prasad, Amritanshu	amri
Raghavan, K. N.	knr
Roy, Indrava	indrava
Srinivas, K.	srini
Sundar, S.	ssundar
Sushmita Venugopalan	sushmita
Viswanath, S.	svis

Physics

Adhikari, Ronojoy	rjoy
Ashok, Sujay K.	sashok
Bagchi, Manjari	manjari
Balram, Ajit C.	ajit
Chandrashekar, C.M.	chandru
Chaudhuri, Pinaki	pinakic
Digal, Sanatan	digal
Ghosh, Sibasish	sibasish
Gopalakrishna, Shrihari	shri
Hassan, Syed Raghib	shassan
Hazra, Dhiraj Kumar	dhiraj
Indumathi, D.	indu
Laad, Mukul S.	mslaad
Menon, Gautam I.	menon
Mukhopadhyay, Partha	parthamu
Nemani, Venkata Suryanarayana	nemani
Pal, Arnab	arnabpal
Pius, Roji	rojipius
Rajesh, Ravindran	rrajesh
Ramachandran, Ganesh	ganesh
Ravindran, V.	ravindra
Sayantan Sharma	sayantans
Siddharthan, Rahul	rsidd
Sinha, Nita	nita
Sinha, Rahul	sinha
Sinha, Sitabhra	sitabhra
Vemparala, Satyavani	vani

Theoretical Computer Science

Arvind, V.	arvind
Gupta, Sushmita	sushmitagupta

Mahajan, Meena	meena
Raman, Venkatesh	vraman
Ramanujam, R.	jam
Saivasan, Prakash	prakashs
Saurabh, Saket	saket
Sharma, Vikram	vikram
Subramanian, C.R.	crs

1.4 Emeritus Faculty Members

Balasubramanian, R.	balu
Rajasekaran, G.	graj

1.5 Scientific Staff

Subramoniam G.	gsmoni
Raveendra Reddy B.	ravi
Paul Pandian M.	pandian
Mohan S.	smohan
Usha Devi P.	usha
Sundar M.	msundar
Maruthu Pandiyan B.	maruthu

1.6 Administrative & Accounts Staff members

Vishnu Prasad S. [1]
Registrar
Vinayalatha S. [2]
Registrar

Gayatri E.
Accounts Officer

Indra R.
Administrative Officer

Shankaran, K.P.
Seenivasa Raghavan N.
Usha Otheeswaran
Archana Shukla
Babu, B.
Parthiban, V.
Ashfack Ahmed, G.
Geetha, M.
Padmanabhan, T.
Prema, P.

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[1] (Upto 31-07-2021)
[2] (From 27-08-2021)

Johnson, P.
Gopinath, S.
Amulraj, D.
Moorthy, E.
Rajasekaran, N.
Ravichandran, N.
Jayanthi, S.
Baskaran, R.
Janakiraman, J.
Munuswamy, N.
Ramesh, M.
Tamil Mani, M.

1.7 Project Staff

1.7.1 Project Staff [Non Academic]

Name	*Userid*
Balachander M.	mbchander
Gayathri S.	gayathris
Hari Priya T.V.	tvhpriya
Hemamalini A.	ahema
Imran Khan H.	imrankhan
Karthikeyan B.S.	bskarthi
Karthikeyan M.	mkarthikeyan
Kirubananth P.	kirubananth
Krishna Balaji R.	rkbalaji
Kavyaa Kumaravel	kavyaak
Manikandan Sambasivam	
Moovendan M.	moovendan
Parthasarathi N.	npsarathi
Prashanna K.	prasannak
Rajkumar S.	srajkumar
Rethinasamy D.	drsamy
Sadhana R.	sadhana
Sakthivel Murugan E.	esakthi
Shalieni D.	shalienid
Sivasubbu Raj B.	sivaraj
Sreelakshmi P.K.	lakshmipk
Srinadh G.	gsrinadh
Srinivasan G.	gsvasan
Sree Raj T.P.	sreeraj
Thennarasu S.D.	sdthennarasu
Vaideeswaran	mveswaran
Vimalraj J.	vimalraj

1.7.2 Project Staff [Scientific/Academic]

Name	*Userid*
Anns Mariya Soney	annsmaria
Gajendra Singh Badwal	
Gokul Balaji	gokulb
Irine Skeiviya	
Md. Izhar Ashraf	ashraf
Janaki Raghavan	rjanaki
Madhumita Mondal	madhumitam
Pavithra Elumalai	pavithrae
Ranjith Venkatrama	ranjithv
Shakthi N. Menon	shakthi
Shrikant Utagi	shrikantu
Soumya Easwaran	soumyae
Sriram Bhyravarapu	sriramb
Sudharshan A.	
Surendra Singh Badwal	
Varuni Prabhakar	varuni
Vinod Kumar T.	tvinodkumar
Yasharth Yadav	yasharthby

1.8 Post-Doctoral Fellows

Name	*Userid*
Computational Biology	
Balamurugan Kanagasabai	balamurugank
Nayana Mukerjee	nayanam
Solingyur Zimik Kachui	soling
Sushmita Ghosh	susmitag
Swarnendu Banerjee	swarnendub
Mathematics	
Abhishek T. Bharadwaj	abhishektb
Abishek Juyal	ajuyal
Amit Kumar Singh	amitsingh
Anbu Arjunan	aanbu
Hassain M.	hassainm
Jyotirmoy Ganguly	jyotirmoy
Kathiravan T.	tkathiravan

Mithun Kumar Das	mithundas
Selvakumar A.	selvakumar
Soumya Dey	soumyadey
Veekesh Kumar	veekeshk

Physics

Abhiram Kaushik B	abhiramkb
Aman Abhishek	amanabhi
Amit Mukherjee	amitm
Aneesh P.B.	aneeshpb
Arpita Choudhary	arpitac
Asweel Ahemed A Jaleel	asweel
Chandrima Paul	chandrimap
Debabrata Sinha	debabratas
Deeptak Biswas	deeptakb
Dibyajyoti Mohanta	dibyajyotim
Disha Bhatia	dishabhatia
Gautam Sharma	gsharma
Iyyappan I.	iyyappan
Jetin E. Thomas	jetinthomas
Prasad V.V.	prasadvv
Pratik Tarafdar	pratikt
Projesh Roy	projeshkr
Rohitashwa Chattopadhyay	rohitashwa
Samapan Sikdar	samapans
Shreyansh Shankar Dave	shreyanshsd
Sitender Pratap Kashyap	sitenderpk
Soumyadip Banerjee	soumyadipb
Subhadeep Roy	sroy
Suprabh Prakash	suprabh
Surbhi Khetrapal	surbhik
Vishnudath K.N.	vishnudathkn

Theoretical Computer Science

Gurumuruhan Ganesan	ghurumg
Manas Jyoti kashyop	manasjk
Sameera Muhamed Salam	sameerams
Satyabrata Jana	satyabrataj
Sayani Das	sayanidas
Shaily Verma	shailyverma
Sriram Bhyravarapu	sriramb

1.9 Ph.D. Students

Name	*Userid*
Computational Biology	
Ajay Subbaroyan	sajay
Ajaya Kumar Sahoo	ajayaks
Aniruddha, N.	naniruddha
Chandrani Kumari	chandranik
Chandrashekar K. A.	kachandra
Devanand T.	devanandt
Farhina Mozaffer	farihinam
Janani R.	jananir
Nikhil Chivukula	nikhilc
Pavitra S.	spavitra
Priyotosh Sil	priyotosh
Rakshika Lakshmi, A.	rakshikal
Reshma M	reshmam
Ria Ghosh	riaghosh
Rohit Kumar Singh	rohits
Roni Saiba	ronis
Shanmugapriya Priya B.	shanmugapriya
Sreevidya T.S	tssreevidya
Sunayanaa Sridharan	sunayanaas
Vadnala Rakesh Netha	rakeshnetha
Vivek Ananth R.P.	vivekananth
Mathematics	
Abhirup Chatterjee	abhirupc
Ankur Sarkar	ankurs
Aritra Bhattacharya	baritra
Arunabha Mukhopadhyay	arunabham
Aryan D	aryand
Astrid Swizell Dias	astridsd
Dhananjaya Saha	dhananjayas
Jayakumar R.	rjayakumar
Joseph Judy	josephjudy
Karthick Babu C.G.	cgkbabu
Manas Mandal	manasm
Manav Gaddam	manavg
Mrigendra Singh Kushwaha	mrigendra
Namitha C.H	namithach
Neelam	neelam
Piyasa Sarkar	psarkar
Priyamvad Srivastav	priyamvads

Rashi Sanjay Lunia	rashisl
Ratheesh T.V	ratheeshtv
Sathish Kumar, V.	vsathish
Siddheswar Kundu	siddheswark
Soumyadip Sarkar	soumyadips
Sushant	sushant
Sridhar P. Narayanan	sridharn
Sruthy Murali	sruthym
Sunil L Naik	sunilnaik
Suhas Rao Devraj	suhasrao
Saurav Holme Choudhury	sauravhe
Tanmoy Bera	tanmoyb
Tirtharaj Basu	tirtharajb
Ujjal Das	ujjaldas
Velmurugan S	velmurugan

Physics

Abinash Kumar Nayak	abinashkn
Adarsh Sudhakar	adarshsu
Ajjath A.H.	ajjathah
Akhil Antony	akhilantony
Amir Suhail	amirs
Amit Kumar	kamit
Amit Suthar	amitsuthar
Anand Pathak	anandb
Anjali Kundalpady	anjalik
Anupam A.H.	anupam
Anupam Sarkar	asarkar
Aparna Sankar	aparnas
Apurba Biswas, G.	apurbab
Arindam Mitra	amitra
Arjun Hariharan	arjunh
Arkajyoti Manna	arkajyotim
Arpan Kundu	akundu
Arup Biswas	
Deep Maity	deepmaity
Dhruv Pathak	dhruvpathak
Gopal Prakash	gopalp
Harshit Pandey	harshitp
Himanshu Badhani	himanshub
Hitesh Garg	hiteshgarg
Jatin Ghai	jghai
Jyotijwal Debnath	jdebnath
Koyena Bose	koyenb
Krishna Jalan	krishnajalan
Mamale Vinod Suryakant	mvinod

Manish	manishd
Manog Negi	manojn
Mohammad Shabbir	mshabbir
Nirmal Ghorai	nirmalg
Nishant Gupta	nishantg
Pavan Dharanipragada	pavand
Pooja Mukherjee	poojamukherjee
Prabhat Butola	prabhatb
Prateek Chawla	prateekc
Prem Kumar	premk
Pritam Sen	pritamsen
Raghvendra Singh	raghvendra
Rakesh Dora	prakeshdora
Ravi T	travi
Ria Sain	riasain
Ravi Shanker	rshanker
Sabiar Shaikh	sabiarshaikh
Sahil	sahilmd
Samim Akhtar	saminakhtar
Sarbartha Sengupta	sarbartha
Sashikanta Mohapatra	sashikanta
Saurav Goyal	sauravg
Sayak Guin	smallik
Sayantan Ghosh	sayantang
Semanti Dutta	semantid
Shivam Gola	shivamg
Shivani Singh	shivanis
Soumya Sur	soumyasur
Sourav Ballav	sballav
Subhankar Khatua	shubankark
Sujoy Mahato	sujoymahato
Surabhi Tiwari	surabhit
Subashri, V.	subashriv
Sushovan Mondal	smondal
Sumit Shaw	sumitshaw
Swagatam Tah	swagatamt
Tanishk Shrimal	sayakg
Tanmay Mitra	tmitra
Tanmay Saha	sahatanmay
Tanmoy Sengupta	tsengupta
Toshali Mitra	toshalim
Umang A. Dattani	umangad
Vaibhav Pathak	vaibhavp
Varun Gupta	varungupta
Vigneshwaran K.	vigneshwaran
Vinay Vaibhav	vinayv
Vishwajeet Kumar	vishwajeet

Theoretical Computer Science

Abhijit R Nair	abhijitrn
Abhimanyu Choudhury	abhimanyuc
Abhishek Sahu	asahu
Abhranil Chatterjee	abhranilc
Anannya Upasana	anannyaupad
Arindam Biswas	barindam
Ashwin Jacob	ajacob
Gaurav Sood	gauravs
Koduri Siddharth Choudary	kodurisc
Niranka Banerjee	nirankab
Pratik Shastri	pratiks
Ramit Das	ramitd
Sanjay Seetharaman	sanjays
Singanporia Kushal Piyushkumar	kushalps
Sounak Modak	sounakm
Souvik Saha	souviks
Yogesh Dahiya	yogeshdahiya

1.10 Summer Students

Every summer, a small number of students from various Institutes/Universities come to our institute and work on some learning/research projects with some faculty member for a period of four to six weeks. The following students visited the institute during Apr, 2021 - Mar, 2022.

Student	Faculty
Mathematics	
Metya, Nilava, Chennai Mathematical Institute	Dixit, Anup B.
Balakrishnan, Sai Sajeev, IISc Bangalore	Dixit, Anup B.
Agrawal, Rishika, Indian Statistical Institute, Bangalore	Dixit, Anup B.
Sahoo, Pragna P., IISER Behrampur	Dixit, Anup B.
Bhattacharya, Shubhrajit, Chennai Mathematical Institute	Dixit, Anup B.
Physics	
Dey, Suroj, IISER Mohali	Sharma, Sayantan
Singh, Mihir , IISER Mohali	Sharma, Sayantan

Theoretical Computer Science

Chaudhari, Hrishit, PES Univ., Bangalore	Mahajan, Meena B.
Ram, Shankar V., CMI	Mahajan, Meena B.

1.10.1 Other Students

Students also do their projects under the supervision of our faculty during the academic year.The following student has visited the institute during Apr, 2021 - Mar, 2022.

Student	Faculty
Physics	
Mallikarjun, Rahul, St. Stephen's College, Delhi	Pal, Arnab

Chapter 2

Research and Teaching

2.1 Computational Biology

2.1.1 Research Summary & Highlights

Computational Biology

Neuroimaging methods enable us to understand structural and functional brain development in people with Autism spectrum disorder (ASD). In a recent study [E], the group of Areejit Samal has extended the utility of geometry-inspired measures to brain functional connectivity networks (FCNs) in ASD. By performing global and node-level network analysis to compare the FCNs in the ASD group and the healthy group [E], it was shown that average edge Forman-Ricci curvature is significantly lower in the ASD group compared to the healthy group. After comparing the node curvatures of the FCNs in the ASD and healthy groups, the study [E] identified 83 brain regions that are significantly different in Forman-Ricci curvature. Thereafter, the study showed that brain regions with altered Forman-Ricci curvature in individuals with ASD overlap with those brain regions whose non-invasive stimulation with TMS/tDCS have been reported to result in improvement of ASD-related symptoms. These results support the use of graph Ricci curvatures as a source of hypotheses about clinically relevant brain regions underlying ASD. All the datasets and computer programs generated during this study are openly accessible at: https://github.com/asamallab/Curvature-FCN-ASD. Further, a protocol video explaining the computational workflow is available at: https://www.youtube.com/watch?v=ch7-dOA-Vlo.

Boolean modeling is an established framework for studying gene regulatory networks. In a Boolean network, different molecular components correspond to the nodes that receive inputs and relay outputs according to node-specific input-output rules, determining how their states change with time. In a recent study [S1], the group of Areejit Samal have examined the logic rules arising in curated Boolean models of diverse regulatory networks using two definitions of complexity in computer science, namely, Boolean complexity based on string lengths in formal logic, and the average sensitivity. It was shown that an overwhelming majority of the rules in these biological models minimize the two complexities, pointing to complexity as a major force in selecting regulatory logic in living systems [S1]. This study provides quantitative support for the long-standing hypothesis that logic rules in gene regulatory networks are likely to be ‘simple, or in other words, possess ‘minimum complexity. In another study [**S2**], the group has examined the occurrence and importance of certain type of veto Boolean functions namely, link operator functions, in biological regulatory networks. The results from these two studies [**S1**, **S2**] have implications for ongoing efforts to build predictive models of biological systems.

Severe fever with thrombocytopenia syndrome virus (SFTSV) causes a highly infectious disease with reported mortality in the range 2.8% to 47%. The replication and transcription of the SFTSV genome is performed by L polymerase, which has both an RNA dependent RNA polymerase domain and an N-terminal endonuclease (endoN) domain. Due to its crucial role in the cap-snatching mechanism required for initiation of viral RNA transcription, the endoN domain is an ideal antiviral drug target. In a computational study [**V3**], the group of Areejit Samal has identified potential inhibitors of the endoN domain of SFTSV L polymerase by exploring the natural product space of 14011 phytochemicals from Indian medicinal plants. Apart from the ligand binding energy from ensemble docking, the screening workflow imposed additional filters such as drug-likeness, non-covalent interactions with key active site residues, toxicity and chemical similarity with other hits, to identify top 5 potential phytochemical inhibitors of endoN domain of SFTSV L polymerase [**V3**]. Further, the stability of the protein-ligand docked complexes for the top 5 potential inhibitors was analyzed using MD simulations. The potential phytochemical inhibitors from this study [**V3**] are expected to serve as lead molecules in future experimental studies on SFTSV.

The framework of hypergraphs is particularly suited for chemical reaction networks. In a recent study [**Y**], hypergraphs were represented as partially ordered sets or posets. It is shown that the poset-based representation provides a canonical method to construct a two-dimensional simplicial complex associated with a hypergraph, such that the vertices of the simplicial complex represent the vertices and hyperedges of the original hypergraph. Thereafter, the Forman-Ricci curvature of the vertices and the hyperedges can be computed as the scalar curvature of the associated vertices in the simplicial complex. An emprirical analysis of real-world hypergraphs using this method finds that Forman-Ricci curvature shows a moderate to high absolute correlation with standard hypergraph measures such as eigenvector centrality and cardinality. In sum, the poset-based approach extends the notion of Forman-Ricci curvature to hypergraphs, and thus, enables investigation of higher-order interactions in real-world hypernetworks.

Neurotoxicants can cause permanent or irreversible damage to the nervous system and early screening of environmental chemicals for potential neurotoxicity is important for human well-being. The group of Areejit Samal has built the first dedicated resource, NeurotoxKb (https://cb.imsc.res.in/neurotoxkb/), which contains information on 475 potential non-biogenic neurotoxicants curated from 835 published studies specific to mammals [**Ra4**]. After compiling the chemical space of 475 potential neurotoxicants, the following analyses were performed. Firstly, a comparative analysis of NeurotoxKb with 55 chemical lists which include inventories, regulations and guidelines found that several potential neurotoxicants are both in regular use and produced in high volume. Secondly, a comparative analysis of NeurotoxKb and chemicals detected in 31 different human biospecimens found that several potential neurotoxicants have been detected in different biospecimens. Thirdly, based on a comparative analysis of NeurotoxKb with SVHC REACH regulation and high production volume chemicals, a hazard priority list of 18 potential neurotoxicants was proposed. Fourthly, the network of interactions between potential neurotoxicants and human neuroreceptors was explored. Fifthly, the chemical similarity network was constructed to reveal the diversity of the toxicological space of 475 potential neurotoxicants.

The detection of environmental chemicals in human tissues is considered an important biomarker of human exposure. In this direction, a unique resource, Tissue-specific Exposome Atlas or TExAs (https://cb.imsc.res.in/texas) was built, which compiles 380 environmental chemicals detected across 27 human tissues [**Ra1**]. After compiling the tissue-specific chemical exposome of 380 environmental chemicals, the following analyses were performed. Firstly, the chemicals in TExAs were compared with 55 global chemical regulations, guidelines, and inventories, which represent several categories of the external exposome of humans. Secondly, to better understand the potential implications on human health of environmental chemicals detected across human tissues, a network biology approach was employed to explore possible chemical exposure-disease associations. Specifically, tissue-specific chemical-gene-disease networks were constructed and analyzed for the environmental chemicals compiled in TExAs. Subsequent analyses revealed the possibilities of disease comorbidities and show the application of network biology in unraveling complex disease associations due to chemical exposure [**Ra1**].

In a recent study [**Ra3**], the steps involved in the characterization, development and investigation of an adverse outcome pathway (AOP) network derived to capture the endocrine-mediated perturbations resulting from environmental exposure were described. In this study, the quality and completeness of information of each AOP compiled in AOP-Wiki was assessed, and thereafter, high-confidence AOPs relevant to endocrine disruption (ED-AOPs) were identified. The identified ED-AOPs were used to construct an ED-AOP network by assembling the information on shared KEs and KERs among them. Further, a graph-theoretic approach was utilized to study the ED-AOP network and identify critical biological events perturbed upon endocrine disruption. Besides, the systems-level perturbations caused by endocrine disruption, emergent paths, and stressor-event associations were studied.

In another study [**Ra2**], a repository of Fragrance Chemicals in Children's Products (FCCP) that compiles fragrance chemicals from published experimental studies has been created. FCCP is accessible at: https://cb.imsc.res.in/fccp/. Since the fragrance chemicals in children's products are known to be poorly regulated, the study explores the current regulatory status of these chemicals and the potential health effects in children upon exposure. Further, the structural diversity of the space of compiled fragrance chemicals and banned allergenic fragrance chemicals in EU Toy Safety Directive has been analyzed.

Some of our events / research activities that received many likes from the public via twitter. Few are listed as below:

Intercellular signaling

Development in multicellular organisms is marked by a high degree of spatial organization of the cells attaining distinct fates in the embryo. Recent experiments showing that suppression of intercellular interactions can alter the spatial patterns arising during development suggest that cell fates cannot be determined by the exclusive regulation of differential gene expression by morphogen gradients (the conventional view encapsulated in the French flag model).

Using a mathematical model that describes the receptor-ligand interaction between cells in close physical proximity, we show that such intercellular signaling can regulate the process of selective gene expression within each cell, allowing information from the cellular neighborhood to influence the process by which the thresholds of morphogen concentration that dictate cell fates adaptively emerge. This results in local modulations of the positional cues provided by the global field set up by the morphogen, allowing interaction-mediated self-organized pattern formation to complement boundary-organized mechanisms in the context of development.

2.1.2 List of Publications

The list of publications follows the following conventions: firstly, names of (co)authors who are not IMSc members are marked with a superscript *; secondly, the citation labels used for cross-referencing with the research summary are constructed from the last name of the first IMSc author and finally the list is ordered alphabetically according to the labels.

[B1]
S. Banerjee, B. Saha*, M. Rietkerk*, M. Baudena*, and J. Chattopadhyay*.
Chemical contamination-mediated regime shifts in planktonic systems.

Theor Ecol. 2021 Dec; 14(4) 559-574 DOI: 10.1007/s12080-021-00516-8, **14(4)**, 559–574, 2021.

[**B2**]

M. Rietkerk*, R. Bastiaansen*, S. Banerjee, J. van de Koppel*, M. Baudena*, and A. Doelman*.

Evasion of tipping in complex systems through spatial pattern formation.

Science. DOI: 10.1126/science.abj0359, **374(6564)**, eabj0359, 2021.

[**E**]

Pavithra Elumalai, Yasharth Yadav, Nitin Williama*, Emil Saucan*, Jürgen Jost*, and Areejit Samal.

Graph Ricci Curvatures Reveal Atypical Functional Connectivity in Autism Spectrum Disorder.

2021.

(Preprint: bioRxiv 2021.11.28.470231).

[**G**]

Ria Ghosh and Shakti N. Menon.

Spontaneous generation of persistent activity in diffusively coupled cellular assemblies.

Phys Rev E., **105(1-1)**, 014311, 2022.

[**J**]

R. Janaki and A. Vytheeswaran*.

Combined effect of chemical and electrical synapses in coupled inhibitory neurons results in emergence of persistent activity.

Journal of Computational Neuroscience, **49(SUPPL 1, 1, SI)**, S196–S197, 2021.

[**M1**]

G. Babu *, D. Ray*, R. Bhaduri *, G. Menon, and et al.

COVID-19 pandemic in india: Through the lens of modeling.

Glob Health Sci Pract, **9(2)**, 220–228, 2021.

[**M2**]

S. Bandopadhyay*, A. Dhar*, and G. Menon.

Arun M. Jayannavar (1956-2021).

Current Science, **122(2)**, 220–221, 2022.

[**M3**]

P. Cherian*, S. Krishna*, and G. Menon.

Optimizing testing for COVID-19 in india.

PLoS Comput Biol. DOI: 10.1371/journal.pcbi.1009126, **17(7)**, e1009126, 2021.

[**Me**]

Shakti N. Menon, P. Varuni, Freddy Bunbury*, Devaki Bhaya*, and Gautam I. Menon.

Phototaxis in cyanobacteria: From mutants to models of collective behavior.
mBio, **12(6)**, e02398–21, 2021.

[Mu]
Reeta Yadav*, Nayana Mukherjee, and Moitri Sen*.
Spatiotemporal dynamics of a prey-predator model with Allee effect in prey and hunting cooperation in a Holling type III functional response.
Nonlinear Dyn., **107(1)**, 1397–1410, 2022.

[R]
A. Narayanan*, Vadnala Rakesh Netha, P. Ganguly*, P. Selvakumar, S. Rudramurthy*, R. Prasad*, A. Chakrabarti*, Rahul Siddharthan, and K. Sanyal*.
Functional and comparative analysis of centromeres reveals clade-specific genome rearrangements in candida auris and a chromosome number change in related species.
MBio. DOI: 10.1128/mBio.00905-21, **12(3)**, mBio.00905–21, 2021.

[Ra1]
Janani Ravichandran, Bagavathy Shanmugam Karthikeyan, S.R. Aparna, and Areejit Samal.
Network biology approach to human tissue-specific chemical exposome.
The Journal of Steroid Biochemistry and Molecular Biology, **214**, 105998, 2021.

[Ra2]
Janani Ravichandran, Bagavathy Shanmugam Karthikeyan, Jürgen Jost*, and Areejit Samal.
An atlas of fragrance chemicals in childrenś products.
Science of the Total Environment, **818**, 151682, 2022.

[Ra3]
Janani Ravichandran, Bagavathy Shanmugam Karthikeyan, and Areejit Samal.
Investigation of a derived adverse outcome pathway (AOP) network for endocrine-mediated perturbations.
Science of the Total Environment, **826**, 154112, 2022.

[Ra4]
Janani Ravichandran, Bagavathy Shanmugam Karthikeyan, Palak Singla, S.R. Aparna, and Areejit Samal.
NeurotoxKb 1.0: compilation, curation and exploration of a knowledgebase of environmental neurotoxicants specific to mammals.
Chemosphere, **278**, 130387, 2021.

[S1]
Ajay Subbaroyan, Olivier C. Martin*, and Areejit Samal.
Minimum complexity drives regulatory logic in Boolean models of living systems.
2021.
(Preprint: bioRxiv 2021.09.20.461164).

[**S2**]
Ajay Subbaroyan, Olivier C. Martin*, **and Areejit Samal**.
A preference for Link Operator Functions can drive Boolean biological networks towards critical dynamics.
Journal of Bioscienes, **47**, 17, 2022.

[**V1**]
Carmen Aguilar*, **Susana Costa***, **Claire Maudet***, **R.P. Vivek-Ananth, Sara Zaldivar-Lopez***, **Juan J. Garrido***, **Areejit Samal, Miguel Mano***, **and Ana Eulalio***.
Reprogramming of microRNA expression via E2F1 downregulation promotes Salmonella infection both in infected and bystander cells.
Nature communications, **12**, 3392, 2021.

[**V2**]
R.P. Vivek Ananth, Sankaran Krishnaswamy, and Areejit Samal.
Potential phytochemical inhibitors of SARS-CoV-2 helicase Nsp13: a molecular docking and dynamic simulation study.
Molecular Diversity, **26**, 429–442, 2022.

[**V3**]
R.P. Vivek-Ananth, Ajaya K. Sahoo, Ashutosh Srivastava*, **and Areejit Samal**.
Virtual screening of phytochemicals from Indian medicinal plants against the endonuclease domain of SFTS virus L polymerase.
RSC Advances, **12**, 6234–6247, 2022.

[**Y**]
Yasharth Yadav, Areejit Samal, and Emil Saucan*.
A poset-based approach to curvature of hypergraphs.
Symmetry, **14(2)**, 420, 2022.

[**Z**]
Mahesh K. Mulimani1*, **Soling Zimik, and Rahul Pandit***.
An in silico study of electrophysiological parameters that affect the spiral-wave frequency in mathematical models for cardiac tissue.
Front Phys., **9**, (phy.2021.819873), 2022.

2.2 Mathematics

2.2.1 Research Summary & Highlights

Algebra

Mrigendra Singh Kushwaha, KN Raghavan and Sankaran Viswanath of IMSc obtained a refined version of Knutson-Tao's celebrated saturation theorem for Littlewood-Richardson coefficients. An extended abstract titled ”The saturation Problem for Refined Littlewood-Richardson Coefficients” has been accepted as a talk at the FPSAC 2021 conference.

Algebraic Geometry

In [**Ko2**], we give a satisfying characterisation of ideals in two-dimensional regular local rings that arise as ideals of maximal minors of indecomposable integrally closed modules of rank two. Work is underway to understand the higher rank case.

Algebraic Number Theory

K. Srinivas, M. Subramani and Usha K. Sangale in a recent work showed that all imaginary biquadratic fields and cyclic quartic fields of class number 1 are Euclidean. This has appeared in the Journal **Rendiconti del Circolo Matematico di Palermo Series 2** with the title *Euclidean algorithm in Galois Quartic Fields.*

It is proved that all imaginary biquadratic fields and cyclic quartic fields of class number 1 are Euclidean [**Ks**] .

Let $f(x) = a_n x^n + a_{n-1}x^{n-1} + \cdots + a_0, a_0 \neq 0$ be a polynomial with rational coefficients and let p be a prime number whose highest power r_i dividing a_i (where $a_i = \infty$ if $a_i = 0$) satisfies $r_n = 0, r_i \geq 1$ for $0 \leq i \leq n-1$. In [**J2**], it is shown that each irreducible factor of $f(x)$ is bounded below by a number d which depends only on r_i's. This extends the well-known Eisenstein-Dumas irreducibility criteria. The analogous results over arbitrary valued fields have also been obtained.

On the Generalized Brauer-Siegel Theorem for asymptotically exact families with solvable Galois closure: The Brauer-Siegel theorem is a statement about how the class number times the regulator $h_K R_K$ of a number field vary over a family of number fields K. Siegel (for quadratic) and Brauer (for Galois) gave its description for certain families. A modern interpretation to this problem was given by Tsfasman and Vladut, who introduced the notion of asymptotically exact families and made the Brauer-Siegel conjecture for these families. Anup Dixit settled this conjecture in the case when the family consisted of number fields with solvable Galois closure [**Di3**]. This work is published in IMRN. The techniques used in this paper has already been used by Peng-Jie Wong to establish this result in a slightly more general setting.

Analytic Number Theory

Anirban Mukhopadhyay and Karthick Babu, worked on explicit Galois groups of multi-quadratic extensions of rationals [**Mu**]. Completed a work on correlation and distribution of values of multiplicative functions over function fields. Further work on pair correlation is in progress.

On generalized Diophantine m-tuples: A Diophantine m-tuple is a set $\{a_1, a_2, \cdots, a_m\}$ such that $a_i a_j + 1$ is a perfect square for all $i \neq j$. A classical question, considered by Diophantus, but posed by Fermat and later Euler is, how large can the cardinality of a Diophantine tuple consisting of integers be. This question was answered in 2016 by Togbé and Ziegler, who showed that there are no Diophantine quintuples. Anup Dixit, Ram Murty and Seoyoung Kim [**Di4**] considered the higher power analog of this problem, i.e., $a_i a_j + n$ is a k-th power for $k > 2$. They show that the cardinality of this set cannot exceed a constant times $\log n$. They also produced finer bounds under the Payley-graph conjecture. This work was published in Proceeding of American mathematical Society [**Di4**].

On limit theorem of zeta-functions: The limit theorem for the Riemann zeta-function $\zeta(s)$ is a probabilistic statement describing the value distribution of $\zeta(s)$ on vertical lines $\Re(s) = \sigma$ and $\sigma > 1/2$. This was proved by Bohr and Jessen in early 20th century. Subsequently, many generalizations and newer proofs of this statement has surfaced with more sophisticated tools in probability theory. In the survey article [**Di1**], Anup Dixit provide the essential ingredients involved in proving these results from a modern perspective, highlighting unsolved problems, future directions and some newer proofs of known results. This work is submitted to the Proceedings of the conference in honour of Prof. Subbarao.

Large values of L-functions on the 1-line: The values of the Riemann zeta-function capture information on the prime distribution and hence are interesting object of study. Anup Dixit and K. Mahatab [**Di2**] studied the question of how large can the values of a general L-function on the 1-line be, and established a result for a large family of L-functions.

Combinatorics

In [**Pra5**] Amritanshu Prasad and Ram defined a remarkable new class of polynomials parametrized by integer partitions. At prime powers they count the number of subspaces in a finite vector space that transform under a regular diagonal matrix in a specified manner. At 1, they count set partitions with specified block sizes. At 0, they count standard tableaux of specified shape. At 8722;1 they count standard shifted tableaux of a specified shape. These polynomials are generated by a new statistic on set partitions (called the interlacing number) as well as a polynomial statistic on standard tableaux. They allow one to express q-Stirling numbers of the second kind as sums over standard tableaux and as sums over set partitions. In a special case these polynomials coincide with those defined by Touchard in his study of crossings of chord diagrams.

Representation Theory

A study was undertaken of Siegel modular forms that are constructed using Jacobi forms that arise in Umbral moonshine. They are related to the Weyl-Kac-Borcherds denominator formula of some Borcherds-Kac-Moody algebras. Expansions of these Siegel forms in terms of $\widehat{sl_2}$ characters were studied [**Sh**].

The fusion product decomposition theorem for higher-level affine Demazure modules was established for all affine Lie algebras by giving a uniform proof of the combinatorial lemma that was a key ingredient of the proof in the literature [**V2**].

Operator Algebras

The paper titled ”Remarks on CCR and CAR flows over closed convex cones” got accepted for publication in the journal Infinite Dimensional Analysis, Quantum Probability and Related Topics on August 19, 2021.

A paper on KMS states of certain C*-dynamical systems, entitled KMS states on $C_c^*\mathbb{N}^2$ is submitted on arXiv.
This is joint work by Anbu Arjunan with Sruthymurali and S. Sundar

NBHM Selection procedures for the national level NBHM Scholarship Schemes:

IMSc has been the nodal agency for several years now for conducting the selection procedures (written test + interview) for the national level NBHM Scholarship Schemes. The written test for the Doctoral Scholarship Scheme—which also doubles up as the screening test for Mathematics PhD / Integrated PhD admissions for various institutions including IMSc—was conducted on 18 August 2021 in about 50 centres across the length and breadth of the country. (This test is usually conducted in the month of January. This year, it was initially scheduled to be held in April, but it suffered an indefinite postponement due to the rise of the second wave of the pandemic.) Over 3000 candidates were registered for the test, 1675 attended, and 88 were shortlisted for the interview based on the test scores. The interviews were held on 13–15 September online by five panels of experts drawn from institutions across the country. The final selection results are awaited.

2.2.2 List of Publications

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[**A**]
T. Anoop and Ujjal Das.
The compactness and the concentration compactness via p-capacity.
Annali di Matematica Pura ed Applicata (1923 -), **200**, 27152740(2021), 2021.

[**Ar**]
Anbu Arjunan.
Remarks on ccr and car flows over closed convex cones.
Infin. Dimens. Anal. Quantum. Probab. Relat. Top.., **24(04)**, 2150021 (2021), 2021.

[**As**]
Suhas Pandit* and Selvakumar A.
A note on open book embeddings of 3−manifolds in s^5.
Bulletin of the Australian Mathematical Society, 2021.
(To be published).

[**B1**]
Karthick Babu C.G.
Primes in beatty sequence.
Proc Math Sci 131, 14 (2021), **131(1)**, Article. 14, 2021.

[**B2**]
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2.3 Physics

2.3.1 Research Summary & Highlights

Astrophysics and Cosmology

"Indian Pulsar Timing Array" experiment has now become a full member of the "International Pulsar Timing Array" in February 2021. This experiment aims to detect nano-Hertz gravitational waves. Observations using the upgraded Giant Metrewave Radio Telescope (uGMRT) have been performed.

An Indian Pulsar Timing Array (InPTA) experiment has started in 2015 using the upgraded Giant Metrewave Radio Telescope (uGMRT). IMSc members are involved in this experment since then. Like other Pulsar Timing AArray (PTA) experiments, this experiment aim to detect nan-Herts gravitational waves using radio pulsars as tools.

InPTA experiment is a joint venture among various Indian institutes (IMSc, TIFR, NCRA-TIFR, IIT-Hyderabad, RRI, etc). Four IMSc members (one faculty, one student and two postdocs) are part of this experiment.

IMSc faculty member is also serving as a co-chair of the education and public outreach working group of International Pulsar Timing Array.

InPTA data will provide very accurate measurements of the interstellar dispersion measure of multiple pulsars. Recently InPTA found the signature of the coronal mass ejection from the Sun in the data of PSR J2145-0750 [Ba1]. InPTA has also reported the vidence for profile changes in PSR J1713+0747 using the uGMRT [T].

Dhiraj Kumar Hazra and collaborators have completed [H3], [H4] on early and late Universe that appeared as preprints (presently being reviewed) during this period. In one of the works, titled 'Primordial Standard Clock Models and CMB Residual Anomalies', a model of early Universe was developed that provides best fit to the latest Cosmic Microwave Background observation data from Planck.

Moreover in [H5],a theoretical framework was developed which solves major anomalies and tensions in cosmology.
A python notebook was released in git repository 'Codes in Cosmology, where several notebooks that cover a broad area in cosmology were provided . These are helpful in learning Cosmology at the Masters level or in the initial couple of years of PhD. To our knowledge, this is the first effort that attempts to provide resources in numerical cosmology and data analysis at the Masters' and PhD level.
Link: https://gitlab.com/dhirajhazra/simple-codes-in-cosmology

Classical and Quantum Gravity, Black Holes, Cosmology

A configuration space approach to few body problem in curved space has been explored. A unified fibre bundle description exists that incorporates both Dixon's construction of gravitational multipole moments and the few body problem. However, the results are too formal and observational relevance is obscure at the moment. One concrete result that emerges from this analysis is the following: Dixon suggested a definition of centre of mass (CM) of a compact source in probe approximation. A more relaxed definition exists which matches with the same considered in our earlier work in the context of small sting quantisation in curved space in a loop space approach.

With the motivation of more directly relating the non-perturbative multipole moments approach to observation, a recent work is initiated to generalise Dixon's construction by replacing space-like foliation with totally geodesic leaves to light-cone foliation.

Classical and Quantum Optics

It was demonstrated [Gho2] that there exists an entanglement in a system of harmonic oscillators placed in the noncommutative plane ('exotic oscillators') by computing the entanglement entropy as measured by the von Neumann entropy of the reduced density matrix. It is explicitly verified that the entanglement arises from the noncommutativity, which controls the coupling strength between the spatial modes. This can easily be generalized to the case where the momentum components also satisfy noncommutative relations, so that the entire phase space becomes noncommutative. It was noted that the underlying mathematical structure is reminiscent of the Unruh effect and using the Landau problem in the presence of a harmonic interaction, a concrete physical realization has been illustrated. Finally, it was shown that phase-space noncommutativity can give rise to the non-classical effect of squeezing, which generally results from the non-linearity of a medium in a three-wave mixing process.

Collisional models are a category of microscopic framework designed to study open quantum systems. The framework involves a system sequentially interacting with a bath comprised of identically prepared units. In this regard, quantum homogenization is a process where the system state approaches the identically prepared state of bath unit in the asymptotic limit. In [S], the homogenization process for non-Markovian collisional model generated via additional bath-bath interaction was studied. With partial swap operation as both system-bath and bath-bath unitary, it was shown that homogenization is achieved irrespective of the initial states of the system or bath units. This is reminiscent of the Markovian scenario, where partial swap is the unique operation for a universal quantum homogenizer. On the other hand, it was observed that the rate of homogenization is slower than its Markovian counter part. Interestingly, a different choice of bath-bath unitary speeds up the homogenization process but loses the universality being dependent on the initial states of the bath units.

Condensed Matter Physics

Using extensive molecular dynamics simulations, the slowdown of dynamics in a 3D system of ring polymers was investigated by varying the ambient pressure and the stiffness of the rings [**Ro**]. This work is in the context of recent interest in understanding the emergence of glassy dynamics in soft deformable objects. This study demonstrates that the stiffness of the rings determines the dynamics of the ring polymers, leading to glassiness at lower pressures for stiffer rings. The threading of the ring polymers, a unique feature that emerges only due to the topological nature of such polymers in three dimensions, is shown to be the determinant feature of dynamical slowdown, albeit only in a certain stiffness range. These results suggest a possible framework for exploring the phase space spanned by ring stiffness and pressure to obtain spontaneously emerging topologically constrained polymer glasses.

In the context of understanding the thermomechanical properties of glassy systems, it was shown how the Poiseuille flow of a model confined soft glass is determined by thermalization protocols [**V**]. The steady-state behavior as well as the onset of flow was contrasted, using two different thermostats, one where the confined glass is directly thermalized, whereas in the other case the glass is thermalized via the confining walls. The latter setup leads to a spatially non-uniform temperature profile within the channel, during flow, which allows for probing the rheological response of the confined glass under this additional perturbation thereby allowing to investigate the deviations from bulk rheology. Finally, it was examined how this response depends upon varying the channel widths. This study illustrates the competing effects due to the stress gradients, the intrinsic non-local correlations of glassy systems, and the presence or absence of thermal gradients.

For developing efficient multiscale models, a framework has been recently built to study the mechanical response of athermal amorphous solids via a coupling of mesoscale and microscopic models [**Chau**]. Using measurements of coarse-grained quantities from simulations of dense disordered particulate systems, a coherent elastoplastic model approach for deformation and flow of yield stress materials was presented. For a given set of parameters, this model allows us to match consistently transient and steady state features of driven disordered systems with diverse preparation histories under both applied shear-rate and creep protocols.

Research efforts in the group has also continued to focus on novel fractional quantum Hall (FQH) states.

Contrary to common belief, it was shown that the 1/2 state observed in wide quantum wells is a single-component Moore-Read Pfaffian state [**C7**]. Extending the parton paradigm it was shown that delicate FQH states in the lowest Landau level between fillings 1/3 and 2/5 can be described as parton states [**C5**, **C1**]. Furthermore the nature of the FQH state at 2+3/8, was described which aside from the famous 5/2 state, is the only other even denominator state observed in the second Landau level [**C2**].

Foundations of Quantum Mechanics

Hardy-type arguments manifest Bell nonlocality in one of the simplest possible ways. Except for demonstrating nonclassical signature of entangled states in question, they can also serve for device-independent self-testing of states, as shown, e.g., in *Phys. Rev. Lett.* **109**, 180401 (2012). In [Gho3] these results were broadened and developed to an extended version of Hardy's argument, often referred to as Cabello's nonlocality argument. It was shown that, as in the simpler case of Hardy's nonlocality argument, the maximum quantum value for Cabello's nonlocality is achieved by a pure two-qubit state and projective measurements that are unique up to local isometries. The properties of a more realistic case were examined when small errors in the ideal constraints are accepted within the probabilities obtained and was proved also in this case where the two-qubit state and measurements are sufficient for obtaining the maximum quantum violation of the classical bound.

The action of qubit channels on projective measurements on a qubit state was used [Gho1] to establish an equivalence between channels and properties of generalized measurements characterized by bias and sharpness parameters. This can be interpreted as shifting the description of measurement dynamics from the Schrodinger to the Heisenberg picture. In particular, unital quantum channels were shown to induce unbiased measurements. The Markovian channels were found to be equivalent to measurements for which sharpness is a monotonically decreasing function of time. These results were illustrated by considering various noise channels. The effect of bias and sharpness parameters on various quantum correlations and on the energy cost of measurements was discussed. Further, the quantum circuit implementation of the two element positive operator-valued measures characterized by the bias and sharpness parameters were illustrated [Mi1, Mi4] .

Self-testing protocols enable certification of quantum devices without demanding full knowledge about their inner workings. A typical approach in designing such protocols is based on observing nonlocal correlations which exhibit maximum violation in a Bell test. It was shown that [Gho4] in Bell experiment known as Hardy's test of nonlocality not only the maximally nonlocal correlation self-tests a quantum state, rather a non-maximal nonlocal behavior can serve the same purpose. All such behaviors were completely characterized leading to self-test of every pure two qubit entangled state except the maximally entangled ones. Apart from originating a novel self-testing protocol, this method provides a powerful tool towards characterizing the complex boundary of the set of quantum correlations.

Mathematical Physics

In [Gh], techniques of obtaining optimal ways to determine a d-level quantum state or distinguish such states were introduced. It entails designing constrained elementary measurements extracted from maximal abelian subsets of a unitary basis $\mathbb{U}$ for the operator algebra $\mathfrak{B}(\mathcal{H})$ of a Hilbert space $\mathcal{H}$ of finite dimension $d > 3$ or, after choosing an orthonormal basis for $\mathcal{H}$, for the $\star$-algebra $\mathbb{M}_d$ of complex matrices of order $d > 3$. Illustrations are given for the techniques.
It is shown that the Schwinger basis $\mathbb{U}$ of unitary operators can give for d, a product of primes p and a, the ideal number d^2 of rank one projectors that have a few quantum mechanical overlaps (or, for that matter, a few angles between the corresponding unit vectors). Finally, a combination of the tensor product and constrained elementary measurement techniques to

deal with all d was given, though with more overlaps or angles depending on the factorization of d as a product of primes or their powers like $d = \Pi^k{}_{j=1} d_j$ with $d_j = \rho_j^{s_j}$, , $\rho_1 \rho_2 < ... < \rho_k$, all primes, $s_j \geq 1$ for $1 \leq j \leq k$, or other types. A comparison is drawn for different forms of unitary bases for the Hilbert space factors of the tensor product like $L^2(\mathbb{F}_t)$ or $L^2(\mathbb{Z}_u)$, where $\mathbb{F}_t$ is the Galois field of size $t = \rho^s$ and $\mathbb{Z}_u$ is the ring of integers modulo u. Even though as Hilbert spaces they are isomorphic, but quantum mechanical system-wise, these tensor products are different.
In the process, an equivalence relation on unitary bases defined by R. F. Werner (2001), J.Phys. A : Math. Gen.34 (2001) 7081-7094 was studied connecting it to local operations on maximally entangled vectors bases, to find an invariant for equivalence classes in terms of certain commuting systems, called fan representations. It was related to mutually unbiased bases and Hadamard matrices. Illustrations are given in the context of Latin squares and projective representations as well. For further details see: https://www.worldscientific.com/doi/abs/10.1142/S012

Non-perturbative QCD, Lattice Gauge Theory, QGP

A progress towards resolving a long-standing puzzle about the fate of anomalous axial U(1) symmetry for QCD with two light quark flavours in the chiral limit has been recently published [**Shar3**].
The authors have used the chirality property of the fermion zero modes to understand the topological vacuum of gauge theories. For the first time they showed that the anomalous U(1) part of the chiral symmetry in Quantum Chromodynamics (QCD) remains broken in the massless limit for the light quarks even when the non-singlet part of chiral symmetry is restored. They also discussed the microscopic origin of it and the consequences of this work in the overall context of understanding phase diagram of strongly interacting matter described by QCD.

Confinement of color quantum number accounts for more than 99 percent of the mass of visible universe yet its precise mechanism is not known. What causes confinement? It is a millennium prize problem after all. 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. It is now shown that one can indeed isolate these topological hot-spots using the chirality or handedness of the light quarks. Using ab-initio lattice gauge theory techniques which requires large supercomputers, to unravel the inner workings of the vacuum of strongly interacting gauge theories, it is now observed that in 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 to deeper connections between the two phenomena [**Shar2**].

Nonlinear Dynamics, Solitons and Chaos

In [**Cha**] the onset of amplitude death is studied in diffusively coupled replicator maps. Each replicator map represents a sub-population, and the diffusive coupling denotes the migration of agents from one sub-population to the other. The replicator map shows many evolutionary outcomes: from fixed points to chaos. The central focus of this work was to explore the role of chaotic dynamics (demonstrated by the replicator maps) in bringing about cooperation in the entire population where individual agents tend to defect in order to promote their self-interest. Furthermore, the effect of the coupling between the maps was explored, the heterogeneity in the games played by the agents in each sub-population, the network degree, and the cost associated with the migration.

A rejection-free, flat histogram, cluster algorithm was introduced to determine the density of states of hardcore lattice gases [**J2**]. It was shown that the algorithm is able to efficiently sample low entropy states that are usually difficult to access, even when the excluded volume per particle is large. The algorithm was implemented for the particular case of the hard-core lattice gas in which the first k next-nearest neighbors of a particle are excluded from being occupied. It was shown that the algorithm is able to reproduce the known results for k = 1, 2, 3 both on the square and cubic lattices.

On triangular lattice, it was shown there is only one transition as opposed to a recent claim that there are two transitions [**J1**].

Particle Interactions

Semileptonic flavor-changing neutral-current transitions with a pair of neutrinos in the final state are very accurately determined in the Standard Model (SM) and thus provide an accurate and sensitive probe for physics beyond the SM. Until recently, the poor tagging efficiency for the $B \to K^{(*)} v\bar{(}v)$ modes made them less advantageous as a probe of new physics (NP) compared to the charged lepton counterparts. The most recent Belle II result on $B \to K^{(*)} v\bar{(}v)$ uses an innovative inclusive tagging technique, resulting in a higher tagging efficiency; this together with previous BABAR and Belle results indicates a possible enhancement in the branching fraction of $B^+ \to K^+ v\bar{(}v)$. A reanalysis of the full Belle dataset together with the upcoming Belle II dataset is expected to result in a much more precise measurement of this mode. If the branching ratio is indeed found to be enhanced with improved measurements, this would provide an unambiguous signal of NP without uncertainties due to long-distance non -factorizable effects or power corrections (in contrast to $B \to K^{(*)}\ell\ell$). We have explored the possibilities of such an enhancement as a signal of New Physics within several scenarios, which can also explain some of the other tensions observed in neutral- as well as charged-current B decays. In an effective field theory approach, with the most general dimension-6 Hamiltonian including light right-handed neutrinos, we explore the viability of all scalar and vector leptoquarks, as well as the parameter space possible with a generic vector gauge boson Z' model, assuming minimal new particle content. While being consistent with all data, correlations between the observed intriguing discrepancies in B decays are also obtained, which will discriminate between the various NP scenarios [**Sinha1**]. https://doi.org/10.1103/PhysRevD.104.053007).

Quantum Computations

It is well known that the quantum switch is an example of the indefinite causal order. Recently, the applications of the quantum switch on quantum channels have become a hot topic of discussion. It has been observed that it is possible to achieve significant improvement in communication when a quantum switch is applied on quantum channels. Although, while the above-said improvement is not possible for all quantum channels, for some quantum channels, the improvement can be very high. One such example has been discussed in [*New J. of Phys.* **23**, 033039 (2021)] where perfect communication through an entanglement-breaking channel has been achieved with the help of the switch. But incidentally, such a channel is unique up to unitary transformations. Therefore, it is important to study the applications of a quantum switch on other quantum channels where improvement may not be ultimate but significant. In [**Mi2**], the applications of the quantum switch on various quantum channels were studied. In particular, it was shown that if it is not possible to achieve improvement deterministically, it may be possible to achieve improvement probabilistically. It was known that if a quantum channel is useless for an information-theoretic task, concatenation generally does not provide any advantage. It is now shown in [**Mi2**] that if a quantum channel is useless even after the use of the quantum switch, concatenation of quantum channels can make it useful. It is also demonstrated that the quantum switch can help to get the quantum advantage in quantum random access code as well as it can help in demonstrating quantum steering even when only useless channels are available for communication. It is further shown in [**Mi2**] that the quantum switch can also be useful in preventing the loss of coherence in a quantum system. If noise is introduced in the switch, then the improvement can be significantly decreased.

A beautiful idea about the incompatibility of physical context (IPC) was introduced in *Phys. Rev. A* **102**, 050201(R) (2020). Here, a context was defined as a set of a quantum state and two sharp rank-one measurements, and the incompatibility of physical context defined as the leakage of information while implementing those two measurements successively in that quantum state. In this work [**Mi4**], the limitations of the previous approach were shown. The three primary limitations were: (i) the earlier approach was not generalized for positive operator-valued measurements; (ii) the previous study restricted information theoretic agents Alice, Eve, and Bob to specific quantum operations and did not consider most general quantum operations, i.e., quantum instruments; and (iii) the earlier measure of IPC can take negative values in specific cases in a more general scenario, which implies the limitation of their information measure. Thereby, in [**Mi4**] a modification of the earlier approach was proposed, in a more general and convenient way, such that this idea is well defined for generic measurements, without these limitations. A comparison of the measure of the IPC through their and the new method was shown. Lastly, it was shown how the IPC reduces in the presence of memory using our modification, which further validates our approach.

Statistical Mechanics

The problem of enumerating the numbering of tilings of lattices with rigid rods of length k has a long history. The only solution that is known is for dimers on planar lattices. In [**R1**], rigorous results were obtained for the asymptotic behavior of the entropy of full coverings in the limit of large k. Based on non-rigorous perturbative series expansion, it was conjectured that this large-k behavior of entropy per site is super-universal and continues to hold on all d-dimensional hyper-cubic lattices, with $d \geq 2$ [**R1**].

Multiphase materials, such as composite materials, exhibit multiple competing failure mechanisms during fracture. The specific role of disorder in the cell-wall material of a two-dimensional cellular solid on its deformation and crushing failure under uni-axial compression was examined numerically and validated with existing experimental data. A discrete element model was formulated to model the fracture behaviour under compression. The model is shown to be capable of reproducing the non-linear behavior of honeycombs resulting from the damage accumulation and results are shown to be in agreement with experimental measurements in terms of stiffness, strength and energy absorption. Further, the role of disorder in the material properties on the types of failure modes was investigated [**R2**].

Mpemba effect refers to the counterintuitive result that, when quenched to a low temperature, a system at higher temperature may equilibrate faster than one at intermediate temperatures. Though seen in experiments, the effect is poorly understood. A system where theoretical progress is possible as well as realisable in experiments is driven granular systems. Here, it was shown that an ansiotropically driven granular gas can exhibit Mpembda effect. Through an exact analysis of two different models, the exact phase diagram was derived [**Bi2**, **Bi1**].

Shock propagation in conservative as well as dissipative systems has been a topic of interest for a long time. Well-known examples include the spread of disturbance after a nuclear explosion. The solution for the radial distribution of pressure, density, temperature and flow velocity fields in a blast wave propagating through a medium at rest, following an intense explosion, starting from hydrodynamic equations, is one of the classic problems in gas dynamics. However, there is very little direct verification of the theory and its assumptions from simulations of microscopic models. In [**Jo**, **Ku**], the results and assumptions of the hydrodynamic theory were compared with results from large scale event driven molecular dynamics simulations of a hard sphere gas in two dimensions. It was found that the predictions for the radial distribution of the thermodynamic quantities do not match well with the numerical data. The theory is improved by replacing the ideal gas law with a more realistic virial equation of state for the hard sphere gas. While this improves the theoretical predictions, it still fails to describe the data well. To understand the reasons for this discrepancy, the results were compared with direct numerical simulations of the navier stokes equation. It was shown that including heat conduction is crucial to obtain a match between hard sphere simulations and hydrodynamics [**Jo**, **Ku**].

The study of phase transitions in hard core lattice gases is impeded by the lack of good algorithms that equilibrate the system at high densities. A rejection-free, flat histogram, cluster algorithm is introduced to determine the density of states of hard core lattice gases. It was shown that the algorithm is able to efficiently sample low entropy states that are usually difficult to access, even when the excluded volume per particle is large. The algorithm was implemented for the particular case of the hard-core lattice gas in which the first k next-nearest neighbours of a particle are excluded from being occupied. It was shown that the algorithm is able to reproduce the known results for $k = 1, 2, 3$ both on the square and cubic lattices. It was also used to resolve some contradictions in the literature for the hard core gas on triangular lattices [**Ja2**, **Ja1**]

Models with only hard interactions have been studied for a long time as the simplest models to show phase transitions. In these models, the phases and phase transitions are determined by only the shape and density of the particles. The phase diagram and nature of the phase transitions were determined for a system of hard rods in two dimensions and hard plates in three dimensions in [**R4**, **R3**, **R5**].

String Theory

A covariant lattice construction was developed last year in order to find covariant description of string bits. It was also generalised to higher dimensional field theories in a wide class of curved backgrounds. This analysis was done in position space where the ordinary partial derivative of the continuum is replaced by a certain discrete logarithmic derivative on the lattice. Such a derivative receives contribution from all powers of difference operator and therefore, configuration space needs to be defined carefully in order to make its action well defined. This year this problem was addressed and with the development of various technical components, a solution has been arrived at. The construction has been developed in detail for Lorentz invariant field theories in arbitrary dimension where charge conservation equation for spacetime symmetries has been established on the lattice.

It is hoped that the construction can be applied successfully to quantise string bits consistently. Indications are seen that the resultant quantum mechanics will take the form of the DeWitt-Virasoro construction developed in our earlier work in the context of small string quantisation in curved space in a loop space framework. But this is yet to be proved in detailed.

Various aspects of string theory in asymptotically anti-de Sitter (AdS) backgrounds in three dimensions were studied. This was made possible due the fact that the two dimensional conformal field theory that describes string propagation in such backgrounds is a Wess-Zumino-Witten model and hence exactly solvable.

For the best studied (4,4) supersymmetric models, the one loop string amplitude was obtained and rewritten in a manifestly spacetime supersymmetric form in [**?**]. These methods were extended to string-scale AdS models with reduced supersymmetry in [**As1**], by means of novel theta function identites. In addition, the operator product expansion coefficients of supersymmetric (BPS) operators for backgrounds with at least (2,2) supersymmetry were determined in [**As2**]. Finally, the study of string propagation in three dimensional black holes in asymptotically anti-de Sitter spacetime was initiated in [**As3**].

2.3.2 List of Publications

The list of publications follows the following conventions: firstly, names of (co)authors who are not IMSc members are marked with a superscript *; secondly, the citation labels used for cross-referencing with the research summary are constructed from the last name of the first IMSc author and finally the list is ordered alphabetically according to the labels.

[**A1**]
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Rapidity distribution at soft-virtual and beyond for n-colorless particles to N^4LO in QCD.
The European Physical Journal C, **81**, Article number: 943 (2021), 2021.

[**A2**]
A. Ajjath, Pooja Mukherjee, V. Ravindran, Aparna Sankar, and Surabhi Tiwari.
On next to soft threshold corrections to DIS and SIA processes.
J. High Energ. Phys., **2021**, Article number: 131 (2021), 2021.

[**A3**]
A. Ajjath, Pooja Mukherjee, V. Ravindran, Aparna Sankar, and Surabhi Tiwari.
Next-to-soft corrections for Drell-Yan and Higgs boson rapidity distributions beyond.
Phys. Rev. D., **103(11)**, L111502, 2021.

[**A4**]
A. Ajjath, Pooja Mukherjee, V. Ravindran, Aparna Sankar, and Surabhi Tiwari.
Next-to SV resummed Drell Yan cross section beyond leading-logarithm.
Eur. Phys. J. C., **82(3)**, 234, 2022.

[**An**]
T. Sreeraj* and Ramesh Anishetty.
Gauss law in lattice qcd and its gauge-invariant Hilbert space.
Indian Journal of Physics, **95(8)**, 1651–1668, 2021.

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Discordances in cosmology and the violation of slow-roll inflationary dynamics.
2022.
arXiv:2202.14028 (Submitted).

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Generalized bms algebra at timelike infinity.
Phys. Rev. D., DOI: 10.1103/PhysRevD.103.104030, **103**, 104030, 2021.

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Sujay K. Ashok and Jan Troost*.
String scale thermal anti-de sitter spaces.
Journal of High Energy Physics, **05(2021)**, 024, 2021.

[**As2**]
Sujay K. Ashok and Jan Troost*.
The AdS3 x S1 chiral ring.
Journal of High Energy Physics, **11(2021)**, 176, 2021.

[**As3**]
Sujay K. Ashok and Jan Troost*.
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(Preprint: 2112.08784).

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Gravitationally induced entanglement dynamics between two quantum walkers.
The European Physical Journal C, **81(5)**, Article number: 454 (2021), 2021.

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Astronomy & Astrophysics, **651**, A5, 2021.

[**Ba2**]
K. Nobleson*, Nikita Agarwal*, Raghav Girgaonkar*, Arul Pandian*, Bhal Chandra Joshi*, M. Krishnakumar*, Abhimanyu Susobhanan*, Shantanu Desai*, T. Prabu*, Adarsh Bathula*, Timothy T. Pennucci*, Sarmistha Banik*, Manjari Bagchi, Neelam Dhanda Batra*, Arpita Choudhary, Subhajit Dandapat*, Lankeswar Dey*, Yashwant Gupta*, Shinnosuke Hisano*, Ryo Kato*, Divyansh Kharbanda*, Tomonosuke Kikunaga*, Neel Kolhe*, Yogesh Maan*, Piyush Marmat*, P. Arumugam*, P. Manoharan*, Dhruv Pathak, Jaikhomba Singha*, Mayuresh P. Surnis*, Sai Chaitanya Susarla*, and Keitaro Takahashi*.
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[**Bi2**]
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Mpemba effect in anisotropically driven inelastic maxwell gases.
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Ajit C. Balram.
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[**H1**]

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[S]
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Quantum homogenization in non-markovian collisional model.
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[Sa]
Diganta Das* and Ria Sain.
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[Sh]
Suresh Govindarajan*, Mohammad Shabbir, and Sankaran Viswanath.
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Sanuja D. Mohanty*, Gautam Sharma, Sk Sazim*, Biswajit Pradhan*, and Arun K. Pati *.
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Sayantan Sharma, Peter Petreczky*, and Johannes Weber*.
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[Shar2]
Rasmus Larsen*, Sayantan Sharma, and Edward Shuryak*.
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Universal quantum computing using single-particle discrete-time quantum walk.
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P. Agostini*, H. Aksakal*, S. Alekhin*, Nita Sinha, and] [et al.
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Measuring cp violating phase in beauty baryon decays.
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On the non-markovianity of quantum semi-markov processes.
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2.4 Theoretical Computer Science

2.4.1 Research Summary & Highlights

Algorithms and Data Structures

A study of the design of algorithms which, given bounds on running time and an array of numbers, produce outputs with guaranteed quality of being almost-sorted, with respect to several parameters measuring the quality of sorted-ness, was carried out.

In [**Su2**], we study how to reduce the resources used by looking at the underlying patterns and sequences in the input; and to leverage the output quality. The analysis of patterns is applied to obtain algorithms that perform approximate sorting in $O(nD)$ comparisons, for a given $D > 0$ with guaranteed quality of sorted-ness. We also provide algorithms to find the rank of a value given its position in an approximately sorted array and vice versa.

In [**Su3**], we design algorithms (and also perform experiments) that performs at most $O(n.D)$ comparisons and produces an output π with guaranteed upper bounds for each of the three metrics, namely, the number of inversions, maximum displacement $md()$ and farthest inversion $dis()$. We also present a modified binary search algorithm that is nearly optimal (with respect to number of comparisons) in theory and in practice, given an approximately sorted input τ with upper bound L on each of $md()$ and $dis()$ and a x, correctly determines whether $x \in \tau$ and also its position in τ if the answer is yes. This search algorithm is used for extensive experimentation to search for x on a given π, to prove that even if the input π is only approximately sorted, binary search can still be performed in comparable time.

In [**Su4**], we present algorithms which, given an almost sorted array of numbers and number x, determine if x is in the array and if so, also output its position. We show that when an upper bound L is known for *dis* and *md* metrics, the binary search can be completed with $\log n + 4L + 1$ and $\log n + 2L + 3$ comparisons, respectively. We extend these results and provide an algorithm for a catalog search using concepts from Fractional Cascading. We further point out that our catalog search can be used to perform two-dimensional range search on an approximately sorted array for the metrics *dis* and *md* with $2(\log n)+16+2+k$ comparisons, where k is the size of the output.

Computational Complexity

In the decision tree computation model for Boolean functions, the depth corresponds to query complexity, and size corresponds to storage space. The depth measure is the most well-studied one, and is known to be polynomially related to several non-computational complexity measures of functions such as certificate complexity. The size measure is also studied, but to a lesser extent. Another decision tree measure that has received very little attention is the minimal rank of the decision tree, first introduced by Ehrenfeucht and Haussler in 1989. This measure is not polynomially related to depth, and hence it can reveal additional information about the complexity of a function. It is characterised by the value of a Prover-Delayer game first proposed by Pudlák and Impagliazzo in the context of tree-like resolution proofs. In the paper [**D2**] this measure is studied further. Upper and lower bounds on rank in terms of (variants of) certificate complexity are obtained as also upper and lower bounds on the rank for composed functions in terms of the depth of the outer function and the rank of the inner function. The rank is computed exactly for several natural functions and used to show that all the bounds obtained are tight. The size-rank relationship for decision trees, obtained by Ehrenfeucht and Haussler, is observed to be tight upto constant factors.

On the topic of Graph Isomorphism in [**A8**] it is shown chordal graph isomorphism is fixed parameter tractable with the leafage of the chordal graph as fixed parameter. In [**A9**] a fixed parameter tractability result for tournament isomorphism is shown with respect to a new parameter, called span, for tournaments. The complexity of computing small weight automorphisms and isomorphisms of graphs in a parameterized complexity setting is studied in [**A7**].

On the topic of polynomial identity testing the article [**A1**] studies the complexity of weighted automata equivalence over partially commutative monoids. It turns out that this problem is essentially identity testing of algebraic branching programs over a partially set of indeterminates. When the commuting relation has a small clique cover we obtain an efficient deterministic black-box identity test for the problem by a hitting set construction. The article [**A5**] solves the problem of black-box rational identity testing for rational formulas of inversion height 2 again by a hitting set construction.

The article [**A2**] explores the problem of finding a satisfying assignment for an n-variable k-

CNF formula in a given subspace over the space of all assignments (which is the n-dimensional vector space over the binary field). New algorithms are obtained in some special case that have savings of $O(1/k)$ in the exponent, comparable to the best algorithms for k-SAT, and which are polynomial space-bounded. The articles [**A4**] and [**A3**] develops techniques, based on algebraic complexity, that yields new algorithms for several combinatorial problems in a parameter-complexity setting.

Graph Theory and Combinatorics

The counting version (determining the number of witnesses of a given instance) of NP languages often turn out be $\#P$-complete as illustrated by the examples of k-colorability, k-SAT, etc. In this submission, we study the counting version of a general (d, l)-CSP problem for semi-random and smoothed instances. Smoothed instances are obtained by introducing a random noise (perturbation) to a given arbitrary input. Semi-random instances were introduced in literature as a trade-off between random and worst-case instances. In [**Su5**], we introduce and study a very general formulation of semi-random binary sequences (which allows one to flip both 0s and 1s in the initial random component) and apply it to define models for generating semi-random instances of (d, l)-CSP problems. We propose and study a simple backtrack algorithm for counting witnesses and analyse it to obtain tight upper bounds on its expected time over semi-random and smoothed instances. In particular, we obtain that backtrack heuristic takes (i) polynomial expected time to count witnesses for dense semi-random/smoothed instances of problems like k-colorability, k-SAT, k-NAE-SAT, etc, (ii) $O(1)$ expected time to count the number of k-colorings over dense semi-random/smoothed instances for every fixed k, (iii) $e^{(0.5)p^{-1}(\ln np)^2[1-o(1)]}$ expected time to count the numbers of independent sets of each size, where p is the lower bound on the probability of presence of any edge (noise probability) in the semi-random (smoothed) instance. We also show that our analysis is tight (for k-colorings, k-SAT/NAESAT assignments and independent sets) in the sense that the exponent of the running time is determined precisely (upto negligible second order terms) and cannot be brought down further. The wide class of distributions and the associated bounds on expected times presented here brings out the huge gap between worst-case and average-case complexities of several NP-hard problems.

2.4.2 List of Publications

The list of publications follows the following conventions: firstly, names of (co)authors who are not IMSc members are marked with a superscript *; secondly, the citation labels used for cross-referencing with the research summary are constructed from the last name of the first IMSc author and finally the list is ordered alphabetically according to the labels.

[**A1**]
V. Arvind, A. Chatterjee, R. Datta*, and P. Mukhopadhyay*.
Equivalence testing of weighted automata over partially commutative monoids.
In Filippo Bonchi and Simon J. Puglisi, editors, *46th International Symposium on Mathematical Foundations of Computer Science (MFCS 2021)*, page 10:1. Schloss Dagstuhl – Leibniz-Zentrum f
ür Informatik, Aug 2021.

[**A2**]
V. Arvind and V. Guruswami*.
CNF satisfiability in a subspace and related problems.
In Petr A. Golovach and Meirav Zehavi, editors, *16th International Symposium on Parameterized and Exact Computation (IPEC 2021)*, page 5:1. Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Nov 2021.

[**A3**]
V. Arvind, A. Chatterjee, R. Datta***, and P. Mukhopadhyay***.
Univariate ideal membership parameterized by rank, degree, and number of generators.
Theory of Computing Systems, **66(1)**, 56, 2021.

[**A4**]
V. Arvind, A. Chatterjee, R. Datta***, and P. Mukhopadhyay***.
Fast exact algorithms using hadamard product of polynomials.
Algorithmica, **84(2)**, 436, 2022.

[**A5**]
V. Arvind, A. Chatterjee***, and P. Mukhopadhyay***.
Black-box identity testing of noncommutative rational formulas of inversion height two in deterministic quasipolynomial-time.
2022.
(Preprint: arXiv:2202.05693v1).

[**A6**]
V. Arvind and P. Joglekar*.
On efficient noncommutative polynomial factorization via higman linearization.
2022.
(Preprint: arXiv:2202.09883v2).

[**A7**]
V. Arvind, J. Koebler***, S. Kuhnert*****, and J. Toran***.
Parameterized complexity of small weight automorphisms and isomorphisms.
Algorithmica, **83(12)**, 3567, 2021.

[**A8**]
V. Arvind, R. Nedela***, I. Ponomarenko*****, and P. Zeman***.
Testing isomorphism of chordal graphs of bounded leafage is fixed-parameter tractable.
2021.
(Preprint: arXiv:2107.10689v2).

[**A9**]
V. Arvind, I. Ponomarenko***, and G. Ryabov***.
Isomorphism testing of k-spanning tournaments is fixed parameter tractable.
2022.
(Preprint: arXiv:2201.12312v1).

[**B1**]
Arindam Biswas and Venkatesh Raman.
Sublinear-Space Approximation Algorithms for Max r-SAT.
In Chi-Yeh Chen, Wing-Kai Hon, Ling-Ju Hung, and Chia-Wei Lee, editors, *COCOON: Computing and Combinatorics Conference*, pages 124 – 136. Springer-Verlag, Oct 2021.

[**B2**]
Arindam Biswas, Venkatesh Raman, and Saket Saurabh.
Approximation in (poly-) logarithmic space.
Algorithmica, **83(7)**, 2303, 2021.

[**D1**]
Yogesh Dahiya, Fedor Fomin*, Fahad Panolan*, and Kirill Simonov*.
Fixed parameter and approximation algorithms for pca with outliers.
In *Proceedings of the 38th International Conference on Machine Learning, PMLR 139:2341-2351, 2021*, pages 2341–2351, Jul 2021.

[**D2**]
Yogesh Dahiya and Meena Mahajan.
On (simple) decision tree rank.
In *Proceedings of 41st FSTTCS Conference, LIPIcs vol 213*, pages 15:1–15:16. Schloss Dagstuhl LZI, Dec 2021.

[**G1**]
Ghurumuruhan Ganesan.
Redundancy of linear codes based on finite rings.
52nd Annual Iranian Mathematics Conference (AIMC), 2021, pages 53–55, 2021.

[**G2**]
Ghurumuruhan Ganesan.
Strong identification codes for graphs.
Discrete Math., **344(9)**, 112475, 2021.

[**G3**]
Ghurumuruhan Ganesan.
Minimum spanning trees of random geometric graphs with location dependent weights.
Bernoulli., **27(4)**, 2473–2493, 2021.

[**G4**]
Ghurumuruhan Ganesan.
Deviation estimates for eulerian edit numbers of random graphs.
Statistics & Probability Letters, **171**, 109025, 2021.

[**G5**]
Ghurumuruhan Ganesan.
Strong and weighted matchings in inhomogenous random graphs.
Electron. Commun. Probab., 26, 2021.

[**G6**]
Ghurumuruhan Ganesan.
Asymptotically optimal matrix codes with Hamming and rank distances.
Adv Appl Math., **131**, 102264, 2021.

[**G7**]
Ghurumuruhan Ganesan.
Law of large numbers for permanents of random constrained matrices.
Indian J Pure Appl Math., 2021, 2021.

[**G8**]
Ghurumuruhan Ganesan.
Linear recurrences over a finite field with exactly two periods.
Adv Appl Math., **127**, 102180, 2021.

[**G9**]
Ghurumuruhan Ganesan.
Minimum spanning trees across well-connected cities and with location-dependent weights.
Commun. Math. Stat., **10(1)**, 1–50, 2022.

[**Gu1**]
Sharmistha Chatterjee* and Sushmita Gupta.
An incremental real-time learning framework for sentiment classification: Indian general election 2019, a case study.
In *Proceedings of the IEEE 6th International Conference on Big Data Analytics (ICBDA), 2021*, pages p.198–203, Apr 2021.

[**Gu2**]
Sushmita Gupta, Sanjukta Roy, Saket Saurabh, and Meirav Zehavi*.
Balanced stable marriage: How close is close enough?
Theoretical Computer Science DOI: 10.1016/j.tcs.2021.05.015, **883**, 19–43, 2021.

[**J**]
Ashwin Jacob, Diptapriyo Majumdar*, and Venkatesh Raman.
Faster fpt algorithms for deletion to pairs of graph classes.
In Aris Pagourtzis Evripidis Bampis, editor, *Fundamentals of Computation Theory 2021*, pages 314–326. Springer, Sep 2021.

[**K1**]
Akanksha Agrawal*, Lawqueen Kanesh, Fahad Panolan*, M. Ramanujan*, and Saket Saurabh.
An fpt algorithm for elimination distance to bounded degree graphs.
In *38th International Symposium on Theoretical Aspects of Computer Science (STACS 2021): Leibniz International Proceedings in Informatics (LIPIcs)*, pages 5:1–5:11. Schloss Dagstuhl-Leibniz-Zentrum für Informatik, Oct 2021.

[**K2**]
Lawqueen Kanesh, Soumen Maity*, Komal Muluk, and Saket Saurabh.
Parameterized complexity of fair feedback vertex set problem.
Theoretical Computer Science, **867**, 1–12, 2021.

[**N**]
Mathew Francis*, Rian Neogi, and Venkatesh Raman.
Recognizing k-clique extendible orderings.
Algorithmica DOI: 10.1007/s00453-021-00857-0, **83**, 3338–3362, 2021.

[**R**]
Sankardeep Chakraborty*, Anish Mukherjee*, Venkatesh Raman, and Satti S. Rao*.
Frameworks for designing in-place graph algorithms.
Journal of Computer and System Sciences, **123**, 1, 2022.

[**S**]
Stephane Bessy*, Marin Bougeret*, R. Krithika*, Abhishek Sahu, Saket Saurabh, Jocelyn Thiebaut*, and Meirav Zehavi.
Packing arc-disjoint cycles in tournaments.
Algorithmica, **83(5)**, 1393 – 1420, 2021.

[**Sa**]
Peter Chini*, Roland Meyer*, and Prakash Saivasan.
Liveness in broadcast networks.
Computing, 2021.

[**Sau1**]
Fedor V. Fomin*, Petr A. Golovach*, Fahad Panolan*, Philip Geevarghese*, and Saket Saurabh.
Diverse collections in matroids and graphs.
In *38th International Symposium on Theoretical Aspects of Computer Science (STACS 2021:v.187) https://drops.dagstuhl.de/opus/volltexte/2021/13676*, pages 31:1–31:14. Schloss Dagstuhl-Leibniz-Zentrum für Informatik, Oct 2021.

[**Sau2**]
N. Kumar*, D. Lokshtanov*, Saket Saurabh, and S. Suri*.
A constant factor approximation for navigating through connected obstacles in the plane.
In *Proceedings of the 2021 ACM-SIAM Symposium on Discrete Algorithms (SODA)*, pages 822–839p. SIAM, Apr 2021.

[**Sau3**]
William Lochet *, Daniel Lokshtanov*, Saket Saurabh, and Meirav Zehavi *.
Exploiting dense structures in parameterized complexity.
In *Schloss Dagstuhl - Leibniz-Zentrum fr Informatik 2021*, page DOI:10.4230/LIPIcs.STACS.2021.50, Oct 2021.

[**Sau4**]
Pradeesha Ashok***, Sudeshna Kolay*****, Neeldhara Misra*****, and Saket Saurabh**.
Exact multi-covering problems with geometric sets.
Theory of Computing Systems, **66**, 89–113 (2022), 2022.

[**Sau5**]
* **Fedor V. Fomin,** * **Petr A. Golovach, William Lochet*****, Pranabendu Misra*****, Saket Saurabh, and Roohani Sharma***.
Parameterized complexity of directed spanner problems.
Algorithmica, **2021**, DOI: 10.1007/s00453–021–00911–x, 2021.

[**Sau6**]
F. Fomin***, F. Panolan*****, M. Ramanujan*****, and Saket Saurabh**.
On the optimality of pseudo-polynomial algorithms for integer programming.
Math Program., **103**, DOI: 10.1007/s10107–022–01783–x, 2022.

[**Sau7**]
D. Lokshtanov***, A. Bjrklund*****, Saket Saurabh, and M. Zehavi***.
Approximate counting of k -paths: Simpler, deterministic, and in polynomial space.
ACM Trans. Algorithms. 2021 Aug; 17(3) 1-44 DOI: 10.1145/3461477, **17(3)**, 1–44, 2021.

[**Sau8**]
D. Lokshtanov***, P. Misra*****, J. Mukherjee*****, F. Panolan*****, G. Philip*****, and Saket Saurabh**.
2-approximating feedback vertex set in tournaments.
ACM Trans. Algorithms. DOI: 10.1145/3446969, **17(2)**, 1–14, 2021.
(Submitted).

[**Sau9**]
Saket Saurabh and Prafullkumar Tale*.
On the parameterized complexity of maximum degree contraction problem.
Algorithmica, DOI: 10.1007/s00453-021-00897-6, **84**, 405–435, 2022.

[**Su1**]
Abhirukh Lahiri***, Joydeep Mukherjee*****, and C.R. Subramanian**.
On approximating mis over b_1-vpg graphs.
Discrete Mathematics, Algorithms and Applications (https://doi.org/10.1142/S1793830922500355), 2021.
(To be published).

[**Su2**]
A. Narasimhan***, S. Radhakrishnan*****, and C.R. Subramanian**.
Approximate sorting and sequence analysis.
2022.
(Submitted).

[**Su3**]
A. Narasimhan*, S. Radhakrishnan*, and C.R. Subramanian.
Approximate sorting, searching and experimental analysis.
2022.
(Submitted).

[**Su4**]
A. Narasimhan*, S. Radhakrishnan*, and C.R. Subramanian.
On searching an approximately sorted array.
2022.
(Submitted).

[**Su5**]
C.R. Subramanian.
Semi-random sources, counting witnesses for CSP instances.
2021.
(Submitted).

[**Su6**]
C.R. Subramanian.
Inductive graph invariants and approximation algorithms.
Discrete Mathematics, Algorithms and Applications (https://doi.org/10.1142/S1793830922500197), 2021.
(To be published).

[**Su7**]
Zuyuan Zhang*, Sridhar Radhakrishnan*, C.R. Subramanian, Kash Barker*, and Andres D. Gonzalez*.
Causal node failures and computation of giant and small components in networks.
IEEE Transactions on Network Science and Engineering, **8(4)**, 3048, 2021.

2.5 Student Programmes

2.5.1 Degrees Awarded

Doctoral Degrees Awarded during 2021 – 2022

Mathematics

Name: **Karthick Babu, C.G.**
Thesis Title: A study on some arithmetic properties of the Beatty sequences.
Thesis Advisor: Mukhopadhyay, Anirban
University: HBNI

Name: **Kushwaha, Mrigendra S.**
Thesis Title: A study of Kostant-Kumar modules via Littelmann paths
Thesis Advisor: Viswanath, Sankaran
University: HBNI

Name: **Narayanan, P A**
Thesis Title: Eigenvalue statistics of higher rank Anderson tight binding model over the canopy tree
Thesis Advisor: Kodiyalam, Vijay
University: HBNI

Name: **Das, Ujjal**
Thesis Title: On the Hardy type potentials
Thesis Advisor: Kodiyalam, Vijay
University: HBNI

Name: **Oorna Mitra**
Thesis Title: Quasi-isometries of Zn and twisted conjugacy in certain linear groups
Thesis Advisor: Amritanshu Prasad
University: HBNI

Name: **Rupam Karmakar**
Thesis Title: Positive cones of cycles and Seshadri constants on certain projective varieties
Thesis Advisor: Sanoli Gun
University: HBNI

Name: **Sruthi Murali**
Thesis Title: Planar algebras, quantum information theory and subfactors
Thesis Advisor: Vijay Kodiyalam
University: HBNI

Physics

Name: **Anupam, A.**
Thesis Title: Double soft theorems and asymptotic symmetries
Thesis Advisor: Ashok, Sujay K.
University: HBNI

Name: **Pathak, Dhruv**
Thesis Title: Probing structural and orbital properties of binary pulsars
Thesis Advisor: Bagchi, Manjari
University: HBNI

Name: **Mahato, Sujoy**
Thesis Title: Surface defects from fractional branes
Thesis Advisor: Ashok, Sujay K.
University: HBNI

Name: **Gupta, Varun**
Thesis Title: Surface operators, holography and BPS equations
Thesis Advisor: Ashok, Sujay K.
University: HBNI

Name: **Prashanth Raman**
Thesis Title: Positive Geometry Of Scalar Theories
Thesis Advisor: Nemani venakata suryanarayana
University: HBNI

Name: **Sourav Ballav**
Thesis Title: Surface Operators, Seiberg-Dual Quivers and Contours
Thesis Advisor: Sujay K Ashok
University: HBNI

Name: **Somdeb Ghose**
Thesis Title: Population Fluctuations, Nonequilibrium Flows and Instabilities in Some Model Systems
Thesis Advisor: Ronojoy Adhikari
University: HBNI

Name: **Anand Pathak**
Thesis Title: Uncovering Functional Correlates of Structural Organization in Brain Networks at Multiple Scales : From the worm to the human
Thesis Advisor: Sitabhra Sinha
University: HBNI

Name: **Garima Rani**
Thesis Title: Understanding the mechanical response of bacterial cell walls and cell membranes against antimicrobial agents
Thesis Advisor: Satyavani Vemparala
University: HBNI

Name: **Shibasis Roy**
Thesis Title: SU(3)-flavor analysis of hadronic bottom baryon decays
Thesis Advisor: Rahul Sinha
University: HBNI

Name: **Anupam, A.H.**
Thesis Title: Generalized BMS Symmetry and Double Soft THeorems
Thesis Advisor: Sujay K. Ashok
University: HBNI

Name: **Ajjath, A.H.**
Thesis Title: Radiative Corrections and Resummation Effects to Higgs Physics in QCD
Thesis Advisor: Ravindran, V.
University: HBNI

Name: **Kamal Tripathi**
Thesis Title: Confined polymers in Biophysical contexts
Thesis Advisori(s): Gautam I Menon & Satyavani Vemparala
University: HBNI

Name: **Abinesh Kumar Nayak**
Thesis Title: Right-Handed currents and Electroweak penguins in B decays
Thesis Advisor: Rahul Sinha
University: HBNI

Theoretical Computer Science

Name: **Biswas, Arindam**
Thesis Title: Algorithms for NP-hard Problems in the Sublinear Space Regime
Thesis Advisor: Raman, Venkatesh
University: HBNI

Name: **Banerjee, Niranka**
Thesis Title: Dynamizing Graph Classes and Output Sensitive Fault Tolerant Subgraphs
Thesis Advisor: Raman, Venkatesh
University: HBNI

Name: **Prafullkumar Prabhakar Tale**
Thesis Title: Some Results On Graph Contraction Problems
Thesis Advisor: Saket Saurabh
University: HBNI

Name: **Lawqueen Kanesh**
Thesis Title: Parameterized complexity of conflict free solutions
Thesis Advisor: Saket Saurabh
University: HBNI

Name: **Sanjukta Roy**
Thesis Title: Select, Allocate, and Manipulate via Multivariate Analysis
Thesis Advisor: Saket Saurabh
University: HBNI

Doctoral Theses Submitted during 2021 – 2022

Mathematics

Name: **Sridhar P Narayanan**
Thesis Title: Two restriction problems in the representation theory of symmetric groups
Thesis Advisor: Amritanshu Prasad
University: HBNI

Physics

Name: **Kuyyamudi, Chandrashekar**
Thesis Title: Contact-mediated signaling in developmental pattern formation
Thesis Advisor: Sinha, Sitabhra
University: HBNI

Name: **Ghosh, Ria**
Thesis Title: Emergent patterns of activity in disordered biological systems
Thesis Advisor: Sinha, Sitabhra
University: HBNI

Name: **Ria Sain**
Thesis Title: Model independent study of the rare decay of b-Baryon
Thesis Advisor: Rahul Sinha
University: HBNI

Name: **Pritam Sen**
Thesis Title: A study of infra-red behaviour of gauge theories involving dark matter
Thesis Advisor: Indumathi, D.
University: HBNI

Name: **Subhankar Khatuva**
Thesis Title: Low Energy Theories of Quantum Magnets: Emergent Descriptions and Order by Singularity
Thesis Advisor: Ganesh, R.
University: HBNI

Theoretical Computer Science

Name: **Chatterjee, Abhranil**

Thesis Title: New Algorithmic Results using Noncommutative Algebraic Complexity
Thesis Advisor: Arvind, V.
University: HBNI

Name: **Jayakrishnan**
Thesis Title: Cross and Part: Beyond the Known Boundaries
Thesis Advisor: Saket Saurabh
University: HBNI

Computational Biology

Name: **Ravichandran, Janani**
Thesis Title: Exposome and health: Characterization and network-based exploration of diverse environmental chemical spaces
Thesis Advisor: Samal, Areejit
University: Homi Bhabha National Institute

Masters Degrees Awarded during 2021 – 2022

Physics

Name: **Sasank, Budaraju**
Thesis Title: Discrimination of multi=photon entangled states using linear optics
Thesis Advisor: Ghosh, Sibasish
University: IISER-Mohali (jointly supervised with Dr. Sandeep Goyal at IISER-Mohali)

Name: **Kumar, Prem**
Thesis Title: Dynamics of open quantum Systems: Different approaches to non-Markovianity
Thesis Advisor: Ghosh, Sibasish
University: HBNI

Name: **Naik, Sharvari**
Thesis Title: Inflation: Baby steps of the Universe down the hill
Thesis Advisor: HAZRA, Dhiraj Kumar
University: Department of Physics, St. Xavier‘s College (Autonomous), Mumbai

Name: **Mahaveer Prasad**
Thesis Title: Bosonization Technique
Thesis Advisor: Rajesh, R.
University: HBNI

Computational Biology

Name: **Yadav, Yasharth**

Thesis Title: Geometry-inspired measures for Network Science
Thesis Advisor: Samal, Areejit
University: IISER Pune

Masters Thesis Submitted during 2021 – 2022

Theoretical Computer Science

Name: **Mal, Soumodev**
Thesis Title: On the Satisfiability of Straight-Line constraints over Sub-Word Ordering
Thesis Advisor: Saivasan, Prakash
University: Chennai Mathematical Institute

2.5.2 Lecture Courses During 2021 – 2022.

The following **lecture courses** were offered during 2021 – 2022.

Course Title	Period	Lecturer
Mathematics		
Algebra II	Jan-Apr 2021	Viswanath, Sankaran
Algebraic Number Theory	Jan-Apr 2021	Gun, S.
Complex Analysis	Jan-May 2021	Srinivas, K.
Algebra (core course for KSoM integrated PhD students; online)	May-Aug 2021	Raghavan, K. N.
Laplace transform	Jul-Aug 2021	Roy, Indrava
Measure theory	Jul-Sep 2021	Roy, Indrava
Measure Theory	Sep-Dec 2021	Mukhopadhyay, Anirban
Topology-I	Oct-Jan 2022	Roy, Indrava
Algebra II	Feb-Jun 2022	Kodiyalam, Vijay
Analytic theory of algebraic numbers	Feb-Jun 2022	Dixit, Anup B.
Topology-II	Feb-Jun 2022	Raghavan, K. N.
Physics		
Mathematical Methods II	Sep-Jan 2021	Sharma, Sayantan
Nonlinear Dynamics	Jan-Jul 2021	Sinha, Sitabhra
Quantum Field Theory II	Jan-May 2021	Ashok, Sujay K.
Advanced condensed matter physics	Feb-May 2021	Coimbatore Balram, Ajit
General Relativity and Cosmology	Feb-May 2022	HAZRA, Dhiraj Kumar
Statistical Field Theory	Feb-May 2021	Sharma, Sayantan
Classical Mechanics	Aug-Nov 2021	Ghosh, Sibasish

Mathematical Methods II	Aug-Dec 2021	Ashok, Sujay K.
Physical Biology	Sep-Mar 2022	Sinha, Sitabhra
Electrodynamics	Oct-Jan 2022	Sharma, Sayantan
Quantum Mechanics - I	Oct-Jan 2022	Bagchi, Manjari
Statistical Mechanics II	Oct-Jan 2022	Chaudhuri, Pinaki P.
Advanced condensed matter physics	Feb-Jun 2022	Coimbatore Balram, Ajit
Computational Physics	Feb-May 2022	HAZRA, Dhiraj Kumar
Computational Physics	Feb-Jun 2022	Sharma, Sayantan

Theoretical Computer Science

Algorithm Design and Analysis	Sep-Jan 2021	Raman, Venkatesh
Theory of Computation	Sep-Jan 2021	Saivasan, Prakash
Infinite State Verification	Jan-Jul 2021	Saivasan, Prakash
Boolean Function Complexity	Feb-Jul 2021	Mahajan, Meena B.
Computational Complexity	Feb-Jul 2021	Mahajan, Meena B.
Discrete Mathematics	Oct-Feb 2022	Arvind, V.
Theory of Computation	Oct-Feb 2022	Subramanian, C. R.

Computational Biology

Biology-1	Oct-Feb 2021	Samal, Areejit
Biology-1	Oct-Feb 2022	Samal, Areejit

2.6 Honours and Awards

S. Gun was awarded Elected standing committee member of the Asia-Pacific association for women in Mathematics, for 2021, by the Asia-Pacific association for women in Mathematics under the auspices of CWM, IMU.

Vijay Kodiyalam was awarded V. Ramaswamy Aiyer Memorial Award Lecture, for 2021, by the Indian Mathematical Society. Gave a talk on “Ramanujan graphs”

Meena B. Mahajan was elected FASc, Fellow of the Indian Academy of Sciences, effective from 2022, by the IAS.

Sitabhra Sinha was awarded P. C. Mahalanobis National Award for the year 2021, for 2021, by the Government of India’s Ministry of Statistics Programme Implementation.

Saket Saurabh was awarded Shanti Swarup Bhatnagar Prize for Science and Technology(SSB) in 2021, for his contributions in Mathematical Sciences, by the Council of Scientific and Industrial Research, Government of India.

Dishant M. Pancholi was elected as a Fellow of the Indian Academy of Sciences, for the year 2022.

Amritanshu Prasad was recognized in the Book ”75 under 50: Scientists Shaping Today’s India” published by VigyanPrasar, Department of Science and Technology, Government of India.

Figure 2.1: 75 under 50: Scientists shaping Today’s India, - VigyanPrasar

Chapter 3

Other Professional Activities

This chapter lists the activities carried out by the individual members of the institute in their professional capacity.

Arvind, V.

Associate Editor of Editorial Board, ACM Transactions on Computation Theory

Associate Editor of Editorial Board, Indian Journal of Pure and Applied Mathematics during Jul 2021 – Mar 2022.

Bagchi, Manjari

Life membership of International Astronomical Union (IAU) during Aug 2018 – Dec 2021.

Member of The Board of Studies, Thiruvalluvar University, Vellore, Tamil Nadu during Apr 2019 – Dec 2021.

Member of Co-chair, Education and Public Outreach Working Group of International Pulsar Timing Array (IPTA) during Jan 2021 – Feb 2022.

Convener of International Organising Committee for Annual Meeting of the International Pulsar Timing Array held at Online during Jun 21 – Jun 25, 2021.

Lecture at Online on Aug 5, 2021. Neutron stars: the undead stars that help study gravity and particle physics. Lecture to the students of Satyabhama University

Neutron stars: the undead stars that help us understand gravity at Online on Oct 9, 2021. An online talk in the celebration of World Space Week (2021) organized by the astronomy club Brahmand of Pandit Deendayal Energy University, Gandhinagar, India.

Ghosh, Sibasish

External Member of Doctoral Committee of two Ph.D. students in the Physics Department of IIITDM-Kancheepuram

Gun, S.

Indian Representative of Association for Asian Women in Mathematics (AAWM) during Jan – Dec, 2021.

Convener of International Organising Committee for The first Asian-Oceanian CWM ambassador meeting Hosted by IMSc in online mode during Jun 25 – Jun 26, 2021.

Kodiyalam, Vijay

Member of Board of Studies for Mathematics for CMI, Chennai

Mahajan, Meena B.

Member of Editorial Board of the journal Logical Methods in Computer Science

Member (and Paper Chair) of Board of Trustees, Computational Complexity Foundation Inc.

Member of Council of IARCS: Indian Association for Research in Computing Science

Member of Programme Committee, 24th International Conference on Theory and Applications of Satisfiability Testing SAT 2021

Member. of Advisory Board, TheoretiCS; and Executive Board, TheoretiCS Foundation.

Vigyan Prasar, DST is organising a Webinar Series Each-for-Equal to promote women in STEMM. In this series, gave a talk titled "The Fascinating World of Computational Complexity" on 31 Aug 2021.

Raghavan, K. N.

Member, Editorial Board of Indian Journal of Pure and Applied Mathematics

Member of Programme Committee for AFS of NCM

Member of Board of Studies (Mathematical Sciences) of HBNI

Member of Board of Studies in Mathematics, CUSAT

Member of School Board, School of Mathematics and Statistics, University of Hyderabad

Member of Science Education Panel, Indian Academy of Sciences

Secretary of Forum D'Analystes

Member of Steering Committee of the Talent Nurture Programme of Kerala School of Mathematics

Member, South Zone Convener of National Library Committee, NBHM

Member (Board), Chair (Exams) of National Board for Higher Mathematics

Associate Editor of Journal of the Ramanujan Mathematical Society during Sep 2021 – Mar 2022.

Member of Research Council of Kerala School of Mathematics during Nov 2021 – Mar 2022.

Member of Board of Studies of Kerala School of Mathematics during Mar – Mar, 2022.

Raman, Venkatesh

Member of Board of Studies in Computer Science at Stella Maris College, Chennai during Apr 2017 – Mar 2022.

Secretary of ACM-India Executive Council during Jun 2020 – Mar 2022.

Member of Program Committee of Workshop on Algorithms and Data Structures (WADS) during Jan – Jun, 2021.

Member of Board of Studies in Mathematics at PSG College of Technology, Coimbatore

Convener of National Organising Committee for Workshop for CACM India Region Special Issue held Virtual during Mar 23 – Mar 24, 2022.

Samal, Areejit

Associate Editor of Heliyon Quantitative Biology, Biotechnology and Bioengineering (Cell Press)

Associate Editor of Theory in Biosciences (Springer)

External Participant of Tamil Nadu Govt Finance Department: BI Tool Development under the IFHRMS and Preparation of Citizen's Budget during Oct – Oct, 2021.

External Participant of Tamil Nadu State Planning Commission: Meeting on Application of Modern Technology and Data Analytics in Tax Administration during Nov – Nov, 2021.

Associate Editor of Frontiers in Fungal Biology during Jan – Mar, 2022.

Sharma, Sayantan

Convener of Local Organising Committee for Topological aspects of strong correlations and gauge theories held online, organized by ICTS-TIFR, Bengaluru during Sep 6 – Sep 10, 2021.

Sinha, Sitabhra

Section Editor of Frontiers in Physics Editorial Board

Srinivas, K.

Convener of Local Organising Committee for Teachers' Enrichment Workshop on Complex Analysis and Number Theory held Online, Organized by NISER, Bhubaneswar during Dec 18 – Dec 31, 2021.

Subramanian, C. R.

Member of Programme Committee, 8th International Conference on Algorithms and Discrete Applied Mathematics (CALDAM-2022), Central University of Pondicherry, Pondicherry, February 10-12,2022. during Apr 2021 – Feb 2022.

Viswanath, Sankaran

Member of Local Organising Committee for Conference on applications of Macdonald polynomials held at IISc Bangalore (online) during Jul 19 – Jul 23, 2021.

External participant of Tamil Nadu Govt Finance Department: BI Tool Development under the IFHRMS and Preparation of Citizen's Budget during Oct – Oct, 2021.

Resource person for the Olympiad training Programme. at Online, hosted by PS Senior Secondary School, Chennai. on Oct 30, 2021. Gave a lecture to school students aspiring for the Indian National Mathematics Olympiad on some problem solving techniques

External participant of Tamil Nadu State Planning Commission: Meeting on Application of Modern Technology and Data Analytics in tax Administration during Nov – Nov, 2021.

Delivered a webinar at Online, hosted by DDGD Vaishnav college,Chennai on Dec 4, 2021. Gave a lecture on "Problem Solving Techniques for B.Sc mathematics students.

Chapter 4

Colloquia

4.1 Conferences/Workshops Held at IMSc

4.1.1 Special Lecture & Public Talks (Conducted at IMSc as Webinar), during 21st May, 2021

Special Lecture Public Talks (Conducted at IMSc as Webinar), on Friday, May 21 2021, 16:00 - 18:00 (IMSc Webinar-Public Talk), Talking about 'Cancer : Reducing Risk, Early Detection and Treatment'.

Speaker(s): Dr. R. A. Badwe, Dr. Pankaj Chaturvedi, Dr. S.D. Banavali, TMC, Mumbai
www.imsc.res.in/ semadm/webinars/HBNI-lecture-talking-about-cancer.pdf
(On Webex): hbni.webex.com/hbni/j.php?MTID=m67f63d0660a8cdf05bfba98ad138b99a
Youtube Live: youtu.be/eZHWoxIEvbI

4.1.2 Steps towards Life: Chemistry, on 3rd Jun, 2021

"Steps towards Life: Chemistry", was held on Thursday, June 3 2021, 14:00 - 16:30 (IMSc Webinar-Public Talk).
Speaker: Prof Jean-Marie Lehn, Nobel Laureate, University of Strasbourg, France. HBNI Foundation Day: J. B. Joshi Research Foundation Endowment Lecture

4.1.3 Recent Developments in the Mathematics of Neural Nets, on 21st Apr, 2021

Recent Developments in the Mathematics of Neural Nets, IMSc Webinar Special Lecture was held on Wednesday, April 21 2021, 17:30 - 18:30
Speaker: Anirbit Mukherjee University of Pennsylvania
zoom.us/j/91782375389?pwd=aUo4UWZKZjh1SlBYWkV2QlBnY3VyZz09

4.1.4 The hadronic vacuum polarization from lattice QCD: contributions to the muon anomalous magnetic moment and to the running of electroweak couplings, on 18th Jun, 2021

The hadronic vacuum polarization from lattice QCD: contributions to the muon anomalous magnetic moment and to the running of electroweak couplings was held on Friday, June 18 2021, 16:30 - 18:30 (IMSc Webinar-Physics Colloquium) Speaker: Marco Ce, CERN
The recent Fermilab experimental result, combined with the previous BNL one, confirms the ongoing four-sigma tension between the SM theory prediction of the anomalous magnetic moment (g-2) of the muon and the experimental value.

However, some lattice QCD calculations have produced results for the hadronic vacuum polarization (HVP) contribution to the muon g-2 that solve the discrepancy with the experiments without the need of BSM physics. If this is confirmed, a new tension would arise either with the hadronic cross-section at low energies or with global electroweak fits. Lattice QCD results for the HVP contribution to the running of the electroweak couplings can shed light on this possible tension.

4.1.5 Mini-symposium on "Looking back, looking forward", on the Science of COVID19 (28th June, 2021)

IMSc has conducted mini-symposium "Looking back, looking forward", on 28th June 2021, presenting short talks and discussion on the science of COVID19, zoonotic diseases and spillover, immune response, epidemiology, and variant tracking etc.,
Prof. Gautam I Menon, Ashoka University Sonipat[NCR]/IMSc Chennai, was the Moderator for this symposium.
Speakers: Uma Ramakrishnan (NCBS Bengaluru), Vineeta Bal (IISER Pune), Rajesh Sundaresan(IISc Bengaluru), Dhiraj Hazra(IMSc Chennai)Chitra Pattabiraman (NIMHANS Bengaluru) and Vinod Scaria(CSIR-IGIB Delhi).
DOI: https://twitter.com/IMScChennai/status/1407222655812395013

4.1.6 Workshop on Algorithms (March 2-5, 2022)

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

4.2 Other Conferences/Workshops Organized by IMSc

4.2.1 The first Asian-Oceanian CWM ambassador meeting during Jun 25 – Jun 26, 2021.

In agreement with CWM, IMU, Sanoli Gun (India), M. Kotani (Japan), K. K. Pak (South Korea), Polly Sy (Philippine) and Dongmei Xiao (China) organized the first CWM ambassadors meeting for Asia-Pacific region. The objective of this meeting was to form a mathematical association for Asia-Pacific region to facilitate exchange of mathematical ideas, foster collaboration and extend support to women in these mathematical communities.

4.2.2 Annual Meeting of the International Pulsar Timing Array during Jun 21 – Jun 25, 2021.

The International Pulsar Timing Array (IPTA) is a consortium of consortia, comprised of the European Pulsar Timing Array (EPTA), the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), the Indian Pulsar Timing Array Project (InPTA), and the Parkes Pulsar Timing Array (PPTA). The goal of the IPTA is to detect and characterize the low-frequency gravitational wave universe through timing a number of pulsars.
Before the pandemic, every year one of the constitutent PTA used to host annual meeting of IPTA. Since 2020, it is being held online.In this annual meeting series, members of each PTA give updates on their works. One IMSc member was part of the scientific organising commmittee of the 2021 (online) meeting.
Details can be found at http://ipta4gw.org/meetings/2021/

4.2.3 Conference on applications of Macdonald polynomials during Jul 19 – Jul 23, 2021.

This conference is devoted to recent advances in this theory, with a focus on its applications to algebraic combinatorics, special functions, probability, representation theory, geometry, and mathematical physics.
Scientific committee:- Arun Ram K. N. Raghavan.
Organizers :- R. Venkatesh S. Viswanath
Venue:- Zoom (online)

4.2.4 Topological aspects of strong correlations and gauge theories during Sep 6 – Sep 10, 2021.

This workshop aimed at bringing together researchers from lattice gauge theory and condensed matter theory to develop common techniques to address several interesting phenomena driven by topology both in gauge theories and other strongly correlated systems.

4.2.5 Modular forms, an online conference, during 17th Sep – 19th Sep, 2021

Modular forms: an online conference in honour of Prof. B. Ramakrishnan's 60th birthday (17th to 19th September 2021)
Prof. Ramakrishnan has made significant contributions in the theory of integral and half-integral weight modular forms, Jacobi forms and Siegel modular forms. The conference highlighted his work in these areas on the occasion of his 60th birthday.
More Details in: https://sites.google.com/view/modularformsconference/home
Support: The Institute of Mathematical Sciences (IMSc) and Chennai Mathematical Institute (CMI).

4.2.6 Teachers' Enrichment Workshop on Complex Analysis and Number Theory during Dec 18 – Dec 31, 2021.

This is a 3 weeks programme for college teachers. About 56 participants registered for the programme. The event is financially supported by NCM.

4.2.7 Workshop for CACM India Region Special Issue during Mar 23 – Mar 24, 2022.

Communications of the ACM, the flagship magazine of the ACM is coming out with a special issue to highlight activities from India region. This workshop was a meeting that had talks on possible abstracts that can be submitted to the special issue.

4.3 Outreach Activities

IMSc Ganakam program:
IMSc students have been running a weekend program for staff children to help them with school work etc. The general plan is to help children with whatever they want to learn.
Currently, IMSc volunteers help children with languages (English, Hindi), Maths/Science HW/doubts, basic programming (with use of computer lab) as well as some fun activity/experiment sessions. The program runs every Saturday (4:30-6:00pm) and Sunday (3:30-6:00pm) since March, 2022 and has been regularly attended by 20 students from 5th-12th std. Organizers: IMSc students

Azadi Ka Amrit Mahotsav

The Institute of Mathematical Sciences (IMSc), Chennai, is celebrating the 75th anniversary of India's independence with a year-long calendar of popular scientific talks, a line-up of distinguished lectures, public outreach programmes, exhibitions and educational initiatives. The following are some of these lectures organized during 2021-2022 :

IMSc Distinguished Lectures

Physical Sciences: Synergy with Mathematics

Speaker: Prof. R. Chidambaram, DAE Homi Bhabha Chair Professor, Former Principal Scientific Adviser to the Government of India, Former Chairman, Atomic Energy Commission Secretary, Department of Atomic Energy.
Date Time : 21 October 2021, 11:00 AM - 12:00 PM
Abstract: Physical Sciences and Mathematics are very closely linked, from high energy physics to condensed matter physics and chemistry. Mathematics is used widely in other areas like nuclear reactor design, artificial intelligence and cyber security. Computational Mathematics is also playing an increasingly important role.
Video Link : https://youtu.be/YMaGYw3yrgQ

Figure 4.1: Physical Sciences: Synergy with Mathematics

Equity and Inclusion in Science: Role that individuals, institutions and society can play

Speaker: Prof. Rohini Godbole, Centre for High Energy Physics, Indian Institute of Science, Bengaluru
Date & Time: 30 November 2021, 16:00 hrs - 17:00 hrs
Abstract: This talk discusses why it is essential to have equity and inclusion in the practice of science and how it benefits science as well. Specialise to some extent, to case of Gender inequity. Then review the Equity and Inclusion discussions in the Science, Technology and Innovation Policy released recently - STIP-2020 and the measures suggested therein. And ending by - commenting what all of us, individuals, institutions and society can do in this context.
Video Link : https://youtu.be/01mo2A8bEuU

Figure 4.2: Equity and Inclusion in Science

Online Bipartite Matching and Adwords

Speaker: Prof. Vijay Vazirani, Distinguished Professor, University of California, Irvine, USA
Date Time : 15 December 2021, 10:30 AM - 11:30 AM
Abstract: Over the last three decades, online bipartite matching (OBM) has emerged as a central problem in the area of Online Algorithms. Perhaps even more important is its role in Matching-Based Market Design. The resurgence of this area, with the revolutions of the Internet and mobile computing, has opened up novel, path-breaking applications, and OBM has emerged as its paradigmatic algorithmic problem. In this talk, we will discuss a simple optimal OBM algorithm and its generalization to the notoriously hard Adwords problem. We will also provide a broad overview of the area of Matching-Based Market Design and pinpoint the role of OBM.
Video Link : https://youtu.be/PZ8oRce-zEU

Figure 4.3: Online Bipartite Matching and Adwords

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. Discussing some examples, from the speaker's personal knowledge. This list is only partial. In the wide world many inspiring examples exist.
URL : https://www.youtube.com/watch?v=11-L09ykiV8

Figure 4.4: Out of the Box Science-Some recent Inspiring Examples

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. Speaks 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

Figure 4.5: Value of a Quiet Life: Muscle Stem Cells & their Balancing act in Tissue Repair

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

Precision challenges in particle physics
Speaker : Prof. 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

IMSc Heritage Lecture
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. It sketches a few of these in Astronomy, Mathematics and Archaeology. Presenting some unsolved questions in our understanding too. And ending with some discussions on what we gave the outside world and what we learnt.
URL : https://youtu.be/grIA5AoAzmE

Figure 4.6: History of Science in Ancient India

IMSc Popular Lectures

Lecture on the Nobel Prize in Physiology or Medicine 2021 : Sensing Heat and Pressure

Speaker: Prof. S. Krishnaswamy, Visiting Professor, Computational Biology Group, The Institute of Mathematical Sciences (IMSc), Chennai
Date: 18 October 2021, 16:00 hrs - 17:00 hrs
Abstract: The 2021 Nobel Prize in Physiology or Medicine was jointly awarded to David Julius and Ardem Patapoutian for their discoveries of receptors for temperature and touch. The talk goes into how the discoveries were made and their importance in understanding one of our essential senses.
Video Link : https://youtu.be/C9F5o7DSD8s

Figure 4.7: Sensing Heat and Pressure, Popular lecture on Nobel Prize in Physiology or Medicine 2021

Lecture on The Nobel Prize in Physics 2021 : Physics of complex systems: disordered materials and the earth's climate

Speaker: Prof. Pinaki Chaudhuri and Prof. R. Shankar The Institute of Mathematical Sciences (IMSc), Chennai, India
Date: 8 November 2021, 16:00 hrs - 17:00 hrs
Abstract: The 2021 Nobel Prize for Physics was awarded "for groundbreaking contributions to our understanding of complex systems". One half of the prize is awarded to Giorgio Parisi, for discovering hidden patterns in disordered complex materials. This first half of this talk will discuss these findings and how they have permeated to understand other physical problems and phenomena in other scientific domains. The other half of the prize is shared by Syukuro Manbe and Klaus Hasselmann for their contributions to the physics of climate science, a specific complex system, in another scientific domain, namely the Earth's climate. A specific complex system, in another scientific domain, namely the Earth's climate. The second part of the talk will outline the historical evolution of ideas and discoveries in climate physics and attempt to describe the significance of their contributions in this context.
Video Link : https://youtu.be/TS-llCjzJrc

Figure 4.8: Physics of Complex Systems: Popular Lecture on Nobel Prize in Physics, 2021

Playing games during a pandemic: Mathematical modeling for public health

Speaker: Prof. Sitabhra Sinha, The Institute of Mathematical Sciences (IMSc), Chennai, India
Date: 26 November 2021, 16:00 hrs - 17:00 hrs
Abstract: Using the language of game theory, we explore how individual responses to public health measures for containing pandemics constrain their effectiveness. Even when the benefits of such measures-which may involve vaccination or non-pharmaceutical interventions such as quarantining or mask-wearing - may appear obvious, individuals upon weighing the

risk of infection against the cost(s) of adopting such measures, may decide not to conform. Not surprisingly, the course of the epidemic will itself depend on the collective aggregate of such individual decisions, with less-than-complete adherence bringing about multiple resurgences of the epidemic.
This event was also to felicitate Prof. Sitabhra Sinha who was awarded the prestigious Prof. P.C. Mahalanobis National Award 2021.
Video Link : https://youtu.be/rzA1kYqbonw

Figure 4.9: Mathematical Modeling for Public Health-Popular Lecture

Coping with Intractability Using Parameters

Speaker: Prof. Saket Saurabh, The Institute of Mathematical Sciences (IMSc), Chennai, India
Date: 13 December 2021, 16:00 hrs - 17:00 hrs
Abstract: One of the greatest achievements in theoretical computer science is the development of NP-completeness theory. NP-completeness theory provides a solid and convincing foundation for the study of computationally intractable problems. However, the theory does not make obsolete the pressing need for solving these hard problems because of their practical importance. Many approaches have been proposed, including polynomial-time approximation algorithms, randomized algorithms, and heuristic algorithms. The focus of this talk will be another approach to cope with NP-completeness, namely, fixed-parameter tractability (FPT for short). The talk will be in the form of a story – accessible to most.
This event was also organized to felicitate Prof. Saket Saurabh who was awarded the prestigious Shanti Swarup Bhatnagar Prize (SSB) for Science and Technology 2021, in Mathematical Sciences.
Video Link : https://youtu.be/e6gJCvbQbkc

Figure 4.10: Coping with Intractability using parameters

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

Figure 4.11: How does the Sun shine?, How do we know this?

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

Figure 4.12: Contributions to Mathematics & Science Education

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

Figure 4.13: Complexity of Formal Proofs

Threads on Twitter:

Some of our events / research activities have received wide coverage among the public through our official twitter page. Few of them are listed below:

https://twitter.com/IMScChennai/status/1407222655812395013
Mini-symposium on "Looking back, looking forward", on the Science of COVID19 (28th June, 2021).
IMSc has conducted mini-symposium "Looking back, looking forward", on 28th June 2021, presenting short talks and discussion on the science of COVID19, zoonotic diseases and

spillover, immune response, epidemiology, and variant tracking etc., Prof. Gautam I Menon, Ashoka University Sonipat[NCR]/IMSc Chennai, was the Moderator for this symposium. Speakers: Uma Ramakrishnan (NCBS Bengaluru), Vineeta Bal (IISER Pune), Rajesh Sundaresan(IISc Bengaluru), Dhiraj Hazra(IMSc Chennai)Chitra Pattabiraman (NIMHANS Bengaluru) and Vinod Scaria(CSIR-IGIB Delhi).

https://twitter.com/IMScChennai/status/1408034688241836033
Intercellular signaling
One of the publications by our member has received a tweet.
DOI:https://doi.org/10.1103/PhysRevE.103.062409
Development in multicellular organisms is marked by a high degree of spatial organization of the cells attaining distinct fates in the embryo. Recent experiments showing that suppression of intercellular interactions can alter the spatial patterns arising during development suggest that cell fates cannot be determined by the exclusive regulation of differential gene expression by morphogen gradients (the conventional view encapsulated in the French flag model).
Using a mathematical model that describes the receptor-ligand interaction between cells in close physical proximity, we show that such intercellular signaling can regulate the process of selective gene expression within each cell, allowing information from the cellular neighborhood to influence the process by which the thresholds of morphogen concentration that dictate cell fates adaptively emerge. This results in local modulations of the positional cues provided by the global field set up by the morphogen, allowing interaction-mediated self-organized pattern formation to complement boundary-organized mechanisms in the context of development.

Figure 4.14: Intercellular Interactions - Spatial patterns

https://twitter.com/IMScChennai/status/1437292070134108161
Recent observations by a team of astronomers from IMSc including Pratik Tarafdar, Manjari Bagchi, Dhruv Pathak and Arpita Choudhary received media coverage.
The original article can be found at
https://academic.oup.com/mnrasl/article/507/1/L57/6356572

Figure 4.15: Pulse Phase

https://twitter.com/IMScChennai/status/1435821828740567047
Prof. Sitabhra Sinha (IMSc) spoke on ”The Maths of Epidemics” : from the surprising beginning of epidemiological modeling by a British doctor in Indian colonial medical service to the present” in a webinar organised by the Science City, National Council of Science Museums, Ministry of Culture, Government of India.

https://twitter.com/ManavAtlas/status/1452903823400333312

Prof. Areejit Samal, Faculty, Computational Biology Group, gave a talk on "A phytochemical atlas of Indian medicinal plants for harnessing traditional knowledge", organised by *MANAV- The Human Atlas Initiative* on 11 November 2021.

https://twitter.com/IMScChennai/status/1468174412230782976
IMSc announced a lecture series by Prof. Michel Waldschmidt, Sorbonne University on "Multivariate Lidstone Interpolation" for graduate students and researchers.

Member publications on IMSc twitter handle

https://twitter.com/IMScChennai/status/1462108972006055937
Disorder in cellular packing can alter proliferation dynamics to regulate growth
The mechanisms by which an organ regulates its growth are not yet fully understood, especially when the cells are closely packed as in epithelial tissues. We explain growth arrest as a collective dynamical transition in coupled oscillators on disordered lattices. As the cellular morphologies become homogeneous over the course of development, the signals induced by cell-cell contact increase beyond a critical value that triggers coordinated cessation of the cell-cycle oscillators driving cell division. Thus, control of cell proliferation is causally related to the geometry of cellular packing.

https://twitter.com/IMScChennai/status/1463511989930496001
Phototaxis in Cyanobacteria: From Mutants to Models of Collective Behavior
Cyanobacteria rely on photosynthesis, and thus have evolved complex responses to light. These include phototaxis, the ability of cells to sense light direction and move towards or away from it. Analysis of mutants has demonstrated that phototaxis requires the coordination of multiple photoreceptors and signal transduction networks. The output of these networks is relayed to type IV pili (T4P) that attach to and exert forces on surfaces or other neighboring cells to drive "twitching" or "gliding" motility. This, along with the extrusion of polysaccharides or "slime" by cells, facilitates the emergence of group behavior. We evaluate recent models that describe the emergence of collective colony-scale behavior from the responses of individual, interacting cells. We highlight the advantages of "active matter" approaches in the study of bacterial communities, discussing key differences between emergent behavior in cyanobacterial phototaxis and similar behavior in chemotaxis or quorum sensing.

https://twitter.com/IMScChennai/status/1464255033348820993
Morphogen-regulated contact-mediated signaling between cells can drive the transitions underlying body segmentation in vertebrates
We propose a unified mechanism that reproduces the sequence of dynamical transitions observed during somitogenesis, the process of body segmentation during embryonic development, that is invariant across all vertebrate species. This is achieved by combining intercellular interactions mediated via receptor-ligand coupling with global spatial heterogeneity introduced through a morphogen gradient known to occur along the anteroposterior axis. Our model reproduces synchronized oscillations in the gene expression in cells at the anterior of the presomitic mesoderm as it grows by adding new cells at its posterior, followed by travelling waves and subsequent arrest of activity, with the eventual appearance of somite-like patterns. This framework integrates a boundary-organized pattern formation mechanism, which uses positional information provided by a morphogen gradient, with the coupling-

mediated self-organized emergence of collective dynamics, to explain the processes that lead to segmentation.

4.4 Seminars

Date	Speaker Affiliation	Title
7-4-2021	Gyan Prakash HRI	Sum-free sets, counting sets with small sumset and hypergraph container lemma
15-4-2021	C Ramya TIFR	Algebraic Complexity Theory: A gripping tale of two polynomials.
16-4-2021	Krishnan Rajkumar JNU	Irrationality of zeta(2) by determinantal methods
21-4-2021	Sandeep E. M. KSOM	A weighted sum of L-functions of modular forms
21-4-2021	Anirbit Mukherjee University of Pennsylvania	Recent Developments in the Mathematics of Neural Nets
26-4-2021	Santanu Das Raman Research Institute, India	Non-equilibrium behavior in Self-driven Systems
28-4-2021	Abhishek T Bharadwaj IMSc	On vanishing of periodic Dirichlet series at positive integers.
28-4-2021	Mahesh Gandikota Syracuse University, USA	Convexity-induced rigidity transitions and compression stiffening of cells
29-4-2021	Sameera Salam IMSc	Determining perfectness of maximal planar graph in quadratic time.
29-4-2021	Debabrata Sinha Indian Institute of Technology, Kharagpur	Chiral planar Hall effect in Weyl semimetals
30-4-2021	Hassain Maliyekkal IMSc	Representations of Compact Special Linear Groups of Degree Two
4-5-2021	Swagato Sanyal IIT Kharagpur	XOR functions, log-rank conjecture and parity decision trees.

5-5-2021	Ria Sain IMSc	Model independent study of the rare decay of b-Baryon
6-5-2021	Ghurumuruhan Ganesan IMSc	Computing Prices for Target Profits in Contracts
12-5-2021	Satnam Singh IISER-Mohali	Optimization of the quantum engines
21-5-2021	R. A. Badwe, Pankaj Chaturvedi, S.D. Banavali, TMC, Mumbai	Talking about Cancer : Reducing Risk, Early Detection and Treatment
27-5-2021	B Srivathsan CMI	A Bridge between polynomial optimization and games with imperfect recall
3-6-2021	Jean-Marie Lehn Nobel Laureate, University of Strasbourg, France	Steps towards Life: Chemistry
10-6-2021	Abhranil Chatterjee IMSc	New Algorithmic Results using Noncommutative Algebraic Complexity
24-6-2021	R Ramanujam IMSc	A formal model for the emergence of collective memory
28-6-2021	Amlan Chakraborty Michigen University	Infrared structure of gauge theory : A comparison between N=4 SYM and QCD
29-6-2021	Sanjay Moudgalya, California Institute of Technology (CalTech)	New Forms of Ergodicity Breaking in Quantum Many-Body Systems
1-7-2021	Anurag Pandey Saarland University, Germany	Heroes Zeros in computational complexity
6-7-2021	Nutan Limaye IIT Bombay	Superpolynomial lower bounds against low-depth algebraic circuits
7-7-2021	Online training by NIC experts on eProcurement	Online training by NIC experts on eProcurement

8-7-2021	Kamal NCBS, Bangalore	Confined Polymers in Biophysical Contexts
13-7-2021	Sruthy Murali CMI, Chennai	Planar algebras, quantum information theory and subfactors
22-7-2021	Mrigendra Singh Kushwaha IMSc Chennai	A study of Kostant-Kumar modules via Littelmann paths
23-7-2021	Subhadeep Roy	Disordered systems under external drive: Application to fracture and flow
27-7-2021	K A Chandrashekar IMSc, Chennai	Contact-mediated signaling in developmental pattern formation
29-7-2021	Ramit Das IMSc	A logical description of strategizing in social network games
29-7-2021	Prashanth Raman IISc, Bangalore	QFT, EFT and GFT
4-8-2021	Ujjal Das IMSc	On the Hardy type potentials
5-8-2021	Bivash Kaity Department of Physics, IIT Bombay, Powai, Mumbai 400 076	Theoretical modeling of epigenetic landscapes and embryonic development
9-8-2021	Shibasis Roy IMSc	$SU(3)$ flavour analysis of b-baryon decays
17-8-2021	Soumyadip Banerjee Department of Electrical Engineering, IIT Delhi	Analysis of Oscillatory Behaviour in Coupled Dynamical Systems
19-8-2021	Ajjath A H IMSc, Chennai	Radiative Corrections and Resummation Effects to Higgs Physics in QCD
20-8-2021	Soling Zimik IMSc Chennai	Mechanism of somite formation in zebrafish model

25-8-2021	B Sriram Shastry University of California, Santa Cruz	Towards unraveling the puzzling cuprates
27-8-2021	Varun Gupta IMSc, Chennai	Surface Operators, Holography and BPS equations
6-9-2021	V Ramgopal Rao IIT Delhi	Teacher's Day 2021 – HBNI
9-9-2021	A H Anupam IMSc	Generalized BMS Symmetry and Double Soft Theorems
13-9-2021	Pooja Mukherjee IMSc, Chennai	QCD Corrections and Resummation Beyond Threshold in Hadronic Collisions
15-9-2021	Asweel Ahmed A Jaleel The Institute of Mathematical Sciences	Rejection free cluster Wang Landau algorithm for hard core lattice gases
16-9-2021	Arindam Biswas IMSc	Sub-linear Space Algorithms for NP-hard Problems (Synopsis Seminar)
24-9-2021	Jayakrishnan M IMSc	Cross and Part: Beyond the known Boundaries
29-9-2021	Rahul Sinha IMSc	Measuring CP violating phase in beauty baryon decays
4-10-2021	Sayan Choudhury, University of Pittsburgh	Evading Thermalization in Periodically Driven Quantum Matter
6-10-2021	Disha Bhatia IMSc	Frugal $U(1)_X$ models for flavor anomalies and neutrino mixings
8-10-2021	Prasenjit Das Georg-August-Universität Göttingen	Plastic Instabilities and Density of Low-frequency States in Amorphous Solids
18-10-2021	Ria Sain IMSc	Model independent study of the rare decay of b-Baryon
18-10-2021	S Krishnaswamy IMSc	Sensing Heat and Pressure

21-10-2021	Sutanu Gayen NUS Singapore	PAC learning high dimensional distributions
21-10-2021	Anup Dixit IMSc	On limit theorems of zeta and L-functions
21-10-2021	R. Chidambaram DAE Homi Bhabha Chair Professor	Physical Sciences: Synergy with Mathematics
28-10-2021	Veekesh Kumar IMSc	On arithmetic nature of values of theta-constants
28-10-2021	Sridhar P Narayanan IIT Bombay	Two restriction problems in the representation theory of symmetric groups
28-10-2021	Niranka Banerjee Research Institute of Mathematical Sciences, Kyoto University	Dynamizing Graph Classes and Output Sensitive Fault Tolerant Subgraph Problems
28-10-2021	Digjoy Paul TIFR Mumbai	Symmetric q, t Catalan polynomials
1-11-2021	I. Iyyappan IMSc	Efficiency of a heat engine with finite-sized heat bath
8-11-2021	Pinaki Chaudhuri, R. Shankar IMSc, Chennai	Physics of complex systems: disordered materials and the earth's climate
10-11-2021	Dibyajyoti Mohanta IIT, BHU	Behavior of Bio-polymers under confinement
10-11-2021	I. Iyyappan IMSc	Efficiency of a heat engine with finite-sized heat bath
11-11-2021	Yogesh Dahiya IMSc	On (Simple) Decision Tree Rank
12-11-2021	Tamal Guha Indian Statistical Institute, Kolkata	Quantum events: An indefinite causal structure

12-11-2021	Vijay Kodiyalam IMSc	Planar algebras
15-11-2021	Pritam Sen IMSc	A study of infra-red behaviour of gauge theories involving dark matter Public Viva Voce
16-11-2021	Shivani Singh The Institute of Mathematical Sciences	Quantum simulation and computation using discrete-time quantum walk
16-11-2021	Vijay Kodiyalam IMSc	Ramanujan graphs
17-11-2021	B. Ananthanarayan CHEP, Indian Institute of Science	$(g-2)$ of the Muon: Theory and Experiment Challenge One Another
18-11-2021	Sujoy Mahato IMSc, Chennai	Surface Defects from Fractional Branes
18-11-2021	Souvik Saha IMSc	FPT-Approximation for Partial Hitting Set Problems
19-11-2021	Chandrodoy Chattopadhyay Ohio State University	Higher-order relativistic dissipative hydrodynamics from kinetic theory
25-11-2021	Tanmoy Bera IMSc	Good sequences of integers
25-11-2021	Nishu Kumari Indian Institute of Science	Factorization of Classical Characters twisted by Roots of Unity
26-11-2021	Somenath Pal University of Calcutta	Effect of repulsive interactions in a system of hadrons
2-12-2021	Rathish Das Univ. Waterloo, Canada	Algorithmic foundation of parallel paging
2-12-2021	Snehal M Shekatkar	Resource dependency and survivability in complex networks
6-12-2021	Karthick Babu IISER Berhampur	On the explicit Galois group of multi quadratic extension over Q.

8-12-2021	Claudio Bonati INFN Pisa	Critical phenomena in systems with gauge symmetries
8-12-2021	Vijay Kodiyalam IMSc	Ramanujan Graphs
9-12-2021	Neelam Kandhil IMSc	Gelfond-Schneider theorem
10-12-2021	Shivam Gola IMSc	Dark Matter from *Physical Review Letters 127,191802 (2021)* Exponential growth,
11-12-2021	Michel Waldschmidt Sorbonne University	Lidstone interpolation
13-12-2021	Michel Waldschmidt Sorbonne University	Lidstone interpolation
13-12-2021	Saket Saurabh IMSc, Chennai	Coping with Intractability Using Parameters
13-12-2021	Darshan G. Joshi Department of Physics, Harvard University	Strongly correlated phases in models with random interactions
14-12-2021	M. Waldschmidt Sorbonne University	Lidstone interpolation
15-12-2021	Vijay Vazirani University of California, Irvine, USA	Bipartite Matching and Adwords (Online)
15-12-2021	Pracheta Singha Bose Institute	Effective model study of QCD thermodynamics and transport coefficients.
16-12-2021	Mithun Kumar Das IMSc	Angular equidistribution of zeros of polynomials
16-12-2021	Debayan Chakraborty Department of Chemistry, The University of Texas at Austin	Learning about folding and aggregation from energy landscapes

27-12-2021	Sunil L Naik IMSc	Siegel-Tatuzawa Theorem
10-1-2022	Adithya Rajagopalan HHMI Janelia Research Campus Johns Hopkins School of Medicine	Learning rules underlying operant matching in D. melanogaster
12-1-2022	Atul Rathor SN Bose Center, Kolkata	A New Disorder Operator For SU(N) Lattice Gauge Theory
13-1-2022	Ashreya Jayaram Uni-Mainz	Forces on objects immersed in active fluids
13-1-2022	Ashwin Jacob IMSc	New Directions in Parameterized Deletion Problems (Synopsis Talk)
13-1-2022	Alexander Yong University of Illinois at Urbana-Champaign	Newell-Littlewood Numbers
25-1-2022	Naren Manjunath	The shift invariant and a new Hofstadter butterfly
25-1-2022	Sitender Pratap Kashyap IMSc, Chennai	Modular flow, bulk reconstruction and black hole interior
27-1-2022	Abhishek Sahu IMSc	Packing and Covering: New Paradigms and Algorithms
27-1-2022	Sunil Chebolu Illinois State University	How many units can a commutative ring have?
31-1-2022	G. Baskaran IMSc, Chennai IIT Madras	Out of the Box Science - Some recent Inspiring Examples
4-2-2022	Aditi Kanhere University of Liverpool	Non-coding RNAs and regulation of epigenome
4-2-2022	Matteo Giordano Eötvös Loránd University, Institute for Theoretical Physics	Localisation of Dirac eigenmodes in finite-temperature lattice gauge theory

9-2-2022	Deep Chatterjee University of Illinois Urbana-Champaign	Measuring the Hubble constant using neutron star universal relations
16-2-2022	Students Oral Presentation IMSc	Particle Physics Course, Vivek Datar
16-2-2022	D. Indumathi IMSc, Chennai	How does the Sun shine? How do we know this?
18-2-2022	Ratan Sarkar IISc/ Visitor to IMSc	Asymptotic analysis of multi-scale, multi-loop Feynman integrals
25-2-2022	T.R. Govindarajan IMSc, Chennai	Snippets from History of Science in Ancient India
25-2-2022	Semanti Dutta IMSc	Exact Renormalization Group and the $O(N)$ Model
28-2-2022	R Ramanujam IMSc (Ret'd) / APU	What can / should scientists do for mathematics and science education?
2-3-2022	Pintu Patra Institute for Theoretical Physics, Heidelberg University	Malaria parasites as a novel model system for chiral active matter
3-3-2022	Ashish Mishra Universidade Federal do Pará, Belém	The Jucys–Murphy elements
7-3-2022	Dhruv Pathak IMSc (and IUCAA)	Probing the structural and orbital properties of binary pulsars
10-3-2022	Tarun Dalal IIT Hyderabad	The structure of Drinfeld modular forms of level $\Gamma_0(T)$ and applications
11-3-2022	K A Chandrashekar IMSc Chennai	Contact-mediated signaling in developmental pattern formation
11-3-2022	Arvind Ayyer Indian Institute of Science	A multispecies totally asymmetric zero range process and Macdonald polynomials

11-3-2022	Pranjal Raleganka r University of Illinois, Urbana-Champaign	Reheating in two-sector cosmology
14-3-2022	Meena Mahajan IMSc, Chennai	The complexity of formal proofs
16-3-2022	Olivier Pironneau Universite Pierre et Marie Curie, Laboratoire Jacques-Louis Lions	What is Control Theory in 2021? Can AI do Better?
17-3-2022	Arnab Pal	Stochastic processes
24-3-2022	Keshab Chandra Bakshi CMI	Angle between intermediate subfactors.
24-3-2022	Arkajyoti Manna IMSc	Scattering amplitudes from Generalized Recursion
25-3-2022	HEP journal club	HEP journal club
25-3-2022	Sven-Olaf Moch Institut für Theoretische Physik, Universität Hamburg	Precision challenges in particle physics
29-3-2022	Arindam Biswas TU IImenuau, Germany	Algorithms for NP-hard Problems in the Sublinear Space Regime
31-3-2022	Satyanarayan Rao University of Colorado, Denver / Anschutz Medical Campus	Competing for DNA
31-3-2022	Naveen Prabhakar ICTS-TIFR	A Hilbert space for large N Chern-Simons matter theories

Chapter 5

External Interactions

5.1 Collaborative Projects with Other Institutions

{item **Arecibo 327 MHz Drift Pulsar Survey (AO327)** ** ongoing project ** AO327 has been running using the Arecibo radio telescope (USA) since 2010. To date, the survey has discovered 87 pulsars and transients (http://www.naic.edu/ deneva/drift-search). Papers have been published reporting results of this survey. This collaboration has members rom different institutes across the world, e.g., Naval Research Laboratory USA, University of New Mexico USA, West Virginia University USA, IMSc India (Manjari Bagchi), Max-Planck-Institut fur Radioastronomie Bonn Germany, etc.

- **Geometric methods for deep learning and topological characterization of complex networks** The project envisages a collaborative research effort of members from the Mathematics and Computational Biology groups at IMSc. In particular, it entails the application of deep and abstract mathematical ideas from algebraic topology and geometry to concrete, real-world problems arising in complex networks. We shall investigate the topological properties of particular kinds of networks (e.g. brain networks from fMRI data) via newly developed methods in persistent homology and graph Laplacians, as well as apply geometric methods to deep neural networks arising in machine learning via Formans discretized version of Ricci curvature. Both methods are expected to yield new insights in the analysis of high-dimensional data and complex networks.

- **Hardness in QBF Proof Complexity** This is an Indo-German joint collaborative project funded by the DST in India and the DAAD in Germany. The PIs are Meena Mahajan (IMSc) and Olaf Beyersdorff (Friedrich-Schiller University, Jena). The project aims to understand QBF proof systems better through developing new lower bound techniques, characterising hardness in known systems, and advancing the scope of known techniques. The project runs for 2 years.

- **Indian Pulsar Timing Array (InPTA) experiment** ** ongoing project **

  Pulsar Timing Array (PTA) uses an ensemble of pulsar clocks in an attempt to detect Gravitational Waves (GW) from a stochastic background resulting from a superposition of an ensemble of super-massive black hole binary systems (BSMBH). The Indian PTA

(InPTA) experiment is going on since 2015 using the upgraded Giant Metrewave Radio Telescope (uGMRT). Observations and data analysis is going on. The preliminary results were presented in various national and international meetings and some papers have been published. This collaboration has become a full member of the International Pulsar Timing Array consortium in February 2021.

Members of this collaboration are affiliated to various institute across the country and abroad, e.g., NCRA-TIFR Pune, TIFR Mumbai, IIT-Hyderabad, West Virginia University (USA), ASTRON (The Netherlands), IMSC Chennai (Manjari Bagchi, Dhruv Pathak), etc. IMSc faculty M. Bagchi is a member (out of three) of InPTA steering committee. M. Bagchi is also the co-chair of the Education and Public outreach working group of the International Pulsar Timing Array.

- **Modelling of amorphous solids for large scale simulations** DST/NSM/RD HPC Applications/2021/29, in collaboration with Smarajit Karmakar, Physics (Tata Institute of Fundamental Research, Hyderabad), Shi- laditya Sengupta (Indian Institute of Technology, Roorkee), Vishwas V, (Indian Institute of Technology, Palakkad). The project proposes to develop a computational modeling methodology and tools that will enable faithful modeling of a diverse range of amorphous solids and allow such solids to be simulated for a variety of mechanical deformation protocols, on large length scales that are not possible with atomistic simulation methods.

- **Self-testing of bi-partite quantum states using non-locality without inequality type arguments** We have used Hardy-type as well as Cabello-type nonlocality arguments to provide alternative proofs of self-testing of non-maximally entangled bipartite pure states. Our method uses the structure of the probabilities (rather than statistical inequalities – unlike in the case of Bell-type inequalities) satisfying the aforesaid non-locality arguments. Outcome of this project are the two papers [**Gho3**], [**Gho4**].

5.2 Conference Participation and Visits to Other Institutions

Ashok, Sujay K.

Participated in *Indian Strings Meeting* held at IIT Roorkee (online) during Dec 12 – Dec 17, 2021. Invited Speaker

Chaudhuri, Pinaki P.

Participated in *Supercomputing Frontiers Europe 2021 (Edition 7)* held at online [organised by nterdisciplinary Centre for Mathematical and Computational Modelling (ICM), University of Warsaw] during Jul 19 – Jul 23, 2021. Talk on ”Studying amorphous materials via large-scale computing”

Coimbatore Balram, Ajit

Participated in *Virtual Workshop Quantum Hall Effect: Status Report* held at Online. Hosted by the Simons Center for Geometry and Physics. during May 3 – May 7, 2021. Participant in the workshop. http://scgp.stonybrook.edu/archives/29732

Participated in *The 8th International Workshop on Emergent Phenomena in Quantum Hall Systems (EPQHS-8)* held at Online. Hosted by Princeton University. during May 17 – May 21, 2021. Participant in the workshop. https://epqhs-8.princeton.edu/

Participated in *Young Investigator's Meet on Quantum Condensed Matter Theory - 2021* held at online (organized by NISER, Bhubaneswar) during Nov 16 – Nov 19, 2021. Gave an invited talk

Participated in *APS March meeting 2022* held at hybrid meeting online and onsite in Chicago during Mar 14 – Mar 18, 2022. Gave an invited and a focus talk

Dixit, Anup B.

Participated in *Symposium on Number theory, In honour of Prof. M. V. Subbarao* held at IISER Pune (held online) during Jul 12 – Jul 16, 2021. Invited speaker to this conference

Participated in *Olympiad training for school students* held at PS Senior Secondary School during Nov 6 – Nov 20, 2021. Gave a series of 3 lectures on various topics related to RMO/INMO preparation targeted at high school students.

Participated in *Refresher's course for University lecturers* held at Pune University (held online) during Nov 16 – Nov 29, 2021. Invited to give a series of lectures on Complex analysis.

Ghosh, Sibasish

Participated in *National Quantum Science and Technology Symposium* held at IIIT-Hyderabad (online) during Jul 26 – Aug 3, 2021. Gave an invited talk

Participated in *Quantum Information and Computation: From Foundations to Applications - 2021* held at IIT-Jodhpur (Online mode) during Oct 18 – Oct 23, 2021. Gave an invited talk

Participated in *Winter School on Quantum Computing* held at IIT-Madras (online) during Jan 3 – Jan 15, 2022. Gave a series of invited talks

Participated in *International Conference on Quantum Information and Foundations* held at ISI-Kolkata (online) during Feb 14 – Feb 24, 2022. Gave an invited talk

Gun, S.

Participated in *Pan Asian Number Theory Conference 2021-Kyoto* held at RIMS, Kyoto (Online) during Dec 6 – Dec 10, 2021. Invited Speaker

Participated in *BRICS Mathematics Conference* held at IISER Thiruvananthapuram (Online) during Dec 7 – Dec 10, 2021. Invited Talk

Hazra, Dhiraj Kumar

Participated in *School-cum-Workshop on Data Analysis in Cosmology and Astroparticle Physics* held at Technology Innovation Hub, ISI Kolkata, West Bengal during Aug 23 – Sep 4, 2021. 6 lectures delivered (including hands-on sessions)
Link: https://www.isical.ac.in/sites/default/files/TIH.pdf

Presented a talk on “Primordial features: how relevant are they?”, at IITM, Chennai during Aug 28, 2021.

Gave a talk on “Primordial features: how relevant are they?” at IIT Hyderabad, during Dec 8, 2021.

Visited Ramakrishna Mission Vivekananda Educational and Research Institute, Belur Math, Howrah and gave a talk on “Primordial features: how relevant are they?”, on Dec 15, 2021.

LineSpacing Participated in *40th meeting of the Astronomical Society of India* held at IIT Roorkee/Online during Mar 25 – Mar 29, 2022. Presented an invited talk, ’One spectrum to cure them all’

Kodiyalam, Vijay

Participated in *CMI-NASI 1st Winter Training program in Mathematics* held at RIASM, Chennai during Dec 13 – Dec 22, 2021. Gave 4 lectures in Algebra

Visited RIASM, Chennai on Dec 22, 2021. Gave a lecture on the occasion of National Mathematics Day

Participated in *CMI-NASI online workshop on "Linear algebra and elementary number theory"* held at Mepco Schlenk Engineering College, Sivakasi during Jan 27 – Feb 26, 2022. Gave 6 lectures on basics of ring theory

Mahajan, Meena B.

Participated in *Satisfiability: Theory, Practice and Beyond* held online during Jan 12 – May 14, 2021. Semester-long program of the Simons Institute for the Theory of Computing, Berkeley, USA. Conducted fully online, with multiple workshops and seminars. Gave a talk titled "Refuting false QBFs with Merge Resolution" on 19 Apr 2021.

Participated in *Online Worldwide Seminar on Logic and Semantics OWLS.* https://www.cl.cam.ac.uk/events/owls/ on Jun 2, 2021. Gave a talk titled "Refuting false QBFs with Merge Resolution".

Participated in *24th International Conference on Theory and Applications of Satisfiability Testing (SAT)* held in Hybrid format; Barcelona (Spain), during Jul 5 – Jul 9, 2021.

Participated in *Computational Complexity Conference* held Online during Jul 20 – Jul 22, 2021.

Visited Oriental Institute of Science & Technology, Bhopal, India and Pune Institute of Computer Technology PICT, Pune, India on Sep 4, 2021. Gave a talk titled "Compute, compute, compute: How hard can it get?" to the ACM student chapter, as part of the ACM India Eminent Speakers Program.

Visited University School of Information, Communication and Technology USICT, GGS Indraprastha University, Delhi. on Sep 15, 2021. Gave a talk titled "Compute, compute, compute: How hard can it get?" to the ACM student chapter, as part of the ACM India Eminent Speakers Program.

Participated in *4th BRICS Mathematics Conference* held in hybrid mode – IISER Thiruvanthapuram during Dec 7 – Dec 10, 2021. Gave a plenary talk titled "The complexity of formal proofs".

Participated in *41st FSTTCS Conference* held Online during Dec 15 – Dec 17, 2021. Gave a short presentation on the paper "On (Simple) Decision Tree Rank"

Participated in *School and Conference on Geometric Complexity Theory* held online (organised by CMI and UMI-ReLaX) during Jan 21 – Jan 28, 2022.

Participated in *ACM India Event* held as Virtual Event during Feb 9 – Feb 12, 2022. In the ACM-Women India workshop on 9th Feb, participated as panelist in a panel discussion on “Influence of Social Media on Professional Visibility”.

Mukherjee, Nayana

Delivered a talk on *Reaction-diffusion systems: an overview* in *BIOM: Recent advances in Mathematical Biology(A one day National Level Webinar)*, at Karanjia Autonomous College, Odisha, India.

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.

Mukhopadhyay, Anirban

Participated in *Online workshop on Linear Algebra and Elementary Number Theory* held at Hosted by Mepco Schlenk Engineering College, Sivakasi during Jan 27 – Feb 27, 2022. Gave a series of 6 talks on number theory.

Participated in *Workshop in Number theory and combinatorics* held at RKMVERI, Belur, West Bengal during Mar 14 – Mar 15, 2022. Gave a lecture on ”Turan-Kubilius inequality”

Raghavan, K. N.

Participated in *Workshop on Macdonald Polynomials* held at Online; organised by IISc during Apr 5 – Jun 30, 2021. Attended the workshop as a participant; also gave three lectures as a resource person

Participated in *Dr. P. Kesava Menon Endowment Lecture Series 2021(Online)* held at Online (University of Calicut) during Aug 28 – Sep 18, 2021. Delivered four lectures on “Symmetric Polynomials”

Visited Kerala School of Mathematics during Sep 12 – Sep 19, 2021. NBHM Doctoral Scholarship Interviews; Student seminars

Participated in *UGC-HRDC Refresher Course in Mathematics and Statistics–Batch XXXV* held at University of Madras during Nov 3 – Nov 5, 2021. Gave two lectures as a resource person

Participated in *Workshop on Representation Theory of Affine Lie Algebras* held at Online; Orgnised by IISc and IIT-Tirupati during Dec 13 – Dec 18, 2021. Gave two lectures as a resource person; attended the workshop as a participant

Participated in *CMI-NASI 1st Winter Training Programme in Mathematics* held at Ramanujan Institute for Advanced Study in Mathematics, University of Madras during Dec 13 – Dec 24, 2021. Helped organize the event; gave two lectures as a resource person

Participated in *International e-conference on Number Theory and Differential Equations* held at Online; Central University of Karnataka on Dec 24, 2021. Gave a talk on "Saturation for refined Littlewood-Richardson Coefficients"

Participated in *Online Refresher Course in Mathematics* held at Pandit Ravishankar Shukla University, Raipur during Jan 15 – Jan 22, 2022. Gave two lectures as a resource person

Participated in *CMI-NASI Online Workshop on Linear Algebra and Elementary Number Theory* held at Mepco Schlenk Engineering College, Sivakasi (online) during Jan 27 – Feb 27, 2022. Helped organize the event; Gave six lectures as a resource person

Samal, Areejit

Participated in *Perspectives in Computational Biology* held at IISER Mohali during Apr 1 – Apr 3, 2021. Invited talk (online)

Participated in *Networks and Dynamical Systems* held at IIT Madras, Chennai on Aug 27, 2021. Invited talk (online)

Participated in *MANAV Data Science Webinar* held at IISER Pune on Nov 11, 2021. Invited talk (online)

Visited IIIT Bengaluru on Nov 29, 2021. Samvaad Talk (online)

Participated in *ATAL Online FDP on Foundations of Data Science and Machine Learning* held at PSG College of Technology, Coimbatore on Dec 30, 2021. Invited talk (online)

Sharma, Sayantan

Participated in *LATTICE 2021* held at Online conference organized by MIT, Cambridge, USA during Jul 26 – Jul 30, 2021. Selected for oral talk titled "Bottomonia screening masses from 2+1 flavor QCD"

Visited Bose Institute, Kolkata during Sep 8 – Sep 21, 2021. Gave 4 online lectures on "Standard Model of Particle Physics" as a part of the 4th ALICE-India school on Quark-Gluon

Plasma. Bose Institute Kolkata was hosting this school in virtual mode. Presented invited lecture. The lectures are available online in the following link:
https://indico.cern.ch/event/1090153/timetable/

Sinha, Sitabhra

Participated in *Workshop on Omics Data Analysis* held at JIIT Noida during Apr 16 – Apr 17, 2021. Gave invited talk on ”Network Biology: Integrating the Omics”

Participated in *Ranjan Ray Memorial Lecture* held at St Xavier's College, Kolkata on Apr 28, 2021. Gave invited talk on ”To see the world in a grain of sand...”

Participated in *Knowledge Leadership Forum* held at SASTRA Thanjavur on May 1, 2021. Gave invited talk on ”Patterns, Broken Symmetries and Computation”

Participated in *National Webinar on Epidemiology and Mathematics* held at Ramkrishna Mission Vivekananda Centenary College, Rahara on Jul 5, 2021. Gave invited talk on ”Epidemics and the Mathematical Modeler”

Participated in *CSD International Workshop on Networks and Dynamical Systems* held at IIT Madras during Aug 25 – Aug 28, 2021. Gave invited talk on ”Framing the fearful symmetry: Developmental pattern formation as interaction between global fields and local interaction among cells”

Participated in *Exhibition on Vaccines* held at Science City, Kolkata on Sep 5, 2021. Gave a public talk on ”The Maths of Epidemics”

Participated in *IMSc Popular Lecture* held at IMSc on Nov 26, 2021. Gave invited talk on ”Playing games during a pandemic: Mathematical modeling for public health”

Participated in *FDP Recent Trends in Research and Applied Statistics* held at SRM IST during Dec 15 – Dec 21, 2021. Gave invited talk on ”Using statistics to find patterns in data”

Participated in *MM ICE Workshop* held at SSN College of Engineering during Jan 27 – Jan 28, 2022. Gave invited talk on ”What the brain can teach us about learning machines, and vice versa”

Srinivas, K.

Participated in *Subbarao centenary symposium on number theory* held at Online mode, Organized by IISER, Pune during Jul 12 – Jul 16, 2021. Delivered a talk with the title Euclidean algorithm in quartic number fields

Participated in *Second International Webinar on Recent Developments in Number Theory* held at Online Mode, Organized by KIIT, Bhubaneswar. during Oct 1 – Oct 4, 2021. Delivered a talk with the title On the zeros of Riemann zeta-function and its analogues.

Participated in *International Conference on Class Groups of Number Fields and Related Topics* held at Online Mode, Organized by KSoM, Kerala. during Oct 21 – Oct 24, 2021. Delivered a talk with the title Parametrized families of quadratic fields with n-rank at least 2

Subramanian, C. R.

Participated in *8th International Conference on Algorithms and Discrete Applied Mathematics (CALDAM-2022)* held at Pondicherry University, Puducherry. during Feb 10 – Feb 12, 2022.

Viswanath, Sankaran

Participated in *Workshop on Macdonald polynomials* held at IISc Bangalore (online) during Apr 5 – Jun 30, 2021. Gave 4 lectures

5.3 Visitors

Faculty Visitors

David Sinnou	14.09.21 - 31.08.22	CNRS
Satadal Ganguly	21.11.21 - 24.11.21	ISI, Kolkata
Ramare Olivier	03.11.21 - 24.11.21	Marseille, France
Waldschmidt, E.M.	01.12.21 - 14.12.21	Paris IV, France
Viay Vazirani	14.12.21 - 19.12.21	University of California at Irvine, USA
Colmez Pierre	31.12.21 - 26.01.22	CNRS
Jean Dreze	06.01.22 - 12.01.22	Tamilnadu Government, Economic Advisory Council
Patrice Phillippon	07.01.22 - 11.02.22	CNRS, France
Fahad Panolan	21.02.22 - 25.02.22	IIT, Hyderabad
Pallavi Jain	24.02.22 - 02.03.22	IIT, Jodhpur
Loic Merel	15.03.22 - 15.04.22	Paris VII
Arun Kumar , G.	03.03.22 - 07.03.22	IIT, Dhawad
Anuj Jakhar	13.03.22 - 21.03.22	IIT, Bhilai
Sven - Olaf Mach	20.03.22 - 27.03.22	University of Hamburg, Germany

Post Doctoral Visitors

Pritam Sen	01.08.21 - 31.01.22	Former IMSc JRF
I. Iyyappan	28.09.21 - 27.12.21	JNCASR
Shasvath Kapadia	08.09.21 - 09.09.21	ICTS - TIFR
Pappu Acharya	04.11.21 - 03.01.22	TIFR, Hyderabad
Sagnik Chakraborty	02.11.21 - 05.11.21	Nicolaus Copernicus, University in Torun, Poland
Lawqueen Kanesh	02.11.21 - 31.12.21	National University of Singapore
Veekesh Kumar	30.11.21 - 07.12.21	Former IMSc PDF
Rathish Das	01.12.21 - 05.12.21	University of Waterloo
Sankar Deep Chakraborty	05.12.21 - 18.12.21	University of Tokyo
Richa Sharma	06.12.21 - 17.12.21	Kerala School of Mathematics, Kerala
Lalit Vaishya	06.12.21 - 17.12.21	KSOM, Kerala
Kajal Samanta	01.12.21 - 31.12.21	IIT, Guwahati
Ratan Sarkar	01.12.21 - 28.02.22	IISc, Bangalore
Pranendu Darbar	27.12.21 - 16.01.22	ISI, Kolkata
Tanmoy Inamdar	06.01.22 - 20.02.22	University of Bergen, Norway
R. Janani	01.02.22 - 30.06.22	Former IMSc SRF
S. Manikandan	03.01.22 - 02.04.22	IISER, Tirupati
Maguni Mahakhud	14.02.22 - 13.03.22	IISER, Mohali
Karthick Babu , C.G.	22.02.22 - 31.03.22	IISER, Berhampur
Murugan , S.P.	21.03.22 - 31.05.22	Former PDF, IISER, Mohali

Doctoral Visitors

Karthick Babu, C.G.	01.07.21 - 30.09.21	Former IMSc JRF
Ujjal Das	01.07.21 - 30.07.21	Former IMSc JRF
Chandrashekar, K.A.	10.11.21 - 09.02.22	Former IMSc JRF
Hareesh, J.	10.11.21 - 09.02.22	BITS, Goa
Madhumita Kundu	23.11.21 - 15.12.21 & 05.01.22 - 17.01.22	University of Bergen, Norway
Mammatha Roy	25.11.21 - 29.11.21	ISI, Kolkata
Sujoy Mahato	01.02.22 - 30.04.22	Former IMSc JRF
Nidhi Purohit	07.01.22 - 30.04.22	University of Bergan, Norway

Non-Doctoral Student Visitors

Ananya Natarajan	19.12.21 - 02.01.22	IISER, Mohali
Gokul Balaji, D.	21.12.21 - 28.02.22	University of Madras
Harshini, S.	18.12.21 - 10.01.22	NIT, Thiruchy
Sruthi, B.	03.01.22 - 30.06.22	PSG College of Tech., Coimbatore
Gaurav Kumar	01.01.22 - 30.06.22	Central University of South Bihar
Kishan Kumar	01.01.22 - 30.06.22	Central University of South Bihar
Abhinayaa, A.S.	10.02.22 - 31.05.22	PGG College of Technology
Sankaran, S.V.	23.02.22 - 30.06.22	Shastra University, Thanjavur
Geetha, R.	01.01.22 - 30.06.22	Bharathidasan University, Thiruchirapalli
Rahul Mallikarjun	01.02.22 - 30.04.22	St. Stephen‘s College, New Delhi

Chapter 6

Infrastructure

6.1 Computer Facilities

Enhancement of Computer Facility during 2021-22

- The new Laptops were issued to newly joined faculty and those faculty requested for replacement of laptops which are older than 4 years.
- Zoom Academic license was renewed for one more year with additional licenses to meet the large participants conferences and all virtual meetings.
- The internet bandwidth speed was upgraded to 67 Mbps 1:1 fiberloop internet bandwidth.
- Hathway internet connection installed at the Pallavaram Unit.
- IMSc .in domains are migrated from Net4 to GoDaddy.com
- Mathematica single user licenses and network group licenses are upgraded to latest version.
- Matlab with additional toolboxes 15 new licenses are purchased and installed.
- Autocad LT 2022 purchased and installed for Civil/Electrical

Activities :

E-Procurement online training was conducted and initiated for the procurement activities.

Continuous system support was provided to the Institute members for the remote work during the pandemic period

Media team has supported and fulfilled the requirements during virtual classes, virtual official meetings, virtual conference and webinars. Approximate 144 hours lectures are recorded.

6.2 The Library

The Institute Library holds a total collection of 76041 books and bound periodicals as on March 31, 2022 inclusive of current year's addition. The NBHM has recognized this Institute library as the Regional Library in the areas of Mathematics and Allied subject disciplines - in order to share our information resources to all bonafide members of other academic and research institutions.

The library has a well balanced collection both print and online on the major subject areas of research such as Theoretical Physics, Mathematics and Theoretical Computer Science. The library subscribes to over 350 national and international journals.

The library has access to over 3500+ online journals from major publishers such as Elsevier, American Mathematical Society, American Physical Society, Springer Verlag, World Scientific, Institute of Physics, Wiley, etc.

Library has also access to Nature online, Science Online, ACM Digital Library, SIAM Journals Archive, Duke Mathematical Journal, and JSTOR Full digital archive. It has also perpetual online access to backfile collection of journals contents from Volume 1 from some of the major publishers like Elesevier under DAE consortium, Springer, World Scientific, Wiley, deGruyter, Cambridge University Press, Turpion, IOP Publishing and Annual Reviews Electronic Backvolume collection.

Access to online journals is restricted to members of the Institute. Also, remote access during work from home situations to the subscribed online resources was facilitated by institutes' VPN (Virtual Private Network) service.

Services:

Apart from developing the collection, the library offers reprographic and inter library loan services. Library has migrated from commercial proprietary software Libsys to open source software Koha on a linux platform, the library catalogue has been computerized and made available online to the readers both within and outside the Institute Campus. Online request for acquisition of books and status of borrowings have also been enabled using Koha. Library has implemented RFID based system for self check-in and checkout of library materials.

With the help of RFID enabled access control system, the library provides effective 24x7 access to its resources,perhaps the only library of this kind in the country.

Library has a website dedicated to host all the electronic information resources and to provide information about the library and its services.

Library is a member of DAE Libraries Consortium that subscribes to SCIENCE DIRECT SERVICE of Elsevier.

Library is also coordinating the MathSciNet consortium which provides online access to MathSciNet for participating institutions in the southern region.

Library is an institutional member of AMS, MALIBNET, CURRENT SCIENCE Association, and IAPT.

In addition, library also assists in annual report preparation that includes compilation of publications and other editorial processes.

Acknowledgment:

The Library gratefully acknowledges the donation of valuable books, journals and other reading materials received during the current year from the persons and organizations mentioned below:

Balachandran Sathiapalan, IMSc
S. Kesavan, IMSc
R. Ramanujam, IMSc
Venkatesh Raman, IMSc
Director's Office
M. Jayakrishnan, IMSc
Kamal Lodaya, IMSc
Rahul Sinha, IMSc
Sanoli Gun, IMSc
G. Subramoniam, IMSc
NBHM
Shivani Singh, IMSc