THE INSTITUTE OF MATHEMATICAL SCIENCES

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Chennai - 600 113.

ANNUAL REPORT

Apr 2017 - Mar 2018

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Foreword

I am very pleased to present the annual report of the Institute for 2017-2018 and put forth the distinctive achievements of its members during the year along with a perspective for the future.

During April 2017 - March 2018, there were 148 students pursuing their PhD and 43 scholars pursuing their post-doctoral programme at IMSc.

Through the year the Institute conducted a number of workshops and conferences. Specifically, the International workshop on "Economy as a complex system" was a workshop focusing on statistical physics as a tool in economics. There was a research school on "Mechanical properties of complex solids" focusing on bringing together a wide range of physics in the field to share techniques and recent developments. There was a conference on the broad topic of "disorder and interaction" in both classical and quantum systems. In the field of mathematical modeling of diseases, the computational biology group conducted a mini-workshop on tuberculosis research. An international conference on number theory, bringing together several leading number theorists, was organized by the Institute this year. A conference on "recent advances in parameterized complexity" which included a school for graduate students was also conducted this year. One off-campus meeting on 'Logic and Automata Theory : A tribute to Zoltan Esik' was organized by IMSc faculty during this period.

We are very pleased to note that our outreach programmes like 'Teachers' Enrichment Workshop', 'Summer School Students Workshop', 'Facets', 'kaNita-kAnakam", 'Foldscope Workshop', 'Nag Memorial Endowment Lecture', 'Student Talks on Trending Topics in Theory 2017', 'Enriching Mathematics Education', 'Science Fun, Science Toys', 'Scientists and school education : A discussion', 'Indian Women in Science' and 'Science at the Sabha' are increasingly popular. These programmes have been attracting more and more students and teachers, mainly from nearby regions, but some from other parts of the country. The outreach related activity in the Institute is the initiative of several faculty members. Their untiring efforts, enthusiastically supported by the IMSc administration, PhD students and postdoctoral fellows, to make scientific research accessible and exciting to students and teachers at various levels, deserves all praise.

Academic research productivity of the members of the Institute has been excellent this year as well. Several significant publications have been reported in national and international journals. Our faculty have edited a few books as well.

10 students were awarded PhD, and 7 students have submitted their PhD theses. 3 students were awarded MSc by Research, and a student has submitted her Master's thesis under the supervision of our faculty.

There was, as usual, a lot of participation of IMSc members in international conferences, in the form of invited talks, paper presentations etc. Among several such we highlight a few: Prof. Sitabhra Sinha was an invited speaker at the joint conference Econophysics Colloquium (EC) 2017 and Polish Symposium on Econo- and Sociophysics (FENS) 2017, during 5-7 July 2017, and Prof. Meena Mahajan was an invited speaker at the CSL 2017 (Computer Science Logic conference) held during Aug 20-24, 2017 and at STACS 2018 (Symposium on Theoretical Aspects of Computer Science) held during Feb 2018.

There are several ongoing collaborations, both national and international, with research groups IMSc. Some of these collaborations are as formal agreements and MoUs. In the last year there are two such collaborative projects on "Precision physics for the large hadron collider" with Universite de Louvain, Belgium and Universita de Milano, Italy. There is a collaborative project on "modeling soft glass flow" with Universite Grenoble, France. An international joint research unit (UMI) RELAX, (which stands for Research Lab in Computer Science), has been set up (based in Chennai Mathematical Institute) to facilitate bringing together research institutions/universities in France and India, including IMSc.

There were 44 lecture courses conducted at the Institute during the reporting period. Additionally, 2 lecture courses were given at Chennai Mathematical Institute for its National Undergraduate Programme.

We are proud to note the awards and honors bestowed on our faculty for their contributions.

Dishant M Pancholi was awarded 'B M Birla Science Prize' jointly with Neena Gupta of ISI. Parthasarathi Chakraborty was elected as a Fellow of the Indian Academy of Sciences, Bangalore. Gautam I. Menon was awarded Shasgtri Mobility Program Fellowship, for 2018, by the Shastri Indo-Canadian Institute. Prasad,

Amritanshu was awarded Srinivasa Ramanujan Memorial Award Lecture, for 2017, by the Indian Mathematical Society.

This report was compiled through the efforts of the IMSc Annual Report Committee comprising of Drs. C. R. Subramanian, Shrihari Gopalakrishna, Sankaran Viswanath, Paul Pandian and Usha Devi. I owe my gratitude to all of them.

June, 2018 **V. Arvind**

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Chapter 1

The Institute

1.1 Governing Board

Thiru. **K**.P. Anbalagan,
Hon'ble Minister for Higher Education,
Government of Tamil Nadu, Chennai
(**Chairman**)

Dr. **Sekhar Basu**,
Chairman, Atomic Energy Commission & Secretary to Government of India,
Department of Atomic Energy, Mumbai
(**Vice-Chairman**)

Prof. **S. K. Joshi**,
Honorary Scientist Emeritus, CSIR
Vikram Sarabhai Professor,
National Physical Laboratory, New Delhi
(**Member**)

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

Prof. **Mustansir Barma**,
Former Director, TIFR, Professor Emeritus,
TIFR Center for interdisciplinary Science,
Hyderabad
(**Member**)

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

Shri. **A.R. Sule**,
Joint Secretary(R&D),
Department of Atomic Energy, Mumbai
(**Member**)

Shri. **C.M. Sane**,
IA&AS Joint Secretary(Finance),
Department of Atomic Energy, Mumbai
(**Member**)

Prof. **P. Duraisamy**,
Vice Chancellor,
University of Madras, Chennai
(**Member**)

Shri **Sunil Paliwal**, IAS,
Principal Secretary to Government,
Secretariat, Higher Education Department,
Govt of Tamil Nadu, Chennai
(**Member**)

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

1.2 Executive Council

Prof. **S.K. Joshi**,
Honorary Scientist Emeritus,
CSIR Vikram Sarabhai Professor,
National Physical Laboratory,
New Delhi
(**Chairman**)

Prof. **Mustansir Barma**,
Former Director,
Professor Emeritus,
TIFR Center for interdisciplinary Science,
Hyderabad
(**Member**)

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

Shri. **A.R. Sule**,
Joint Secretary (R&D),
Department of Atomic Energy, Mumbai
(**Member**)

Shri. **C.M. Sane**,
IA&AS, Joint Secretary (Finance),
Department of Atomic Energy, Mumbai
(**Member**)

Shri. **Sunil Paliwal**, IAS,
Principal Secretary to Government,
Secretariat, Higher Education Department,
Govt of Tamil Nadu, Chennai
(**Member**)

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

1.2.1 Profiles of Governing Board and Executive Council Members

Thiru **K.P. Anbalagan**, Hon'ble Minister for Higher Education, Government of Tamilnadu, Chennai
(**Chairman**, *Governing Board*)
He was previously the Information Minister of Government of Tamilnadu.

Dr. Sekhar Basu, Chairman, Atomic Energy Commission & Secretary to Govt. of India, Department of Atomic Energy, CSM Marg, Mumbai
(**Vice-Chairman**, *Governing Board*)
Dr. Sekhar Basu, a renowned nuclear scientist, was the Director of Bhabha Atomic Research Centre (BARC) before taking over as Chairman, Atomic Energy Commission & Secretary Department of Atomic Energy, Govt. of India. Dr. Basu was awarded "Padma Shri" by the Government of India in 2014.

Prof. S. K. Joshi, Honorary Scientist Emeritus CSIR Vikram Sarabhai Professor National Physical Laboratory Dr. K.S. Krishnan Road New Delhi 110 012.
(**Member**, *Governing Board*) & (**Chairman**, *Executive Council*)
Prof. Joshi has held numerous important positions in the field of science in India, including Director General CSIR, and Director, National Physical Laboratory. He is member of several national and international academies, including the Indian National Science Academy and the Third World Academy of Sciences. For his work in physics Prof. Joshi is the recipient of numerous national and international awards, including the Won Watumull memorial Prize and the Bhatnagar Prize. He is recipient of the Padma Shri and the Padma Bhushan for his contributions.

Prof. Mustansir Barma Professor Emeritus, TIFR Center for interdisciplinary Science, No.36/P, Gopanapally Village, Serilingampally Mandal, Ranga Reddy - Dist Hyderabad 500107..
(**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 Sir Tarak Nath Palit Professor of Physics, 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.

P. Duraisamy, Vice Chancellor, University of Madras, Chennai
(**Member**, *Governing Board*)
Duraisamy is a former HOD of econometrics department in University of Madras and has a PhD from Paris University

Prof. Sudhanshu Jha, 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.

Shri A.R. Sule Joint Secretary (R & D), Department of Atomic Energy, CSM Marg, Mumbai.
(**Member**, *Governing Board & Executive Council*)

Shri. Sunil Paliwal, IAS, Principal Secretary to Government Secretariat, Higher Education Department, Government of Tamilnadu, Chennai
(**Member**, *Governing Board & Executive Council*)

Prof. V. Arvind, Director, IMSc Chennai
(**Member Secretary**, *Governing Board & Executive Council*)
Prof. V. Arvind was a faculty member at IIT, Madras and IIT, Delhi prior to joining IMSc as a faculty member

1.2.2 Director's Advisory Committee

Academic Programme Coordinators

Dr. **V.S. Nemani**	Physics
Dr. **Indrava Roy**	Mathematics
Dr. **Vikram Sharma**	TCS

Annual Report

Prof. **C. R. Subramanian**	Chair
Prof. **S. Viswanath**	
Prof. **Shrihari Gopalakrishna**	
Dr. **Paul Pandian**	(Library)

Approval Coordinators

Prof. **Sitabhra Sinha**	Physics
Prof. **K.N. Raghavan**	Mathematics
Prof. **Meena Mahajan**	TCS
Prof. **Gautam Menon**	Computational Biology

Associates Programme

Prof. **V. Arvind**	Chair
Prof. **Venkatesh Raman**	TCS
Profs. **K. Srinivas & Partha Sarathi**	Maths
Prof. **Mukul Laad**	Physics

Colloquium & Seminar

Dr. **Ganesh Ramachandran**	Physics
Prof. **Jaya N. Iyer**	Mathematics
Dr. **Vikram Sharma**	TCS

Computer Media & Web

Dr. **Pinaki Choudhuri**	Chair
Prof. **Venkatesh Raman**	
Prof. **K.N. Raghavan**	
Prof. **Rahul Siddarthan**	
Prof. **Satyavani Vemparala**	
Dr. **Areejit Samal**	
Dr. **G. Subramoniam,**	SO'F'(Systems)
Shri. **B. Raveendra Reddy,**	SO'F'(Systems)
Mr. **Vigneshwar Narayanan,**	(Student Member)

Events / Outreach

Prof. **R. Ramanujam** Chair
Prof. **K.N. Raghavan**
Dr. **Areejit Samal**
Dr. **Ganesh Ramachandran**

Gender Bias Redressal

Prof. **D. Indumathi** Chair
Prof. **Satyavani Vemparala**
Prof. **Rahul Siddarthan**
Prof. **Sanoli Gun**
Smt. **E. Gayatri,** (Accounts Officer)
Smt. **V. Geetha,** (External Member)
Shri. **S. Vishnu Prasad,** Registrar

Grievance Redressal

Prof. **Meena Mahajan** Chair
Prof. **Amritanshu Prasad**
Prof. **Sanatan Digal**
Prof. **Sujay Ashok**

Guest House Advisory

Prof. **Parameswaran Sankaran**
Prof. **Pralay Chatterjee** Chair
Prof. **V. Ravindran**
Dr. **Indrava Roy**
Shri. **S. Vishnu Prasad,** Registrar
Mr. **Prasanna Kumar Dhani,** (Student Member)

HBNI Coordinators

Prof. **Rahul Sinha**	Physics	Dean, Physical Sciences
Prof. **Sibasish Ghosh**	Physics	Associate Dean, Physical Sciences
Prof. **Vijay Kodiyalam**	Mathematics	Dean, Mathematical Sciences
Prof. **Gautam Menon**	Computational Biology	Dean, Life Sciences

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

Prof. **Saket Saurabh**
Dr. **Manjari Bagchi**
Dr. **Ganesh Ramachandran**

Housing & Up-Keep

Prof. **V. Ravindran**	Chair
Dr. **Pinaki Chaudhuri**	
Dr. **C.M. Chandrashekar**	
Shri. **S. Vishnu Prasad**	Registrar
Smt. **R. Indra**	Administrative Officer

JEST Coordinators

Prof. **D. Indumathi**
Prof. **Pralay Chatterjee**
Prof. **Kamal Lodaya**

Library

Prof. **Gautam Menon**	Chair
Prof. **C. R. Subramanian**	
Prof. **Amritanshu Prasad**	
Prof. **Sitabhra Sinha**	
Dr. **Manjari Bagchi**	
Dr. **Paul Pandian**	S/O 'F' (Library)
Mr. **K. Chandrashekhar**	(Student Member)

National Science Day

Prof. **K.N. Raghavan**
Prof. **V. Ravindran**
Dr. **Vikram Sharma**

Official Language Implementation

Prof. **V. Arvind**	Chair
Prof. **Saket Saurabh**	
Prof. **Mukul Laad**	
Prof. **Syed Raghib Hassan**	
Shri. **S. Vishnu Prasad,**	Registrar
Mr. **Vinay Vaibhav,**	(Student Member)

Maths PDF Committee

Prof. **K. Srinivas**
Prof. **Parthasarathi Chakraborty**

Physics PDF Committee

Prof. **V. Ravindran**	Chair
Prof. **Sitabhra Sinha**	
Prof. **Mukul Laad**	
Prof. **Sibasish Ghosh**	
Dr. **Partha Mukhopadhyay**	
Prof. **Shrihari Gopalakrishna**	

Refurbishment

Prof. **Syed Raghib Hassan**	Chair
Prof. **Saket Saurabh**	
Dr. **Anirban Mukhopadhyay**	
Shri. **K. Chandrasekar,**	Ex-Chief Architect, IGCAR
Shri. **S. Vishnu Prasad,**	Registrar
Shri. **Sunder,**	S/O 'C' (Civil)
Shri. **S. Mohan,**	S/O 'E'(Electrical)

Right To Information Act [RTI]

Prof. **Bala Sathiapalan**	Appellate Authority
Shri. **S. Vishnu Prasad**	Public Information Officer

Space Planning & Allocation

Prof. **V. Arvind**	Chair
Prof. **Indumathi**	
Prof. **Pralay Chatterjee**	
Dr. **C.M. Chandrashekar**	
Shri. **S. Vishnu Prasad**	Registrar

Summer Programme

Prof. **Ramanujam**	TCS
Prof. **Sanoli Gun**	Maths
Prof. **Pinaki Chaudhuri**	Physics

Tender

Prof. **Ramanujam**	Chair
Prof. **Parthasarathi Chakraborty**	

The Chair of the Committee may always co-opt any other member of IMSc when required.

1.3 Faculty

Name	*Userid*

Computational Biology

Menon, Gautam I.	menon
Samal, Areejit	asamal
Siddharthan, Rahul	rsidd
Sinha, Sitabhra	sitabhra

Mathematics

Chakraborty, Partha Sarathi	parthac
Chatterjee, Pralay	pralay
Gun, Sanoli	sanoli
Iyer, Jaya N.	jniyer
Kodiyalam, Vijay	vijay
Mohari, Anilesh	anilesh
Mukhopadhyay, Anirban	anirban
Nagaraj, D. S.	dsn
Pancholi, Dishant Mayurbhai	dishant
Prasad, Amritanshu	amri
Raghavan, K. N.	knr
Roy, Indrava	indrava
Sankaran, P.	sankaran
Srinivas, K.	srini
Sunder, V. S.	sunder
Sushmita Venugopalan	sushmita
Viswanath, S.	svis

Physics

Adhikari, Ronojoy	rjoy
Ashok, Sujay K.	sashok
Bagchi, Manjari	manjari
Chandrashekar, C.M.	chandru
Chaudhuri, Pinaki	pinakic
Date, G.	shyam
Digal, Sanatan	digal
Ghosh, Sibasish	sibasish
Gopalakrishna, Shrihari	shri
Hassan, Syed Raghib	shassan
Indumathi, D.	indu
Kaul, Romesh K.	kaul
Laad, Mukul S.	mslaad
Menon, Gautam I.	menon
Mukhopadhyay, Partha	parthamu
Nemani, Venkata Suryanarayana	nemani
Rajesh, Ravindran	rrajesh
Rama, S. Kalyana	krama
Ramachandran, Ganesh	ganesh
Ravindran, V.	ravindra

Ray, Purusattam	ray
Sathiapalan, Balachandran	bala
Sayantan Sharma	sayantans
Shankar, R.	shankar
Siddharthan, Rahul	rsidd
Sinha, Nita	nita
Sinha, Rahul	sinha
Sinha, Sitabhra	sitabhra
Vemparala, Satyavani	vani

Theoretical Computer Science

Arvind, V.	arvind
Lodaya, Kamal	kamal
Mahajan, Meena	meena
Raman, Venkatesh	vraman
Ramanujam, R.	jam
Saurabh, Saket	saket
Sharma, Vikram	vikram
Subramanian, C.R.	crs

1.4 Honorary Senior Academic Members

Balasubramanian, R.	balu
Baskaran, G.	baskaran
Rajasekaran, G.	graj
Simon, R.	simon

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.
Registrar

Gayatri E.
Accounts Officer

Indra R.
Administrative Officer

Amulraj, D.
Ashfack Ahmed, G.
Balakrishnan, J.
Geetha, M.
Janakiraman, J.
Johnson, P.
Munuswamy, N.
Padmanabhan, T.
Parthiban, V.
Radhakrishnan, M. G.
Rajendran, C.
Ravichandran, N.
Seenivasa Raghavan N.
Vasudevan, T.V.
Archana Shukla
Babu, B.
Baskaran, R.
Gopinath, S.
Jayanthi, S.
Moorthy, E.
Otheeswaran Usha
Parijatham, S.M.
Prema, P.
Rajasekaran, N.
Ramesh, M.
Shankaran, K.P.
Tamil Mani, M.

1.7 Project Staff

1.7.1 Project Staff [Non Academic]

Aiswaryalakshmi PL	lakshmipl
Balachander M.	mbchander
Gayathri S.	gayathris
Harikrishnan B.	hkrishnan
Hari Priya T. V.	tvhpriya
Jahir Hussain M.	jahir
Jayakumar P.	jayakumarp
Jegannathan J.	jjegan
Karthik M.	mkarthik
Karthikeyan B.S.	bskarthi
Keerthana	keerthana
Kirubananth P	kirubananth
Krishna Balaji R.	rkbalaji
Madhura Nithiya J.	jmnithiya
Mangala Pandi P.	mangal
Moovendan M.	moovendan
Nambirajan E	nambirajan
Parthasarathi N.	npsarathi
Rajkumar S.	srajkumar
Ramakrishnan S.	skrishnan
Rethinasamy D.	drsamy
Revathi J.	jrevathi
Sadhana R.	sadhana
Sakthivel Murugan E.	esakthi
Sathishkumar	sathishka
Sinnakaruppan S.	sskp
Sivasubbu Raj B.	sivaraj
Sivathanu Pillai	csp
Sreelakshmi P.K	lakshmipk
Srinivasan G.	gsvasan
Srinithi Varsha S.	varsha
Vaideeswaran	mveswaran
Vignesh Kumar T	vignesh
Vijay S	vijays
Vimalraj J.	vimalraj

1.7.2 Project Staff [Scientific/Academic]

Able E Alias	ableea
Amruta Sahoo	amrutasah
Archana Mishra	amishra
Arya S	aryas
Ashwij Mayya	ashwij
Bharath Chand R.P	bharathc
Eleonora Dell' Aquila	edellaquila
Gajendra Singh Badwal	
Janaki Raghavan	rjanaki
Karthikeyan B.S	bskarthi
Karthikeyan M	mkarthikeyan
Krishanu Deyasi	krishanud
Md. Izhar Ashraf	ashraf
Nadeesh Garg	nadeeshg
Parveena Shamim A	parveenasa
Pradeep Kumar N	pradeepnpk
Saveetha H.	saveetha
Shakthi N. Menon	shakthi
Snehal V Sambare	snehalvs
Soumya Easwaran	soumyae
Surendra Singh Badwal	
Theerthagiri L.	ltgiri
Vandanashree M.	vandanashree
Varuni Prabhakar	varuni
Vinod Kumar T.	tvinodkumar

1.8 Post-Doctoral Fellows

Computational Biology

Anupama Sharma	anupama

Mathematics

Antony Selvam A.	antonya
Bidyut Sanki	bidyuts
Karimilla Bi N.	karimilla
Narasimha Chary B.	nchary
Nirupama Mallick	nirupamam
Rohit Varma	rvarma
Kasi Viswanadham	viswanadh
Prathamesh T.V.H.	prathamesh
Divakaran D	divakaran
Akhilesh P	akhi
Bipul Saurabh	saurabhb
Sarita Agrawal	saritaa
Pranabesh Das	pranabesh
Arideep Saha	arideep
Poornapushkala Narayanan	porrnap

Physics

Aradhana Singh	aradhanas
Arpita Choudary	arpitac
Aravinda S	aravinda
Avijit Mishra	avijitm
Balesh Kumar	baleshk
Debabrata Sinha	debabratas
Goutam Das	goutam
Jayaprasath, E.	jayaprasath
Sreeraj T. P.	sreerajtp
Bimla	bimladanu
Prasad V V	prasadvv
Manik Banik	manikbanik
Himadri Barman	hbar
Suman Ganguli	sganguli
George Thomas	georget
Bijoy Daga	bijoydaga
Asutosh Kumar	asutoshk
Suratno Basu	suratnob
Rahul Dandekar	rsdandekar
Arunprasath V	arunprasath
Amit Mukherjee	amitm

Theoretical Computer Science

Abhisekh Sankaran	abhisekhs
Krithika R	Krithikaraman
Pallavi Jain	pallavij
Pradeesha Ashok	pradeesha
Ragukumar P.	ragukumar
Srinivasa Murthy T	tsmurthy
Suresh Dara V.V.P.R.V.B.	sureshdara
Vibha Sahlot	vibhasahlot

1.9 Ph.D. Students

Name	*Userid*

Computational Biology

Ankit Agrawal	aagrawal
Bodhayan Prasad	bodhayanp
Chandrani Kumari	chandranik
Chandrashekar K. A.	kachandra
Devanand T.	devanandt
Deepika Choubey	cdeepika
Farhina Mozaffer	farihinam
Janani R.	jananir
Pavitra S	spavitra
Reshma M	reshmam
Ria Ghosh	riaghosh

Sreevidya T.S	tssreevidya
Vadnala Rakesh Netha	rakeshnetha
Vivek Ananth R. P.	vivekananth

Mathematics

Arghya Sadhukan	arghyas
Arun G. Kumar	gakumar
Avijit Nath	avijitnath
Biplab Paul	biplabpaul
Chayan Karmakar	chayank
Digjoy Paul	digjoypaul
Jayakumar R.	rjayakumar
Jyothsnaa S.	jyothsnaa
Karthick Babu C G	cgkbabu
Keshab Chandra Bakshi	keshabcb
Krishanu Roy	krishanur
Mita Banik	mitabanik
Mrigendra Singh Kushwaha	mrigendra
Nabanita Roy	nabanitar
Narayanan P. A.	panarayanan
Neelam	neelam
Oorna Mitra	oornamitra
Piyasa Sarkar	psarkar
Pranendu Darbar	dpranendu
Priyamvad Srivastav	priyamvads
Ratheesh T.V	ratheeshtv
Rupam Karmakar	rupamk
Snehajit Misra	snehajitm
Sohan Lal Saini	slsaini
Sridhar P. Narayanan	sridharn
Sruthy Murali	sruthym
Surajit Biswas	surajitb
Uday Bhaskar Sharma	udaybs
Ujjal Das	ujjaldas
Vaibhav Krushankant Dimble	vaibhavkd

Physics

Abinash Kumar Nayak	abinashkn
Ajjath A.H.	ajjathah
Akhil Antony	akhilantony
Amir Suhail	amirs
Amit Kumar	kamit
Amlan Chakraborty	amlanchak
Anand Pathak	anandb
Anirban Karan	kanirban
Ankit Aggarwal	aankita
Ankit Dhanuka	ankitdhanuka
Ankita Chakrabarti	ankitac
Anupam A. H.	anupam
Anupam Sarkar	asarkar
Anvy Moly Tom	anvym
Aparna Sankar	aparnas
Apurba Dutta	dapurba

Arindam Mallick	marindam
Arindam Mitra	amitra
Arjun Hariharan	arjunh
Arkajyoti Manna	arkajyotim
Arnab Priya Saha	arnabps
Arpan Kundu	akundu
Atanu Bhatta	batanu
Bhargava B.A.	bhargavaba
Dhargyal	dhargyal
Dheeraj Kumar Mishra	dkmishra
Dhruv Pathak	dhruvpathak
Dipanjan Mandal	mdipanjan
Garima Rani	grani
Gopal Prakash	gopalp
Jilmy P. Joy	jilmyo
Kamal Tripathi	kamalt
Madhusudhan Raman	madhur
Mahaveer Prasad	mahaveerp
Minati Biswal	mbiswal
Mohammad Shabbir	mshabbir
Nana Siddarth	nanasid
Pavan Dharanipragada	pavand
Pinaki Banerjee	pinakib
Pooja Mukherjee	poojamukherjee
Prafulla Oak	prafullao
Prasanna Kumar Dhani	prasannakd
Prashanth Raman	prashanthr
Prathik Cherian J.	prathikcj
Pritam Sen	pritamsen
Prosenjit Haldar	prosenjit
Pulak Banerjee	bpulak
Raghvendra Singh	raghvendra
Rajesh Singh	rsingh
Rathul Nath	rathulnr
Ravi T	travi
Renjan Rajan John	renjan
Ria Sain	riasain
Rishu Kumar Singh	rksingh
Rusa Mandal	rusam
Sabiar Shaikh	sabiarshaikh
Sagnik Chakraborty	csagnik
Sahil	sahilmd
Sanjoy Mandal	smandal
Saroj Prasad Chhatoi	sarojpc
Sayantan Ghosh	sayantang
Semanti Dutta	semantid
Shanu Karmakar	shanuk
Shibasis Roy	shibasisr
Shilpa Kastha	shilpakastha
Shivam Gola	shivamg
Shivani Singh	shivanis
SK Jahanur Hoque	jahanur
Soumya Sur	soumyasur
Sourav Ballav	sballav
Srivatsa N. S.	srivatsans
Subhankar Khatua	shubankark
Sujoy Mahato	sujoymahato
Surabhi Tiwari	surabhit
Tanmay Mitra	tmitra

Thiru Senthil R.	rtsenthil
Umang A. Dattani	umangad
Varun Gupta	varungupta
Varun Sethi	varunsethi
Vigneshwar N.	vigneshwarn
Vigneshwaran K.	vigneshwaran
Vinay Vaibhav	vinayv

Theoretical Computer Science

Abhishek Sahu	asahu
Abhranil Chatterjee	abhranilc
Aditi Dudeja	aditid
Anantha Padmanabha M.S.	ananthap
Anuj Vijay Tawari	anujvt
Anup Basil Mathew	anupbasil
Arindam Biswas	barindam
Ashwin Jacob	ajacob
Diptapriyo Majumdar	diptapriyam
Gaurav Sood	gauravs
Jayakrishnan M.	jayakrishnan
Lawqueen Kanesh	lawqueen
Niranka Banerjee	nirankab
Prafullakumar Prabhakar Tale	pptale
Ramanathan Thinniyam Srinivasan	thinniyam
Ramit Das	ramitd
Roohani Sharma	roohani
Sanjukta Roy	sanjukta
Sankar Deep Chakraborty	sankardeep
Swaroop N.P.	npswaroop
Syed Mohhammad Meesum	meesum

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, 2017 - Mar, 2018.

Student	Faculty

Mathematics

Chirantan Mukherjee	Pralay Chatterjee
Deepak Bakal	Sanoli Gun
Ankit Sahu, IIT Ropar	Sanoli Gun
Neethi Konar	Sanoli Gun
Kumar, Naman , IIT Kanpur	Sanoli Gun
Roy, Arnab, IISERBPR	Sanoli Gun
Saha, Subham, CMI	Sanoli Gun
Sayan Kundu	Srinivas, K.
Gaurish Korpal	Srinivas, K.
Rahul Ghosh	Raghavan, K.N.

Debmalya Basak	Anirban Mukhopadhyay
Bidesh Das	Anirban Mukhopadhyay
Jomin K. J.	Sanoli Gun
Arnab Dey Sarkar	Sanoli Gun
Ipsit Chopra	Sanoli Gun
Ravi Dwivedi	Sanoli Gun
Mithun P. V	Pralay Chatterjee
Aarthi S	Sanoli Gun
Krithika Manogaran	Sanoli Gun
Deshmukh Yash, CMI	Sushmita, V
Sabyasachi Mukherjee	Anirban Mukhopadhyay
Sahil Singhal	Raghavan, K.N.
Kabeer M.R.	Sanoli Gun
Chitra Venugopal	Sanoli Gun
Aditya Kumar Shukla	Raghavan, K.N.
Aritra Mishra	Sitabhra Sinha
George Pauly	Nagaraj, D.S.
Subham Bhakta	Srinivas, K.

Physics

Sindhana Selvi, IISc Bangalore	Rajesh Ravindran
Aldric Anto Rosario, IIT Madras	Rajesh Ravindran
Darsa N, Kerala	Satyavani, V.
Aswathi, K., Kerala	Gautam I. Menon
Monira Fatma, Bihar	Sitabhra Sinha
Prantar Dutta	Sitabhra Sinha
Sagar Bildani, BITS Goa Campus	Sitabhra Sinha
Manish Yadav, IISER Mohali	Sitabhra Sinha
Rohit Goswami, IIT Kanpur	Sibasish Ghosh
Abhishek Roy, Bose Institute, Darjeeling	Sibasish Ghosh
Durgabatee Rout	Sanatan Digal
Roopini V.	Sibasish Ghosh
Bohnishikha Ghosh, IISER Kolkata	Chandrashekar C.M.
Nikhil Ramesh	Sitabhra Sinha
Mishra, Aritra, IISER, Bhopal	Sitabhra Sinha
Jayanth Kumar,	Sitabhra Sinha
Yalamarthy, Krishna Praveen, IIT, Guwahati	Sitabhra Sinha
Arkalekha Neogi	Manjari Bagchi
Vishnu Narayanan Nampoothiri, IISER Mohali	Gautam I. Menon
Muthusamy R.	Rahul Sinha
Suresh, Namitha, BITS Philani	Rahul Sinha

Theoretical Computer Science

Bisht Harshit, IIT Kanpur	Kamal Lodaya
Purohit, Nidhi, Delhi University	Saurabh, Saket

Computational Biology

Prakruthi Burra, BITS Pilani	Areejit Samal
Mishra, Richa, BITS Philani	Areejit Samal
Aparna, S.R., Stella Maris College	Areejit Samal
Revathy Menon, IISER Tirupati	Gautam I. Menon
Akhil Babu, IISER Pune	Sitabhra Sinha

Sarangthem Dinamani Singh, Manipur	Rahul Siddharthan
Janavi M.	Rahul Siddharthan
Anushree Dhar, Kolkata	Areejit Samal
Priyadharshini Lingesan	Rahul Siddharthan
Aniket Kulkarni	Rahul Siddharthan
Rajalaxmi Saha	Vani, Vemparala

Chapter 2

Research and Teaching

Faculty members at IMSc carry out research in their areas of interests in a self-directed manner, often in collaboration with doctoral students, post-doctoral fellows and researchers from elsewhere. Research output is disseminated primarily as refereed journal articles as well as articles in conference proceedings. The expertise available at the institute is organized below according to the areas of specialization.

2.1 Computational Biology

2.1.1 Research Summary & Highlights

Seeing the Light
Many micro-organisms can move in response to stimuli. Phototaxis, motion in response to the sensing of light, leads to complex collective dynamics in colony-forming cyanobacteria such as Synechocystis sp. Physical interactions between cells play an important role in the collective motion of cell colonies when light is sensed. These aspects of phototaxis can be modelled using a powerful theoretical and simulational framework developed in recent years, that of active matter systems. Research at IMSc addresses phototaxis in cyanobacterial colonies through an agent-based model of motile units. The model allows for cells to physically interact with each other as well as with their environment. It replicates many experimentally observed colony behaviours including cell aggregation and finger-formation and includes a number of predictions for future experiments. This is the first application of active matter ideas to the problem of collective phototaxis and should stimulate research along similar lines into other problems involving the physics of collective bacterial motion. The related paper, authored by P. Varuni P, Shakti N. Menon and Gautam I Menon, is accessible on the Bioarxiv and has been submitted for publication.

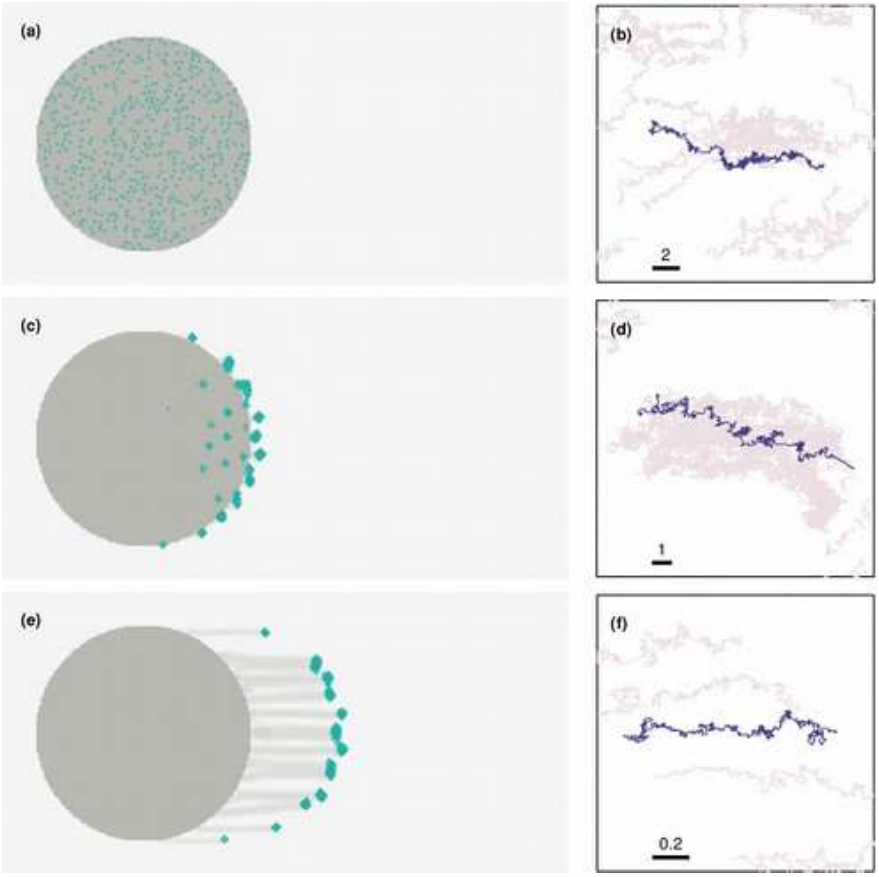

Figure 2.1: Seeing the Light

A model for the positioning and other properties of chromosomes in human cells first proposed in Nucl. Acids Res (2014), which emphasizes the importance of active energy transduction into work arising from the hydrolysis of ATP molecules, has been extended in several ways[**A1**]. The model now incorporates several cell-type specific features, such as activity distributions computed from RNA-seq experiments and looping as inferred from Hi-C experiments. It predicts a variety of physical behaviour, including the distribution of individual chromosomes by gene density and by their centre of mass, the shapes and other statistical properties of individual chromosome territories as well as the nature of contacts between individual chromosomes. This work attempts to solve a number of outstanding problems in the understanding of nuclear architecture, the origins of chromosome territories, the separation of heterochromatin and euchromatin and the separation of distribution functions of active and inactive X chromosomes. It represents currently the only model which can reproduce these features. Its advantage is that it is a first-principles model, with the advantage that it enables us to concentrate on underlying principles that are often obscured by the complexity of real data, including intrinsic heterogeneities across cell populations, varied experimental and analysis procedures and the lack of sufficient statistics in some cases. Prior models for nuclear architecture in mammalian cells fail to reproduce many general attributes of nuclear architecture known from experiment. These properties are emergent in our calculations. This suggests that our methodologies provide hitherto unavailable biophysical insights into the determinants of large-scale nuclear architecture in metazoans [**A1**].

A general agent-based model for the transmission of infectious diseases is currently being improved with further functionality. This model uses GIS-derived information as well as information from a large-scale population census from CMC, Vellore to model the movement and disease dynamics of a large number of individuals (agents). Currently, the extension of the model to include vectors such as mosquitoes, in addition to movies with visualisations is being carried out. A parallel effort is in the construction of synthetic populations, to avoid issues of confidentiality in the handling of data collected in the census. Our codes currently use GAMA, a specialized agent-based modeling platform.

A model for phototaxis in cyanobacteria, the motion of bacteria away from or towards a source of light, has been developed [P]. We emphasize collective effects in our model, since these bacteria are known to interact and exert forces on each other through extensions called type-IV pili, and the initial migration towards the light source only happens after cells aggregate at the boundaries of the colony. Our agent-based model reproduces most features of what is experimentally seen and is general enough that we can assess the effects of various mutants as well as of "cheaters" i.e. members of the population of bacteria that are insensitive to light. The model is the first of its kind to investigate these phenomena.

Levels of immunity to strains of H1N1 influenza can vary, depending on the individual. This strongly influences how the disease spreads in a population. Accounting for such variations is a major challenge for the epidemiology of infectious diseases. The effect of population-level genetic heterogeneity on the epidemic spread of different 4 strains of H1N1 influenza has been studied [M3]. The immune response of specific ethnicities to a number of H1N1 viral strains is modeled and this information used to study disease spread for these (ethnicity, viral strain) epidemic pairs. It is shown that larger genetic diversity at the level of immune response, leading to the presence of susceptibility sub-populations with a broad distribution of susceptibilities, protects against the spread of influenza in a population. It is also shown that populations with a small number of highly susceptible individuals, but with a large number of less susceptible ones, should exhibit smaller outbreaks than populations with the same average susceptibility but where it is more uniformly distributed. A number of qualitative trends of influenza spread worldwide are captured, providing a first attempt at understanding how susceptibility heterogeneities arising from variations in immune response determine disease spread in populations [M3].

Knowledge base on phytochemicals of Indian medicinal plants

The largest online knowledgebase IMPPAT [Mo], on phytochemicals of Indian Medicinal Plants was built by some of us. 1742 Indian Medicinal Plants, 9596 Phytochemicals and 1124 Therapeutic uses are captured within IMPPAT database. Importantly, a small molecule library of 9596 phytochemicals with two-dimensional (2D) and three-dimensional (3D) structures that can be used for virtual screening and drug discovery is provided by IMPPAT. For the phytochemicals, computed physicochemical properties, predicted Absorption, distribution, metabolism, excretion and toxicity (ADMET) properties, drug-likeliness scores and predicted human targets of phytochemicals are provided by IMPPAT. Notably, based on multiple scoring schemes a subset of 960 IMPPAT phytochemicals are found to be potentially druggable. Importantly, among the 960 druggable IMPPAT phytochemicals, only 28 are existing FDA approved drugs and only 369 share chemical similarity with approved drugs. By comparing the distributions of physicochemical properties of 9596 IMPPAT phytochemicals with small molecule collections of commercial compounds, diversity-oriented synthesis compounds, natural products and phytochemicals from Chinese medicinal plants, physicochemical properties of IMPPAT phytochemicals are shown by us to be closer to library of natural products or phytochemicals from Chinese medicinal plants. The druggable IMPPAT phytochemicals from Indian herbs are also compared by us with the druggable TCM-Mesh phytochemicals from Chinese herbs to show that approximately 75% of the phytochemicals are unique to each database. Thus, the vast potential of phytochemicals from both Indian and Chinese herbs for future drug discovery has been underlined by our results. In conclusion, a unifying platform for the application of computational approaches to elucidate mechanistic links between phytochemicals of Indian medicinal plants and their therapeutic action is provided by IMPPAT.

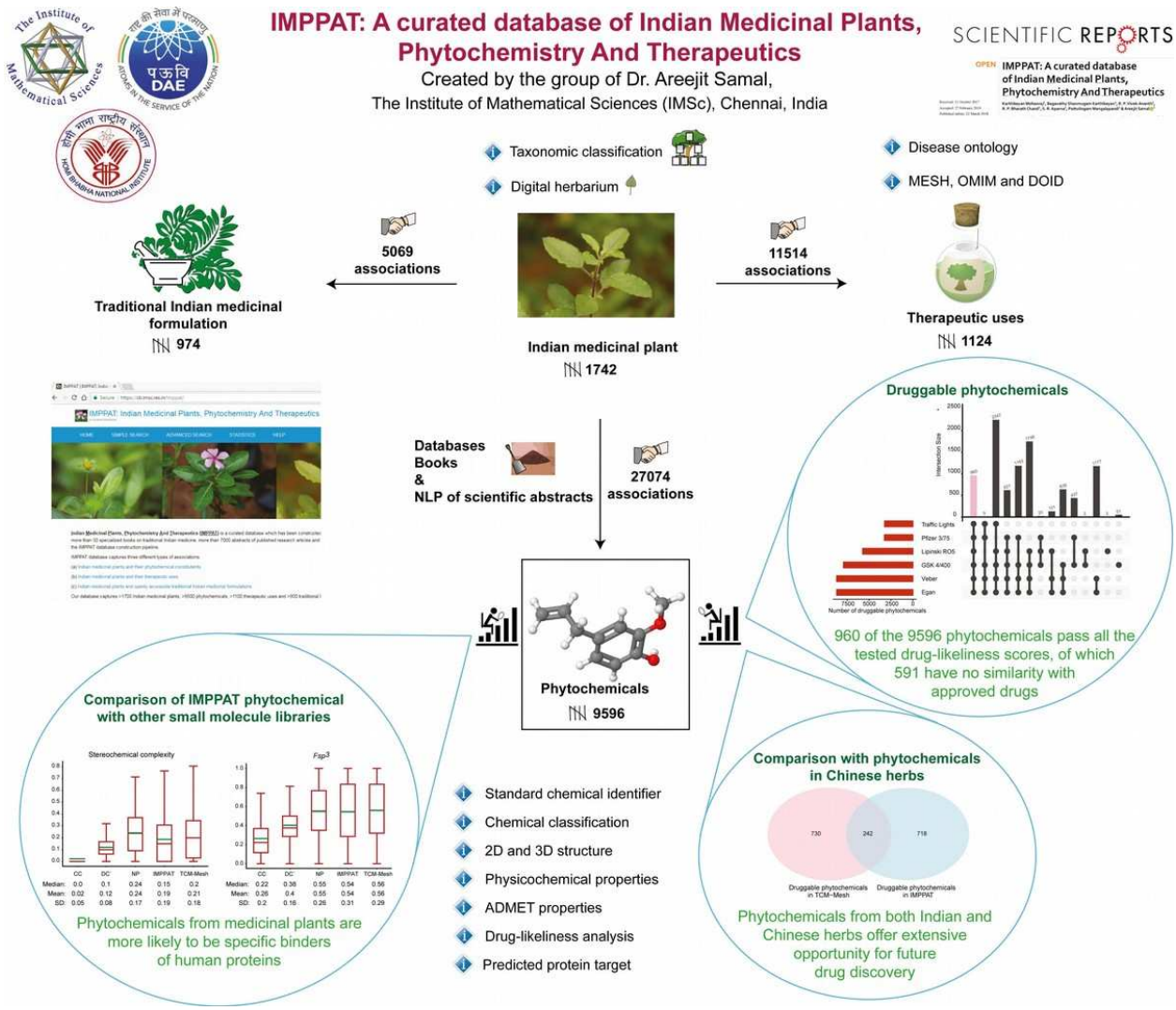

Figure 2.2: IMPPAT: A curated database of Indian Medicinal Plants, Phytochemistry and Therapeutics

A wide range of lung infections, collectively termed aspergillosis are caused by Aspergillus fumigatus and multiple other Aspergillus species. Aspergilli are ubiquitous in environment with healthy immune systems routinely eliminating inhaled conidia, however, Aspergilli can become an opportunistic pathogen in immune-compromised patients. The aspergillosis mortality rate and emergence of drug-resistance reveals an urgent need to identify novel targets. A critical role in fungal-host interactions and pathogenesis is played by secreted and cell membrane proteins. Using a computational pipeline integrating data from high-throughput experiments and bioinformatic predictions, secreted and cell membrane proteins in ten Aspergillus species known to cause aspergillosis have been identified by us [**Vi**]. Small secreted and effector-like proteins similar to agents of fungal-plant pathogenesis were also identified within each secretome [**Vi**]. A comparison with humans revealed that at least 70% of Aspergillus secretomes have no sequence similarity with the human proteome [**Vi**]. An analysis of antigenic qualities of Aspergillus proteins revealed that the secretome is significantly more antigenic than cell membrane proteins or the complete proteome [**Vi**]. Finally, overlaying an expression dataset, four A. fumigatus proteins upregulated during infection and with available structures, were found to be structurally similar to known drug target proteins in other organisms, and were able to dock in silico with the respective drug [**Vi**].

An empirical comparison of two distinct notions of discrete Ricci curvature for graphs or networks, namely, the Forman-Ricci curvature and Ollivier-Ricci curvature have been performed by some of us. Importantly, the two discretizations of the Ricci curvature, Forman-Ricci and Ollivier-Ricci, were developed based on different properties of the classical smooth notion, and thus, the two notions shed light on different aspects of network structure and behaviour. Nevertheless, the two discretizations of Ricci curvature are shown by our extensive computational analysis to be well correlated in a wide range of both model and real-world networks

[S3]. Besides the potential theoretical implications of these observations, the close relationship between the two discretizations has practical implications whereby Forman-Ricci curvature can be employed in place of Ollivier-Ricci curvature for faster computation in larger networks whenever coarse analysis suffices.

Molecular dynamics have been used by some of us to simulate an amorphous glassy polymer with long chains to study deformation mechanism of crazing and associated void statistics.The Van der Waals interactions and the entanglements between chains constituting the polymer play a crucial role in crazing. Thus, two underlying weighted networks, namely, the Van der Waals network and the Entanglement network from polymer configurations extracted from the molecular dynamics simulation have been reconstructed by us. Subsequently, graph-theoretic analysis of the two reconstructed networks have been performed by us to reveal the role played by them in crazing of polymers [V]. Various stages of crazing is captured by our analysis through specific trends in the network measures for Van der Waals networks and entanglement networks [V]. To further corroborate the effectiveness of network analysis in unravelling the underlying physics of crazing in polymers, the trends in network measures for Van der Waals networks and entanglement networks have been contrasted in the light of stress-strain behaviour and voids statistics during deformation. Van der Waals network is found by us to plays a crucial role in craze initiation and growth. Although, the entanglement network was found to maintain its structure during craze initiation stage, it was found to progressively weaken and undergo dynamic changes during the hardening and failure stages of crazing phenomena. The utility of network theory in quantifying the underlying physics of polymer crazing is demonstrated by our work, and the scope of applications of network science for characterization of deformation mechanisms in diverse polymers is also widened by our work [V].

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.

[**A1**]
Ankit Agrawal, Nirmalendu Ganai*, Surajit Sengupta*, and Gautam I. Menon.
A first-principles approach to large-scale nuclear architecture.
2018.
(Submitted).

[**A2**]
Ankit Agrawal, Snehal V Sambare, Leelavati Narlikar*, and Rahul Siddharthan.
Thicweed: fast, sensitive detection of sequence features by clustering big datasets.
Nucleic Acids Research, **0(doi:10.1093/nar/gkx1251)**, gkx1251, 2017.

[**A3**]
Chloe-Agathe Azencott*, Tero Aittokallio*, Sushmita Roy*, Thea Norman *, Stephen Friend *, Gustavo Stolovitzky*, Anna Goldenberg*, Ankit Agrawal, Emmanuel Barillot*, Nikolai Bessonov*, Deborah Chasman*, Urszula Czerwinska*, Alireza Fotuhi Siahpirani*, Jan Greenberg*, Manuel Huber*, Samuel Kaski*, Christoph Kurz*, Marsha Mailick*, Michael Merzenich*, Nadya Morozova*, Arezoo Movaghar*, Mor Nahum*, Torbjorn E M Nordling*, Robert Penner*, Krishanu Saha*, Asif Salim*, Siamak Sorooshyari*, Vassili Soumelis*, Alit Stark-Inbar*, Audra Sterling*, S S Shiju*, Jing Tang*, Alen Tosenberger*, Thomas Van Vieet *, Krister Wennerberg*, and Andrey Zinovyev*.
The inconvenience of data of convenience: computational research beyond post-mortem analyses.
Nature Methods, **14(10)**, 937, 2017.

[**K**]
Madhuparna Karmakar, Gautam I. Menon, and R. Ganesh.
Vortex core order and field-driven phase coexistence in the attractive hubbard model.
Physical Review B, **96**, 174501, 2017.

[**Ku**]
Parul Sood*, **Kausalya Murthy***, **Vinod Kumar, Michael Nonet***, **Gautam I. Menon, and Sandhya Koushika***.
Cargo crowding at actin-rich regions along axons causes local traffic jams in neurons.
Traffic, **19**, 166, 2018.

[**M1**]
Renu Mann*, **Gautam I. Menon, and Pramod Pullarkat***.
Modeling Cell-substrate De-adhesion Dynamics under Fluid Shear.
2017.
https://doi.org/10.1101/166371 (Submitted).

[**M2**]
Gautam I. Menon.
Yes, indian science does need a revamp, but how should we go about it?
Current Science, **113(1)**, 17, 2017.

[**M3**]
Narmada Sambaturu*, **Sumanta Mukherjee***, **Martin Lopez-Garcia***, **Carmen Molina-Paris***, **Gautam I. Menon, and Nagasuma Chandra***.
Evaluating epidemiological impact of genetic heterogeneity using multi-compartment sir models for h1n1 influenza.
PLoS Computational Biology, **14(3)**, e1006069, 2018.

[**Mo**]
Karthikeyan Mohanraj, Bagavathy S. Karthikeyan, R.P. Vivek-Ananth, R.P. Bharath Chand, S.R. Aparna*, **Pattulingam Mangalapandi, and Areejit Samal**.
IMPPAT: A curated database of indian medicinal plants, phytochemistry and therapeutics.
Scientific Reports, **8**, 4329, 2018.

[**P**]
Varuni Prabhakar, Shakti N. Menon, and Gautam I. Menon.
Modelling Phototaxis as a Collective Phenomenon in Cyanobacterial colonies.
Scientific Reports, **7**, 17799, 2017.

[**S1**]
Areejit Samal, James P. Craig*, **Samuel T. Coradetti***, **J. P. Benz***, **James A. Eddy***, **Nathan D. Price***, **and N. L. Glass***.
Network reconstruction and systems analysis of plant cell wall deconstruction by Neurospora crassa.
Biotechnology for Biofuels, **10**, 225, 2017.

[**S2**]
Areejit Samal and Olivier C. Martin*.
Haldane, Waddington and recombinant inbred lines: extension of their work to any number of genes.
Journal of Genetics, **96(5)**, 795, 2017.

[**S3**]
Areejit Samal, R.P. Sreejith, Jiao Gu*, **Shiping Liu***, **Emil Saucan***, **and Jürgen Jost***.
Comparative analysis of two discretizations of Ricci curvature for complex networks.
2017.
arxiv:1712.07600 (Submitted).

[**S4**]
Emil Saucan*, **Areejit Samal, Melanie Weber***, **and Jürgen Jost***.
Discrete curvatures and network analysis.

MATCH Communications in Mathematical and in Computer Chemistry, 2017.
(To be published).

[**Sr**]
R.P. Sreejith, Jürgen Jost*, Emil Saucan*, and Areejit Samal.
Systematic evaluation of a new combinatorial curvature for complex networks.
Chaos, Solitons Fractals, **101**, 50, 2017.

[**V**]
Sudarkodi Venkatesan, R.P. Vivek-Ananth, R.P. Sreejith, Pattulingam Mangalapandi, Ali A. Hassanali*, and Areejit Samal.
Network approach towards understanding the crazing in glassy amorphous polymers, to appear in journal of statistical mechanics: Theory and experiment.
Journal of Statistical Mechanics: Theory and Experiment, 2018.
(To be published).

[**Vi**]
R.P. Vivek-Ananth, Karthikeyan Mohanraj, M. Vandanashree, Anupam Jhingran*, James P. Craig, and Areejit Samal.
Comparative systems analysis of the secretome of the opportunistic pathogen Aspergillus fumigatus and other Aspergillus species.
2017.
bioRxiv 230953 (Submitted).

2.2 Mathematics

2.2.1 Research Summary & Highlights

Algebraic Geometry

Study of morphisms from $\mathbb{P}^2$ to $\mathrm{Gr}(2, \mathbb{C}^4)$ induced by tangent bundle of $\mathbb{P}^2$ was undertaken [**Sn1**]. Seshadri constants on Grassman bundles over curves associated with unstable bundles were discovered (joint work with I. Biswas, Krishna, C and Nestead, P).

Algebraic Number Theory

Let K be quadratic number field with class number 1. An important problem is to characterize all K whore ring of integers $mathcalO_K$ is Euclidean with respect to an Euclidean function ϕ. If ϕ is the norm-function, then a complete characterization is well known. Moreover, all the imaginary quadratic fields which are Euclidean with respect to any ϕ is also known. However, in the case of real quadratic fields, such a characterization is a difficult problem. Under some reasonable assumptions, it is proved that if K is real quadratic field with class number number 1, then it is Euclidean. Further, a family of real quadratic fields are exhibited with the property that they are Euclidean if and only if they have class number one ([**Ks**]).

Analytic Number Theory

The L-functions associated to integral weight modular forms share many common analytical properties with the Riemann zeta-function. However, in the case of L-functions associated to half-integral weight modular forms, they do not have Euler product. In fact, it is known that Riemann Hypothesis fails for L-functions of certain modular forms of half integral weight. Neverthless, they admit infinitely many zeros on the critical line ([**K**]).

The study of arithmetic and analytic behavior of Multiple Lerch zeta functions has gained momentum due to the recent works of Brown, Deligne, Gonchrov, Hoffamann, Kaneko Nori, Teresoma, Zagier et al. In [G5], the authors extend an elegant idea of Ramanujan to establish the meromorphic continuation of these functions. Further, this method allows one to construct a "nice" set containing all possible singularities of these functions. In the particular case of multiple Hurwitz zeta functions, the authors describe the exact set of singularities.

Generalized Dold manifolds

A new class of smooth manifolds, which are higher dimensional analogues of curves and surfaces, that generalize the classical manifolds introduced by Albrecht Dold sixty years ago, were introduced and their properties studied. A research article entitled,"On generalized Dold manifolds" has been submitted for publication by Avijit Nath and P Sankaran.

Modular forms

Deligne, building upon the works of Grothendieck, Hecke, Shimura, Serre and Weil, proved Ramanujan conjecture for cusp forms of integer weight. If one uses the Shimura correspondence and then invokes Waldspurger's result on central critical Hecke L-values and squares of Fourier coefficients of modular forms of half- integral weight, then Lindelöf hypothesis in t aspect for critical values of certain Dirichlet L-sereis is equivalent to Ramanujan bound for Fourier coefficients of cusp forms of half-integer weight. So far nothing is known in this direction. In [G1], the authors investigate the "Ramanujan-conjecture" of Fourier-coefficients of cusp forms of half-integral weight and prove that in many cases such an estimate is best possible.

In [G2], the authors investigate the first sign change of the sequence

$$\{a_f(p^\alpha)a_g(p^\alpha)\}_{p^\alpha\in\mathbf{N},\alpha\leq 2},$$

where p is a prime number, $\alpha \leq 2$, $a_f(n), a_g(n)$ are n-th Fourier coefficients of newforms f, g with weights k_1, k_2 and levels N_1, N_2. Further, the authors study the non-vanishing of the sequence $\{a_f(n)a_g(n)\}_{n\in\mathbf{N}}$ and derive bounds for the first non-vanishing term in this sequence. Their results improves a recent work of Kumari and Ram Murty.

In [G4], the authors prove an omega-result for the Hecke eigenvalues $\lambda_F(n)$ of Maass forms F which are Hecke eigenforms in the space of Siegel modular forms of weight k, genus two for the Siegel modular group $Sp_2(\mathbb{Z})$. In particular, they prove that

$$\lambda_F(n) = \Omega(n^{k-1}exp(c\frac{\sqrt{\log n}}{\log\log n})),$$

when $c > 0$ is an absolute constant. This improves the earlier result of Das and the third author. The authors also show that for any $n \geq 3$, one has

$$\lambda_F(n) \leq n^{k-1}exp\left(c_1\sqrt{\frac{\log n}{\log\log n}}\right),$$

where $c_1 > 0$ is an absolute constant. This improves an earlier result of Pitale and Schmidt. The authors also prove that $\lambda_F(n) > 0$ for all n. This is an important phenomena which characterizes eigenforms in Maass space. This result was also proved by Breulmann using a different technique.

In [Ku], the authors have extended the Doi-Naganuma lifting to higher levels by following the methods of Zagier and Kohnen. The authors prove that there is a Hecke-equivarient linear map from the space of elliptic cusp forms of integer weight k, level N, $((N, D) = 1)$ to Hilbert cusp forms of weight k, level N associated to a real quadratic field of discriminant D ($D \equiv 1 \pmod 4$) with class number one. The above lifting is obtained by computing the explicit image of Poincaré series of weight k, level N for the cusp at ∞. Finally, the authors have shown that the above lifting is closely related to the D-th Shimura lift on the Kohnen plus space. This work is [Ku].

Representation Theory

In a classic paper of 1950, Gelfand and Tsetlin, constructed certain distinguished bases for representations of the Lie algebras of traceless matrices. These Lie algebras and their representations are of great importance in particle physics and in many other areas of science and engineering. This work spawned a vast body of research over the last 60 years.

The combinatorial objects parametrizing these bases are well known as "GT partterns" or just "patterns" (GT stands for Gelfand-Tsetlin). In the early 2000s, Chari, Pressley and Loktev obtained bases for representations of current algebras (associated to Lie algebras of traceless matrices), by extending the Gelfand-Tsetlin construction. Recent work done in the mathematics group at IMSc (K N Raghavan, B. Ravinder and S. Viswanath, Journal of Combinatorial Theory A, 2018 (to appear)) provides a fresh perspective on these new bases, realizing them in a manner that is closer in spirit to the original Gelfand-Tsetlin point of view.

Specifically, a new combinatorial idea, namely that of a "partition overlay" on a GT pattern is introduced. Partition overlaid patterns parametrize the new bases just as patterns parametrized the old bases.

The clarity thus brought to the topic allowed the formulation of some interesting conjectures about the asymptotic stability properties of the new bases. The conjectures have since been proved by B. Ravinder (preprint, 2017) a former doctoral student at IMSc and now an INSPIRE Faculty Fellow at CMI.

Transcendental number theory

While the distribution of the non-trivial zeros of the Riemann zeta function constitutes a central theme in Mathematics, nothing is known about the algebraic nature of these non-trivial zeros. In [**G3**], the authors study the transcendental nature of sums of the form

$$\sum_{\rho} R(\rho) x^{\rho},$$

where the sum is over the non-trivial zeros ρ of $\zeta(s)$, $R(x) \in (x)$ is a rational function over algebraic numbers and $x > 0$ is a real algebraic number. In particular, the authors show that the function

$$f(x) = \sum_{\rho} \frac{x^{\rho}}{\rho}$$

has infinitely many zeros in $(1, \infty)$, at most one of which is algebraic. The transcendence tools required for studying $f(x)$ in the range $x < 1$ seem to be different from those in the range $x > 1$. For $x < 1$, the authors have the following non-vanishing theorem: If for an integer $d \geq 1$, $f(\pi\sqrt{d}x)$ has a rational zero in $(0,\ 1/\pi\sqrt{d})$, then

$$L'(1, \chi_{-d}) \neq 0,$$

where χ_{-d} is the quadratic character associated to the imaginary quadratic field $K := (\sqrt{-d})$. Finally, the authors consider analogous questions for elements in the Selberg class. Their methods involve tools from analytic as well as transcendental number theory.

2.2.2 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**]
Arvind Ayyer*, **Amritanshu Prasad, and Steven Spallone***.
Representations of symmetric groups with non-trivial determinant.
Journal of Combinatorial Theory. Series A, **150**, 208–232, 2017.

[**A2**]
T.Geetha and Amritanshu Prasad.
Comparison of Gelfand-Tsetlin bases for alternating and symmetric groups.
Algebr. Represent. Theory, **21(1)**, 131–143, 2018.

[**B**]
Keshab Chandra Bakshi, Sayan Das*, Zhengwei Liu*, and Yunxiang Ren*.
An angle between intermediate subfactors and its rigidity.
2017.
arXiv:1710.00285 (Submitted).

[**G1**]
S. Gun and W. Kohnen*.
On the Ramanujan-Petersson conjecture for modular forms of half-integral weight.
2018.
(Submitted).

[**G2**]
S. Gun, B. Kumar, and B. Paul.
The first simultaneous sign change and non-vanishing of Hecke eigenvalues of newforms.
2018.
(Submitted).

[**G3**]
S. Gun, M. R. Murty*, and P. Rath*.
Transcendental sums related to the zeros of zeta functions.
2017.
(Submitted).

[**G4**]
S. Gun, B. Paul, and J. Sengupta*.
On Hecke eigenvalues of Siegel modular forms in the Maass space.
Forum Mathematicum, **30(3)**, 775–783, 2017.

[**G5**]
S. Gun and B. Saha*.
Multiple Lerch zeta functions and an idea of Ramanujan.
Michigan Math J., **67(2)**, 267–287, 2018.

[**G6**]
S. Gun and J. Sengupta*.
Sign changes of Fourier coefficients of Siegel cusp forms of degree two on Hecke congruence subgroups.
Int. J. Number Theory, **13(10)**, 2597, 2017.

[**K**]
Jaban Meher*, Sudhir Pujahari*, and Srinivas Kotyada.
Zeros of l functions attached to modular forms of half-integral weight.
Bull. London Math. Soc., **49**, 926, 2017.

[**Ks**]
Ram Murty M*, Srinivas K, and Subramani M*.
Admissible primes and euclidean quadratic fields.
Journal of Ramanujan Mathematical Society, 2018.
505 (To be published).

[**Ku**]
Balesh Kumar and M. Manickam*.
On Doi-Naganuma and Shimura liftings.
The Ramanujan Journal, 2017.
(To be published).

[**N**]
Avijit Nath and Parameswaran Sankaran.
On Generalized Dold Manifolds.
2017.
arXiv:1708.02418 (Submitted).

[**R1**]
S. D. Adhikari***, Anirban Mukhopadhyay, and M. Ram Murty***.
The analog of the Erdös distance problem in finite fields.
International Journal of Number Theory, **13(9)**, 2319–2333, 2017.

[**R2**]
K.N. Raghavan, B. Ravinder***, and Sankaran Viswanath**.
Comparison of Gelfand-Tsetlin bases for alternating and symmetric groups.
Journal of Combinatorial Theory. Series A, **154**, 77–113, 2018.

[**S**]
Sandipan De and Vijay Kodiyalam.
Planar algebras, cabling and the Drinfeld double.
Quantum Topology, **9(1)**, 141–165, 2018.

[**Sa**]
T. Mubeena* **and P. Sankaran**.
Twisted conjugacy and quasi-isometric rigidity of irreducible lattices in semisimple lie groups.
2018.
arxiv:1801.02105 (Submitted).

[**Sn1**]
El Mazouni A* **and Nagaraj D. S**.
Tangent bundle of $\mathbb{P}^2$ and morphism from $\mathbb{P}^2$ to $\mathrm{gr}(2, \mathbb{C}^4)$.
In Anilatmaja Aryasomayajula et all, editor, *Analytic and algebraic geometry*, page 117. Hindustan Book Agency, New Delhi., Jul 2017.

[**Sn2**]
Indranil Biswas***, Subramaniam Senthamarai Kannan*****, and D. S. Nagaraj**.
The full automorphism group of $\overline{T}$.
C. R. Math. Acad. Sci. Paris, **355(4)**, 452–454, 2017.

[**Sr1**]
R. Balasubramanian, Sumit Giri***, and Priyamvad Srivastav**.
On correlations of certain multiplicative functions.
J. Number Theory, **174**, 221, 2017.

[**Sr2**]
R. Balasubramanian and Priyamvad Srivastav.
On selberg's approximation to the twin prime problem.
Acta Arithmetica, **179**, 335, 2017.

[**Sr3**]
R. Balasubramanian and Priyamvad Srivastav.
On the number of factorizations of an integer.
J. Ramanujan Math. Soc., **32**, 417, 2017.

[**Sr4**]
Olivier Ramarè* **and Priyamvad Srivastav**.
Product of primes in arithmetic progressions.
2017.
(Submitted).

[**V**]
Sushmita Venugopalan and Guangbo Xu*.
Local model for the moduli space of affine vortices.
International Journal of Mathematics, **29(3)**, 1850020, 54pp., 2018.

2.3 Physics

2.3.1 Research Summary & Highlights

Biological Physics

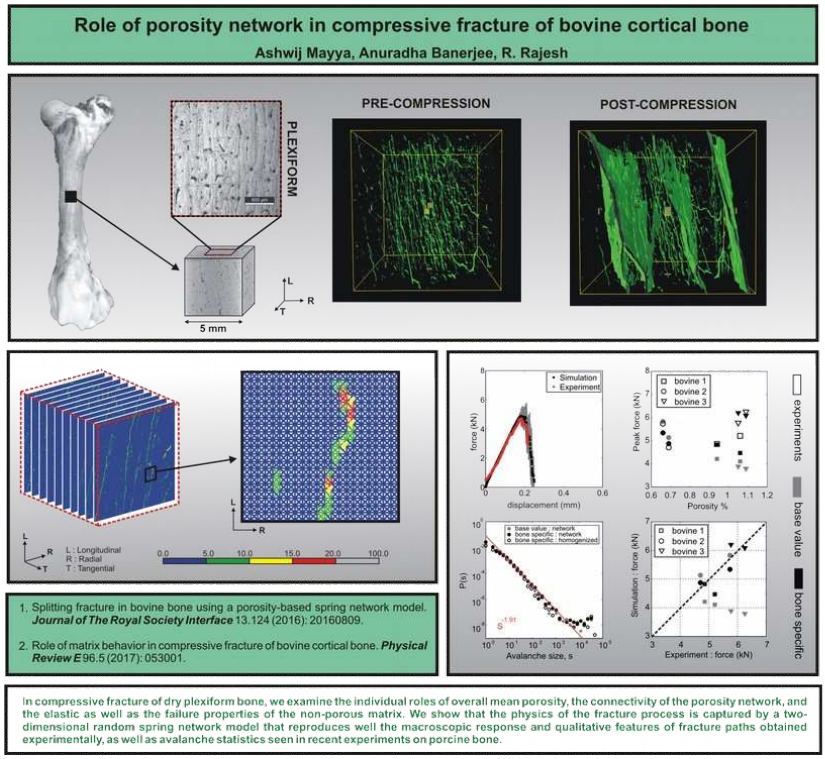

Figure 2.3: Role of porosity network in compressive fracture of bovine cortical bone

Cortical or compact bone, found in the midshaft of load-bearing bones such as femurs and tibiae, is a brittle, porous biomaterial. Being a living tissue, the local microstructure and porosity network of the cortical bone evolves in response to the mechanical stresses to which the bone is subjected, and this in turn modifies the local mechanical properties. Under-standing the relationship between microstructure

and mechanical properties is crucial for applications such as the extraction of bone grafts, in designing mechanically compatible im-plants and porous scaffolds for bone tissue engineering, in order to interpret loading history, evaluate the effectiveness of chemical and physical therapeutical measures for bone healing etc. An important aspect of this understanding is the development and testing of mod-els that incorporate microstructural features and predict material properties such as failure strength, elastic modulus, fracture paths, etc. Such models, if general enough, would also be of use in understanding failure behavior of a wider class of brittle materials with a well-defined porosity network, such as wood, rock, etc. We develop and test a discrete porosity based model that captures the physics of the fracture process of the bone and reproduces well the macroscopic response and qualitative features of experimentally obtained fracture paths, as well as avalanche statistics seen in experiments on porcine bone.

Charged Polymers

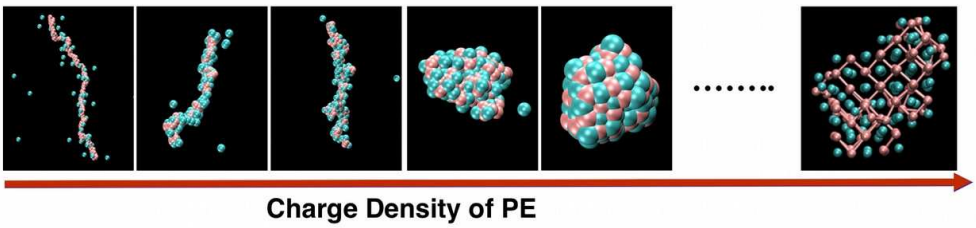

Figure 2.4: Charge Density of PE

In chemical, pharmaceutical, food and bio-industries, applications such as gene therapy, drug coating, water purification, colour removal, paper making etc., involve charged polymers in solution. The mechanical and chemical properties of these polymers depend on their conformational state which could be linear and extended, compact and collapsed or in the form of complex aggregates. The precise role of electric charge in determining the conformational properties is clarified through a combinational of large scale simulations and theoretical modelling.

Classical and Quantum Gravity, Black Holes, Cosmology

In [**Ra1**], we studied the tunneling of massless scalars across black hole horizons in any number of spacetime dimensions greater than three. Our analysis found that corrections due to backreaction and the inverse dimensional expansion are naturally concomitant, and furnished a simple proof of the classic relation between entropy and area in all spacetime dimensions, finite or infinite. We concluded with a discussion of the limit in which the number of spacetime dimensions was taken to infinity, where we found that thermodynamic quantities are related to the "thickness" of the membrane on which all the curvature is localized.

Condensed Matter Physics

We have studied the response of different disordered materials (e.g. polycrystals, glasses, gels, etc.) to perturbations of various kinds, using numerical simulations.

Plastic deformation in solids induced by external stresses is of both fundamental and practical interest. Using both phase field crystal modeling and molecular dynamics simulations, we study the shear response of monocomponent polycrystalline solids [**C3**]. We subject mesocale polycrystalline samples to constant strain rates in a planar Couette flow geometry for studying its plastic flow, in particular its grain deformation dynamics. As opposed to equilibrium solids where grain dynamics is mainly driven by thermal diffusion, external stress/strain induce a much higher level of grain deformation activity in the form of grain rotation, coalescence, and breakage, mediated by dislocations. Despite this, the grain size distribution of this driven system shows only a weak power-law correction to its equilibrium log-normal behavior. We interpret the grain reorganization dynamics using a stochastic model.

Is an active glass different from a conventional passive glass? To address this, we study the dynamics of a

dense binary mixture of soft dumbbells, each subject to an active propulsion force and thermal fluctuations [C2]. This dense assembly shows dynamical arrest, first to a translational and then to a rotational glass, as one reduces temperature T or the self-propulsion force f. We monitor the dynamics along an iso-relaxation-time contour in the (T-f) plane. We find dramatic differences both in the fragility and in the nature of dynamical heterogeneity, which characterize the onset of glass formationthe activity-induced glass exhibits large swirls or vortices, whose scale is set by activity, and it appears to diverge as one approaches the glass transition. This large collective swirling movement should have implications for collective cell migration in epithelial layers. We construct continuum hydrodynamic equations for the simulated system, and we show that the observed behavior of this growing dynamic length scale can be understood from these equations.

We have explored the nonequilibrium aging dynamics in colloidal gels, using extensive numerical simulations of a microscopic model gel [C1]. We find that gelation resulting from a kinetically arrested phase separation is accompanied by anomalous particle dynamics revealed by superdiffusive particle motion and compressed exponential relaxation of time correlation functions. Spatiotemporal analysis of the dynamics reveals intermittent heterogeneities producing spatial correlations over extremely large length scales. Our study is a microscopically resolved model reproducing all features of the spontaneous aging dynamics observed experimentally in soft materials.

Mathematical Physics

We study the number P(n) of partitions of an integer n into sums of distinct squares. Using semiclassical and quantum statistical methods, we first determine its asymptotic average part Pav(n). We derive a correction to the known leading expression which yields a faster convergence to the average values of the exact P(n). Then we focus on the oscillating part difference P(n) - Pav(n) and analyze it in the spirit of a semiclassical trace formula. From the Fourier spectrum of P(n) we obtain hints to the smallest Pythagorean triples (PT) of integers as the leading "periodic orbits". We then use a many-body expansion of the quantum statistical partition function of P(n) to demonstrate statistically the importance of PTs in the large-N limit. A semi-empirical trace formula is finally derived that reproduces the main aspects of the asymptotic P(n). This work is now being finalised.

We studied two aspects of Hecke symmetry in [Ra2]. First, we built evidence for and conjectured a generalization of the Ramanujan identities to the case of automorphic forms of Hecke groups. Second, motivated by the appearance of Hecke symmetry in an example of low-orders/low-orders resurgence, we conjectured a generalization of an inversion formula from the theory of elliptic functions.

Non-perturbative QCD, Lattice Gauge Theory, QGP

$SU(N)$ gauge theories at finite temperature allow for gauge transformations to be aperiodic along the temporal direction. The gauge transformations are periodic upto the elements of the center $Z_N \in SU(N)$. Hence all the allowed gauge transformations in this case are classified by the center Z_N. The path-integral partition function is invariant under this Z_N group which plays an important role in the confinement-deconfinment phase transition. It is conjectured that this transition is "universally equivalent" to the magnetization transition in ferromagnetic Z_N spins. The Z_N symmetry and it's implications are well understood in pure gauge theories. It is much more important to study this symmetry, in realistic theories, in the presence of fundamental matter fields. At the outset it would seem that the Z_N group is no more a symmetry in the presence of matter fields. The aperiodic gauge transformations will be in conflict with fermi/bose statistics of the matter fields. We show that for suitable bare couplings (in parts of the phase diagram), thermal fluctuations "effectively" restore the Z_N symmetry [**?**].

Nonlinear Dynamics, Solitons and Chaos

Recently, there have been many attempts to understand the collective dynamics of large, complex systems that occur in a variety of physical, biological and social contexts. Several of these studies suggest that detailed knowledge of the connection topology of a system is crucial for explaining the resulting dynamical behavior. Contrary to the expectation that complicated connection topologies are needed to generate the complex patterns observed in real-world systems, a recent study has shown that, in fact, even simple, ho-

mogeneous systems are capable of exhibiting non-trivial dynamical patterns through spontaneous symmetry breaking [**Me4**]. An important implication of this study is that certain features of the collective dynamics of complex systems can be explained even without complete knowledge of their wiring diagrams.

The study has looked at the specific example of a densely connected network of brain regions, whose collective dynamical activity correspond to large-scale patterns of neural excitation can have important physiological implications. Each node of the network is modeled using the well-known Wilson-Cowan model that describes the local aggregate activity in a brain region. A rich variety of dynamical patterns has been observed that arise through spontaneous symmetry breaking, some of which qualitatively resemble those seen using a realistic connection topology of a primate brain (indicating their relative independence from the specific details of the underlying connectivity structure). Another important observation, of particular importance to physicists, is that while the attractors of the globally coupled system are preserved if the connectivity is decreased, even a marginal deviation from this mean-field situation can radically alter the robustness of certain patterns. The study also suggest an intriguing connection between seemingly contradictory findings from two recent experiments: while the disruption of communication between areas of the cerebral cortex has been linked to loss of consciousness in one set of experiments, another study has found that the development of fatigue is accompanied by an increase in the degree of synchronization between brain areas. Taken together these results imply that decreased strength of communication between brain regions can be accompanied by increased synchronization in their activity. Although this may appear counter-intuitive, the study results demonstrate that these observations need not in fact be incompatible.

The heart is a fascinating example of nonlinear dynamics at work in biology. Disruptions in the normal rhythmic functioning of the heart, termed as arrhythmia, often result from qualitative changes in the excitation dynamics of the organ. It has recently been observed that the occurrence of sudden cardiac death has a close statistical relationship with the time of day, viz., ventricular fibrillation is most likely to occur between 12 am-6 am, with 6 pm-12 am being the next most likely period. Consequently there has been significant interest in understanding how cardiac activity is influenced by the circadian clock, i.e., temporal oscillations in physiological activity with a period close to 24 hours and synchronized with the day-night cycle. Although studies have identified the genetic basis of circadian rhythm at the intracellular level, the mechanisms by which they influence cardiac pathologies are not yet fully understood. Evidence has suggested that diurnal variations in the conductance properties of ion channel proteins that govern the excitation dynamics of cardiac cells may provide the crucial link. Recent work has investigated the relationship between the circadian rhythm as manifested in modulations of ion channel properties and the susceptibility to cardiac arrhythmias by using a mathematical model that describes the electrical activity in ventricular tissue. It shows that changes in the channel conductance that lead to extreme values for the duration of action potentials in cardiac cells can result either in abnormally high-frequency reentrant activity or spontaneous conduction block of excitation waves. Both phenomena increase the likelihood of wavebreaks that are known to initiate potentially life- threatening arrhythmias. Thus, disruptive cardiac excitation dynamics are most likely to occur in time-intervals of the day-night cycle during which the channel properties are closest to these extreme values, providing an intriguing relation between circadian rhythms and cardiac pathologies.

Strategies incorporating direct reciprocity, e.g., Tit-for-Tat and Pavlov, have been shown to be successful for playing the Iterated Prisoners Dilemma (IPD), a paradigmatic problem for studying the evolution of cooperation among non-kin individuals. However it is an open question whether such reciprocal strategies can emerge as the rational outcome of repeated interactions between selfish agents. It has been shown recently that adopting a co-action perspective, which takes into account the symmetry between agents - a relevant consideration in biological and social contexts - naturally leads to such a strategy. For a 2-player IPD, it is shown that the co-action solution corresponds to the Pavlov strategy, thereby providing a rational basis for it. For an IPD involving many players, an instance of the Public Goods game where cooperation is generally considered to be harder to achieve, it is shown that the cooperators always outnumber defectors in the co-action equilibrium. This can be seen as a generalization of Pavlov to contests involving many players. In general, repeated interactions allow rational agents to become aware of the inherent symmetry of their situation, enabling them to achieve robust cooperation through co-action strategies - which, in the case of IPD, is a reciprocal Pavlovian one.

Many complex systems that occur in biological, technological, and socioeconomic contexts are strongly influenced by the behavior of other systems. Such interdependence can result in perturbations in one system propagating to others, potentially resulting in a cascading avalanche through the network of networks. Although it has been suggested that interdependence makes the entire system fragile, a proper appraisal of the role of interdependence on the stability of complex systems necessarily needs to take into account the

dynamical processes occurring on them. Compared to a purely structural approach (such as percolation, which considers the effect of removing nodes or links), a dynamical system perspective provides a richer framework for assessing the robustness of systems. Using such a perspective it has recently been shown [Si] that strong interdependence between networks can increase the robustness of the system in terms of its dynamical stability. In particular, for a pair of networks it has been shown that there exists an optimal range of interdependence which substantially enhances the persistence probability of active nodes. By contrast, decreasing the internetwork coupling strength so that the networks are effectively independent results in a catastrophic collapse with extinction of activity in the system almost in its entirety. The increased persistence at optimal coupling is related to the appearance of attractors of the global dynamics comprising disjoint sets of stable activity. These results also suggest that the nature of internetwork interactions is a crucial determinant of the role of interdependence on the dynamical robustness of complex systems. For example, increasing the intensity of nonlinear interactions between nodes leads to loss of stability and subsequent transition to a quiescent state, while stronger diffusive coupling between the networks can make a global state corresponding to persistent activity extremely robust.

Novel Signals of New Physics

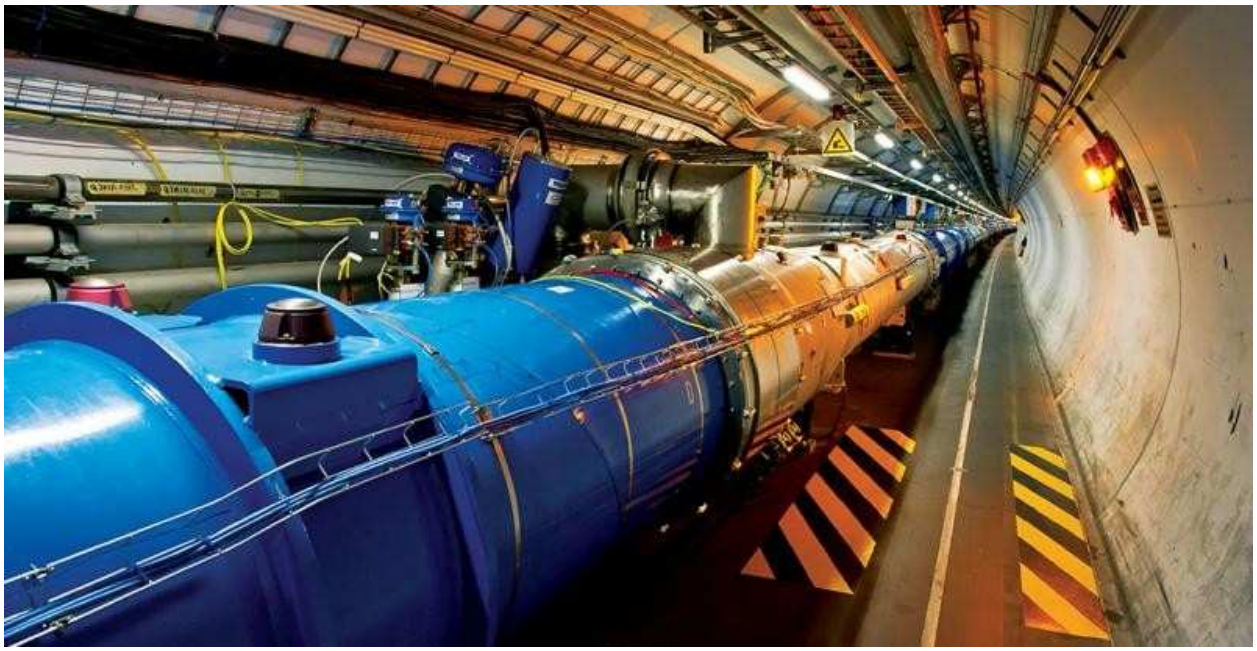

Figure 2.5: Large Hardon Collider

The standard model of particle physics is a remarkably successful theory, but questions as to its completeness remain. In recent papers, Rahul Sinha (Contact person) and students Anirban Karan, Rusa Mandal and Abinash KumarNayak have addressed the possibility of new physics (NP) beyond the Standard Model of particle physics in rare decays of beauty quarks to strange quarks and pairs of leptons.

The work by the IMSC team has been presented at a number of international particle physics conferences. Their most recent paper (with Tom Browder of the University of Hawaii, Belle II spokesperson), published in Physical Review D, fnds a 5 standard deviation signal of new physics in the angular distribution of certain decays of B particles. This work has been covered extensively by the press including in articles in the Hindu and Frontline Magazine.

Statistical Mechanics

While mainstream economic theory has been primarily concerned with the behavior of agents having complete information and perfect rationality, it is unlikely that either of these assumptions are valid in reality. This has led to the development (among others, by statistical physicists) of theories that incorporate bounded

rationality and also to the study of the role of information in economic interactions (information economics). In particular, information asymmetry, where all the agents do not have access to the same information has aroused much attention, as it has potential to significantly distort economic outcomes resulting in the failure of the market mechanism. It is often assumed that having more data than others gives agents a relative advantage in their interactions.Recent work has considered the situation where agents differ in terms of the granularity (as well as the quantity) of the information that they can access. This has been investigated in the framework of a model system comprising agents with bounded rationality competing for limited resources, viz., the minority game. It has been shown that there is no simple relation between the amount of information available to an agent and its success as measured by payoffs received by it. In particular, an agent having access to a much coarser-grained information (that is also quantitatively less) than the rest of the population can have a relative advantage under certain conditions. The work shows that the success of individual agents can depend crucially on the relative fraction of the population that uses information of a specific type.

The emergence of cooperation among selfish agents that have no incentive to cooperate is a non-trivial phenomenon that has long intrigued biologists, social scientists and physicists. The iterated Prisoners Dilemma (IPD) game provides a natural framework for investigating this phenomenon. Here, agents repeatedly interact with their opponents, and their choice to either cooperate or defect is determined at each round by knowledge of the previous outcomes. The spatial version of IPD, where each agent interacts only with their nearest neighbors on a specified connection topology, has been used to study the evolution of cooperation under conditions of bounded rationality. Recent work [**Me3**] has investigated how the collective behavior that arises from the simultaneous actions of the agents (implemented by synchronous update) is affected by (i) uncertainty, measured as noise intensity K, (ii) the payoff b, quantifying the temptation to defect, and (iii) the nature of the underlying connection topology. In particular, the phase transitions between states characterized by distinct collective dynamics that occurs as the connection topology is gradually altered from a two-dimensional lattice to a random network has been studied. This is achieved by rewiring links between agents with a probability p following the small-world network construction paradigm. On crossing a specified threshold value of b, the game switches from being Prisoners Dilemma, characterized by a unique equilibrium, to Stag Hunt, a well-known coordination game having multiple equilibria. The system can exhibit three collective states corresponding to a pair of absorbing states (viz., all agents cooperating or defecting) and a fluctuating state characterized by agents switching intermittently between cooperation and defection. As noise and temptation can be interpreted as temperature and an external field respectively, a strong analogy can be drawn between the phase diagrams of such games with that of interacting spin systems. Considering the 3-dimensional p-K-b parameter space allows one to investigate the different phase transitions that occur between these collective states and characterize them using finite-size scaling. The values of the critical exponents depend on the connection topology and are seen to be different from the Directed Percolation (DP) universality class.

Language, which allows complex ideas to be communicated through symbolic sequences, is a characteristic feature of our species and manifested in a multitude of forms. Using large written corpora for many different languages and scripts, it has recently been shown that that the occurrence probability distributions of signs at the left and right ends of words have a distinct heterogeneous nature [**As**]. Characterizing this asymmetry using quantitative inequality measures, viz. information entropy and the Gini index, it has been shown that the beginning of a word is less restrictive in sign usage than the end. This property is not simply attributable to the use of common affixes as it is seen even when only word roots are considered. The existence of this asymmetry has been used to infer the direction of writing in undeciphered inscriptions that agrees with the archaeological evidence. Unlike traditional investigations of phonotactic constraints which focus on language-specific patterns, such a study reveals a property valid across languages and writing systems. As both language and writing are unique aspects of our species, this universal signature may reflect an innate feature of the human cognitive phenomenon.

Hard squares interacting through only excluded volume interactions have been studied for a long time as the prototypical model showing columnar or striped order. Despite the long history, analytical estimates of the critical parameters are poor, off by a factor of five or more. A systematic calculation of the interfacial tension between two columnar phases is developed leading to an accurate estimate of the critical parameters for the hard square gas as well as a mixture of hard squares and dimers [**Ma**, **M2**].

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. Here, the phase diagram and nature of the phase transitions are determined for two different systems: for rods on a three dimensional cubic lattice, and for Y-shaped molecules on a triangular lattice. By implementing a cluster move, it is possible to access densities close to full packing. Both systems undergo phase transitions with increasing density, contrary to what was seen and expected up to now. The kinetics of hard rods in two dimensions is also studied [**M1**, **Vi**, **R3**].

The hard sphere system in two dimensionsional continuum is known to undergo two entropy driven transitions with increasing density: first from a liquid phase to a hexatic phase with quasi long range orientational order and second from the hexatic phase to a solid phase with quasi long range positional order and long range orientational order. The corresponding lattice problem, relevant for the study of adsorption of gas molecules onto surfaces, is not that well understood. The k-NN hard core lattice gas model in which the first k next nearest neighbour sites of a particle are excluded from occupation by other particles is studied on a two dimensional square lattice. This model is the lattice version of the hard disc system with increasing k corresponding to decreasing lattice spacing. It is shown that the lattice model will show multiple transitions only if the high density phase has columnar order. It is shown that there are only eighteen values of k, all less than k = 4134, that show columnar order, while the others show solid-like sub-lattice order [**?**].

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. Here, shock propagation in a dissipative system is studied by modelling it as a spread of disturbance in a system of initially stationary hard spheres that is driven by a continuous injection of particles at the origin. The disturbance created by the injection of energy spreads radially outward through collisions between particles. Using scaling arguments, the exponent characterizing the power-law growth of this disturbance is determined in all dimensions. The scaling functions describing the various physical quantities are determined using large-scale event-driven simulations in two and three dimensions for both elastic and inelastic systems. The results are shown to describe well the data from two different experiments on granular systems that are similarly driven [**J**].

The nature of the velocity distribution of a driven granular gas, though well studied, is unknown as to whether it is universal or not, and if universal what the distribution is. The tails of the steady state velocity distribution is determined exactly for a microscopic model for a one-component granular gas. For generic parameters, it is shown that the steady state velocity distribution is non-universal and depends strongly on the nature of driving. For specific values of the parameters, a universal distribution is obtained, but different from the distributions that have been earlier used to fit experimental data [**Pr**].

Cortical bone, found in the central part of long bones like femur, is primarily responsible for maintaining structural integrity. Cortical bone is of two types: Plexiform bone and Haversian bone. The specific role of the structure of the network of pores in bone on its fracture behaviour under compression is examined. CT scan images of the sample pre- and post- compressive failure show the existence of local weak planes formed by aligned thin long pores extending through the length. It is shown that the physics of the fracture process, for both plexiform bone and Haversian bone, is captured by a two dimensional random spring network model that reproduces well the macroscopic response and qualitative features of fracture paths obtained experimentally, as well as avalanche statistics seen in experiments on porcine bone [**R1**, **R2**].

The distribution of the sizes of particles constituting the rings of Saturn have been measured in recent as well as past voyages of spacecrafts past Saturn. These distributions have been argued to be result of a stochastic evolution of the particles though coagulation and fragmentation. Here, the asymptotic properties of the steady state mass distribution for a class of collision kernels in an aggregation-shattering model is determined in the limit of small shattering probabilities. It is shown that the asymptotic behaviour of the mass distribution may be divided into three categories depending on the asymptotic behaviour of the collision kernel. The resulting distribution is consistent with the experimentally observed distribution [**Du**].

Most biopolymers in nature are charged polymers in a neutralising solution. Understanding the dependence of the equilibrium phases and the dynamics of the process of aggregation on parameters such as backbone flexibility and charge density of such polymers is crucial for insights into various biological processes which involve biological polyelectrolytes such as protein, DNA etc. Using large-scale coarse-grained molecular dynamics simulations, the phase diagram of the aggregated structures of flexible charged polymers in the presence of trivalent counterions is determined, while the detailed morphology of the aggregates as well as the aggregation dynamics are characterized quantitatively. Three different phases are observed depending on the charge density: no aggregation, a finite bundle phase where multiple small aggregates coexist with a

large aggregate, and a fully phase separated phase [T1].

String Theory

A Holographic form of Wilsonian RG was formulated and it was shown that it reproduced results known from the AdS/CFT correspondence. [S]

This work is being extended to a non trivial fixed point in $4-$ dimensions - the Wilson-Fisher fixed point. The Wilson action for this is worked out. The anomalous dimension information can be incorporated and the two point function calculated using the mapping to AdS.

In the context of small string quantisation in curved space two problems have been attempted. Both of them are work-in-progress. The tubular geometry of loop space was earlier computed from a finite dimensional cut-off space that can naturally be interpreted as the relativistic configuration space of an odd number (N) of string-bits. A dynamical model for the bits has been proposed which shares certain symmetries of the original worldsheet. In particular, it admits a set of constraints that approach to the set of Virasoro constraints in the large-N limit. A successful quantisation of this model will be an example of a fully relativistic finite model of bound state. It is also straightforward to couple this model to an arbitrary curved space following a procedure developed earlier in the same context. This can be viewed as a lattice regularisation of the original worldsheet theory. A discrete version of the complex analysis has been developed with the hope of finding its application in the aforementioned quantisation. However, its use has so far been found to be limited. More efficient methods of constraint analysis are being explored.

Polyakov path integral corresponding to small string quantisation in curved space has a non-trivial measure. Certain treatment for such a measure for worldliness theories has been pursued earlier by other authors using ghost variables. However, the procedure is not unique. Work is in progress to define the measure suitably so that a semi-classical (α') expansion of the worldsheet theory can be performed.

Supersymmetric defects have been studied in four and five dimensional gauge theories. These defects have many avatars: one description is in terms of monodromy defects, in which the bulk gauge fields have a non-trivial monodromy around the defect. Another is as coupled 2d/4d (or 3d5d) quiver gauge theories. In the papers [A1, A2], we clarified the precise relation between the different descriptions by calculating the low energy effective action on the defect and matching them across the two descriptions.

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**]
Sujay K. Ashok, Marco Billo*, Eleonora DellAquila*, Marialuisa Frau*, Varun Gupta, Renjan R. John, and Alberto Lerda*.
Surface operators, chiral rings and localization in n=2 gauge theories.
Journal of High Energy Physics, **11(1711)**, 137, 2017.

[**A2**]
Sujay K. Ashok, Marco Billo*, Eleonora DellAquila, Marialuisa Frau*, Varun Gupta, Renjan R. John*, and Alberto Lerda*.
Surface operators in 5d gauge theories and duality relations.
Journal of High Energy Physics, 2017.
1712.06946 (Submitted).

[**As**]
Md Izhar Ashraf and Sitabhra Sinha.

The handedness of language: Directional symmetry breaking of sign usage in words.
PLOS ONE, **13(1)**, e0190735, 2018.

[**B**]
J. Martinez*, **K. Stovall***, **P. Freire***, **J. Deneva***, **T. Tauris***, **A. Ridolfi***, **N. Wex***, **F. Jenet***, **M. McLaughlin***, **and M. Bagchi**.
Pulsar J1411+2551: A low-mass double neutron star system.
The Astrophysical Journal Letters, **851(2)**, L29, 2017.

[**Ba1**]
Manjari Bagchi.
Prospects of constraining the dense matter equation of state from the timing analysis of pulsars in double neutron star binaries: the cases of PSR J0737-3039A and PSR J1757-1854.
In Alexandra Friesen David Blaschke, Alexander Ayriyan and Hovik Grigorian, editors, *Universe, 2018, 4(2); dedicated to the conference: "Compact Stars in the QCD Phase Diagram VI" held at The Joint Institute for Nuclear Research (JINR), Dubna, Russia; during 26 - 29 September, 2017*, page 36. MDPI, Feb 2018.

[**Ba2**]
Manjari Bagchi.
A unified model for repeating and non-repeating Fast Radio Bursts.
The Astrophysical Journal Letter, **838**, L16, 2017.

[**Bi**]
Minati M. Biswal, Mridupawan D. Deka*, **Sanatan D. Digal, and P.S. D. Saumia**.
Confinement-deconfinement transition in su(2) higgs theory.
Phys. ReV. D, **96(1)**, 014503, 2017.

[**C1**]
Pinaki Chaudhuri and Ludovic Berthier*.
Ultra-long-range dynamic correlations in a microscopic model for aging gels.
Physical Review E, **95**, 060601, 2017.

[**C2**]
Rituparno Mandal*, **Pranab J. Bhuyan***, **Pinaki Chaudhuri, Madan Rao***, **and Chandan Dasgupta***.
Glassy swirls of active dumbbells.
Phys. Rev. E, **96**, 042605, 2017.

[**C3**]
Tanmoy Sarkar*, **Santidan Biswas***, **Pinaki Chaudhuri, and Anirban Sain***.
Grain size distribution in sheared polycrystals.
Physical Review Materials, **1**, 070601, 2017.

[**D**]
Ghanashyam Date and Sk. Jahanur Hoque.
Cosmological horizon and the quadrupole formula in de sitter background.
Phys. Rev. D, **96**, 044026, 2017.

[**Du**]
C. Connaughton*, **A. Dutta, R. Rajesh, N. Siddharth, and O. Zaboronski***.
Stationary mass distribution and non-locality in models of coalescence and shattering.
Physical Review E, **97**, 022137, 2018.

[**J**]
J. Joy, S. N. Pathak*, **D. Das***, **and R. Rajesh**.

Shock propagation in locally driven granular systems.
Physical Review E, **96**, 032908, 2017.

[**M1**]
D. Mandal, T. Nath*, and R. Rajesh.
Phase transitions in a system of hard y-shaped particles on the triangular lattice.
Physical Review E, **97**, 032131, 2018.

[**M2**]
D. Mandal and R. Rajesh.
The columnar-disorder phase boundary in a mixture of hard squares and dimers.
Physical Review E, **96**, 012140, 2017.

[**Ma**]
Dipanjan Mandal, Trisha Nath*, and R. Rajesh.
Estimating the critical parameters of the hard square lattice gas model.
Journal of Statistical Mechanics, **2017**, 043201, 2017.

[**Me1**]
Shakti N. Menon, Trilochan Bagarti, and Abhijit Chakraborty.
Jamming in a lattice model of stochastically interacting agents with a field of view.
Europhysics Letters, **117**, 50007, 2017.

[**Me2**]
Shakti N. Menon, Cameron L. Hall*, Scott W. McCue*, and Sean McElwain*.
A model for one-dimensional morphoelasticity and its application to fibroblast-populated collagen lattices.
Biomechanics and Modeling in Mechanobiology, **16(5)**, 1743, 2017.

[**Me3**]
Shakti N. Menon, V. Sasidevan*, and Sitabhra Sinha.
Emergence of cooperation as a non-equilibrium transition in noisy spatial games.
Frontiers in Physics, 2018.
(To be published).

[**Me4**]
Varsha Sreenivasan*, Shakti N. Menon, and Sitabhra Sinha.
Emergence of coupling-induced oscillations and broken symmetries in heterogeneously driven nonlinear reaction networks.
Scientific Reports, **7**, 1594, 2017.

[**Mi**]
Tanmay Mitra, Shakti N. Menon, and Sitabhra Sinha.
Emergent memory in cell signaling: Persistent adaptive dynamics in cascades can arise from the diversity of relaxation time-scales.
2018.
(Preprint: 1801.04057).

[**Mu**]
Johann Bartel*, Rajat K. Bhaduri*, Matthias Brack*, and M. Murthy.
On the asymptotic prime partitions of integers.
Physical Review E, **95**, 052108, 2017.

[**P**]
Varuni Prabhakar, Shakti N. Menon, and Gautam I. Menon.

Phototaxis as a collective phenomenon in cyanobacterial colonies.
Scientific Reports, **7**, 17799, 2017.

[**Pr**]
V. V. Prasad and R. Rajesh.
Asymptotic behavior of the velocity distribution of driven inelastic one-component granular gases: exact results.
Physical Review E, 2018.
arXiv:1803.11031 (Submitted).

[**R1**]
A. Mayya*, A. Banerjee*, and R. Rajesh.
On role of matrix behavior in compressive fracture of bovine cortical bone.
Physical Review E, **96**, 053001, 2017.

[**R2**]
Ashwij Mayya*, Anuradha Banerjee*, and R. Rajesh.
Role of porosity and matrix behavior on compressive fracture of haversian bone using random spring network model.
Journal of the Mechanical Behavior of Biomedical Materials, 2018.
(To Appear).

[**R3**]
S. Patra*, D. Das*, R. Rajesh, and M. K. Mitra*.
Diffusion dynamics and steady states of systems of hard rods on the square lattice.
Physical Review E, **97**, 022108, 2018.

[**Ra1**]
Madhusudhan Raman.
Horizon tunneling revisited: the case of higher dimensional black holes.
Journal of High Energy Physics, **2017(12)**, 144, 2017.

[**Ra2**]
Madhusudhan Raman.
Aspects of Hecke symmetry: Generalized Ramanujan identities and a universal inversion formula.
2018.
(Preprint: arXiv:1803.10224).

[**S**]
B. Sathiapalan and Hidenori Sonoda*.
A holographic form for wilson's rg.
Nucl.Phys. B924 (2017), **B924**, 603, 2017.

[**Sh**]
Anupama Sharma, Shakti N. Menon, Sasidevan Vijayakumar*, and Sitabhra Sinha.
Epidemic prevalence information on social networks mediates emergent collective outcomes in voluntary vaccine schemes.
2017.
(Preprint: 1709.07674).

[**Si**]
Rishu K. Singh* and Sitabhra Sinha.
Optimal interdependence enhances the dynamical robustness of complex systems.
Physical Review E, **96(2)**, 020301(R), 2017.

[**T1**]
A. M. Tom, R. Rajesh, and Satyavani Vemparala.
Aggregation of flexible polyelectrolytes: Phase diagram and dynamics.
Journal of Chemical Physics, **147**, 144903, 2017.

[**T2**]
A. M. Tom, Satyavani Vemparala, R. Rajesh, and N.V. Brilliantov*.
Regimes of strong electrostatic collapse of a highly charged polyelectrolyte in a poor solvent.
Soft Matter, **13**, 1862, 2017.

[**V1**]
Upayan Baul* and Satyavani Vemparala.
Influence of lipid composition of model membranes on methacrylate antimicrobial polymer - membrane interactions.
Soft Matter, **13**, 7665, 2017.

[**V2**]
Haruko Takahashi*, Gregory Caputo*, Satyavani Vemparala, and Kenichi Kuroda*.
Synthetic random copolymers as a molecular platform to mimic host-defense antimicrobial peptides.
Bioconjugate Chemistry, **28**, 1340, 2017.

[**Vi**]
N. Vigneshwar, D. Dhar*, and R. Rajesh.
Different phases of a system of hard rods on three dimensional cubic lattice.
Journal of Statistical Mechanics, **2017**, 113304, 2017.

2.4 Theoretical Computer Science

2.4.1 Research Summary & Highlights

Algorithms and Data Structures

In parameterized complexity each problem instance comes with a parameter k and the parameterized problem is said to admit a *polynomial kernel* if there is a polynomial time algorithm (the degree of polynomial is independent of k), called a *kernelization* algorithm, that reduces the input instance down to an instance with size bounded by a polynomial $p(k)$ in k, while preserving the answer. This reduced instance is called a $p(k)$ *kernel* for the problem. If $p(k) = O(k)$, then it is called a *linear kernel*. A central notion in parameterized complexity is *fixed parameter tractability (FPT)*, which means, for a given instance (x, k), solvability in time $f(k) \cdot p(|x|)$, where f is an arbitrary function of k and p is a polynomial in the input size.

In [**As2**] we studied the parameterized complexity of Minimum Volume Packing and Strip Packing. In the two dimensional version the input consists of a set of rectangles S with integer side lengths. In the Minimum Volume Packing problem, given a set of rectangles S and a number k, the goal is to decide if the rectangles can be packed in a bounding box of volume at most k. In the Strip Packing problem we are given a set of rectangles S, numbers W and k; the objective is to find if all the rectangles can be packed in a box of dimensions $W \times k$. We proved that the 2-dimensional Volume Packing is in FPT by giving an algorithm that runs in $(2 \cdot \sqrt{2})^k \cdot k^{O(1)}$ time. We also showed that Strip Packing is W[1]-hard even in two dimensions and gave an FPT algorithm for a special case of Strip Packing. Some of our results hold for the problems defined in higher dimensions as well.

In [**As3**] we investigated the parameterized complexity of Generalized Red Blue Set Cover (Gen-RBSC), a generalization of the classic Set Cover problem and the more recently studied Red Blue Set Cover problem. Given a universe U containing b blue elements and r red elements, positive integers k_ℓ and k_r, and a family $\mathcal{F}$ of ℓ sets over U, the Gen-RBSC problem is to decide whether there is a subfamily

$\mathcal{F}' \subseteq \mathcal{F}$ of size at most k_ℓ that covers all blue elements, but at most k_r of the red elements. This generalizes Set Cover and thus in full generality it is intractable in the parameterized setting. In this paper, we study a geometric version of this problem, called Gen-RBSC-lines, where the elements are points in the plane and sets are defined by lines. We studied this problem for an array of parameters, namely, k_ℓ, k_r, r, b, and ℓ, and all possible combinations of them. For all these cases, we either proved that the problem is W-hard or showed that the problem is fixed parameter tractable (FPT). In particular, on the algorithmic side, our study showed that a combination of k_ℓ and k_r gave rise to a nontrivial algorithm for Gen-RBSC-lines. On the hardness side, we showed that the problem is para–hard when parameterized by k_r, and W[1]-hard when parameterized by k_ℓ. Finally, for the combination of parameters for which Gen-RBSC-lines admited FPT algorithms, we ask for the existence of polynomial kernels. We were able to provide a complete kernelization dichotomy by either showing that the problem admits a polynomial kernel or that it does not contain a polynomial kernel unless $\mathsf{CoNP} \subseteq \mathsf{NP/poly}$.

In the Survivable Network Design Problem (SNDP), the input is an edge-weighted (di)graph G and an integer r_{uv} for every pair of vertices $u, v \in V(G)$. The objective is to construct a subgraph H of minimum weight which contains r_{uv} edge-disjoint (or node-disjoint) u-v paths. This is a fundamental problem in combinatorial optimization that captures numerous well-studied problems in graph theory and graph algorithms. Consequently, there is a long line of research into exact-polynomial time algorithms as well as approximation algorithms for various restrictions of this problem. An important restriction of this problem is one where the connectivity demands are the same for every pair of vertices.

In [Mi1], we first considered the edge-connectivity version of this problem which we call λ-Edge Connected Subgraph (λ-ECS). In this problem, the input is a λ-edge connected (di)graph G and an integer k and the objective is to check whether G contains a spanning subgraph H that is also λ-edge connected and H excludes *at least* k edges of G. In other words, we are asked to compute a maximum subset of edges, of cardinality at least k, which may be safely deleted from G without affecting its connectivity. If we replace λ-edge connectivity with λ-vertex connectivity we get the λ-Vertex Connected Subgraph (λ-VCS) problem.

We showed that λ-ECS is fixed-parameter tractable (FPT) for both graphs and digraphs even if the (di)graph has non-negative real weights on the edges and the objective is to exclude from H, some edges of G whose total weight exceeds a prescribed value. In particular, we designed an algorithm for the weighted variant of the problem with running time $2^{\mathcal{O}(k \log k)}|V(G)|^{\mathcal{O}(1)}$. We followed up on this result and obtained a polynomial compression for λ-ECS on unweighted graphs. As a direct consequence of our results, we obtained the first FPT algorithm for the parameterized version of the classical Minimum Equivalent Digraph problem. We also showed that λ-VCS is FPT on digraphs; however the problem on undirected graphs remains open. Finally, we complemented our algorithmic findings by showing that SNDP is W[1]-hard for both arc and vertex connectivity versions on digraphs. The core of our algorithms is composed of new combinatorial results on connectivity in digraphs and undirected graphs.

Seymour's decomposition theorem for regular matroids is a fundamental result with a number of combinatorial and algorithmic applications. In this work we demonstrate how this theorem can be used in the design of parameterized algorithms on regular matroids. In [S7], we considered the problem of covering a set of vectors of a given finite dimensional linear space (vector space) by a subspace generated by a set of vectors of minimum size. Specifically, in the Space Cover problem, we are given a matrix M and a subset of its columns T; the task is to find a minimum set F of columns of M disjoint with T such that the linear span of F contains all vectors of T. For graphic matroids this problem is essentially Steiner Forest and for cographic matroids this is a generalization of Multiway Cut.

Our main result was the algorithm with running time $2^{\mathcal{O}(k)} \cdot ||M||^{\mathcal{O}(1)}$ solving in the case when M is a totally unimodular matrix over rationals, where k is the size of F. In other words, we showed that on regular matroids the problem is fixed-parameter tractable parameterized by the rank of the covering subspace.

Max-Cut (MC), Edge Dominating Set (EDS), Graph Coloring (GC) and Hamiltonian Path (HP) on graphs of bounded cliquewidth have received significant attention as they can be formulated in MSO_2 (and therefore have linear-time algorithms on bounded treewidth graphs by the celebrated Courcelle's theorem), but cannot be formulated in MSO_1 (which would have yielded linear-time algorithms on bounded cliquewidth graphs by a well-known theorem of Courcelle, Makowsky, and Rotics). Each of these problems can be solved in time $g(k)n^{f(k)}$ on graphs of cliquewidth k. Fomin et al. [*Intractability of Clique-Width Parameterizations. SIAM J. Comput. 39(5): 1941-1956 (2010)*] showed that the running times cannot be improved to $g(k)n^{\mathcal{O}(1)}$

assuming W[1]≠FPT. However, this did not rule out non-trivial improvements to the exponent $f(k)$ in the running times. In a follow-up paper, Fomin et al. [*Almost Optimal Lower Bounds for Problems Parameterized by Clique-Width. SIAM J. Comput. 43(5): 1541-1563 (2014)*] improved the running times for EDS and MC to $n^{\mathcal{O}(k)}$, and proved $g(k)n^{o(k)}$ lower bounds for EDS, MC and HP assuming the ETH. Recently, Bergougnoux, Kanté and Kwon [*WADS 2017*] gave an $n^{\mathcal{O}(k)}$-time algorithm for HP. Thus, prior to [**S14**], EDS, MC and HP were known to have tight $n^{\Theta(k)}$ algorithmic upper and lower bounds. In contrast, GC had an upper bound of $n^{\mathcal{O}(2^k)}$ and a lower bound of merely $n^{o(\sqrt[4]{k})}$ (implicit from the W[1]-hardness proof). In [**S14**], we closed the gap for GC by proving a lower bound of $n^{2^{o(k)}}$. This showed that GC behaves qualitatively different from the other three problems. To the best of our knowledge, GC was the first natural problem known to require exponential dependence on the parameter in the exponent of n.

In varied real-life situations, ranging from carpooling to workload delegation, several activities are to be performed, to which end each activity should be assigned to a group of agents. These situations are captured by the Group Activity Selection Problem (GASP). Notably, relevant relations among agents, such as acquaintanceship or physical distance, can often be modeled naturally using graphs. To exploit this modeling ability, Igarashi, Peters and Elkind [AAAI 17] introduced (ggasp). Specifically, it is required that each group would correspond to a connected set of the underlying graph. In addition, to enforce the execution of the activities in practice, no individual should desire to desert its group in favor of joining another group. In other words, the assignment should be Nash stable. In [**Ro1**], we studied (ggasp) with Nash stability (gNSGA), whose objective was to compute such an assignment. This problem is computationally hard even on such restricted topologies as paths and stars, which naturally led Igarashi, Bredereck, Peters and Elkind [AAAI 17, AAMAS 17] to the study (gNSGA) in the framework of parameterized complexity. We took this line of investigation forward, significantly advancing the state-of-the-art. First, we showed that (gNSGA) is NP-hard *even when merely one activity is present*. In fact, this special case remained NP-hard when we further restricted the graph to have maximum degree $\Delta = 5$. Consequently, (gNSGA) is not fixed-parameter tractable (FPT), or even XP, when parameterized by $p + \Delta$, where p is the number of activities. However, we were able to design a parameterized algorithm for (gNSGA) on *general graphs* with respect to $p + \Delta + t$, where t is the maximum size of a group. Finally, we developed an algorithm that solved (gNSGA) on graphs of tw in time $4^p \cdot (n + p)^{(\mathbf{tw})}$. Here, $\Delta + t$ can be arbitrarily large. Along the way, we resolved several open questions regarding (gNSGA).

In [**S18**], we gave a fixed-parameter tractable algorithm that, given a parameter k and two graphs G_1, G_2, either concluded that one of these graphs has treewidth at least k, or determined whether G_1 and G_2 are isomorphic. The running time of the algorithm on an n-vertex graph is $2^{\mathcal{O}(k^5 \log k)} \cdot n^5$, and this was the first fixed-parameter algorithm for Subgraph Isomorphismparameterized by treewidth. Our algorithm in fact solved the more general *canonization* problem. We namely designed a procedure working in $2^{\mathcal{O}(k^5 \log k)} \cdot n^5$ time that, for a given graph G on n vertices, either concludes that the treewidth of G is at least k, or:

1. finds in an isomorphic-invariant way a graph $\mathfrak{c}(G)$ that is isomorphic to G;
2. finds an isomorphism-invariant *construction term* — an algebraic expression that encodes G together with a tree decomposition of G of width less than k.

Hence, the isomorphism test reduced to verifying whether the computed isomorphic copies or the construction terms for G_1 and G_2 are equal.

The family of judicious partitioning problems, introduced by Bollobás and Scott to the field of extremal combinatorics, has been extensively studied from a structural point of view for over two decades. This rich realm of problems aims to counterbalance the objectives of classical partitioning problems such as Min Cut, Min Bisection and Max Cut. While these classical problems focus solely on the minimization/maximization of the number of edges crossing the cut, judicious (bi)partitioning problems ask the natural question of the minimization/maximization of the number of edges lying in the (two) sides of the cut. In particular, Judicious Bipartition (JB) seeks a bipartition that is "judicious" in the sense that neither side is burdened by too many edges, and Balanced JB also requires that the sizes of the sides themselves are "balanced" in the sense that neither of them is too large. Both of these problems were defined in the work by Bollobás and Scott, and have received notable scientific attention since then. In [**S6**], we shed light on the study of judicious partitioning problems from the viewpoint of algorithm design. Specifically, we prove that BJB is FPT (which also proves that JB is FPT).

The b-chromatic number of a graph G, $\chi_b(G)$, is the largest integer k such that G has a k-vertex coloring

with the property that each color class has a vertex adjacent to at least one vertex in each of the other color classes. In the b-Chromatic Number problem, the objective is to decide whether $\chi_b(G) \geq k$. In [P2], we showed that b-Chromatic Number is W[1]-hard when parameterized by k, resolving an open question posed by Havet and Sampaio (Algorithmica-2013). When $k = \Delta(G) + 1$, we designed an algorithm running in time $2^{O(k^2 \log k)}|V(G)|^{O(1)}$. Finally, we showed that b-Chromatic Number for an n-vertex graph can be solved in time $O(3^n n^4 \log n)$.

In [R] we studied a generalization of classic Feedback Vertex Set problem in the realm of multivariate complexity analysis. We say that a graph F is an l-forest if we can delete at most l edges from F to get a forest. That is, F is at most l edges away from being a forest. In this paper we introduced the Almost Forest Deletion problem, where given a graph G and integers k and l, the question is whether there exists a subset of at most k vertices such that its deletion leaves us an l-forest. We showed that this problem admits an algorithm with running time $2^{O(k+l)}n^{O(1)}$ and a kernel of size $O(kl(k+l))$. We also showed that the problem admits a $2^{O(tw)}n^{O(1)}$ algorithm on bounded treewidth graphs, using which we designed a subexponential algorithm for the problem on planar graphs.

The $\mathcal{F}$-Minor-Free Deletion problem asks, for a fixed set $\mathcal{F}$ and an input consisting of a graph G and integer k, whether k vertices can be removed from G such that the resulting graph does not contain any member of $\mathcal{F}$ as a minor. Fomin et al. (FOCS 2012) showed that the special case when $\mathcal{F}$ contains at least one planar graph has a kernel of size $f(\mathcal{F}) \cdot k^{g(\mathcal{F})}$ for some functions f and g. They left open whether this Planar -Minor-Free Deletion problem has kernels whose size is uniformly polynomial, of the form $f(\mathcal{F}) \cdot k^c$ for some universal constant c. In [S1], we proved that some Planar -Minor-Free Deletion problems do not have uniformly polynomial kernels (unless $\mathsf{NP} \subseteq \mathsf{coNP/poly}$), not even when parameterized by the vertex cover number. On the positive side, we considered the problem of determining whether k vertices can be removed to obtain a graph of treedepth at most η. We proved that this problem admits uniformly polynomial kernels with $\mathcal{O}(k^6)$ vertices for every fixed η.

In the Directed Feedback Vertex Set (DFVS) problem, we are given a digraph D on n vertices and a positive integer k and the objective is to check whether there exists a set of vertices S of size at most k such that $F = D \setminus S$ is a directed acyclic graph. In a recent paper, Mnich and van Leeuwen [*STACS 2016*] considered the kernelization complexity of DFVS with an additional restriction on F, namely that F must be an out-forest (Out-Forest Vertex Deletion Set), an out-tree (Out-Tree Vertex Deletion Set), or a (directed) pumpkin (Pumpkin Vertex Deletion Set). Their objective was to shed some light on the kernelization complexity of the DFVS problem, a well known open problem in the area of Parameterized Complexity. In [S15], we improved the kernel sizes of Out-Forest Vertex Deletion Set from $O(k^3)$ to $O(k^2)$ and of Pumpkin Vertex Deletion Set from $O(k^{18})$ to $O(k^3)$. We also proved that the former kernel size is tight under certain complexity theoretic assumptions.

In [S17] we gave the first linear kernels for the Dominating Set and Connected Dominating Set problems on graphs excluding a fixed graph H as a topological minor. In other words, we proved the existence of polynomial time algorithms that, for a given H-topological-minor-free graph G and a positive integer k, output an H-topological-minor-free graph G' on $\mathcal{O}(k)$ vertices such that G has a (connected) dominating set of size k if and only if G' has one.

Our results extended the known classes of graphs on which the Dominating Set and Connected Dominating Set problems admit linear kernels. Prior to our work, it was known that these problems admit linear kernels on graphs excluding a fixed apex graph H as a minor. Moreover, for Dominating Set, a kernel of size $k^{c(H)}$, where $c(H)$ is a constant depending on the size of H, follows from a more general result on the kernelization of Dominating Set on graphs of bounded degeneracy. Alon and Gutner explicitly asked whether one can obtain a linear kernel for Dominating Set on H-minor-free graphs. We answered this question in the affirmative and in fact proved a more general result. For Connected Dominating Set no polynomial kernel even on H-minor-free graphs was known prior to our work. On the negative side, it is known that Connected Dominating Set on 2-degenerated graphs does not admit a polynomial kernel unless $\mathsf{coNP} \subseteq \mathsf{NP/poly}$.

Our kernelization algorithm was based on a non-trivial combination of the following ingredients

- The structural theorem of Grohe and Marx [STOC 2012] for graphs excluding a fixed graph H as a topological minor;
- A novel notion of protrusions, different than the one defined in [FOCS 2009];

- Our results were based on a generic reduction rule that produces an equivalent instance (in case the input graph is H-minor-free) of the problem, with treewidth $\mathcal{O}(\sqrt{k})$. The application of this rule in a divide-and-conquer fashion, together with the new notion of protrusions, gave us the linear kernels.

A protrusion in a graph [FOCS 2009] is a subgraph of constant treewidth which is separated from the rest of the graph by at most a constant number of vertices. In our variant of protrusions, instead of stipulating that the subgraph be of constant *treewidth*, we ask that it contains a *constant number of vertices from a solution*. We believe that this new take on protrusions would be useful for other graph problems and in different algorithmic settings.

In [S9], we considered four well-studied NP-complete packing/covering problems on graphs: Feedback Vertex Set in Tournaments (FVST), Cluster Vertex Deletion (CVD), Triangle Packing in Tournaments (TPT) and Induced P_3-Packing. For these four problems kernels with $\mathcal{O}(k^2)$ vertices have been known for a long time. In fact, such kernels can be obtained by interpreting these problems as finding either a packing of k pairwise disjoint sets of size 3 (3) or a hitting set of size at most k for a family of sets of size at most 3 (3). In this paper, we gave the first kernels for FVST, CVD, TPT and Induced P_3-Packing with a subquadratic number of vertices. Specifically, we obtained the following results.

- FVST admits a kernel with $\mathcal{O}(k^{\frac{3}{2}})$ vertices.
- CVD admits a kernel with $\mathcal{O}(k^{\frac{5}{3}})$ vertices.
- TPT admits a kernel with $\mathcal{O}(k^{\frac{3}{2}})$ vertices.
- Induced P_3-Packing admits a kernel with $\mathcal{O}(k^{\frac{5}{3}})$ vertices.

Our results resolved an open problem from WorKer 2010 on the existence of kernels with $\mathcal{O}(k^{2-\epsilon})$ vertices for FVST and CVD. All of our results were based on novel uses of old and new "expansion lemmas", and a weak form of crown decomposition where (i) *almost all* of the head is used by the solution (as opposed to *all*), (ii) *almost none* of the crown is used by the solution (as opposed to *none*), and (iii) if H is removed from G, then there is *almost no* interaction between the head and the rest (as opposed to *no* interaction at all).

In [S2] we proposed a new framework for analyzing the performance of preprocessing algorithms. Our framework built on the notion of kernelization from parameterized complexity. However, as opposed to the original notion of kernelization, our definitions combine well with approximation algorithms and heuristics. The key new definition was that of a polynomial size α-approximate kernel. Loosely speaking, a polynomial size α-approximate kernel is a polynomial time pre-processing algorithm that takes as input an instance (I, k) to a parameterized problem, and outputs another instance (I', k') to the same problem, such that $|I'| + k' \leq k^{\mathcal{O}(1)}$. Additionally, for every $c \geq 1$, a c-approximate solution s' to the pre-processed instance (I', k') can be turned in polynomial time into a $(c \cdot \alpha)$-approximate solution s to the original instance (I, k).

Our main technical contribution were α-approximate kernels of polynomial size for three problems, namely Connecte Vertex Cover, Cycle Packing and Disjoint Factor. These problems are known not to admit any polynomial size kernels unless unless $\mathsf{NP} \subseteq \mathsf{coNP/poly}$. Our approximate kernels simultaneously beat both the lower bounds on the (normal) kernel size, and the hardness of approximation lower bounds for all three problems. On the negative side we proved that parameterized by the length of the path and Set Cover parameterized by the universe size do not admit even an α-approximate kernel of polynomial size, for any $\alpha \geq 1$, unless $\mathsf{NP} \subseteq \mathsf{coNP/poly}$. In order to prove this lower bound we needed to combine in a non-trivial way the techniques used for showing kernelization lower bounds with the methods for showing hardness of approximation.

In [S4] we gave algorithms with running time $2^{\mathcal{O}(\sqrt{k}\log k)} \cdot n^{\mathcal{O}(1)}$ for the following problems. Given an n-vertex unit disk graph G and an integer k, decide whether G contains

- a path on exactly/at least k vertices,
- a cycle on exactly k vertices,
- a cycle on at least k vertices,
- a feedback vertex set of size at most k, and
- a set of k pairwise vertex-disjoint cycles.

For the first three problems, no subexponential time parameterized algorithms were previously known. For the remaining two problems, our algorithms significantly outperformed the previously best known parameterized algorithms that ran in time $2^{\mathcal{O}(k^{0.75}\log k)} \cdot n^{\mathcal{O}(1)}$. Our algorithms were based on a new kind of tree decompositions of unit disk graphs where the separators can have size up to $k^{\mathcal{O}(1)}$ and there exists a solution that crosses every separator at most $\mathcal{O}(\sqrt{k})$ times. The running times of our algorithms were optimal up to the $\log k$ factor in the exponent, assuming the Exponential Time Hypothesis.

A subfamily $\mathcal{F}'$ of a set family $\mathcal{F}$ is said to *q-represent* $\mathcal{F}$ if for every $A \in \mathcal{F}$ and B of size q such that $A \cap B = \emptyset$ there exists a set $A' \in \mathcal{F}'$ such that $A' \cap B = \emptyset$. Recently, we provided an algorithm that for a given family $\mathcal{F}$ of sets of size p together with an integer q, efficiently computes a q-representative family $\mathcal{F}'$ of $\mathcal{F}$ of size approximately $\binom{p+q}{p}$. In [**P1**], we considered the efficient computation of q-representative families for *product* families $\mathcal{F}$. A family $\mathcal{F}$ is a product family if there exist families $\mathcal{A}$ and $\mathcal{B}$ such that $\mathcal{F} = \{A \cup B \ : \ A \in \mathcal{A}, B \in \mathcal{B}, A \cap B = \emptyset\}$. Our main technical contribution was an algorithm which given $\mathcal{A}$, $\mathcal{B}$ and q computes a q-representative family $\mathcal{F}'$ of $\mathcal{F}$. The running time of our algorithm was *sublinear* in $|\mathcal{F}|$ for many choices of $\mathcal{A}$, $\mathcal{B}$ and q which occur naturally in several dynamic programming algorithms. We also gave an algorithm for the computation of q-representative families for product families $\mathcal{F}$ in the more general setting where q-representation also involves independence in a matroid in addition to disjointness. This algorithm considerably outperforms the naive approach where one first computes $\mathcal{F}$ from $\mathcal{A}$ and $\mathcal{B}$, and then computes the q-representative family $\mathcal{F}'$ from $\mathcal{F}$.

We gave two applications of our new algorithms for computing q-representative families for product families. The first is a $3.8408^k n^{\mathcal{O}(1)}$ deterministic algorithm for the Multilinear Monomial Detection (k-MLD) problem. The second is a significant improvement of deterministic dynamic programming algorithms for "connectivity problems" on graphs of bounded treewidth.

In [**Ro2**], we studied the NP-complete *colorful* variant of the classical Matching problem, namely, the Rainbow Matching problem. Given an edge-colored graph G and a positive integer k, this problem asks whether there exists a matching of size at least k such that all the edges in the matching have distinct colors. We first developed a deterministic algorithm that solves Rainbow Matching on paths in time $\mathcal{O}^\star(\left(\frac{1+\sqrt{5}}{2}\right)^k)$ and polynomial space. This algorithm was based on a curious combination of the method of bounded search trees and a "divide-and-conquer-like" approach, where the branching process is guided by the maintenance of an auxiliary bipartite graph where one side captures "divided-and-conquered" pieces of the path. Our second result was a randomized algorithm that solves Rainbow Matching on general graphs in time $\mathcal{O}^\star(2^k)$ and polynomial-space. Here, we showed how a result by Björklund et al. [JCSS, 2017] can be invoked as a black box, wrapped by a probability-based analysis tailored to our problem. We also complemented our two main results by designing kernels for Rainbow Matching on general and bounded-degree graphs.

In [**Ram1**] we studied the parameterized complexity of the directed variant of the classical Steiner Tree problem on various classes of directed sparse graphs. While the parameterized complexity of Steiner Tree parameterized by the number of terminals was well understood, not much was known about the parameterization by the number of non-terminals in the solution tree. All that was known for this parameterization is that both the directed and the undirected versions are W[2]-hard on general graphs, and hence unlikely to be fixed parameter tractable (FPT). The undirected Steiner Tree problem becomes FPT when restricted to sparse classes of graphs such as planar graphs, but the techniques used to show this result break down on directed planar graphs.

In this article we precisely charted the tractability border for Directed Steiner Tree (DST) on sparse graphs parameterized by the number of non-terminals in the solution tree. Specifically, we showed that the problem is fixed parameter tractable on graphs excluding a topological minor, but becomes W[2]-hard on graphs of degeneracy 2. On the other hand we showed that if the subgraph induced by the terminals is acyclic then the problem becomes FPT on graphs of bounded degeneracy. We further showed that our algorithm achieves the best possible asymptotic running time dependence on the solution size and degeneracy of the input graph, under standard complexity theoretic assumptions. Using the ideas developed for DST, we also obtained improved algorithms for Dominating Set on sparse undirected graphs. These algorithms were asymptotically optimal.

The Cycle Packing problem asks whether a given undirected graph $G = (V, E)$ contains k vertex-disjoint cycles. Since the publication of the classic Erdős-Pósa theorem in 1965, this problem received significant scientific attention in the fields of Graph Theory and Algorithm Design. In particular, this problem was one of

the first problems studied in the framework of Parameterized Complexity. The non-uniform fixed-parameter tractability of Cycle Packing follows from the Robertson Seymour theorem, a fact already observed by Fellows and Langston in the 1980s. In 1994, Bodlaender showed that Cycle Packing can be solved in time $2^{\mathcal{O}(k^2)} \cdot |V|$ using exponential space. In case a solution exists, Bodlaender's algorithm also outputs a solution (in the same time). It has later become common knowledge that Cycle Packing admits a $2^{\mathcal{O}(k \log^2 k)} \cdot |V|$-time (deterministic) algorithm using exponential space, which is a consequence of the Erdős-Pósa theorem. Nowadays, the design of this algorithm is given as an exercise in textbooks on Parameterized Complexity. Yet, no algorithm that runs in time $2^{o(k \log^2 k)} \cdot |V|^{\mathcal{O}(1)}$, beating the bound $2^{\mathcal{O}(k \log^2 k)} \cdot |V|^{\mathcal{O}(1)}$, has been found. In light of this, it seemed natural to ask whether the $2^{(k \log^2 k)} \cdot |V|^{\mathcal{O}(1)}$ bound is essentially optimal. In [**S3**], we answered this question negatively by developing a $2^{\mathcal{O}(\frac{k \log^2 k}{\log \log k})} \cdot |V|$-time (deterministic) algorithm for Cycle Packing. In case a solution exists, our algorithm also outputed a solution (in the same time). Moreover, apart from beating the bound $2^{\mathcal{O}(k \log^2 k)} \cdot |V|^{\mathcal{O}(1)}$, our algorithm ran in time linear in $|V|$, and its space complexity is polynomial in the input size.

Given a graph G and a pair $(\mathcal{F}_1, \mathcal{F}_2)$ of graph families, the function $\mathsf{GDISJ}_{G,\mathcal{F}_1,\mathcal{F}_2}$ takes as input, two induced subgraphs G_1 and G_2 of G, such that $G_1 \in \mathcal{F}_1$ and $G_2 \in \mathcal{F}_2$ and returns 1 if $V(G_1) \cap V(G_2) = \emptyset$ and 0 otherwise. In [**Ko1**] we studied the communication complexity of this problem in the two-party model. In particular, we looked at pairs of hereditary graph families. We showed that the communication complexity of this function, when the two graph families are hereditary, is sublinear if and only if there are finitely many graphs in the intersection of these two families. Then, using concepts from parameterized complexity, we obtain nuanced upper bounds on the communication complexity of $\mathsf{GDISJ}_{G,\mathcal{F}_1,\mathcal{F}_2}$. A concept related to communication protocols is that of a $(\mathcal{F}_1, \mathcal{F}_2)$-separating family of a graph G. A collection $\mathcal{F}$ of subsets of $V(G)$ is called a $(\mathcal{F}_1, \mathcal{F}_2)$-*separating family* for G, if for any two vertex disjoint induced subgraphs $G_1 \in \mathcal{F}_1, G_2 \in \mathcal{F}_2$, there is a set $F \in \mathcal{F}$ with $V(G_1) \subseteq F$ and $V(G_2) \cap F = \emptyset$. Given a graph G on n vertices, for any pair $(\mathcal{F}_1, \mathcal{F}_2)$ of hereditary graph families with sublinear communication complexity for $\mathsf{GDISJ}_{G,\mathcal{F}_1,\mathcal{F}_2}$, we gave an enumeration algorithm that finds a subexponential sized $(\mathcal{F}_1, \mathcal{F}_2)$-separating family. In fact, we gave an enumeration algorithm that finds a $2^{o(k)}n^{(1)}$ sized $(\mathcal{F}_1, \mathcal{F}_2)$-separating family; where k denotes the size of a minimum sized set S of vertices such that $V(G) \setminus S$ has a bipartition (V_1, V_2) with $G[V_1] \in \mathcal{F}_1$ and $G[V_2] \in \mathcal{F}_2$. We exhibited a wide range of applications for these separating families, to obtain combinatorial bounds, enumeration algorithms as well as exact and FPT algorithms for several problems.

Let $\mathcal{F}$ be a family of graphs. Given an n-vertex input graph G and a positive integer k, testing whether G has a vertex subset S of size at most k, such that $G - S$ belongs to $\mathcal{F}$, is a prototype vertex deletion problem. These type of problems have attracted a lot of attention in recent times in the domain of parameterized complexity. In [**Ko2**], we studed two such problems; when $\mathcal{F}$ is either the family of forests of cacti or the family of forests of odd-cacti. A graph H is called a *forest of cacti* if every pair of cycles in H intersect on at most one vertex. Furthermore, a forest of cacti H is called a *forest of odd cacti*, if every cycle of H is of odd length. Let us denote by $\mathcal{C}$ and $\mathcal{C}_{\mathsf{odd}}$, the families of forests of cacti and forests of odd cacti, respectively. The vertex deletion problems corresponding to $\mathcal{C}$ and $\mathcal{C}_{\mathsf{odd}}$ are called Diamond Hitting Set and Even Cycle Transversal, respectively. In [**Ko2**] we designed randomized algorithms with worst case run time for both these problems. These algorithms considerably improved the running time for Diamond Hitting Set and Even Cycle Transversal, compared to what was known about them.

In the Subset Odd Cycle Transversal (Subset OCT) problem, the input is a graph G, a subset of vertices T, a positive integer k and the objective is to determine whether there exists a k-sized vertex subset that intersects every odd cycle containing a vertex from T. Clearly, Subset OCT is a generalization of the classic Odd Cycle Transversal problem where the objective is to determine whether there exists a k-sized vertex subset that intersects every odd cycle in the given graph. Subset OCT also generalizes the well known Multiway Cut problem, as well as a parity constrained variant, the Odd Multiway Cut problem. Recently, Kakimura et al. (SODA 2012) proposed a fixed parameter tractable (FPT) algorithm for this problem that runs in time $f(k)mn^3$ using the theory of graph minors, where f is some function, and n and m denote the number of vertices and edges in the graph. However, the dependence of this function on k is at least triple exponential.

In [**Mi2**], we gave the first FPT algorithm for this problem where the exponential dependence of the running time of the algorithm on k is polynomial. This algorithm avoided the use of the theory of graph minors, is self contained, and runs in time $2^{O(k^3 \log k)} mn^2 \log^2 n$, thus improving upon the algorithm of Kakimura et al. with respect to both the parameter as well as the input size. This algorithm utilized a recursive application of "generalized" important separators to reduce the subset version of this problem to the standard version

of the problem.

In [S11], we presented two new combinatorial tools for the design of parameterized algorithms. The first is a simple linear time randomized algorithm that given as input a d-degenerate graph G and an integer k, outputs an independent set Y, such that for every independent set X in G of size at most k, the probability that X is a subset of Y is at least $\left(\binom{(d+1)k}{k} \cdot k(d+1)\right)^{-1}$. The second is a new (deterministic) polynomial time graph sparsification procedure that given a graph G, a set $T = \{\{s_1, t_1\}, \{s_2, t_2\}, \ldots, \{s_\ell, t_\ell\}\}$ of terminal pairs and an integer k, returns an induced subgraph $G^\star$ of G that maintains *all* the inclusion minimal multicuts of G of size at most k, and does not contain any $(k+2)$-vertex connected set of size $2^{O(k)}$. In particular, $G^\star$ excludes a clique of size $2^{O(k)}$ as a topological minor. Put together, these new tools yielded new randomized fixed parameter tractable (FPT) algorithms for Stable s-t Separator, Stable Odd Cycle Transversal and Stable Multicut on general graphs, and for Stable Directed Feedback Vertex Set on d-degenerate graphs, resolving two problems left open by Marx et al. [ACM Transactions on Algorithms, 2013]. All of these algorithms can be derandomized at the cost of a small overhead in the running time.

The optimization version of the Unique Label Cover problem is at the heart of the Unique Games Conjecture which has played an important role in the proof of several tight inapproximability results. In recent years, this problem has been also studied extensively from the point of view of parameterized complexity. Chitnis et al. [FOCS 2012] proved that this problem is fixed-parameter tractable (FPT) and Wahlström [SODA 2014] gave an FPT algorithm with an improved parameter dependence. Subsequently, Iwata, Wahlström and Yoshida [2014] proved that the *edge* version of Unique Label Cover can be solved in *linear* FPT-time. That is, there is an FPT algorithm whose dependence on the input-size is linear. However, the existence of such an algorithm for the *node* version of the problem remained open. In [S5], we resolved this question by presenting the first linear-time algorithm for Unique Label Cover.

In the Subset Feedback Vertex Set problem, the input is a graph G on n vertices and m edges, a subset of vertices T, referred to as terminals, and an integer k. The objective is to determine whether there exists a set of at most k vertices intersecting every cycle that contains a terminal. The study of parameterized algorithms for this generalization of the Feedback Vertex Set problem has received significant attention over the last few years. In fact the parameterized complexity of this problem was open until 2011, when two groups independently showed that the problem is fixed parameter tractable (FPT). Using tools from graph minors Kawarabayashi and Kobayashi obtained an algorithm for Subset Feedback Vertex Set running in time $\mathcal{O}(f(k) \cdot n^2 m)$ [SODA 2012, JCTB 2012]. Independently, Cygan et al. [ICALP 2011, SIDMA 2013] designed an algorithm for Subset Feedback Vertex Set running in time $2^{\mathcal{O}(k \log k)} \cdot n^{\mathcal{O}(1)}$. More recently, Wahlström obtained the first single exponential time algorithm for Subset Feedback Vertex Set, running in time $4^k \cdot n^{\mathcal{O}(1)}$ [SODA 2014]. While the $2^{\mathcal{O}(k)}$ dependence on the parameter k is optimal under the Exponential Time Hypothesis (ETH), the dependence of this algorithm as well as those preceding it, on the input size is at least quadratic. In [S19] we designed the first linear time parameterized algorithms for Subset Feedback Vertex Set. More precisely, we obtained the following new algorithms for Subset Feedback Vertex Set.

- A randomized algorithm for Subset Feedback Vertex Set running in time $\mathcal{O}(25.6^k \cdot (n+m))$.
- A deterministic algorithm for Subset Feedback Vertex Set running in time $2^{\mathcal{O}(k \log k)} \cdot (n+m)$.

Since it is known that assuming the Exponential Time Hypothesis, Subset FVS cannot have an algorithm running in time $2^{o(k)} n^{\mathcal{O}(1)}$, the first algorithm obtains the best possible asymptotic dependence on both the parameter as well as the input size. Both of these algorithms are based on "cut centrality", in the sense that solution vertices are likely to show up in minimum size cuts between vertices sampled from carefully chosen distributions.

Planarity, bipartiteness and (directed) acyclicity are basic graph properties with classic linear time recognition algorithms. However, the problems of testing whether a given (di)graph has k vertices whose deletion makes it planar, bipartite or a directed acyclic graph (DAG) are all fundamental NP-complete problems when k is part of the input. As a result, a significant amount of research has been devoted to understanding whether, for every *fixed* k, these problems admit a polynomial time algorithm (where the exponent in the polynomial is independent of k) and in particular, whether they admit linear time algorithms.

While we now know that for any fixed k, we can test in linear time whether a graph is k vertices away from being planar [FOCS 2009, SODA 2014] or bipartite [SODA 2014, SICOMP 2016], the best known

algorithms in the case of directed acyclicity are the algorithm of Garey and Tarjan [IPL 78] which runs in time $\mathcal{O}(n^{k-1}m)$ and the algorithm of Chen, Liu, Lu, O'Sullivan and Razgon [JACM 2008] which runs in time $\mathcal{O}(k!4^k k^4 nm)$. In other words, it has remained open whether it is possible to recognize in linear time, a graph which is *2 vertices* away from being acyclic!

In [**S10**], we settled this question by giving an algorithm that decides whether a given graph is k vertices away from being acyclic, in time $\mathcal{O}(k!4^k k^5(n+m))$. That is, for every fixed k, this algorithm runs in time $\mathcal{O}(m+n)$, thus mirroring the case for planarity and bipartiteness.

This algorithm is designed via a general methodology that shaves off a factor of n from some algorithms that use the powerful technique of iterative compression. The two main features of the methodology are: (i) This is the first generic technique for designing linear time algorithms for *directed cut-problems* and (ii) it can be used in combination with future improvements in algorithms for the *compression* version of other well-studied cut-problems such as Multicut and Directed Subset Feedback Vertex Set.

Two of the most widely used approaches to obtain polynomial time approximation schemes (PTASs) on planar graphs are the Lipton-Tarjan separator based approach and Baker's approach. In 2005 Demaine and Hajiaghayi strengthened both approaches using bidimensionality and obtained efficient polynomial time approximation schemes (EPTASs) for several problems, including Connected Dominating Set and Feedback Vertex Set. In [**S16**], we unified the two strengthened approaches to combine the best of both worlds. We developd a framework allowing to design EPTAS on classes of graphs with the subquadratic grid minor (SQGM) property. Roughly speaking, a class of graphs has the SQGM property if, for every graph G from the class, the fact that G contains no $t \times t$ grid as a minor guarantees that the treewidth of G is subquadratic in t. For example, the class of planar graphs, and more generally, classes of graphs excluding some fixed graph as a minor, have the SQGM property. At the heart of this framework was a decomposition lemma which states that for "most" bidimensional problems on a graph class $\mathcal{G}$ with the SQGM property, there is a polynomial time algorithm which given a graph $G \in \mathcal{G}$ as input and an $\epsilon > 0$, outputs a vertex set X of size $\epsilon \cdot OPT$ such that the treewidth of $G - X$ is $f(\epsilon)$. Here, OPT is the objective function value of the problem in question and f is a function depending only on ϵ. This allowed us to obtain EPTASs on (apex)-minor-free graphs for all problems covered by the previous framework, as well as for a wide range of packing problems, partial covering problems and problems that are neither closed under taking minors, nor contractions. To the best of our knowledge for many of these problems no EPTASs even on planar graphs were previously known.

We also proved novel excluded grid theorems in unit disk and map graphs without large cliques. Using these theorems, we showed that these classes of graphs have the SQGM property. Based on the developed framework, we designed EPTASs and subexponential time parameterized algorithms for various classes of problems on unit disk and map graphs.

The duality between packing and covering problems lies at the heart of fundamental combinatorial proofs, as well as well-known algorithmic methods such as the primal-dual method for approximation and win/win-approach for parameterized analysis. The very essence of this duality is encompassed by a well-known property called the Erdős-Pósa property, which has been extensively studied for over five decades. Informally, we say that a class of graphs $\mathcal{F}$ admits the Erdős-Pósa property if for any graph G, either G has k vertex-disjoint "copies" of the graphs in $\mathcal{F}$, or there is a set $S \subseteq V(G)$ of $f(k)$ vertices that intersects all copies of the graphs in $\mathcal{F}$. In the context of any graph class $\mathcal{G}$, the most natural question that arises in this regard is as follows—do obstructions to $\mathcal{G}$ have the Erdős-Pósa property? Having this view in mind, we focused on the class of interval graphs. Structural properties of interval graphs are intensively studied, also as they lead to the design of polynomial-time algorithms for classic problems that are NP-hard on general graphs. Nevertheless, about one of the most basic properties of such graphs, namely, the Erdős-Pósa property, nothing is known. In [**S12**], we settled this anomaly: we proved that the family of obstructions to interval graphs—namely, the family of chordless cycles and ATs—admits the Erdős-Pósa property. Our main theorem immediately resulted in an algorithm to decide whether an input graph G has k vertex-disjoint ATs and chordless cycles, or there exists a set of $\mathcal{O}(k^2 \log k)$ vertices in G that hits all ATs and chordless cycles.

Given a 1.5-dimensional terrain T, also known as an x-monotone polygonal chain, the Terrain Guarding problem seeks a set of points of minimum size on T that *guards* all of the points on T. Here, we say that a point p guards a point q if no point of the line segment $\overline{pq}$ is strictly below T. The Terrain Guarding problem has been extensively studied for over 20 years. In 2005 it was already established that this problem

admits a constant-factor approximation algorithm [SODA 2005]. However, only in 2010 King and Krohn [SODA 2010] finally showed that Terrain Guarding is NP-hard. In spite of the remarkable developments in approximation algorithms for Terrain Guarding, next to nothing is known about its parameterized complexity. In particular, the most intriguing open questions in this direction ask whether, if parameterized by the size k of a solution guard set, it admits a subexponential-time algorithm and whether it is fixed-parameter tractable. In [**As1**], we answered the first question affirmatively by developing an $n^{\mathcal{O}(\sqrt{k})}$-time algorithm for both Discrete Terrain Guarding and Continuous Terrain Guarding. We also made non-trivial progress with respect to the second question: we showed that Discrete Orthogonal Terrain Guarding, a well-studied special case of Terrain Guarding, is fixed-parameter tractable.

Deterministic polynomial-time computation of a representation of a transversal matroid is a longstanding open problem. In [**S13**] we presented a deterministic computation of a so-called union representation of a transversal matroid in time quasipolynomial in the rank of the matroid. More precisely, we output a collection of linear matroids such that a set is independent in the transversal matroid if and only if it is independent in at least one of them. Our proof directly implied that if one is interested in preserving independent sets of size at most r, for a given $r \in \mathbb{N}$, but does not care whether larger independent sets are preserved, then a union representation can be computed deterministically in time quasipolynomial in r. This consequence is of independent interest, and sheds light on the power of union representation.

Our main result also had applications in Parameterized Complexity. First, it yielded a fast computation of representative sets, and due to our relaxation in the context of r, this computation also extends to (standard) truncations. In turn, this computation enables to efficiently solve various problems, such as subcases of subgraph isomorphism, motif search and packing problems, in the presence of color lists. Such problems have been studied to model scenarios where pairs of elements to be matched may not be identical but only similar, and color lists aim to describe the set of compatible elements associated with each element.

In [**Sha2**], we give a survey of the recent state of research on handling non-robustness in geometric computation.

In [**Pra**], we extend the results in [**Pr**]. We provide a hierarchy of bounds that generalize Westerfield's bound to the multivariate setting. One of the bounds in this hierarchy is a generalization of Lagrange's bound. All the bounds are strict quantitative improvements over Hong's bound. We also give an algorithm to compute the multivariate Lagrange bound. The running time of this algorithm matches the running time of the best known algorithm to compute Hong's bound. The algorithm uses the range tree data structure to implement orthogonal range querying. Relying on a result of Fredman (1984), we show that the efficiency of this algorithm cannot be improved by using any other data structure for orthogonal range querying.

Isolating real roots of a square-free polynomial in a given interval is a fundamental problem. Subdivision based algorithms are a standard approach to solve this problem. E.g., Sturm's method, or various algorithms based on the Descartes's rule of signs. For isolating all the real roots of a degree n polynomial with root separation σ, the subdivision tree size of most of these algorithms is bounded by $O(\log 1/\sigma)$ (assume $\sigma < 1$). Recently Sagraloff (2012) and Sagraloff-Mehlhorn (2013) have developed algorithms that combine subdivision with Newton iteration to reduce the size of the subdivision tree to $O(n(\log(n \log 1/\sigma)))$. Their algorithms and analysis crucially depend on the terminating predicates. In [**Sha1**], we describe a subroutine that improves the running time of any subdivision algorithm for real root isolation. The subdivision tree size of our algorithm using predicates based on the Descartes's rule of signs is bounded by $O(n \log n)$.

Our analysis differs in two key aspects from earlier approaches. First, we use the general technique of continuous amortization from Burr-Krahmer-Yap (2009), and hence the analysis extends to other predicates; and second, we use the geometry of clusters of roots instead of root bounds.

In [**Sh**] we describe a subdivision algorithm for isolating the complex roots of a complex polynomial. Our model assumes the existence of an oracle that provides approximations of each of the coefficient of the polynomial to any absolute error bound. Given any square B in the complex plane containing only simple roots of F, our algorithm returns disjoint isolating disks for the roots in B. Our complexity analysis bounds the absolute error to which the coeffi- cients of F have to be provided, the total number of iterations, and the overall bit complexity. It further shows that the complexity of our algo- rithm is controlled by the geometry of the roots in a near neighborhood of the input square B, namely, the number of roots, their

absolute values and pairwise distances. The number of subdivision steps is near-optimal. For the benchmark problem, namely, to isolate all the roots of a polynomial of degree n with integer coefficients of bitsize less than τ, our algorithm needs $O(n^3 + n^2\tau)$ bit operations, which is comparable to the record bound of Pan (2002). It is the first time that such a bound has been achieved using subdivision methods, and independent of divide-and-conquer techniques such as Schönhages splitting circle technique. Our algorithm uses the quadtree construction of Weyl (1924) with two key ingredients: using Pellets Theorem (1881) combined with Graeffe iteration, we derive a soft test to count the number of roots in a disk. Using Newton iteration combined with bisection, in a form inspired by the quadratic interval method from Abbot (2006), we achieve quadratic con- vergence towards root clusters. Relative to the divide-conquer algorithms, our algorithm is quite simple with the potential of being practical. This paper is self-contained: we provide pseudo-code for all subroutines used by our algorithm.

In [**Maj2**], we explored kernelization spectrum of CYCLE PACKING problem in undirected graphs when pair of cycles are allowed to intersect. In other words, the cycles we want to pack are not necessarily pairwise vertex disjoint. The question is whether there are at least k distinct cycles satisfying some intersection criteria among themselves. We consider two cycles to be distinct if they differ by at least one edge (or one vertex). The first relaxation is a global relaxation where every vertex of the graph is allowed to appear in at most t of the k cycles packed. When t is $O(k^{1-\epsilon})$, then we show that this problem still has no polynomial kernel unless $NP \subseteq coNP/poly$. When $t = k/c$ for some constant c, then we provide a polynomial kernel for this problem. More generally, we provide a spectrum of kernelization behavior under various values of t. The second relaxation is local relaxation. In this case, any two of the k cycles can intersect in at most t vertices. When $t = 1$, then we provide a polynomial kernel for this problem and when $t \geq 2$, we provide a polynomial compression for this problem.

In [**Maj1**], we explored the parameterized and kernelization algorithms for FEEDBACK VERTEX SET in undirected graph when it is parameterized by deletion distance to a split graph and a disjoint union of cliques. We provide $O(3.148^k n^{O(1)})$ time algorithm for FEEDBACK VERTEX SET when parameterized by the size of a given split vertex deletion set (k). We provide $O(5^k n^{O(1)})$ time algorithm for FEEDBACK VERTEX SET when parameterized by the size of a given cluster vertex deletion set (k). Then, we provide a complete characterization about the parameterized complexity of FEEDBACK VERTEX SET when it is parameterized by the size of a set (k) whose deletion results in a (c, i)-graph. A graph is called (c, i)-graph when its vertex set can be partitioned into c cliques and i independent sets.

In [**Kr3**], we explored the parameterized complexity of CONNECTED VERTEX COVER problem with respect to the size of different structures of the input. When the parameter is the deletion distance to a bounded degree (degree at most d) graph, we provide a dichotomy result. In particular, we prove that CONNECTED VERTEX COVER is FPT when $d \leq 2$ and NP-Complete for constant value of parameter when $d \geq 3$. We also provide explicit FPT algorithm running in time $O(3^k \cdot n^{O(1)})$ when parameterized by the size of a smallest split vertex deletion set. We also provide a time efficient polynomial sized approximate kernelization scheme (PSAKS) when k is the size of a given split vertex deletion set. We provide an explicit $O(4^k \cdot n^{O(1)})$ time algorithm when k is the size of a smallest cluster vertex deletion set. We also provide a PSAKS for this problem. As a consquence of this, we also get a PSAKS when parameterized by deletion distance to a graph of degree at most one. Finally, we provide an explanation that CONNECTED VERTEX COVER is FPT when parameterized by the size of a given chordal deletion set.

In [**Maj4**], we provide polynomial kernels for VERTEX COVER with respect to two different parameters. – Size of a set S whose deletion results in a graph with degree at most two. We call this as degree-two-modulator. We provide a kernel with $O(k^5)$ vertices for this problem. – Size of a set S whose deletion results in a cluster graph such that each component of $G - S$ has at most d vertices. We provide a kernel with $O(k^d)$ vertices for this problem. Finally we prove that a kernel with $O(k^{d-\epsilon})$ bits cannot exist unless $NP \subseteq coNP/poly$ for this case. – As a consequence of the above mentioned lower bound result, we have that when S is a degree-two-modulator, then VERTEX COVER has no kernel with $O(k^{3-\epsilon})$ bits.

In [**Maj3**], we have explored alternate parameterizations of FEEDBACK VERTEX SET in a complete detail. One part of it is to provide parameterized algorithms and other part is about kernelization. In particular, we prove the following results. – FEEDBACK VERTEX SET is fixed-parameter tractable when parameterized by the number of vertices having degree more than three. This answers a question asked in an earlier paper. We also show that this problem has no polynomial kernel under complexity theoretic assumptions. – We provide parameterized algorithms for FEEDBACK VERTEX SET when parameterized

by split vertex deletion set and cluster vertex deletion set. – Finally, we provide polynomial kernels for FEEDBACK VERTEX SET when parameterized by deletion distance to pseudo-forest and mock-d-forest. We also provide a lower bound for FEEDBACK VERTEX SET when parameterized by the size of a given set whose deletion results in a mock-d-forest.

In [Kr1], the parameterized complexity of simultaneous vertex deletion problems was studied. Fixed-parameter tractability and intractability results were shown.

In [?], lossy kernels and fixed-parameter tractable algorithms for CONNECTED VERTEX COVER for parameters that are functions of the input, and in some cases, smaller than the solution size were exhibited.

In [Kr2], CYCLE PACKING was studied with respect to a structural parameter, namely, distance to proper interval graphs. In particular, it was shown that CYCLE PACKING is fixed-parameter tractable when parameterized by the size of a proper interval deletion set.

Automata, Logic and Concurrency

Nondeterministic exponential time satisfiability of two-variable first order logic on word models is extended to a richer logic which allows checking whether a word position is congruent to r modulo q, for some divisor q and remainder r. Allowing the more powerful modulo counting quantifiers of Straubing, Thérien and Thomas (1995), satisfiability becomes complete for exponential space. It is also shown that adding a more general unary counting quantifier makes the two-variable logic undecidable, strengthening a result of Raphael Robinson (1958) [L1].

For the special structure $(N, +)$ of Presburger arithmetic, the proof of Ferrante and Rackoff (1979) is extended to yield a double exponential space upper bound for first order logic extended with modulo quantifiers. This leaves a gap above the lower bound (for Presburger arithmetic) of alternating double exponential time with a linear number of alternations, due to Leonard Berman (1980) [L2].

A logic is proposed to describe and compare paths in directed acyclic graphs [L3].

In the formal verification of cryptographic protocols, it is often necessary to consider certificates whose verification is necessarily partial. [Ra1] extends the term algebra of the Dolev Yao model with a positive existential first order logic, whose formulas model certificates, and develops its theory. As an application, the FOO electronic voting protocol is shown to satisfy anonymity.

In dynamic games, it is useful to reason not only about the existence of strategies for players, but also about how players select and construct strategies. [Ra2] shows how such reasoning in repeated normal form games can be carried out by composition of local strategies in a a single infinite game.

In imperfect information games, the problem of synthesising finite-state strategies for detecting a deviator from an agreed strategy profile is generally undecidable. [Ra3] shows that this is because the global state cannot be monitored. Under perfect monitoring of the global state and imperfect monitoring of actions, the problem becomes decidable.

Computational Complexity

In [A7], some highlights of the research work of Eric Allender were described. Allender recently turned sixty, and this article was a tribute to him. In his research career spanning over thirty-five years, and still flourishing, Eric has been a leader in the field of computational complexity, with contributions to many different aspects, including circuit complexity, space-bounded complexity classes, Kolmogorov complexity, and, broadly, the structure of complexity classes. The article [A7] gave a broad overview of some of his contributions.

In sharp contrast to classical proof complexity, lower bound techniques are currently lackingfor QBF proof systems. In [Ma3], the feasible interpolation technique was established for all resolution-based QBF systems, whether modelling CDCL or expansion-based solving. This both provided the first general lower bound method for QBF proof systems as well as largely extended the scope of classical feasible interpolation. This

technique was applied to obtain new exponential lower bounds to all resolution-based QBF systems for a new class of QBF formulas based on the clique problem. Finally, it was shown how feasible interpolation relates to a recently established lower bound method based on strategy extraction.

The groundbreaking paper 'Short proofs are narrow – resolution made simple' by Ben-Sasson and Wigde rson (J. ACM 2001) introduced what is today arguably *the* main technique to obtain resolution lower bounds: to show a lower bound for the width of proofs. Another important measure for resolution is space, and in their fundamental work, Atserias and Dalmau (J. Comput. Syst. Sci. 2008) showed that space lower bounds again can be obtained via width lower bounds. Whether similar techniques are effective for resolution calculi for quantified Boolean formulas (QBF) was assessed in [**Ma4**]. There are a number of different QBF resolution calculi like Q-resolution (the classical extension of propositional resolution to QBF) and the more recent calculi Exp+Res and IR-calc. For these systems, a mixed picture emerged. The main results of [**Ma4**] showed that the relations both between size and width and between space and width drastically fail in Q-resolution, even in its weaker tree-like version. On the other hand, positive results were obtained for the expansion-based resolution systems Exp+Res and IR-calc, however, only in the weak tree-like models. Technically, the negative results relied on showing width lower bounds together with simultaneous upper bounds for size and space. The positive results were shown by exhibiting space and width-preserving simulati ons between QBF resolution calculi.

The work in [**Ma5**] continued the study of the *shifted partial derivative measure*, introduced by Kayal (ECCC 2012), which has been used to prove many strong depth-4 circuit lower bounds starting from the work of Kayal, and that of Gupta et al. (CCC 2013). A strong lower bound was shown on the dimension of the shifted partial derivative space of the Elementary Symmetric Polynomials of degree d in N variables for $d < \lg N / \lg \lg N$. This extended the work of Nisan and Wigderson (Computational Complexity 1997), who studied the *partial derivative space* of these polynomials. Prior to this work, there had been no results on the shifted partial derivative measure of these polynomials. The shown result implies a strong lower bound for Elementary Symmetric Polynomials in the homogeneous $\Sigma\Pi\Sigma\Pi$ model with bounded bottom fan-in. This strengthens (under certain degree assumptions) a lower bound of Nisan and Wigderson who proved the analogous result for homogeneous $\Sigma\Pi\Sigma$ model (i.e. $\Sigma\Pi\Sigma\Pi$ formulas with bottom fan-in 1).

The main technical lemma in [**Ma5**] gave a lower bound for the ranks of certain inclusion-like matrices.

In [**Ma2**], recent developments in proving lower bounds for QBF proof systems were surveyed and a broad overview was presented. This survey was the basis of an invited plenary talk at the STACS 2018 conference.

Computation by formulas over $(\min, +)$ was studied in [**Ma1**]. The computation of $\max\{x_1, \ldots, x_n\}$ over $\mathbb{N}$ as a difference of $(\min, +)$ formulas was considered, and size $n + n \log n$ was shown to be sufficient and necessary. The proof also showed that any $(\min, +)$ formula computing the minimum of all sums of $n1$ out of n variables must have $n \log n$ leaves; this too is tight. The proofs use a complexity measure for $(\min, +)$ functions based on minterm-like behaviour and on the entropy of an associated graph.

In [**Ma6**], reductions and completeness for the algebraic complexity classes VP and VNP are further explored. The contribtuions fall into three categories.

1. A list of new natural VNP-intermediate polynomial families, based on basic (combinatorial) NP-complete problems that are complete under *parsimonious* reductions. Over finite fields, these families are in VNP, and under a plausible complexity-theoretic hypothesis, are neither VNP-hard (even under oracle-circuit reductions) nor in VP. Prior to this, only the Cut Enumerator polynomial was known to be VNP-intermediate, as shown by Bürgisser in 2000.

2. Over rationals and reals, it is shown that the clique polynomial cannot be obtained as a monotone p-projection of the permanent polynomial, thus ruling out the possibility of transferring monotone clique lower bounds to the permanent. Further, two of the intermediate polynomials, based on satisfiability and Hamiltonian cycle, are also shown to not be monotone affine polynomial-size projections of the permanent. These results augment recent results along this line due to Grochow.

3. Finally, a (somewhat natural) polynomial defined independent of a computation model is described, and shown to be VP-complete under polynomial-size projections. This complements a recent result of Durand et al. (2014) which established VP-completeness of a related polynomial but under constant-depth oracle circuit reductions. Both polynomials are based on graph homomorphisms. A simple restriction yields a family similarly complete for VBP.

An arithmetic read-once formula (ROF) is a formula (circuit of fan-out 1) over $+, \times$ where each variable labels at most one leaf. Every multilinear polynomial can be expressed as the sum of ROFs. In [Ma7], for certain multilinear polynomials, a tight lower bound on the number of summands in such an expression was proven.

In [A4], as the main result we obtain a randomized polynomial-time algorithm for testing if a given non-commutative circuit that computes a t-sparse polynomial is identically zero. It is based on our result that a nonzero t-sparse non-commutative polynomial cannot be a polynomial identity for the k-dimensional matrix algebra for k more than logarithmic in t.

The main result in [A5] is a deterministic polynomial-time algorithm for finding a fixed point free element in a transitive permutation group given by a generating set. We also study the problem of computing a minimum base for a permutation group giving by a generating set.

In [A2] we study the problem of factorization polynomials in non-associative free rings. Exploiting the non-associative structure we are able to obtain efficient deterministic factorization algorithms.

In [A3] we explore the problem of computing minimum-weight isomorphisms between graphs, where the weight of a permutation is its support size. This problem is akin to the minimum-weight codeword problem, which is well-studied in literature. In the parameterized setting we show the problem is fixed parameter tractable. Our algorithm exploits group-theoretic properties of small support permutations.

Graph Theory and Combinatorics

The report [Su3] reports on some of the results obtained in an on-going research on determining the computational complexity of exact 3-coloring and its list variant over graphs with guaranteed lower bounds on their minimum or average degrees. In particular, we present exponential improvements (over previous work) on the time to solve 3-colorability over graphs with guaranteed lower bounds on their minimum degrees. We also obtain analogous results for list 3-coloring provided we have similar lower bound guarantees on the minimum degree of a uniquely defined spanning subgraph of the input. We also study the evolution of the complexity of 3-colorability as the guaranteed lower bound on minimum degree increases from constant values to values as high as $\Omega(n)$. It is also established that one cannot hope to obtain similar algorithmic results for 3-colorability if we replace minimum degree by average degree unless ETH fails. In particular, it is established that 3-colorability cannot be tested in subexponential time (unless ETH fails) even if the input is assumed to be a graph having at least $n^2/12$ edges. As for list 3-colorability, it is shown that there cannot be any subexponential algorithm even if the input has minimum degree at least n/2, unless the minimumdegree of a suitable spanning subgraph grows with n.

Our efforts to design algorithms for locally updating input G without affecting its chromatic number led us to the formulation and study of monotone NP languages. These are languages where a part of every valid input can be structured in such a way that deciding on the input can be reduced to a series of decisions on local updates. The observations lead to new classes of languages of answer preserving local updates and it is shown that for every monotone NP- complete language L, the corresponding language of answer preserving local updates lies outside $NP \cup coNP$. These results are suitably generalized to monotone NP optimization problems and also for monotone members of higher levels of the Polynomial Hierarchy. Also presented in this submission are illustrations of implications of the above results with a number of natural and monotone complete languages.

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, Abhranil Chatterjee, Rajit Datta*, and Partha Mukhopadhyay*.
Low rank permanents via ideal membership and related results.
Feb 2018.
(Submitted).

[**A2**]
V. Arvind, Rajit Datta*, Partha Mukhopadhyay*, and S. Raja*.
Efficient identity testing and polynomial factorization in nonassociative free rings.
In Jean-Franois Raskin Kim G. Larsen, Hans L. Bodlaender, editor, *42nd International Symposium on Mathematical Foundations of Computer Science, MFCS 2017*, page 38:1. Springer Verlag, Aug 2017.

[**A3**]
V. Arvind, Johannes Koebler*, Sebastian Kuhnert*, and Jacobo Toran*.
Finding small weight isomorphisms with additional constraints is fixed-parameter tractable.
In Daniel Lokshtanov and Naomi Nishimura, editors, *12th International Symposium on Parameterized and Exact Computation, IPEC 2017*, page 2:1. Springer Verlag, Sep 2017.

[**A4**]
V. Arvind, Pushkar Joglekar*, Partha Mukhopadhyay*, and S. Raja*.
Randomized polynomial time identity testing for noncommutative circuits.
In Valerie King Hamed Hatami, Pierre McKenzie, editor, *Proceedings of the 49th Annual ACM SIGACT Symposium on Theory of Computing, STOC 2017*, page 831. Association for Computing Machinery, Jun 2017.

[**A5**]
V. Arvind.
Finding fixed point free elements and small bases in permutation groups.
Theoretical Computer Science, **687**, 70, 2017.

[**A6**]
V. Arvind, Johannes Koebler*, Gaurav Rattan, and Oleg Verbitsky*.
Graph isomorphism, color refinement, and compactness.
Computational Complexity, **26(3)**, 627, 2017.

[**A7**]
V. Arvind and Meena Mahajan.
A quest for structure in complexity.
In *Bulletin of the EATCS, Vol 123, Oct 2017*. EATCS, 2017.

[**A8**]
V. Arvind and Srikanth Srinivasan*.
On the hardness of the noncommutative determinant.
Computational Complexity, **27(1)**, 1, 2018.

[**As1**]
Pradeesha Ashok, Fedor Fomin*, Sudeshna Kolay, Saket Saurabh, and Meirav Zehavi*.
Exact algorithms for terrain guarding. symposium on computational geometry.
In *SoCG*, page 11:1. Lipics, Jul 2017.

[**As2**]
Pradeesha Ashok, Sudeshna Kolay, Syed M. Meesum, and Saket Saurabh.
Parameterized complexity of strip packing and minimum volume packing.
Theor. Comput. Sci., **661**, 56, 2017.

[**As3**]
Pradeesha Ashok, Sudeshna Kolay, and Saket Saurabh.
Multivariate complexity analysis of geometric red blue set cover.
Algorithmica, **79(5)**, 667, 2017.

[**B**]
Arindam Biswas, Varunkumar Jayapaul*, Venkatesh Raman, and Srinivasa R. Satti*.
The complexity of finding (approximate) distance d dominating set in tournaments.
In Xiao M and Rosamond F, editors, *Frontiers in Algorithmics, 11th international workshop (FAW 2017)*, page 22. Springer, Volume 10336, Jun 2017.

[**C**]
Sankardeep Chakraborty, Venkatesh Raman, and Srinivasa R. Satti*.
Biconnectivity, st-numbering and other applications of dfs using o(n) bits.
Journal of Computer and System Sciences (JCSS), **90**, 63, 2017.

[**J**]
Pallavi Jain, Jayakrishnan M., Fahad Panolan*, and Abhishek Sahu.
Mixed dominating set: A parameterized perspective.
In Gerhard J. Woeginger Hans L. Bodlaender, editor, *International Workshop on Graph-Theoretic Concepts in Computer Science (WG 2017)*. Springer, Nov 2017.

[**K**]
Akanksha Agarwal*, Lawqueen Kanesh, Saket Saurabh, and Prafullkumar Tale.
Paths to trees and cacti.
In *Algorithms and Complexity - 10th International Conference, CIAC 2017*, page 31, May 2017.

[**Ko1**]
Sudeshna Kolay, Fahad Panolan, and Saket Saurabh.
Communication complexity of pairs of graph families with applications.
In *MFCS*, page 13:1. Lipics, Aug 2017.

[**Ko2**]
Sudeshna Kolay, Daniel Lokshtanov*, Fahad Panolan*, and Saket Saurabh.
Quick but odd growth of cacti.
Algorithmica, **79(1)**, 271, 2017.

[**Kr1**]
Akanksha Agrawal*, R. Krithika, Daniel Lokshtanov*, Amer E. Mouawad*, and M.S. Ramanujan*.
On the parameterized complexity of simultaneous deletion problems.
In Satya Lokam and R. Ramanujam, editors, *37th IARCS Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2017)*, page 9:1. Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, Dec 2017.

[**Kr2**]
R. Krithika, Abhishek Sahu, Saket Saurabh, and Meirav Zehavi*.
The parameterized complexity of cycle packing: Indifference is not an issue.
In *13th Latin American Theoretical Informatics Symposium (LATIN 2018)*, Apr 2018.
(To be published).

[**Kr3**]
R. Krithika, Diptapriyo Majumdar, and Venkatesh Raman.
Revisiting Connected Vertex Cover: FPT Algorithms and Lossy Kernels.
Theory of Computing Systems, 2018.
arXiv:1711.07872 (https://doi.org/10.1007/s00224-017-9837-y)[Available Online.].

[**Kr4**]
R. Krithika, Abhishek Sahu, and Prafullkumar Tale.
Dynamic parameterized problems.
Algorithmica, 2017.
(To be published).

[**L1**]
Kamal Lodaya and A. Sreejith*.
Two-variable first-order logic with counting quantifiers: complexity results.
In Julien Leroy Émilie Charlier and Michel Rigo, editors, *Proc. 21st DLT, Liège*, pages 260–271. Springer LNCS 10396, Aug 2017.

[**L2**]
Kamal Lodaya and A. Sreejith*.
A note on modulo counting quantifiers and linear arithmetic.
In *Proceedings of the 14th Asian Logic conference, Mumbai.*, Mar 2018.
(Submitted).

[**L3**]
Kamal Lodaya.
Via.
Mar 2018.
(Submitted).

[**M1**]
Jayakrishnan Madathil, Saket Sarah, and Meirav Zehavi*.
Max-cut above spanning tree is fixed-parameter tractable.
In *Proceedings of the 13th International Computer Science Symposium in Russia*, Mar 2018.
(To be published).

[**M2**]
Akanksha Agrawal*, **Grzegorz Guspiel***, **Jayakrishnan Madathil, Saket Saurabh, and Meirav Zehavi***.
On the complexity of crossing minimization.
In *The 45th International Colloquium on Automata, Languages, and Programming (ICALP 2018)*, Feb 2018.
(Submitted).

[**M3**]
Jayakrishnan Madathil, Fahad Panolan*, **Abhishek Sahu, and Saket Saurabh**.
On the complexity of mixed dominating set.
In *The 44th International Workshop on Graph-Theoretic Concepts in Computer Science (WG 2018)*, Feb 2018.
(Submitted).

[**Ma1**]
Meena Mahajan, Prajakta Nimbhorkar*, **and Anuj Tawari**.
Computing the maximum using (min,+) formulas.
In *42nd International Symposium on Mathematical Foundations of Computer Science (MFCS), LIPIcs vol. 83.*, pages 74:1–74:11. LIPIcs, Aug 2017.

[**Ma2**]
Meena Mahajan.
Lower bound techniques for QBF proof systems.
In *35th Symposium on Theoretical Aspects of Computer Science (STACS)*, pages 2:1–2:8. LIPIcs, Mar 2018.

[**Ma3**]
Olaf Beyersdorff*, Leroy Chew*, Meena Mahajan, and Anil Shukla.
Feasible interpolation for QBF resolution calculi.
Logical Methods in Computer Science, **13(2)**, 1, 2017.

[**Ma4**]
Olaf Beyersdorff*, Leroy Chew*, Meena Mahajan, and Anil Shukla.
Are short proofs narrow? QBF is not so simple.
ACM Transactions on Computational Logic, **19(1)**, 1:1–1:26, 2018.

[**Ma5**]
Herve Fournier*, Nutan Limaye*, Meena Mahajan, and Srikanth Srinivasan*.
The shifted partial derivative complexity of elementary symmetric polynomials.
Theory of Computing, **13**, 9:1–34, 2017.

[**Ma6**]
Meena Mahajan and Nitin Saurabh.
Some complete and intermediate polynomials in algebraic complexity theory.
Theory of Computing Systems, **62(3)(622–652)**, dx.doi/10.1007/s00224–016–9740–y, 2018.

[**Ma7**]
Meena Mahajan and Anuj Tawari.
Sums of read-once formulas: how many summands are necessary?
Theoretical Computer Science, **708**, 34–45, 2018.

[**Maj1**]
Diptapriyo Majumdar and Venkatesh Raman.
FPT algorithms for FVS parameterized by split and cluster vertex deletion sets and other parameters.
In Frances Rosamond and Mingyu Xiao, editors, *Frontiers of Algorithmics (FAW 2017)*, page 209. Springer, Cham, Jun 2017.

[**Maj2**]
Akanksha Agrawal*, Daniel Lokshtanov*, Diptapriyo Majumdar, Amer E. Mouawad*, and Saket Saurabh.
Kernelization of Cycle Packing with Relaxed Disjointness Constraints.
2017.
(Submitted).

[**Maj3**]
Diptapriyo Majumdar and Venkatesh Raman.
Structural Parameterizations of Undirected Feedback Vertex Set: FPT Algorithms and Kernelization.
Algorithmica, 2018.
https://doi.org/10.1007/s00453-018-0419-4(Available Online).

[**Maj4**]
Diptapriyo Majumdar, Venkatesh Raman, and Saket Saurabh.
Polynomial Kernels for Vertex Cover Parameterized by Small Degree Modulators.
Theory of Computing Systems, 2018.
https://doi.org/10.1007/s00224-018-9858-1(Available Online).

[**Mi1**]
Jorgen Bang-Jensen*, Manu Basavaraju*, Kristine V. Klinkby*, Pranabendu Misra, M. S. Ramanujan*, Saket Saurabh, and Meirav Zehavi*.
Parameterized algorithms for survivable network design with uniform demands.
In *SODA*, page 2838, Jan 2018.

[**Mi2**]
Daniel Lokshtanov*, Pranabendu Misra, M. S. Ramanujan, and Saket Saurabh.
Hitting selected (odd) cycles.
SIAM J. Discrete Math., **31(3)**, 1581, 2017.

[**N**]
Swaroop N P and Vikram Sharma.
Improved bounds on the absolute positiveness of polynomials.
In Michael Burr, editor, *Proceedings of the 2017 ACM on International Symposium on Symbolic and Algebraic Computation*, page 381. ACM New York., Jul 2017.

[**P1**]
Fedor Fomin*, Daniel Lokshtanov*, Fahad Panolan, and Saket Saurabh.
Representative families of product families.
ACM Trans. Algorithms, **13(3)**, 36:1, 2017.

[**P2**]
Fahad Panolan, Geevarghese Philip*, and Saket Saurabh.
On the parameterized complexity of b-chromatic number.
J. Comput. Syst. Sci., **84**, 120, 2017.

[**Pr**]
Swaroop N. Prabhakaran and Vikram Sharma.
Improved bounds on absolute positiveness of multivariate polynomials.
In Michael A. Burr, Chee K. Yap, and Mohab Safey El Din, editors, *International Symposium on Symbolic and Algebraic Computation, ISSAC 2017*, page 381. ACM, Jul 2017.

[**Pra**]
Swaroop N. Prabhakar and Vikram Sharma.
Improved bounds on absolute positiveness of multivariate polynomials.
2018.
(Submitted).

[**R**]
Ashutosh Rai and Saket Saurabh.
Bivariate complexity analysis of almost forest deletion.
Theor. Comput. Sci., **708**, 18, 2018.

[**Ra1**]
R. Ramanujam, S.P. Suresh*, and Vaishnavi Sundararajan*.
Existential assertions for voting protocols.
In Vanessa Teague, editor, *Financial Cryptography Workshops*, page 337. International Financial Cryptography Association, Apr 2017.

[**Ra2**]
Sujata Ghosh*, Neethi Konar*, and R. Ramanujam.
Strategy composition in dynamic games with simultaneous moves.
In A.P. Rocha J. van den Herik and J. Filipe, editors, *9th International Conference on Agents and Artificial Intelligence*, page 624. Scitepress, Jun 2017.

[**Ra3**]
Dietmar Berwanger* and R Ramanujam.
Deviator detection under imperfect monitoring.
In Aniello Murano Wiebe van der Hoek, Bastien Maubert and Sasha Rubin, editors, *Proceedings of Strategic Reasoning*, Jul 2017.

[**Ram1**]
Mark Jones*, **Daniel Lokshtanov***, **M. S. Ramanujan, Saket Saurabh, and Ondra Suchy***.
Parameterized complexity of directed steiner tree on sparse graphs.
SIAM J. Discrete Math., **31(2)**, 1294, 2017.

[**Ram2**]
M. S. Ramanujan and Saket Saurabh.
Linear-time parameterized algorithms via skew-symmetric multicuts.
ACM Trans. Algorithms, **13(4)**, 46:1, 2017.

[**Rama1**]
Aritra Banik*, **Fahad Panolan***, **Venkatesh Raman, Vibha Sahlot, and Saket Saurabh**.
Parameterized complexity of geometric covering problems with conflicts.
In Antonina Kolokolova Faith Ellen and Jrg-Rdiger Sack, editors, *Workshop on Algorithms and Data Structures (WADS 2017)*, page 61. Springer Verlag, Jul 2017.

[**Rama2**]
Hicham El-Zein*, **Moshe Lewinstein***, **J. I. Munro***, **Venkatesh Raman, and Timothy Chan***.
On the succinct representation of equivalence classes.
Algorithmica, **78(3)**, 1020, 2017.

[**Rama3**]
Varunkumar Jayapaul*, **J. I. Munro***, **Srinivasa R. Satti***, **and Venkatesh Raman**.
Finding modes with equality comparisons.
Theoretical Computer Science, **704**, 28, 2017.

[**Rama4**]
Amer Mouawad*, **Naomi Nishimura***, **Vinayak Pathak***, **and Venkatesh Raman**.
Shortest reconfiguration path in the solution space of boolean formula.
SIAM Journal on Discrete Mathematics, **31(3)**, 2185, 2017.

[**Rama5**]
Amer E. Mouawad*, **Naomi Nishimura***, **Venkatesh Raman, and Sebestian Siebertz***.
Vertex cover reconfiguration and beyond.
Algorithms, **11(2)**, 20, 2018.

[**Rama6**]
Amer E. Mouawad*, **Naomi Nishimura***, **Venkatesh Raman, Narges Simjour***, **and Akira Suzuki***.
On the parameterized complexity of reconfiguration problems.
Algorithmica, **78(1)**, 274, 2017.

[**Ro1**]
Sushmita Gupta*, **Sanjukta Roy, Saket Saurabh, and Meirav Zehavi***.
Group activity selection on graphs: Parameterized analysis.
In *SAGT*, page 106. Springer, Aug 2017.

[**Ro2**]
Sushmita Gupta*, **Sanjukta Roy, Saket Saurabh, and Meirav Zehavi***.
Parameterized algorithms and kernels for rainbow matching.
In 71:1, editor, *MFCS*. Lipics, Aug 2017.

[**S1**]
Archontia C. Giannopoulou *, **Bart M. Jansen***, **Daniel Lokshtanov***, **and Saket Saurabh**.

Uniform kernelization complexity of hitting forbidden minors.
ACM Trans. Algorithms, **13(3)**, 35:1, 2017.

[**S2**]
Daniel Lokshtanov*, **Fahad Panolan***, **M. S. Ramanujan***, **and Saket Saurabh**.
Lossy kernelization.
In *STOC*, page 224, Jun 2017.

[**S3**]
Daniel Lokshtanov*, **Amer E. Mouawad***, **Saket Saurabh, and Meriav Zehavi***.
Packing cycles faster than erdos-posa.
In *ICALP*. Lipics, Jul 2017.

[**S4**]
Fedor Fomin*, **Daniel Lokshtanov***, **Fahad Panoaln***, **Saket Saurabh, and Merirav Zehavi***.
Finding, hitting and packing cycles in subexponential time on unit disk graphs.
In *ICALP*, page 65:1. Lipics, Aug 2017.

[**S5**]
Daniel Lokshtanov*, **M. S. Ramanujan***, **and Saket Saurabh**.
A linear-time parameterized algorithm for node unique label cover.
In *ESA*, page 57:1. Lipics, Sep 2017.

[**S6**]
Daniel Lokshtanov*, **Saket Saurabh, Roohani Sharma, and Meirav Zehavi***.
Balanced judicious bipartition is fixed-parameter tractable.
In *FSTTCS*, page 40:1. Lipics, Dec 2017.

[**S7**]
Fedor Fomin*, **Petr A. Golovach***, **Daniel Lokshtanov***, **and Saket Saurabh**.
Covering vectors by spaces: Regular matroids.
In *ICALP*, page 56:1. Lipics, Jul 2017.

[**S8**]
Akanksha Agrawal*, **Saket Saurabh, and Prafullkumar Tale**.
On the parameterized complexity of contraction to generalization of trees.
In Naomi Nishimura Daniel Lokshtanov, editor, *12th International Symposium on Parameterized and Exact Computation, IPEC 2017*, page 1:1, Sep 2017.

[**S9**]
Tien-Nam Le*, **Daniel Lokshtanov***, **Saket Saurabh, Stephan Thomasse***, **and Meirav Zehavi***.
Subquadratic kernels for implicit 3-hitting set and 3-set packing problems.
In *SODA*, page 331, Jan 2018.

[**S10**]
Daniel Lokshtanov*, **M. S. Ramanujan***, **and Saket Saurabh**.
When recursion is better than iteration: A linear-time algorithm for acyclicity with few error vertices.
In *SODA*, page 1916, Jan 2018.

[**S11**]
Daniel Lokshtanov*, **Fahad Panolan***, **Saket Saurabh, Roohani Sharma, and Meirav Zehavi***.
Covering small independent sets and separators with applications to parameterized algorithms.
In *SODA*, page 2785, Jan 2018.

[**S12**]
Akanksha Agrawal*, Daniel Lokshtanov*, Pranabendu Misra*, Saket Saurabh, and Meirav Zehavi*.
Erdos-posa property of obstructions to interval graphs.
In *STACS*, page 7:1. Lipics, Mar 2018.

[**S13**]
Daniel Lokshtanov*, Pranabendu Misra*, Fahad Panolan*, Saket Saurabh, and Meirav Zehavi*.
Quasipolynomial representation of transversal matroids with applications in parameterized complexity.
In *ITCS*, page 32:1. Lipics, Jan 2018.

[**S14**]
Petr A. Golovach*, Daniel Lokshtanov*, Saket Saurabh, and Meirav Zehavi*.
Cliquewidth iii: The odd case of graph coloring parameterized by cliquewidth.
In *SODA*, page 262, Jan 2018.

[**S15**]
Akanksha Agrawal*, Saket Saurabh, Roohani Sharma, and Meirav Zehavi*.
Kernels for deletion to classes of acyclic digraphs.
J. Comput. Syst. Sci., **92**, 9, 2018.

[**S16**]
Fedo Fomin*, Daniel Lokshtanov*, and Saket Saurabh.
Excluded grid minors and efficient polynomial-time approximation schemes.
Journal of the ACM, **65(2)**, 10:1, 2018.

[**S17**]
Fedor Fomin*, Daniel Lokshtanov*, Saket Saurabh, and Dimitrios Thilikos.
Kernels for (connected) dominating set on graphs with excluded topological minors.
ACM Trans. Algorithms, **14(1)**, 6:1, 2018.

[**S18**]
Daniel Lokshtanov*, Marcin Pilipczuk*, Michal Pilipczuk*, and Saket Saurabh.
Fixed-parameter tractable canonization and isomorphism test for graphs of bounded treewidth.
SIAM J. Comput., **46(1)**, 161, 2017.

[**S19**]
Daniel Lokshtanov*, M. S. Ramanujan*, and Saket Saurabh.
Linear time parameterized algorithms for subset feedback vertex set.
ACM Trans. Algorithms, **14(1)**, 7:1, 2018.

[**S20**]
Sounaka Mishra*, Shijin Rajakrishnan*, and Saket Saurabh.
On approximability of optimization problems related to red/blue-split graphs.
Theor. Comput. Sci., **690**, 104, 2017.

[**Sh**]
Ruben Becker*, Sagraloff*, Sharma, and Yap*.
A near-optimal subdivision algorithm for complex root isolation based on the pellet test and newton iteration.
J. Symb. Comput., **86**, 51, 2018.

[**Sha1**]
Prashant Batra* and Vikram Sharma.
Near optimal subdivision algorithms for real root isolation.
Journal of Symbolic Computation, **83**, 4, 2017.

[**Sha2**]
Vikram Sharma and Chee K. Yap*.
Robust geometric computation.
In Joseph O'Rourke Jacob E. Goodman and Csaba D. Tth, editors, *Handbook of Discrete and Computational Geometry*. CRC Press LLC, 2017.
(Submitted).

[**Su1**]
Kunal Dutta* and C.R. Subramanian.
On induced paths, holes and trees in random graphs.
In Markus Nebel and Stephen Wagner, editors, *Meeting on Analytical Algorithmics and Combinatorics (ANALCO-18)*, pages 168–177. Society for Industrial and Applied Mathematics (SIAM), Jan 2018.

[**Su2**]
Joydeep Mukherjee* and C.R. Subramanian.
Greedy heuristics and stochastic matchings.
Asian Journal of Mathematics and Applications, **2018(ama0452)**, 1–14, 2018.

[**Su3**]
C.R. Subramanian.
Some observations on exact 3-coloring.
2017.
(Submitted).

Books/Monographs Authored/Edited

The list below follows the same conventions as those followed for the list of publications.

[**R1**]
Sujata Ghosh* and R Ramanujam, editors.
Proceedings of the Ninth Workshop on Methods for Modalities, volume 243 of *Electronic Proceedings in Theoretical Computer Science*.
Open Publishing Association, University of New South Wales, Sydney, 2017.

[**R2**]
Satya Lokam* and R. Ramanujam, editors.
Proceedings of the 37th FST&TCS Conference, volume 93 of *LIPIcs: Leibniz International Proceedings in Informatics*.
Leibniz-Zentrum fuer Informatik, Schloss Dagstuhl, Germanay, 2018.

2.5 Student Programmes

2.5.1 Degrees Awarded

Doctoral Degrees Awarded during 2017 – 2018

Mathematics

Name: **Muthukrishnan, Subramani**
Thesis Title: Euclidean Algorithm for Certain Algebraic Number Fields
Thesis Advisor: Srinivas, K.
University: Chennai Mathematical Institute

Physics

Name: **Mayya, Ashwij**
Thesis Title: Role of Microstructure on Compressive Fracture of Cortical Bone: Experiments and Modeling
Thesis Advisor: Rajesh, R.
University: IIT Madras

Name: **John, Renjan R.**
Thesis Title: Non-perturbative aspects of supersymmetric gauge theories with surface operators
Thesis Advisor: Ashok, Sujay K.
University: HBNI

Theoretical Computer Science

Name: **Mathew, Anup Basil**
Thesis Title: Decidable subclasses of the distributed synthesis problem
Thesis Advisor: Ramanujam, R.
University: HBNI

Name: **Rai, Ashutosh**
Thesis Title: Parameterized Algorithms for Graph Modification Problems
Thesis Advisor: Saurabh, Saket
University: IMSc, HBNI

Name: **Misra, Pranabendu**
Thesis Title: Parameterized Algorithms for Network Design
Thesis Advisor: Saurabh, Saket
University: IMSc, HBNI

Name: **Chakraborty, Sankardeep**
Thesis Title: Space Efficient Graph Algorithms
Thesis Advisor: Raman, Venkatesh
University: HBNI

Name: **Kolay, Sudeshna**
Thesis Title: Parameterized Complexity of Graph Partitioning and Geometric Covering
Thesis Advisor: Saurabh, Saket
University: IMSc, HBNI

Name: **Meesum, Syed M.**
Thesis Title: Matrix Editing via Multivariate Lens
Thesis Advisor: Saurabh, Saket
University: IMSc, HBNI

Name: **Jayapaul, Varunkumar**
Thesis Title: Sorting and Selection in Restricted Models of Computation
Thesis Advisor: Raman, Venkatesh
University: Chennai Mathematical Institute (CMI)

Doctoral Theses Submitted during 2017 – 2018

Mathematics

Name: **Arun Kumar, G.**
Thesis Title: Root Multiplicities for Borcherds-Kac-Moody Algebras and Graph coloring. Thesis Advisor: Sankaran, Viswanath
University: HBNI

Physics

Name: **Biswal, Minati M.**
Thesis Title: $Z_N symmetry and confinement - deconfinement transition in SU(N) + Higgs theory$
$Thesis Advisor : Digal, Sanatan D.$
$University : HBNI$

Name: **Banerjee, Pinaki**
Thesis Title: Holography and Brownian Motion
Thesis Advisor: Sathiapalan, Balachandran
University: HBNI

Name: **Singh, Rishu K.**
Thesis Title: Non-equilibrium Dynamics in Complex Networks
Thesis Advisor: Sinha, Sitabhra
University: HBNI

Name: **Hoque, Sk. Jahanur**
Thesis Title: Physics of Gravitational Waves in presence of positive cosmological constant
Thesis Advisor: Date, G.
University: Homi Bhabha National Institute

Name: **Bhattacharya, Soumyadeep**
Thesis Title: Role of topological defects in breaking and enhancing discrete symmetries
Thesis Advisor: Ray, Purusattam
University: HBNI

Name: **Roy, Subhadeep**
Thesis Title: Interplay of stress release range and disorder in fracture
Thesis Advisor: Ray, Purusattam
University: HBNI

Masters Degrees Awarded during 2017 – 2018

Physics

Name: **Vaibhav, Vinay**
Thesis Title: Heat Transport in Glass forming liquids
Thesis Advisor: Chaudhuri, Pinaki P.
University: Homi Bhaba National Institute

Theoretical Computer Science

Name: **Dudeja, Aditi**
Thesis Title: Pebble Games, Resolution and Some Lower Bounds
Thesis Advisor: Mahajan, Meena B.
University: HBNI

Name: **Arora, Vipul**
Thesis Title: Arithmetic Circuits: A Study
Thesis Advisor: Mahajan, Meena B.
University: CMI

Masters Theses Submitted during 2017 – 2018

Mathematics

Name: **Banik, Mita**
Thesis Title: Geodesic and horocycle flow on certain homogeneous manifolds
Thesis Advisor: Sankaran, Parameswaran
University: IMSc, HBNI

2.5.2 Lecture Courses During 2017 – 2018.

The following **lecture courses** were offered during 2017 – 2018.

Course Title	Period	Lecturer
Mathematics		
Symplectic Geometry	Jan-Apr 2017	Venugopalan, Sushmita
Algebraic number theory	Aug-Nov 2017	Srinivas, K.
Algebra I	Aug-Dec 2017	Kodiyalam, Vijay
Algebra II	Jan-Apr 2018	Raghavan, K.N.
Complex Analysis	Aug-Dec 2017	Sankaran, Parameswaran
Measure Theory	Aug-Dec 2017	Mukhopadhyay, Anirban
Topology I	Aug-Dec 2017	Roy, Indrava
Topology 2	Jan-Apr 2018	Venugopalan, Sushmita
Physics		

Nonlinear Dynamics	Jan-May 2017	Sinha, Sitabhra
Quantum Field Theory II	Jan-Apr 2017	Mukhopadhyay, Partha
Quantum Information and Quantum Computation	Jan-Apr 2017	Chandrashekar, C. M.
Renormalisation Group	Jan-Mar 2017	Sathiapalan, Balachandran
Statistical Field Theory	Jan-Apr 2017	Ray, Purusattam
Statistical Mechanics 1	Jan-May 2017	Chaudhuri, Pinaki P.
Systems Biology	Jan-May 2017	Sinha, Sitabhra
Advanced Particle Physics (Along with some other faculty)	Feb-Feb 2017	Murthy, M.V.N.
Classical Mechanics	Aug-Dec 2017	Bagchi, Manjari
Electrodynamics	Aug-Dec 2017	Ashok, Sujay K.
Mathematical Methods II	Aug-Dec 2017	Rajesh, R.
Quantum Mechanics - I	Aug-Nov 2017	Digal, Sanatan D.
Statistical Mechanics II	Aug-Dec 2017	Sinha, Sitabhra
Advanced Particle Physics (with other faculty)	Jan-May 2018	Murthy, M.V.N.
Classical Field Theory	Jan-Apr 2018	Date, G.
General Relativity and Cosmology	Jan-Apr 2018	Mukhopadhyay, Partha
Nonlinear Dynamics	Jan-May 2018	Sinha, Sitabhra
Quantum Field Theory II	Jan-Apr 2018	Sathiapalan, Balachandran
Statistical Field Theory (Reading course)	Jan-Apr 2018	Sathiapalan, Balachandran
Statistical Mechanics	Jan-Apr 2018	Vemparala, Satyavani
Systems Biology	Jan-May 2018	Sinha, Sitabhra

Theoretical Computer Science

Advanced Data Structures	Jan-Apr 2017	Raman, Venkatesh
Advanced Parameterized Complexity	Jan-Apr 2017	Saurabh, Saket
Computational Complexity	Jan-May 2017	Mahajan, Meena B.
Finite model theory	Jan-Apr 2017	Ramanujam, R.
Parameterized Complexity	Jan-Apr 2017	Raman, Venkatesh
Theory of Computation II	Jan-May 2017	Lodaya, Kamal
Advanced modal logic	Aug-Dec 2017	Ramanujam, R.
Advanced Parameterized Complexity	Jan-Apr 2018	Saurabh, Saket
Integer Linear Programming	Jan-Apr 2018	Sharma, Vikram

Computational Biology

Biology-2	Jan-Apr 2017	Samal, Areejit
Classical Field Theory	Jan-Apr 2017	Menon, Gautam I.
Modeling Infectious Diseases	Jan-Apr 2017	Menon, Gautam I.
Biology-1	Aug-Dec 2017	Samal, Areejit
Physical Biology	Aug-Dec 2017	Menon, Gautam I.
Programming for Discrete Mathematics in Research	Aug-Dec 2017	Samal, Areejit & Prasad, Amritanshu

In addition, the following **lecture courses** were offered during 2017 – 2018 by IMSC faculty in the National Undergraduate programme of the Chennai Mathematical Institute.

Course Title	Period	Lecturer

Physics

Quantum Field Theory	Jan-Apr 2017	Rajasekaran, G.
Classical Dynamics	Aug-Nov 2017	Murthy, M.V.N.

2.5.3 Other Students

Students also do their projects under the supervision of our faculty during the academic year.The following students visited the institute during Apr, 2017 - Mar, 2018.

Student	Faculty
Mathematics	
Chowdhury, Sulakhana, IISER, Trivendrum	Srinivas, K.
Physics	
Diwakar, Pranav, BITS, Pilani	Ashok, Sujay K.
Ranjan, Mrinalini, Indian Institute of Space Science and Technology, Trivandrum	Sinha, Sitabhra
Theoretical Computer Science	
Neogi, Rian I., NIIT University, Rajasthan	Raman, Venkatesh
Atulya, M. S., PSG College of Technology, Coimbatore	Raman, Venkatesh
Suryanarayanan, Vaishali, PSG College of Technology	Raman, Venkatesh
Krishna, Pooja, PSG College of Technology	Ramanujam, R.
Akshaya, R., PSG College of Technology	Ramanujam, R.
Kabra, Aditya, IISER, Pune	Saurabh, Saket
Computational Biology	
Kumar, Rachita, SASTRA University	Samal, Areejit
Vijayakumar, Subathra, SASTRA University	Samal, Areejit
Burra, Prakruthi, BITS Hyderabad	Samal, Areejit

2.6 Honours and Awards

Dishant Mayurbhai Pancholi has been awarded 'B M Birla Science prize' jointly with Neena Gupta of ISI. This award is mainly for Dishant Pancholi's contributions to the understanding of 5-manifolds.

Menon, Gautam I. was awarded Shastri Mobility Program Fellowship, for 2018, by the Shastri Indo-Canadian Institute for The programme provides an opportunity for personal enrichment and professional development for senior academicians/educational administrators.

Prasad, Amritanshu was awarded Srinivasa Ramanujan Memorial Award Lecture, for 2017, by the Indian Mathematical Society for On the Timed Plactic Monoid.

Parthasarathi Chakraborty has been elected as Fellow of the Indian Academy of Sciences.

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.

Member of Programme Committee of the 12th Conference on Computability and Randomness 2017 during Mar 2016 – Jul 2017.

Bagchi, Manjari

Lecture at School of Advanced Sciences, VIT University, Chennai, India on Apr 21, 2017. Gave a talk titled "Reaching out for the (neutron) stars" in the workshop on "Women in Science" organised by SPIE Student Chapter.

Chaudhuri, Pinaki P.

Convener of National Organising Committee for Correlation and Disorder in Classical and Quantum Systems held at International Centre for Theoretical Sciences TIFR, Bangalore. during May 29 – Jun 2, 2017.

Convener of Local Organising Committee for Mechanical Properties of Complex Solids held at IMSc during Feb 5 – Feb 9, 2018.

Gun, S.

Reviewer of Mathematical Reviews during Jul 2008 – Mar 2018.

Reviewer of Zentralblatt Reviews during Apr 2011 – Mar 2018.

Managing Editor of IMSc monograph series during Apr 2015 – Mar 2018.

Scientific Committee of WAMS Research School on Topics in Analytic and Transcendental Number Theory during Jul – Jul, 2017.

Scientific Committee of Symposium for women in South Asia in Mathematics (SWAM) 2017 during Oct – Oct, 2017.

Member of International Organising Committee for Number Theory: Arithmetic, Diophantine and Transcendence held at IIT Ropar, Ropar during Dec 22 – Dec 25, 2017.

Mahajan, Meena B.

Speaker at IMSc, Chennai on Nov 7, 2017. Gave a talk titled "Contributions of Stephen Cook and Richard Karp (Turing Award Recipients of 1982 and 1985)" as part of the "50 Years of Turing Award" talk series organised by the Chennai chapter of ACM India.

Menon, Gautam I.

Member of DBT Star College Scheme Committee, Department of Biotechnology, New Delhi during Mar 2017 – Mar 2018.

Member of Grant Review Committee, Human Frontier Science Program, Strasbourg during Mar 2017 – Mar 2018.

Member of Editorial Board, Scientific Reports during Mar 2017 – Mar 2018.

Member of Editorial Board, Texts and Readings in the Physical Sciences during Mar 2017 – Mar 2018.

Early Career Fellowship Committe of DBT-Wellcome India Alliance during Mar 2017 – Mar 2018.

Swaroop, N.P.

Member of International Organising Committee for ISSAC 2017 held at University of Kaiserslautern during Jul 25 – Jul 28, 2017.

Varuni, P.

Understanding mathematics through crafts for schools at Craft Education and Research Center (CERC), Kalakshetra Foundation on Apr 1, 2017. In collaboration with CERC and Sunita Vatuk (City University of New York), I am developing a course for students of the Besant Arundale Senior Secondary School to explore abstract Mathematical Concepts through block printing and weaving.

Convener of Local Organising Committee for Summer School Students Workshop held at IMSc during May 29 – Jun 2, 2017.

Convener of Local Organising Committee for Teachers Enrichment Program held at IMSc during May 22 – May 27, 2017.

Convener of Local Organising Committee for Facets held at IMSc during Jul 3 – Jul 4, 2017.

Convener of Local Organising Committee for Enriching Mathematics Education held at PSBB School, KK Nagar during Sep 14 – Sep 15, 2017.

Convener of Local Organising Committee for kaNita-kAnakamn held at IMSc on Oct 23, 2017.

Convener of Local Organising Committee for Teachers Enrichment Workshop held at IMSc during Nov 27 – Dec 2, 2017.

Convener of Local Organising Committee for Foldscope Workshop held at IMSc on Jan 2, 2018.

Convener of Local Organising Committee for Science at the Sabha held at The Music Academy on Feb 11, 2018.

Indian Women in Science Exhibition at The Music Academy: 11 February 2018 CMI: 5-9 March 2018 on Feb 11, 2018. To mark the International Day of Women and Girls in Science 2018, IMSc partnered with The Life of Science to feature 13 Indian Women in Science in a exhibition. Each poster 3x6 ft included a brief description of her work.

Raghavan, K. N.

Member of Course Expert Committee for course in Algebra, IGNOU during Apr – Apr, 2017.

Member of Course Development Committee for course in Algebra, IGNOU during Apr – Jul, 2017.

Member of Board of Studies in Mathematics, Cochin University of Science and Technology (CUSAT)

Convener of National Organising Committee for Academies' Lecture Workshop on Algebra held at K. S. Rangasamy College of Arts and Science (Autonomous), Tiruchengode, Namakkal District, Tamilnadu during May 2 – May 4, 2017.

Convener of Local Organising Committee for Teacher's Enrichment Workshop held at IMSc during May 22 – May 27, 2017.

Raman, Madhusudhan

Convener of National Organising Committee for Student Talks on Trending Topics in Theory 2017 held at Chennai Mathematical Institute during May 8 – May 19, 2017.

Raman, Venkatesh

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

Member of Board of Studies in Computer Science at Stella Maris College, Chennai

Member of Program Committee of International Symposium on Parameterized and Exact Computation (IPEC) 2017 during Jun – Jul, 2017.

Member of Program Committee of International Conference on Algorithms and Discrete Mathematics (CALDAM) 2018 during Oct – Nov, 2017.

Member of Program Committee of FAW 2018 conference during Dec 2017 – Feb 2018.

Ramanujam, R.

Member of Steering committee of "Logic and Multi-Agent Systems" during Jan 2011 – Mar 2018.

Member of Editorial Board of journal ACM Transactions on Computational Logic during Jan 2011 – Mar 2018.

Member of Board of studies in Computer Science, Stella Maris College, Chennai during Apr 2012 – Mar 2018.

Member of Programme Committee of "Computer Science Logic", Stockholm, August 20-24, 2017 during Feb 2016 – Aug 2017.

Member of Programme Committee of "Fundamentals of Computation Theory", September 11-13, 2017 Bordeaux, France during Oct 2016 – Sep 2017.

Member of Programme Committee of the Eighth International Symposium on Games, Automata, Logics, and Formal Verification, Rome (Italy), 20-21-22 September 2017 during Oct 2016 – Sep 2017.

Member of Curriculum Framework Committee, Govt of Tamil Nadu during Jul 2017 – Mar 2018.

Organizer and speaker at Indian Academy of Sciences, Bengaluru on Aug 18, 2017. At the discussion meeting organized by the Indian Academy of Sciences on school education.

Convener of International Organising Committee for Logic and Automata Theory: A tribute to Zoltan Esik held at Stockholm, Sweden on Aug 25, 2017.

Keynote speaker at North Eastern Regional Institute of Education, NCERT, Shillong on Dec 22, 2017. Gave a talk titled "Mapping the school mathematics curriculum" at the National conference on mathematics education organized by NCERT.

Samal, Areejit

Convener of Local Organising Committee for Mini-symposium on research in Tuberculosis held at IMSc on Jan 19, 2018.

Sankaran, Parameswaran

Convener of Local Organising Committee for Nag Memorial Endowment Lecture held at IMSc on Jan 22, 2018.

Saurabh, Saket

Program committee member of Program committee of WG 2018 during Feb Jun, 2017.

Associate Editor of Journal of Computer and System Sciences

Editor of Theory of Computing Systems

Convener of International Organising Committee for Recent Advances in Parameterized Complexity held at Tel-Aviv, Israel during Dec 2 – Dec 8, 2017.

Sharma, Sayantan

Member of American Physical Society

Sharma, Vikram

Program Committee member of International Symposium on Symbolic and Algebraic Computation during Dec 2016 – Jul 2017.

Sinha, Sitabhra

Member of Editorial Board of Frontiers in Fractal Physiology

Member of Frontiers in Physics Editorial Board

Convener of Local Organising Committee for International Workshop on the Economy as a Complex System IV: Can economics be a physical science held at IMSc during Nov 13 – Nov 14, 2017.

Subramanian, C. R.

Member of Programme Committee of CALDAM-2018 during Apr 2017 – Feb 2018.

Chapter 4

Colloquia

4.1 Conferences/Workshops Held at IMSc

4.1.1 Teachers Enrichment Program during May 22 – May 27, 2017

This week-long workshop was aimed at mathematics teachers in Arts Science colleges, to enable them to revisit and update content knowledge. Discussion hours offered opportunities to get doubts cleared and work out exercises (both routine and advanced). About 65 teachers were selected from about 200 applicants. The workshop was finally attend by 56 teachers. This program was part of IMSc's Enriching Collegiate Education (ECE) series of workshops as an effort to facilitate interactions between research mathematicians and college teachers. Teachers routinely report that they find the program very helpful and are eager to participate in more such events. The workshop was held as a Teacher's Enrichment Workshop, a series sponsored by the National Centre for Mathematics (NCM), during 22/5/2017 - 27/5/2017.

Organizers: K. Srinivas, K. N. Raghavan Speakers: S. Viswanath, P. Sankaran, K. Srinivas, K. N. Raghavan

http://www.imsc.res.in/ knr/tewmay17/

4.1.2 Summer School Students Workshop during May 22 – Jun 2, 2017

IMSc students and post-docs ran a week long summer workshop for students from calss IX - XII. We designed and ran activity and problem session for school students on various topics in mathematics and science from difference in infinities to the history of light. The students enjoyed the sessions, some even wanted the program to be extended!

Organizers: Amritanshu Prasad, , Varuni P Activities: Anantha, Ankit, Chandrashekar, Dheeraj, Madhusudhan, Prathemesh, Varuni, Vinay Speakers: Madhavan Mukund (CMI), Manjari Bagchi, R. Shankar, Sitabra Sinha

4.1.3 Facets during Jul 3 – Jul 4, 2017

Facets is the Institutes's outreach program for advanced undergraduate and postgraduate students of mathematics. This 2 day program is intended for mathematics students to interact with professional mathematicians working in research. Topics of lectures ranged from mathematical applications to linguistics to cartography. The program also featured a science journalist who shared her career experiences. The program also featured a career panel where students asked questions to panellists. This year, over 200 students attended this program.

Organizer: Sushmita V Speakers: Alok Laddha (CMI), Hema Murthy (IITM), Priyavrat Deshpande (CMI), R. Ramanujam, Shubashree Desikan (The Hindu), Vijay Ravikumar (CMI), S. Viswanath

4.1.4 Kanita-Kaanakam on Oct 23, 2017

This was the 1st edition of IMSc's outreach program for school children in Tamil. The workshop is aimed at students of of class VIII - XII. The program included Mathematics activities conducted by IMSc members for students to engage with topics more interactively. About 125 students from various government and corporation schools from the area attended the program.

Organizer: Amritanshu Prasad Activities: Sushmita V, Ramanathan Thinniyam, Janaki Raghavan, Anand Pathak, G. Arun Kumar, Madhusudhan Raman, Karthick Babu Speakers: Athmaraman Rajaratnam (Retired Headmaster), G. Youvaraj (Ramanujan Institute for Advanced Study in Mathematics, University of Madras), S.P. Suresh (CMI)

4.1.5 International Workshop on the Economy as a Complex System IV: Can economics be a physical science during Nov 13 – Nov 14, 2017

The 4th in a series of workshops titled The Economy as a Complex System that have taken place in IMSc from 2004, the meeting was aimed at initiating discussion and debate between scientists from different disciplines united in their common aim of understanding the collective behavior of homo economicus. It provided a forum where physicists, economists and mathematicians came together to discuss diverse scientific approaches to understand economic phenomena. One of the focal themes of the meeting was the prospects of using the tools of statistical physics in economics, an enterprise that was dubbed econophysics just over two decades ago (although physicists have been working on economics problem even earlier). It has also been just about half a century from the publication of Mandelbrots famous paper that showed that price fluctuations (measured by logarithmic returns) are not distributed according to a normal distribution as widely believed at the time but rather has fat tails better described by a power law This observation has had far-reaching implications showing that the kind of phenomena that forms the subject matter of statistical physics may also include economic systems. From the 1990s onwards there has been a virtual avalanche of publications in econophysics focusing on properties of financial markets, wealth and income distribution, strategic decision making, etc.

As discussed in the recent special issue Discussion and Debate: Can Economics be a Physical Science? of European Physical Journal- Special Topics
(https://link.springer.com/journal/11734/225/17/page/1), a distinct character of this literature has been the emphasis on uncovering universal phenomena in economic and social context, through applications of methods borrowed from statistical physics. Analysis of high frequency trading data from financial markets has led to the discovery of a number of remarkably invariant features (e.g., the inverse cubic law of price fluctuations). The workshop focused on this theme and discussed the problems and potentials of viewing (and modelling) socio-economic phenomena through the lens of physical science.

Over 50 speakers and participants interacted over the two days of the meeting. The following invited speakers from Indian and abroad spoke in the Workshop: Frederick Abergel (Ecole Centrale, Paris), Nils Bertschinger (FIAS, Frankfurt), Bikas K Chakrabarti (SINP, Kolkata), Anirban Chakraborti (JNU, New Delhi), Damien Challet (Ecole Centrale, Paris), Siew Ann Cheong (NTU, Singapore), Tiziana Di Matteo (King's College, London), Sanjay Jain (University of Delhi, Delhi), Taisei Kaizoji (ICU, Tokyo), Kimmo Kaski (Aalto University, Finland), Sugata Marjit (CSSS, Kolkata), Sheri Markose (University of Essex), M S Santhanam (IISER, Pune), V Sasidevan (CUSAT, Kochi), Rituparna Sen (ISI, Chennai), Wataru Souma (Nihon University, Tokyo) and Zbigniew R. Struzik (University of Tokyo, Tokyo). Details available in meeting website:

4.1.6 Teacher's Enrichment Workshop during Nov 27 – Dec 2, 2017

This week-long workshop was aimed at mathematics teachers in Engineering colleges, to enable them to revisit and update content knowledge. Discussion hours offered opportunities to get doubts cleared and work out exercises (both routine and advanced). About 65 teachers were selected from about 200 applicants.

This program was part of IMSc's Enriching Collegiate Education (ECE) series of workshops as an effort to facilitate interactions between research mathematicians and college teachers. Teachers routinely report that they find the program very helpful and are eager to participate in more such events. The workshop was held as Teachers Enrichment Workshop, a series co-sponsored by the National Centre for Mathematics (NCM), during 27/11/2017 - 2/12/2017.

Organizers: Anirban Mukhopadhyay, K. Srinivas Speakers: S. Kesavan (IITM), K. N. Raghavan, P. Sankaran, K. Srinivas

4.1.7 Nag Memorial Endowment Lecture on Jan 22, 2018

The Nag Memorial Endowment Lecture was delivered by Prof Kaushal Verma, IISc, Bangalore, on 'Three introductions to several complex variables'. The lecture was well attended by members of the Institute as well as some persons from neighbouring Institutes. The public lecture was followed by three seminar talks on several complex variables, each one developing deeper aspects of each of three narratives presented in the public talk. The seminars talks also attracted participation from students and faculty members of neighbouring Institutes.

4.1.8 Mini-symposium on research in Tuberculosis on Jan 19, 2018

This one day meeting exposed students and researchers to ongoing basic and translational research in Tuberculosis in India. There were 5 invited speakers and more than 40 participants at this meeting. This meeting was funded by the Ramanujan fellowship to Areejit Samal and PRISM project of the IMSc XII Plan.

4.1.9 Foldscope Workshop on Jan 2, 2018

A small workshop for Foldscope users to try out new Foldscopes and develop curricula that uses it as a tool. Organizers: Jayashree Ramadas (TIFR-Hyderabad), Varuni P

4.1.10 Mechanical Properties of Complex Solids during Feb 5 – Feb 9, 2018

There has been tremendous developments in recent times in understanding how various materials, ranging from crystals to amorphous assemblies, spanning across soft and hard matter, respond to mechanical perturbations of various kinds leading to plasticity, fracture, flow etc. Insight into the underlying processes involves physical descriptions and modeling over large length-scales, bringing forth researchers across disciplines with varying expertise to develop a common understanding. The school aims to have pedagogical interactions on related topics and provide students and researchers with an exposure of the recent developments.

4.2 Other Conferences/Workshops Organized by IMSc

4.2.1 Academies' Lecture Workshop on Algebra during May 2 – May 4, 2017

This workshop was convened by K. N. Raghavan at the request of S. Jagadeesan, head of the department of mathematics of the host institution. D. S. Nagaraj and K. N. Raghavan were the resource persons. Altogether 153 persons participated: 83 masters level students, 15 M.Phil./Ph.D. scholars, and 55 faculty.

4.2.2 Correlation and Disorder in Classical and Quantum Systems during May 29 – Jun 2, 2017

This program aims to bring together people working on classical and quantum systems with disorder and interactions. The extensive exploration, through experiments, simulations and model calculations, of growing correlation lengths associated with the rapid increases of viscosity and relaxation times in classical systems is a major recent development in the study of the glass transition. At the same time, there have also been significant advances, recently, in the effort to combine density functional theory with dynamical mean-field theory (DFT+DMFT) to understand the properties of quantum many-body systems. These involve treating interactions using quantum impurity models, thereby connecting directly to the physics of disordered systems. Another interesting recent direction of investigation is understanding how the interplay of interactions and disorder in quantum many-body systems can lead to ergodic and non-ergodic phases and transitions between them. The common themes of disorder and correlation effects run through this diverse class of problems prompting a discussion on the possibility of developing a broad theoretical framework within which to understand the phenomenology of disordered classical and quantum systems. The main focus of this program will be to assess the recent developments in these two fields on a common and inter-disciplinary platform, and also strategize the future directions and requirements for their implementation. A secondary focus will be on inter-disciplinary aspects, where common and complementary methods can be merged from both sides, to develop self-consistent and efficient numerical techniques for the understanding and prediction of new phases of matter.

Organizers: Aveek Bid (IISc, Bangalore), Pinaki Chaudhuri (IMSc, Chennai), Tanmoy Das (IISc, Bangalore), Smarajit Karmakar (TIFR, Hyderabad), Prabal Maiti (IISc, Bangalore), Subroto Mukerjee (IISc, Bangalore) and Srikanth Sastry (JNCASR, Bangalore)

4.2.3 Student Talks on Trending Topics in Theory 2017 during May 8 – May 19, 2017

Student Talks on Trending Topics in Theory 2017 was a discussion meeting on field theory-related topics organised by and for graduate students and postdoctoral fellows working in India. The workshop featured intensive lectures with a strong focus on pedagogy, and featured talks on:

- Conformal Bootstrap
- Entanglement Entropy
- Sachdev-Ye-Kitaev Model
- Scattering Amplitudes and Soft Theorems
- Supersymmetric Gauge Theories and Localization

4.2.4 Logic and Automata Theory: A tribute to Zoltan Esik on Aug 25, 2017

This one-day workshop, co-organized with Thomas Schwentick (Univ. Dortmund, Germany) a satellite event of Computer Science Logic 2017, was intended as a tribute to the late Hungarian automata theorist Zoltan Esik (1951-2016), constituting a discussion of topics that lie at the intersection of automata theory, logic and algebra. It had excellent invited talks by Mikolaj Bojanczyk (University of Warsaw), Szabolcs Ivan (University of Szeged), Wolfgang Thomas (RWTH, Aachen) and Pascal Weil (LaBRI, CNRS and Univ. of Bordeaux).

4.2.5 Enriching Mathematics Education during Sep 14 – Sep 15, 2017

This was the 6th edition of IMSc's outreach program for school teachers of classes XI and XII. This year, the workshop was hosted by PSBB School, KK Nagar, during 14/9/2017 - 15/9/2017. The program included

ideas about new ways to teach syllabus topics as well as discussed different approaches to problem solving. 75 teachers attended the workshop. The change of venue increased participation from schools in areas close to the venue.

Organizer: S. Viswanath Speakers: Anirban Mukhopadhyay, P. Sankaran, R. Ramanujam, S. Viswanath, Varuni P, V. Lakshmi Narayanan (AMTI)

4.2.6 Recent Advances in Parameterized Complexity during Dec 2 – Dec 8, 2017

The aim of Recent Advances in Parameterized Complexity was twofold. First, the event highlighted several recent, exciting advances in the field of Parameterized Complexity. Second, to attract new researchers to work in this ubiquitous, vibrant field of research, the program will also include a preparatory school at the level of an introductory course. We thus invite both graduate students and established researchers to participate in Recent Advances in Parameterized Complexity. A central theme in the program was future directions in Parameterized Complexity.

4.2.7 Number Theory: Arithmetic, Diophantine and Transcendence during Dec 22 – Dec 25, 2017

This international conference was organized to celebrate the ongoing major contribution of Srinivasa Ramanujan on different areas of number theory on the occasion of his 130th birthday anniversary. This conference also had a junior session in which young researchers got chance to interact with international experts.

4.2.8 Science at the Sabha on Feb 11, 2018

As part of our outreach to the general public, we organized a set of four public talks on different aspects of science at The Music Academy (TTK Auditorium) on Sunday, February 11, between 4:00 pm and 7:30 pm. The talks were aimed at anyone with an interest in science, irrespective of age or background. Science at the Sabha is free and open to all.

Science at the Sabha is an annual public science event and conducted in February of each year at the Music Academy. This is its third year.

Organizers: R. Ganesh, Gautam Menon, K. N. Raghavan, Varuni P Speakers: Shubha Tole (TIFR, Mumbai), R Rajesh, Guru Kumaraswamy (NCL-CSIR, Pune), Vijay Kodiyalam

4.3 IMSc OutReach Activities

4.3.1 Science Fun, Science Toys - 2nd November 2017, by Arvind Gupta

(http://www.arvindguptatoys.com/) Arvind Gupta is a toy inventor and popularizer of science for kids. An IIT-Kanpur graduate, he has been working since 1975 on innovative ways to teach and learn science. The talk was accompanied by demonstration of simple toys that he moulds out of trash and everyday goods to simplify the complex concepts of gravity, magnetic eld, friction, electricity, Newtonian laws among several other things. The talk was well attended, with students from CMI and IITM as well. The talk was followed by a discussion about how these toys could be used as educational aids with active participation from the audience.

4.3.2 Scientists and school education: A discussion, 24th November 2017

A discussion with Professor Krishna Kumar, an eminent educationist and scholar, was centred around: "Can disciplinary researchers contribute meaningfully to school education? Should they?" Over the course of the discussion, Prof. Krishna Kumar drew from his experience as the Director of NCERT to elucidate the what scientists can do to contribute to school curriculum and education.

4.3.3 Indian Women in Science, Exhibition

To mark the UN International Day of Women and Girls in Science on 11th February, IMSc partnered with "The Life of Science" (https://thelifeofscience.com/) to feature 13 Indian Women in Science as a poster exhibition. The posters described the work and the achievements of the scientists in their respective fields. The exhibition was displayed at: i) Science at the Sabha 2018, The Music Academy: 11th February 2018, ii) Chennai Mathematical Institute: 5th to 9th March 2018

4.4 Seminars

Date	Speaker Affiliation	Title
7-4-2017	Karthick Babu IMSc, Chennai	Prime Number Theorem
10-4-2017	Arghya Mondal IMSc	Cohomology of locally symmetric spaces
11-4-2017	M S Raghunathan IIT Bombay	Compact forms of symmetric spaces
12-4-2017	Nitin Williams University of Helsinki, Helsinki, Finland	A matter of time: Analysing time-varying functional brain networks in EEG task-related data
13-4-2017	Vijay Ravikumar CMI	Proving Monk's formula for the complete flag variety
14-4-2017	Digjoy Paul IMSc, Chennai	Gelfand Model for S_n :A Combinatorial Approach
17-4-2017	V. Vasumathi Department of Chemistry and Biochemistry, University of Porto, Porto, Portugal	Mixed Self-Assembled Monolayers on Gold Nanoparticles: A Molecular dynamic study
18-4-2017	Rahul Sinha IMSc	Breaking news from LHC
18-4-2017	Roy Joshua Ohio State University	Introduction to homotopical Algebra
18-4-2017	S. Raja Chennai Mathematical Institute	On structure and lower bounds in restricted models of arithmetic computations
18-4-2017	Areejit Samal IMSc, Chennai	Biology-2 Exam
19-4-2017	Dipankar Banerjee IIA	Waves in the solar atmosphere
20-4-2017	Arpita Choudhary IMSc	Optical companions to isolated MSPs radio counterpart to gamma ray emission around PSR J1632-4818

21-4-2017	J Krishnan Department of Chemical Engineering, Imperial College, London, UK	Systems approaches towards elucidating and engineering information processing at multiple levels in cellular systems
21-4-2017	Arghya Mondal ISI, Bangalore	Peter Weyl theorem and applications
24-4-2017	Chittaranjan Hens Department of Mathematics, Bar-Ilan University, Ramat-Gan, Israel	Spatio-temporal propagation of perturbation in complex networks
25-4-2017	Soumya Sadhukhan PRL	Constraining wrong-sign hbb coupling with Higgs to Upsilon gamma decay
25-4-2017	First year JRF IMSc	Research Methodology seminars
26-4-2017	E. Jayaprasath IMSc Chennai	Chaos synchronization in dynamical systems
26-4-2017	Roy Joshua	Equivariant Algebraic K-theory and Derived completion
27-4-2017	Ananthu James JNCASR, Bengaluru	Evolution of mutation rates in asexual populations
27-4-2017	Vijay Kodyalam IMSc	On a snippet of Sunder's work
27-4-2017	Biplab Paul IMSc, Chennai	Wiener-Ikehara Tauberian Theorem and its applications
28-4-2017	V S Sunder IMSc	Two gifts I could have got only from IMSc
1-5-2017	Ashwin Jacob IMSc	A general version of expansion lemma and an application
2-5-2017	Vishaka Datta NCBS Bangalore	How much can we quantitatively infer about transcription factor - DNA binding from sequencing-based experiments?
3-5-2017	Shakti N. Menon IMSc Chennai	Collective motion in living systems
4-5-2017	S Soumya IIT Bombay	Coherent Motion of Monolayer Sheets under active and passive confinement: From build up to consequences

5-5-2017	Bidyut Sanki PDF	Embedding of metric graphs on hyperbolic surfaces
8-5-2017	Shubham Kumar CMI	Fast feedback arc set in tournaments
9-5-2017	Kedar Natarajan Wellcome Trust Sanger Institute, Cambridge, UK	Investigating the interplay between cell cycle and gene expression
9-5-2017	Digjoy Paul IMSc	A Representation Theory Connection of the Schützenberger involution
11-5-2017	Gautam Mandal TIFR, Mumbai	Holographic SYK Models
11-5-2017	Soling Zimik Department of Physics, Indian Institute of Science, Bangalore	Cardiac arrhythmias: Insights from a state-of-the-art mathematical model of cardiac tissue
11-5-2017	Snehajit Misra IMSc, Chennai	Embedded Resolution of curves in surfaces
11-5-2017	Anjali Modi and Keshav Vaishnav Surat Medical College and Surat Municipal Corporation	Dengue Epidemiology
12-5-2017	Sailu Yellaboina CR Rao AIMSCS Hyderabad	Integrative analysis of genomic datasets: discovering disease genes and comorbidities
12-5-2017	Samriddhi Sankar Ray ICTS Bangalore	Decimated Navier-Stokes Turbulence
18-5-2017	Nabanita Ray IMSc, Chennai	Grothendieck group of nonsingular curves
19-5-2017	Pankaj Sheoran Jamia Milia Islamia, New Delhi	Rotating black holes as power sources
23-5-2017	Rahul Singh Northeastern University	Cotangent Bundle of the Flag Variety
24-5-2017	K. Vasanth	'Why Physical Fitness is Very Important'
25-5-2017	Uday Bhaskar Sharma IISER Pune	Counting Similarity Classes of Tuples of Commuting Matrices Over a Finite Field

26-5-2017	Rahul Singh Northeastern University	Conormal Varieties on the Cominuscule Grassmannian
26-5-2017	Sameer Hassan National Institute for Research in Tuberculosis, Chennai	Analysis of variable region in GP120 HIV envelop protein in R5, X4 and R5X4 tropism in HIV viruses
30-5-2017	Sankardeep Chakraborty IMSc Chennai	In-place Graph Algorithms
5-6-2017	Chinmay Das Faculty of Mathematics and Physical Sciences, University of Leeds, Leeds, United Kingdom	Reactor to Rheology: Coupled models for polymer flow
5-6-2017	Debabrata Goswami IIT-Kanpur	Implementation of Quantum Computing
6-6-2017	Manisha Caleb Australian National University, Swinburne University	Fast Radio Bursts
6-6-2017	Chinmay Das University of Leeds	Structure and dynamics of skin lipid membranes
6-6-2017	Debabrata Goswami IIT-Kanpur	Implementation of Quantum Computing
7-6-2017	Pranabendu Misra University of Bergen Norway	Parameterized Algorithms for some network design problems (THESIS DEFENCE)
7-6-2017	Debabrata Goswami IIT-Kanpur	Implementation of Quantum Computing
8-6-2017	Debabrata Goswami IIT-Kanpur	Implementation of Quantum Computing
9-6-2017	Debabrata Goswami IIT-Kanpur	Implementation of Quantum Computing
12-6-2017	Ramandeep S. Johal IISER–Mohali	Duality between heat engines and refrigerators
13-6-2017	Debabrata Goswami IIT-Kanpur	Implementation of Quantum Computing
14-6-2017	Debabrata Goswami IIT-Kanpur	Implementation of Quantum Computing

15-6-2017	Somnath Jha IIT Kanpur	A duality for Selmer groups
15-6-2017	Intel HPC Intel	Intel HPC workshop on Code Optimization using Intel Software Tools
15-6-2017	Debabrata Goswami IIT-Kanpur	Certain Curious Aspects of Light-Matter interactions
16-6-2017	Debabrata Goswami IIT-Kanpur	Certain Curious Aspects of Light-Matter interactions
23-6-2017	Kushal Appilineni Indian Institute of Science, Bengaluru	Investigation of bistability in ecosystems using cellular automaton lattice models
28-6-2017	B Sathiapalan IMSc	A Holographic form for Wilson's RG
5-7-2017	Aditi Dudeja IMSc	Pebble Games, Resolution and Some Lower Bounds
5-7-2017	Sandipan Sengupta IIT Kharagpur	Spherically symmetric vacuum spacetimes in first order gravity: Fate of curvature singularities
6-7-2017	Pavithran S. Iyer Institute Quantique, Universit 769;e de Sherbrooke	Critical noise parameters for fault tolerant quantum computation
6-7-2017	R Ramanujam IMSc	ACM India "50 years of Turing Awards" lecture
7-7-2017	Rishi Vyas Ben Gurion	Torsion in Groups
11-7-2017	Amritanshu Prasad IMSc	Continuous Time Words and their Plactic Monoid
13-7-2017	Alok Laddha CMI, Chennai	How universal are the soft theorems in Quantum Gravity?
19-7-2017	Shashi Thutupalli NCBS and ICTS, Bengaluru	Cell organization out of equilibrium
19-7-2017	Suchetana Sadhukhan Department of Physics, Indian Institute of Technology (IIT) Kharagpur	Statistical analysis of complex systems with dynamical constraints: A random matrix approach

25-7-2017	Arghya Sadhukhan IMSc	RSK Correspondence and Representation Theory
25-7-2017	Anirudh Ranganathan	Fragment-Based Discovery of Subtype-Selective Adenosine Receptor Ligands from Homology Models
27-7-2017	Parimala Raman Emory University	Patching techniques for function fields of curves over complete discrete valued fields.
31-7-2017	Kaja Abbas Department of Population Health Sciences, Virginia Tech, Blacksburg VA, USA	Epidemiological and Economic Modeling of Infectious Diseases
2-8-2017	Soma Sanyal University of Hyderabad	Particle temperature and the Chiral Vortical Effect in the early universe
2-8-2017	M. Muthukumar University of Massachusetts, USA	Dynamics of Charged Gels
3-8-2017	Abhisekh Sankaran IMSc	A finitary analogue of the downward Lowenheim-Skolem property
7-8-2017	Aditya Gilra Laboratory of Computational Neuroscience, EPFL Lausanne, Switzerland	A learning scheme for neural networks in the brain to predict and control body movement
8-8-2017	Upendra Kulkarni CMI	Internal tensor structure on the category of strict polynomial functors
9-8-2017	Satoshi Nawata Fudan University	Knot invariants, topological strings, and 3d/3d correspondence I
9-8-2017	Anuj Tawari IMSc	Computing max using (min,+) formulas
10-8-2017	Rajeev Paramel Pattathil Rutherford Appleton Laboratory, UK	Reaching light-speed in a centimeter!
11-8-2017	Satoshi Nawata	Knot invariants, topological strings, and 3d/3d correspondence - II
11-8-2017	Victor Mukherjee Weizmann Institute, Israel	Control in open quantum systems out of equilibrium
14-8-2017	Satoshi Nawata	Knot invariants, topological strings, and 3d/3d correspondence - III

17-8-2017	Sinnou David Paris VI	Points of small height on elliptic curves
17-8-2017	Satoshi Nawata Fudan University	Knot invariants, topological strings, and 3d/3d correspondence - IV
17-8-2017	Ramanathan S Thinniyam IMSc	Lindstrom's Theorem
18-8-2017	Satoshi Nawata	Knot invariants, topological strings, and 3d/3d correspondence - V
18-8-2017	Keerti Choudhary IIT Kanpur	Dynamic Graph Algorithms
21-8-2017	Satoshi Nawata Fudan University	Knot invariants, topological strings, and 3d/3d correspondence - VI
22-8-2017	Subhankar Khatua IMSc	The quantum spin quadrumer
22-8-2017	Arijit Ghosh ISI Kolkata	Packing, combinatorial Macbeath regions and semi-algebraic set systems
23-8-2017	Satoshi Nawata Fudan University	Knot invariants, topological strings, and 3d/3d correspondence - VII
23-8-2017	Mahul Pandey IISc	Glueball spectra from a Yang-Mills matrix model
24-8-2017	Dileep Jatkar HRI, Allahabad	Tunable Chaos in a complex SYK model
28-8-2017	Eric Laenen NIKHEF	The eikonal approximation and beyond
29-8-2017	Vani	Protein Structure Lab
30-8-2017	S Kalyana Rama IMSc	Bouncing universe in higher dimensions : Models inspired by Loop Quantum Cosmology (I)
30-8-2017	Vani	Protein Structure Lab
31-8-2017	S Kalyana Rama IMSc	Bouncing universe in higher dimensions : Models inspired by Loop Quantum Cosmology (II)

31-8-2017	V Kumar Murty University of Toronto	x$^n + x + a$
1-9-2017	Rishu Kumar Singh IMSc Chennai	Non-equilibrium dynamics in complex networks
1-9-2017	Digjoy Paul IMSc	Splitting the square of a Schur function into its symmetric and antisymmetric parts
1-9-2017	Vani	Protein Structure Lab
4-9-2017	Nigel Calder University of Waikato	Using mobile technologies to enhance the learning of mathematics
5-9-2017	Vani	Protein Structure Class
6-9-2017	Gaurav Sood	AlCom seminar series
7-9-2017	Kavitha Ranganathan T. A. Pai Management Institute, Manipal	Satisficing measures of risk
7-9-2017	Amritanshu Prasad & Digjoy Paul IMSc	Plactic monoid and Littlewood-Richardson, Intro to plethysm
8-9-2017	Aswin Balasubramanian University of Hamburg	Theories of Class S and the Hitchin System
11-9-2017	Aswin Balasubramanian University of Hamburg	Aspects of Geometric Langlands from 4d N=2 Theories
12-9-2017	Amit Mukherjee Indian Statistical Institute, Kolkata	Bayesian Games, Social Welfare Solutions, and Entanglement
12-9-2017	T V H Prathamesh ISI Chnennai	Elementary equivalence in some classes of geometric groups: Artin groups of finite type and mapping class groups of closed surfaces
14-9-2017	M S Santhanam Indian Institute of Science Education and Research (IISER), Pune	Quantum localisation in chaotic systems
14-9-2017	Balesh Kumar IMSc, Chennai	Supersingular elliptic curve and Hasse invariant
15-9-2017	Manik Banik IMSc	Quantum nonlocality does not demand all-out randomness in measurement choice

19-9-2017	Partha Konar PRL, Ahmedabad	Demystifying compressed top squark region with kinematic variables
19-9-2017	Protein Structure	Protein Structure
21-9-2017	Swarup Mohalik Ericsson Labs, Bengaluru	Internet of Things and AI Planning
21-9-2017	Venkatesh Raman IMSc	The work of Donald Knuth
21-9-2017	Biplab Paul IMSc, Chennai	Formal group and elliptic curve
22-9-2017	Raja Mugasimangalam Genotypic Technology, Bengaluru	Ultra long DNA sequence reads from the mobile nanopore sequencers: computational challenges in error correction, assembly and alignment
22-9-2017	Raja Mugasimangalam Genotypic Technology, Bengaluru	Breakout session: Nanopore sequencing
27-9-2017	Soumyadip Sahu CMI, Chennai	Supersingular reduction and Lubin-Tate theory
4-10-2017	A V Sreejith University of Warsaw	Languages over countable linear orderings
4-10-2017	Soumyadip Sahu CMI, Chennai	Supersingular reduction and Lubin-Tate theory
6-10-2017	Hugo Touchette National Institute for Theoretical Physics (NITheP) Stellenbosch, South Africa	Large deviation theory: From physics to mathematics and back
10-10-2017	Pramod Padmanabhan Fields, Gravity and Strings - Institute for Basic Science, South Korea	Using Supersymmetry to create Many Body Localized Phases
11-10-2017	Ashoke Sen HRI, Allahabad	Soft graviton theorem in generic quantum theory of gravity - I
11-10-2017	Jyothsnaa S. IMSc, Chennai	Lower bound for heights in abelian extensions and local metric estimates
12-10-2017	Ashoke Sen HRI, Allahabad	Soft graviton theorem in generic quantum theory of gravity -II

13-10-2017	Ashoke Sen HRI, Allahabad	Soft graviton theorem in generic quantum theory of gravity -III
16-10-2017	Ashoke Sen HRI, Allahabad	How to survive in our strange universe
17-10-2017	Ashoke Sen HRI, Allahabad	Soft graviton theorem in generic quantum theory of gravity - IV
17-10-2017	V. V. Prasad IMSC	Velocity statistics of Granular gases
17-10-2017	R Ramanujam IMSc	Logic Seminar: p equals t Part I
17-10-2017	S P Suresh CMI	Logic Seminar: p equals t Part II
19-10-2017	Abhishek T Bharadwaj CMI, Chennai.	Neron-Tate height and local decomposition
24-10-2017	M. S. Ramanujan University of Warwick, U.K.	To iterate or not to iterate: a linear time algorithm for recognizing almost DAGs
24-10-2017	Mithilesh Mishra TIFR, Mumbai	Cytokinesis: How does a cell make a cut?
25-10-2017	Vigneshwar Narayanan IMSC	Entropy driven transitions: A case of hard rods on a cubic lattice
25-10-2017	Daniel Lokshtanov University of Bergen, Norway	Beating Brute Force for (Quantified) Satisfiability of Circuits of Bounded Treewidth
25-10-2017	Pratik Tale IMSc	Lossy kernelization for some graph contraction problems
25-10-2017	Diptapriyo Majumdar IMSc Chennai	Kernelization for some generalizations of disjoint cycle packing
26-10-2017	Abhisekh Sankaran IMSc Chennai	Kernels via Composition
26-10-2017	Minati Biswal IMSc	$Z_N Symmetry and confinement - deconfinement transition in SU(N) + Higgs theory$

30-10-2017	Mohit Kumar Jolly Center for Theoretical Biological Physics, Rice University	Systems biology of cellular transitions during cancer metastasis: can theory help understand cancer biology?
30-10-2017	Mike Fellows University of Bergen, Norway	Parameterized Algorithms and Complexity: How the field began and where it may go
31-10-2017	Syed Mohammad Meesum	Matrix Editing via Multivariate Lens
1-11-2017	Abhishek T Bharadwaj CMI, Chennai.	Neron-Tate height and local decomposition
2-11-2017	Arvind Gupta arvindguptatoys.com	Science fun, science toys
2-11-2017	Evgeny Smirnov Higher School of Economics Independent University of Moscow, Moscow, Russia	Schubert calculus and Gelfand-Zetlin polytopes
3-11-2017	K. G. Arun CMI	Tale of a binary neutron star merger
3-11-2017	Keshab Bakshi IMSc	On intermediate subfactors
7-11-2017	Bharatram Rangarajan Tel Aviv University	A Combinatorial Proof of Ihara-Bass's Formula for the Zeta Function
8-11-2017	Manabendranath Bera ICFO-The Institute of Photonic Sciences, Spain	Universal Laws of Thermodynamics
10-11-2017	Patrice Philippon CNRS	Beyond Criteria for Algebraic Independence
14-11-2017	Amritanshu Prasad IMSc	Giambelli's identity using the LGV lemma
15-11-2017	Pranendu Darbar IMSc, Chennai	Descending along p^n – $torsionandproofofTheoremsofHabegger.$
16-11-2017	Zbigniew R Struzik University of Tokyo, Tokyo, Japan	Introduction to Wavelet Analysis and Multifractals
16-11-2017	Vivek M Datar Director, INO/TIFR	Nobel prizes in Nuclear Physics

17-11-2017	T.P. Sreeraj IMSc	A Gauge invariant formulation of QCD via canonical transformations
17-11-2017	S. Priyamvad IMSc	Product of primes in arithmetic progression
21-11-2017	S. Aravinda IMSc	Exclusivity principle and unphysicality of Garg-Mermin correlation
21-11-2017	K. N. Raghavan IMSc	Schubert Polynomials
22-11-2017	Sinnou David University of Paris 6	Small height and infinite nonabelian extension
23-11-2017	Ramesh Anishetty & T.P. Sreeraj IMSc	Mass gap in the weak coupling limit of $2+1, SU(2)$ lattice gauge theory
24-11-2017	Krishna Kumar Visiting Fellow, MIDS, Chennai; Formerly Professor, Delhi University and Director, NCERT.	Scientists and school education: A discussion
27-11-2017	Vivek Mishra Oak Ridge National Laboratory	Pairing in cuprates: Signatures of a non-BCS paradigm
28-11-2017	K. Narayan CMI	Extremal surfaces, entanglement in ghost systems and de Sitter entropy
28-11-2017	S. Viswanath IMSc	Littelmann paths and tableaux
29-11-2017	Prafulla Oak IMSc	Exact Renormalization Group and Sine Gordon Theory
30-11-2017	Abhiram M Kidambi Technische Universit4t, Wien	Calabi-Yau manifolds and sporadic groups
5-12-2017	S. Viswanath IMSc	Littelmann paths and tableaux - part 2
6-12-2017	Rahul Dandekar ICTP, Trieste	Hierarchical Models of Hydrogen Bond Networks in Water
6-12-2017	Sinnou David University of Paris 6	On Discriminant Conjecture.
7-12-2017	K Balagopal Saarland University	On the complexity of hazard-free circuits

8-12-2017	Olaf Beyersdorff Leeds Univ, UK	Size, Cost, and Capacity: A Semantic Technique for Hard Random QBFs
13-12-2017	Soham Biswas CUCEI ,Universidad de Guadalajara, Mexico.	Rich structure in the correlation matrix spectra in non-equilibrium steady states
13-12-2017	Venkat Venkatsubramanian Department of Chemical Engineering, Columbia University, New York, USA	How Much Inequality is Fair ? Surprising insights from Game Theory and Statistical Mechanics
14-12-2017	Rohan Sharma Systems Science Focus Group, IIT Jodhpur, Jodhpur, India	Complex network generative models using corona product of graphs
15-12-2017	Digjoy Paul IMSc	The Littlewood-Richardson rule from Robinson's bijection
18-12-2017	Kavitha Arur Texas Tech University	Using bispectral analysis to study quasi-periodic oscillations
18-12-2017	Murali K. Srinivasan IIT Bombay	Eigenvalues and Eigenvectors of the perfect matching association scheme
18-12-2017	Kabir Ramola Brandeis University	Entropy, Disorder and Scaling near the Unjamming Transition
18-12-2017	Denis Thieffry Institut de Biologie de l'9cole Normale Sup9rieure, Paris, France	Computational modelling of immune cell specification and reprogramming
18-12-2017	Krishna R. Kalari Mayo Clinic, Rochester, USA	Casting analytics to capture individual variations in Tumorigenesis
19-12-2017	Anup Basil Mathew IMSc	Some Decidable Classes of the Distributed Synthesis Problem
19-12-2017	Amritanshu Prasad IMSc	Tableau correspondences and representation theory
20-12-2017	Ravi Kunjwal Perimeter Institute, Canada	From statistical proofs of the Kochen-Specker theorem to noise-robust noncontextuality inequalities
20-12-2017	Aradhana Singh IMSc Chennai	Structure and dynamics of modular and anti-modular networks

21-12-2017	Steve Granick Center for Soft and Living Matter, Institute for Basic Science, Korea	Some Surprises and Open Questions in Soft Matter Science
21-12-2017	Amarjit Soni Brookhaven National Laboratory	The 35+ years saga of direct CP violation
22-12-2017	Tanmay Singal Hanyang University (ERICA), South Korea	Necessary condition for local distinguishability of maximally entangled states: Beyond orthogonality preservation
26-12-2017	Venkat Guruswami Carnegie Mellon Univ	Maximally Recoverable Codes with Locality
27-12-2017	N Sukumar Shiv Nadar University	Chemical Space Networks, their Characterization and Applications in Drug Design
28-12-2017	Avijit Misra IMSc	Quantum speed limit constraints on a nanoscale autonomous refrigerator
2-1-2018	Pinaki Banerjee IMSc	Thesis Defense
2-1-2018	Manas Kulkarni ICTS-TIFR, Bengaluru	Driven Incommensurate lattice models in low dimensions
2-1-2018	Chiranjib Mukhopadhyay HRI, Allahabad	Quantum uncertainty relation based on the mean deviation
3-1-2018	Justin David CHEP, IISc	Constraints on parity violating conformal field theories in d=3.
3-1-2018	Ila Varma Columbia University	Counting $D_4 - quartic fields ordered by conductor$
3-1-2018	Glenn Stevens Boston University	PROMYS: a Program in Mathematics for Young Scientists
4-1-2018	Shalom Eliahou ULCO	Monomial ideals with tiny squares
5-1-2018	Prahar Mitra IAS, Princeton	A d-Dimensional Stress Tensor for Minkowski (d+2)-Gravity
5-1-2018	Nikhilesh Natraj University of California San Francisco	Spatiotemporal patterns of eye movements and brain activity underlying the visual perception of complex tool-use

9-1-2018	Gautam Gopal Krishnan Cornell	Nilpotent orbits in flag varieties and associated varieties
9-1-2018	M Vijayalakshmi IBAB Bangalore	Biology-2 Course
9-1-2018	S Krishnaswamy IMSc, Chennai	Bio-2 course
10-1-2018	Kumar Narain ICTP, Trieste, Italy	Boundary Conditions and Localization on AdS
10-1-2018	Geet Rakala TIFR, Mumbai.	Melting of three-sublattice order in triangular Ising anti-ferromagnets with further neighbour couplings
10-1-2018	Ranjith V University of Cagliari, Cagliari, Italy	Quantum First-passage time rendered -speakable : A 1d curious case
10-1-2018	M Vijayalakshmi IBAB Bangalore	Biology-2 Course
10-1-2018	S Krishnaswamy IMSc, Chennai	Bio-2 course
11-1-2018	Poornapushkala N. IMSc, Chennai	Lazarsfeld-Mukai bundles
11-1-2018	Suchitra Sebastian Cavendish Laboratory, Cambridge University, UK	Quantum oscillations and superconductivity in the underdoped cuprates
11-1-2018	M Vijayalakshmi IBAB Bangalore	Biology-2 Course
11-1-2018	M Vijayalakshmi IBAB Bangalore	Biology-2 Course
12-1-2018	Alexandru Oancea Universit9 Pierre et Marie Curie, Paris	Symplectic homology for cobordisms
15-1-2018	Ekta MITP, University of Mainz	Simplifying differential equations for multi-scale Feynman integrals beyond multiple polylogarithms
16-1-2018	Rajesh Singh	Thesis Defense

17-1-2018	Siddharth Prabhu Yale University	A spin on gravitational radiation from the classical double copy
18-1-2018	Rohith Varma	A question on equivariant vector bundles in positive characteristics
22-1-2018	Anirban Kundu Calcutta University	The fourth chiral generation is still alive
22-1-2018	Kaushal Verma Indian Institute of Science, Bengaluru	Three introductions to several complex variables
23-1-2018	Kaushal Verma IISc, Bengaluru	The automorphism group of a domain in $\mathbb{C}^n$.
23-1-2018	Hans van Ditmarch CNRS-INRIA-LORIA, Nancy, France	Asynchronous announcements
24-1-2018	Raju Roychowdhury University of Sao Paulo, Brazil	Emergent Gravity and geometric T-duality
24-1-2018	Kaushal Verma IISc, Bengaluru	Invariant metrics arising from real potential theory
24-1-2018	Mrinal Das ISI Kolkata	Stably free modules over smooth real affine algebras
24-1-2018	Soumyadip Sahu CMI, Chennai	Precise definition, examples of discriminant and conductor of an elliptic curve, Neron classification
25-1-2018	Mrinal Das ISI-Kolkata	The Euler class group and the orbit space of unimodular rows
25-1-2018	Erik van Nimwegen Biozentrum, University of Basel, Switzerland	Single cell gene regulation: Expression noise and the evolution of gene regulation
25-1-2018	Kaushal Verma IISc, Bengaluru	Fatou-Bieberbach domains and Short $\mathbb{C}^{k\prime}s$
29-1-2018	Sujit Sarkar Poornaprajna Institute of Scientific Research	Geometric phase and topological phase transitions in interacting light-matter physics
29-1-2018	G Arunkumar IMSc	Chromatic polynomials and Lie algebras

29-1-2018	Roji Pius Perimeter Institute	The Geometry of Closed String Theory - I
30-1-2018	Roji Pius Perimeter Institute	The Geometry of Closed String Theory - II
31-1-2018	Roji Pius Perimeter Institute	The Geometry of Closed String Theory - III
1-2-2018	Roji Pius Perimeter Institute	On the Possibility of a Closed String Field Theory with Cubic Action
1-2-2018	Alladi Sitaram ISI (retd.)/IISc (retd.)/CMI	A brief journey in Fourier analysis
1-2-2018	Parthasarathi Majumdar R.M. Vivekananda University	The Quantum and the Continuum : Einstein's Dichotomous Legacies
2-2-2018	K. Subramaniam HBCSE, TIFR, Mumbai	Supporting teachers in helping students make sense of mathematics
5-2-2018	T.E.S. Raghavan University of Illinois at Chicago	Determinacy of Gale Stewart Games with a Borel winning set and its implications to stochastic games
7-2-2018	Ayon Patra IISc, Bengaluru	Quintuplet Minimal Dark Matter
7-2-2018	Sampa Dey IITM	Proof of Char =0 case
8-2-2018	Arideep Saha IMSc	Logarithmic connections with given residues
8-2-2018	Kasthuri Kannan NYU School of Medicine, New York	Equations for Selection Under Complete Dominance
8-2-2018	Amilcar Pacheco Universidade Federal do Rio de Janeiro (UFRJ), Brazil	ABC theorem for abelian varieties over function fields in characteristic $p > 0$
12-2-2018	Shubha Tole TIFR, Mumbai	Signals and responses: How the brain is built
14-2-2018	Aritra Biswas IACS	$b- > c$ l nu anomalies in light of extended scalar sectors
15-2-2018	Shraddha Srivastava IMSc	On representations of the rook monoid algebra

15-2-2018	Sagar Chakraborty Department of Physics, Indian Institute of Technology, Kanpur	Occasional uncoupling induced chaotic synchronization
15-2-2018	Sitabhra Sinha	Systems Biology Lecture
15-2-2018	Amilcar Pacheco Universidade Federal do Rio de Janeiro (UFRJ), Brazil	The component height inequality for abelian varieties over global fields
16-2-2018	Antonio Gonzalez-Arroyo Universidad Aut3noma de Madrid	Probing Yang-Mills fields dynamics with Topology
16-2-2018	Sreraman Muralidharan Army Research laboratory, USA	Architectures for quantum repeaters
16-2-2018	Vasudharani Devanathan IISER TVM	Biology-2 Course
19-2-2018	Bhaskar Saha Department of Life Sciences and Biochemistry, St Xavier's College, Mumbai	Combating Neurodegeneration: Are Stem Cells the Final Answer?
19-2-2018	Alexandre Serantes ICTS	Periodically driven holographic CFTs
19-2-2018	Xavier Viennot CNRS, France	Maule: tilings, Young and Tamari lattices under the same roof
20-2-2018	Manoj Kumar Mandal CP3, Belgium	Higgs pair production through gluon fusion with full top quark mass effects at NLO
20-2-2018	Sitender Kashyap HRI, Allahabad	Construction of Integrated vertex operator in pure spinor superstrings
20-2-2018	Dietmar Berwanger CNRS, ENS Paris-Saclay	Complexity Measures for Distributed Games
21-2-2018	Sitender Kashyap HRI, Allahabad	Construction of Integrated vertex operator is pure spinor superstrings - I
22-2-2018	Suratno Basu IMSc	Stability of Parabolic Poincare bundle
22-2-2018	W. Kohnen University of Heidelberg	Shifted products of Fourier coefficients of cusp forms

22-2-2018	Sitender Kashyap HRI, Allahabad	Construction of Integrated vertex operator in pure spinor superstrings
22-2-2018	Vasudharani Devanathan IISER TVM	Biology-2 Course
22-2-2018	Vasudharani Devanathan IISER TVM	Biology-2 Course
23-2-2018	Emil Saucan Department of Applied Mathematics, ORT Braude College and Technion, Israel	Ricci Forman curvature: From Networks to Hyper-networks and back again
23-2-2018	Himadri Barman	Disorder physics and quantum thermodynamics of the Hubbard model.
23-2-2018	Vasudharani Devanathan IISER TVM	Biology-2 Course
26-2-2018	Xavier Viennot CNRS, France	The lattice Tamari(v) is a maule
27-2-2018	Eshita Mazumdar -	Some combinatorial invariants for a finite abelian group
27-2-2018	C P Anil Kumar Center for Science,Technology and Policy (CSTEP) Bengaluru	A Representation Theorem of Line Arrangements and its Generalization to Hyperplane Arrangements via Convex Positive Bijections
28-2-2018	Soumyakanti Bose S. N. Bose National Centre for Basic Sciences	Information Processing with a class of non-Gaussian Quantum Optical States
1-3-2018	Mahesh Kakde King's college London	On Gross-Stark conjecture
2-3-2018	Akira Kinjo Institute for Protein Research, Osaka, Japan	Mechanism of evolution by genetic assimilation: Equivalence and independence of genetic mutation and epigenetic modulation in phenotypic expression
2-3-2018	Ravi Kuchimanchi	Towards understanding grassroots India
7-3-2018	Debmalya Das HRI–Allahabad	Quantum state estimation using weak measurements
8-3-2018	Biplab Paul IMSc, Chennai	Efficient Conductor

9-3-2018	P. Sathish Kumar IMSc, Chennai	Dirac cones and mass terms in bosonic spectra
9-3-2018	Makoto Sakuda Okayama University, Japan	Measurement of gamma rays from giant resonances of 12C/16O(p,p2)
14-3-2018	Vishaka Datta NCBS Bangalore	ChIP-seq simulations reveal key sources of variations and suggest experimental design
14-3-2018	Sridhar Hannenhalli University of Maryland / IISc Bangalore	Transcriptional Genomics
15-3-2018	Rekha Biswal Universite Laval, Canada	Demazure flags: connections to algebraic combinatorics and number theory.
15-3-2018	Sridhar Hannenhalli University of Maryland / visiting IISc Bangalore	Transcriptional Enhancers 6 Looking out for the genes and each other
15-3-2018	Ayan Mukhopadhyay Physics Department, IIT Madras	A hybrid non-perturbative model for the Quark Gluon Plasma
16-3-2018	Sankardeep Chakraborty	Space Efficient Graph Algorithms (Thesis Defence)
19-3-2018	Pulak Banerjee IMSc	Higher order QCD corrections and resummation effects in the Drell-Yan process in the Standard Model and beyond
19-3-2018	Prasanna Kumar Dhani IMSc	Threshold resummation of rapidity distribution for Higgs production at NNLO+NNLL
20-3-2018	George Thomas IMSc	Two models of quantum heat engines
21-3-2018	Madhav Ranganathan IIT Kanpur	Continuum and Atomistic Modeling of quantum dot growth in heteroepitaxial systems
21-3-2018	Sankar Basu Department of Chemistry, University of Delhi (North Campus), Delhi 110007	The Globular-Disordered Interface in Proteins: Addressing Molecular Evolution from Protein Design
21-3-2018	Biplab Paul IMSc, Chennai	Efficient Conductor

23-3-2018	Vishwas Vasisht LIPhy, Grenoble	Shear banding phenomenon in dense amorphous materials
26-3-2018	Vivek Kumar Singh IIT Bombay	Arborescent knot/link invariant computation
27-3-2018	Vivek Kumar Singh IIT Bombay	Entanglement entropy from link invariants
28-3-2018	P Ramadevi IIT Bombay	Methods for computing arborescent and non-arborecent knot invariants
28-3-2018	Nivedita Chatterjee Sankara Nethralaya	Neuroscience Module of Biology-2 Course
28-3-2018	Nivedita Chatterjee Sankara Nethralaya	Neuroscience Module of Biology-2 Course
29-3-2018	Vivek Kumar Singh IIT Bombay	A example of non-arborescent knot computation
29-3-2018	Sutanu Roy NISER	Semidirect product of groups and beyond
29-3-2018	P Ramadevi IIT Bombay	Topological string duality and integrality checks
30-3-2018	P Ramadevi IIT Bombay	Knot Invariants and M-theory

Figure 4.1: Teachers Enrichment Program 22nd May - 27th May 2017.

Figure 4.2: "Facets", a 2 day outreach program 3rd July 2017 - 4th July 2017.

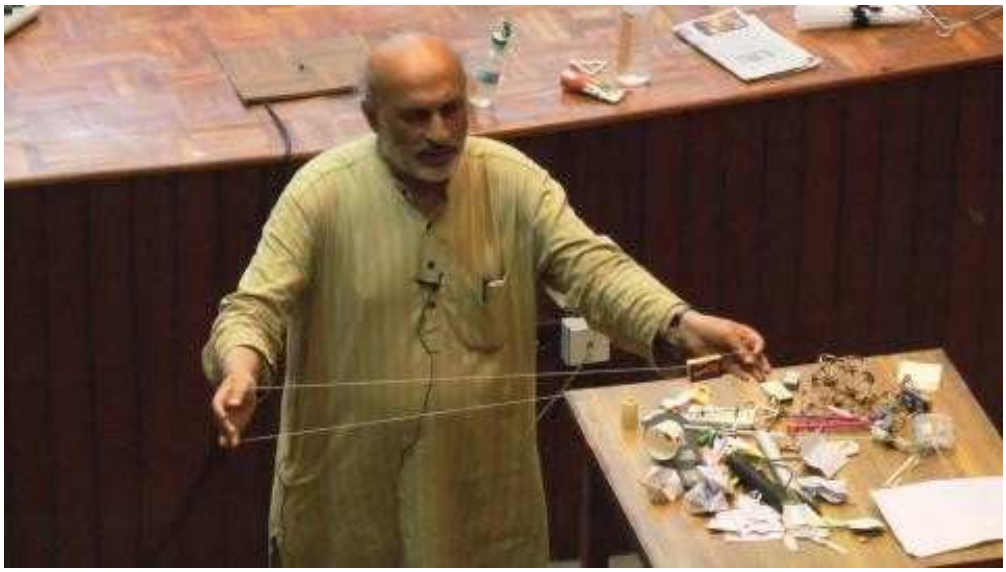

Figure 4.3: Science Fun, Science Toys: 2nd November 2017.

Figure 4.4: Foldscope workshop: 2nd January, 2018.

Figure 4.5: Foldscope workshop: 2nd January, 2018.

Figure 4.6: Foldscope workshop: 2nd January, 2018.

Figure 4.7: Science at the Sabha 2018, The Music Academy: 11th February 2018.

Figure 4.8: Indian Women in Science Exhibition, The Music Academy: 11th February 2018,

Figure 4.9: Indian Women in Science Exhibition, Chennai Mathematical Institute: 5th to 9th March 2018

Chapter 5

External Interactions

5.1 Collaborative Projects with Other Institutions

5.1.1 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 72 pulsars and transients (http://www.naic.edu/ deneva/drift-search). The new discoveries include 8 millisecond pulsars (MSPs), 8 binary pulsars, and 11 rotating radio transients. 4 of the 8 MSPs were found in 2016, along with 1 RRAT and 7 slow pulsars, one of which was found in data taken during the observatory shut-down for hurricane Isaac in 2012. So far two AO327 discoveries have proven to be exceptionally stable rotators and have been added to the The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) data set. The papers have been published reporting results of this survey.

This collaboration has total nine members, from 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.

5.1.2 Automatic Presentation of Numbers (PANO)

Automatic numbers are roughly represented as numbers whose nth bit position is accepted by a DFA. A breakthrough result shows that such numbers are either rational or irrational. We are interested in studying similar properties of numbers accepted by other automatic models, such as PDAs.

The other group members are: Prof. Didier Caucal and Dr. Antoine Meyer from Universit Paris-Est et CNRS, Marne-La-Valle, France and Prof. Christian Delhomme, Prof. Marion Le-Gonidec, from University of Reunion, France

5.1.3 Correctness by Construction (CORCON)

This project is funded by the Marie Curie Actions – International Research Staff Exchange Scheme (IRSES) of the European Union FP7. It involves multiple nations and researchers, and runs for four years beginning January 2014. IMSc is involved in the sub-project on proof verification and proof complexity, jointly with the University of Leeds, UK. The principal investigators for this sub-project are Meena Mahajan from IMSc and Olaf Beyersdorff from the University of Leeds.

5.1.4 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). We are performing an Indian PTA experiment using the Giant Metrewave Radio Telescope (GMRT) and the Ooty Radio Telescope (ORT). Observations and data analysis is going on. The preliminary results were presented in the 2016 Meeting of International Pulsar Timing Array in South Africa. Presently 10 people are involved in this project, members are affiliated to NCRA-TIFR Pune, TIFR Mumbai, RAC TIFR Ooty, ASTRON (The Netherlands), IMSC Chennai (Manjari Bagchi, Dhruv Pathak).

5.1.5 Indo-U.S Joint R&D Networked Joint Center Programme: Emergence and Re-modeling of force chains in soft and Biological Matter

A R& D Networked joint Center involving partners at Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, India, (Srikanth Sastry), Brandeis University, Waltham, MA, USA, (Bulbul Chakraborty), National Centre for Biological Sciences, Bengaluru, (Madan Rao), Institute of Mathematical Sciences, Chennai, (Pinaki Chaudhuri) and Northeastern University, Boston, (Dapeng Bi), to pursue theoretical and computational research on the localization of pathways by which stress propagates in disordered, soft matter and biological systems, and their implications for the propagation of dynamical correlations, and information, in these systems, and in the latter context, their implications for biological function.

5.1.6 ITRA-Media Lab Asia Project on De-congesting India's transportation networks using mobile devices

The project envisages the use of mobile phones to estimate congestion and traffic patterns on urban roads. Based on the congestion metrics thus obtained, the project aims to develop algorithms and tools for traffic planning and management, using the mobile phone as a service platform. The proposed solution strategy consists of two distinct focus areas. The first focus area deals with the problem of estimating mobile phone densities to measure prevailing congestion and traffic patterns. The second focus area involves developing algorithms for traffic routing, control and prediction, based on the estimated congestion. The proposed work has enormous potential for applications, such as dynamic route planning, peak hour rush control, routing of emergency vehicles to and from disaster affected areas, evacuation planning, and traffic prediction. In addition, this work is expected to shed new conceptual insights into the general problem of control of complex networks with strategic agents, by bringing together ideas from several technical disciplines.

5.1.7 Max Planck Partner Group in Mathematical Biology

In the partner group, we are employing concepts from geometry to develop and apply methods based on edges rather than nodes in graphs for differential or comparative analysis of condition-specific biological networks. We are developing general methods that can compare condition-specific networks irrespective of their mathematical representation, and thus, will be applicable to labeled or unlabeled graphs, unweighted or weighted graphs, and undirected or directed graphs. In collaboration with Prof. Jürgen Jost, our partner and host in MPIMIS Leipzig, we have recently introduced an edge-based measure, Forman-Ricci curvature, for the geometrical characterization of complex networks which is applicable to unweighted or weighted graphs and undirected or directed graphs. Forman-Ricci curvature is a concept inspired from Riemannian and polyhedral geometry which quantifies the extent to which the network spreads out at the ends of edges in a complex network. Forman-Ricci curvature is simple to compute in large networks, and its statistics capture global network properties better than more traditional node-based measures in both model and real-world networks. Moreover, the associated Forman-Ricci flow is also a concept inspired by deep results in geometry that offers an elegant scheme for denoising networks. Forman-Ricci curvature also presents a natural method to quantify the difference between multiple networks, via so-called Wasserstein distance, inspired by optimal transport theory. In the partner group, we want to further develop this scheme in collaboration with the

group of Prof. Jürgen Jost, and explore its potential applications in a systematic manner to different types of biological networks.

5.1.8 Mechanism of Active Intracellular Transport: Connecting Theory and Experiment

This DAE-Plan project attempts to combine experimental investigations, using fluorescence microscopy, of the motion of vesicle in axons of touch neurons of C. elegans with theoretical models. Smooth axonal transport is crucial for the healthy functioning of nerve cells and impairment of this transport is often seen in neurodegenerative disease. We plan to closely link the theory and experimental observations to come up with a detailed simulation of axonal transport mechanisms which can then be compared to experiments.

5.1.9 Mechanobiology of cell adhesion and cytoskeleton under dynamic shear

The goals of this study are to explore the differences in cell adhesions, contractility and morphology in response to variations in the mechanical milieu. We have recently fabricated a custom fluid shear device, mounted on a microscope stage, which will be optimized and used to exert different shear stresses on cells. Because cell morphology and orientation may alter cell contractility and mechanotransduction, we will use micropatterning to constrain fibroblasts within circular and triangular shapes in the shear device and subject cells to low (0.5 Pa) and high (1.5 Pa) shear stresses which are physiologically relevant. We plan to measure the de- adhesion of cancerous cells, comparing their behaviour under shear with that of non-cancerous cells. Preliminary investigations show that de-adhesion profile in response to shear stresses of cells may be used to quantify differences in cell types. We hypothesize that both cellular morphologies and traction forces are systematically altered under shear. Cellular traction forces are used as an important measure of the cell contractility. We will quantify dynamic changes in the cellular tractions and relate these to the spatio-temporal variations in the evolution of forces at focal adhesions due to low and high shear stresses. We hypothesize that the amount of talin is altered for fibroblasts under dynamic shear conditions as compared to those under static culture. The fluid shear device can also be used to measure the de-adhesion of cancerous cells, and to compare their behaviour under shear with that of non-cancerous cells. Finally, we will use a systems biology approach, integrated with a cell-scale biophysical model, to better characterize the role of cellular contractility with inputs from the experimental results. Together, such studies should be of considerable interest to biophysicists who study cell adhesion and migration during growth and due to pathologies.

5.1.10 Modeling Soft Glass flow from micro to macro scale (CEFIPRA Project No 5604-1)

The project, funded via CEFIPRA, is a collaboration between Dr. Kirsten Martens, Laboratoire interdisciplinaire de Physique, Universit Grenoble Alpes, Grenoble, and Pinaki Chaudhuri, IMSc, starting from December 2016, for a period of three years. The aim of this project is to understand the complex dynamical features during the yielding and subsequent flow of dense soft disordered materials, via a multi-scale approach, using computational and analytic techniques. Such an approach is necessary in linking macroscopic experimental observations to material's properties at micro-scale, thereby leading to designing new materials. To develop valid descriptions across the scales involved, we start from the scale of individual particles, grains or bubbles, which are modeled using molecular dynamics simulations. Based on these microscopic studies, we aim at coarse-graining the dynamics to stochastic lattice models on the scale of plastic rearrangements. These simpler models are the ideal starting point for a statistical approach to derive stochastic evolution equations for the probability distributions of local observables, relevant for the yielding process. The originality in this bottom up approach, bridging different scales, is the combination of consistent simultaneous studies on the micro and the meso-scale to ensure the validity of the assumptions made for the simplified scenarios, which can thereafter be used to predict effects on larger length-scales.

5.1.11 Présentation automatique des nombres (Automatic presentation of numbers)

This is a project of the Région Réunion on algorithms and properties of numbers which can be represented using finite automata. Kamal Lodaya and Vikram Sharma attended the first academic meeting of the project, gave talks and had discussions, at the Université de La Réunion, 7-9 January 2016.

Didier Caucal, Antoine Meyer (UPEM) and Christian Delhomme, M. Le Gonidec, A. Mansard (U. de La Réunion) visited IMSc during 8–19 October 2016. They also participated in a one-day workshop on Automatic Presentations of Graphs and Numbers, organized by Vikram Sharma on 11 October 2016.

Kamal Lodaya and Vikram Sharma attended the third academic meeting of the project, gave talks and had discussions, at the Université de La Réunion, 23 October–2 November 2017.

5.1.12 Quantitative analysis of Mitochondrial positioning in C. elegans axons

Along with Prof. Gautam Menon, in collaboration with Prof. Sandhya Koushika (TIFR, Mumbai) we have been working on Quantifying mitochondrial positioning in Caenorhabditis elegans neurons. I have been working on an image analysis algorithm to process the microscope images that have been collected in Prof. Koushika's lab in order to understand how mitochondria are positioned along axons of neurons over the development of the worm.

5.1.13 Survey for Pulsars and Fast Transients with the upgraded GMRT : A Pilot Study

** ongoing project **

A survey for pulsars and transients using GMRT (uGMRT) is ongoing. Using population synthesis studies and the available system parameters for the uGMRT, we identified a suitable area of the sky of around 450 sq.deg where we expect discoveries of new pulsars. We have performed total 100 hours of observations divided into 14 epochs (during September-2016 to March-2017). Data analysis is under process.

There are total 20 members in this collaboration presently. There is scope of more people joining in the future. Members of this project are affiliated to various Indian and foreign Institutes, like NCRA-TIFR Pune, IMSc Chennai (Manjari Bagchi) SINP Kolkata, IUCAA Pune, RRI Bangalore, NISER Bhubaneswar, University of California Berkeley (USA), TIFR Mumbai, ASTRON (The Netherlands), CEA Saclay (France), IIT,-Kharagpur, PRL Ahmedabad, and IIT-Roorkie.

GMRT is operated by NCRA-TIFR, Pune.

5.1.14 Towards precision pulsar timing with the uGMRT

** ongoing project **

To test the capacity of upgraded GMRT (uGMRT) to study millisecond pulsars (MSPs), 19 MSPs are being monitored and timed. This is a eight member team from NCRA-TIFR Pune, TIFR Mumbai, IMSc Chennai, and ASTRON (The Netherlands).

5.2 Institute Associateships

The Institute has established short-term associateships in Mathematics, Theoretical Physics, Theoretical Computer Science and Computational Biology to enable teachers from colleges and universities to work at the institute. The programme is envisaged to develop interaction between the members of the faculty of the institute and scientists in the university system. Under this programme, an associate can visit the institute once or twice a year, up to a total of 90 days per year, each visit lasting a minimum of three weeks. The tenure of an associate will be for a period of three years and (s)he is expected to visit the institute at least twice during this period.

The institute will bear the expenses of round-trip travel (by rail) from the Associate's normal place of work to Chennai and will also pay a daily allowance to cover local expenses at Chennai. During their stay at Chennai, Associates will be accommodated in the institute Guest House.

5.3 Conference Participation and Visits to Other Institutions

Agrawal, Ankit

Participated in *EMBO The nucleosome: From atoms to genomes* held at EMBL Heidelberg Germany during Aug 30 – Sep 1, 2017. Received the EMBO travel grant to attend this conference.

Arvind, V.

Participated in *15th Asian Logic Conference* held at Center for Applications of Mathematical Principles, Daejeon, Korea during Jul 10 – Jul 14, 2017.

Participated in *Recent trends in graphs and networks* held at St. Xavier's College for Women, Aluva, Kerala during Oct 30 – Nov 1, 2017.

Ashok, Sujay K.

Participated in *National Strings Meeting* held at NISER, Bhubaneshwar during Dec 5 – Dec 10, 2017. Students presented their work at the conference.

Participated in *Asian Winter School* held at ICTS, Bengaluru during Jan 8 – Jan 18, 2018. Participant

Visited HRI, Allahabad during Feb 5 – Feb 9, 2018. Invited speaker

Visited TIFR, Mumbai during Feb 28 – Mar 7, 2018. Invited speaker

Visited IISER-Pune during Mar 26 – Mar 28, 2018. Invited speaker

Bagchi, Manjari

Participated in *29th meeting of the Indian Association for General Relativity and Gravitation (IAGRG)* held at Indian Institute of Technology-Guwahati, Guwahati, India during May 18 – May 20, 2017. Gave a talk on "Prospects of constraining the dense matter equation of state from observations and data analysis of radio pulsars in binaries"

Participated in *Recent Trends in the Study of Compact Objects - Theory and Observation (RETCO - III)* held at Indian Institute of Space Science Technology, Thiruvananthapuram, India during Jun 5 – Jun 7, 2017. Gave a talk on "Understanding the Mystery of Fast Radio Bursts".

Visited National Centre for Radio Astrophysics - TIFR, Pune, India during Jul 24 – Jul 29, 2017. Gave a colloquium titled "Binary radio pulsars with compact companions to understand basic physics" on July 28, 2017. Also collaborative discussions.

Participated in *Compact Stars in the QCD Phase Diagram VI* held at The Joint Institute for Nuclear Research (JINR), Dubna, Russia during Sep 26 – Sep 29, 2017. Gave a talk on "Prospects of constraining the dense matter equation of state from observations and data analysis of radio pulsars in binaries"

Participated in *Pulsar and FRB Search Software in The Era of Real-Time Surveys* held at The South African Astronomical Observatory, Cape Town, South Africa during Dec 11 – Dec 14, 2017. Gave a talk titled "Binary Pulsars and More"

Participated in *Multi-Wavelength Neutron Star Workshop* held at BITS-Pilani, Hyderabad, India during Jan 7 – Jan 8, 2018. Gave a talk titled "Pulsar Population Synthesis", was also a member of SOC.

Participated in *National Conference on Technological Empowerment of Women - Commemorating the International Womens Day (NASI mega event)* held at Vigyan Bhawan, New Delhi during Mar 8 – Mar 9, 2018.

Banerjee, Pinaki

Participated in *New Development in AdS3/CFT2 Holography* held at Galileo Galilei Institute for Theoretical Physics, Florence, Italy during Mar 27 – Apr 29, 2017. Invited under Young Investigator Training Program (YITP) fellowship.

Biswas, Arindam

Participated in *Recent Advances in Parameterized Complexity* held at Tel Aviv during Dec 3 – Dec 7, 2017. The workshop was an exposition of the current state of affairs in Parameterized Complexity, and possible future research directions. In particular, possible open problems in FPT-approximation were discussed.

Chaudhuri, Pinaki P.

Participated in *CECAM Workshop: Rheology of gel networks: combining experimental, computational and theoretical insights* held at Centre Blaise Pascal, Lyon, France during Jun 21 – Jun 23, 2017. Talk on "Ultra-long-range dynamic correlations during aging of gels"

Participated in *CEFIPRA Seminar on Plasticity, Rheology and Nonlinear response in Driven Amorphous Solids* held at Universite Grenoble, Grenoble, France during Jun 26 – Jun 29, 2017. Talk on "Shear response of glasses: transient heterogeneities"

Visited Institute for Theoretical Physics, University of Duesseldorf during Jul 11 – Aug 11, 2017.

Visited KITP, University of Santa Barbara during Jan 1 – Jan 19, 2018.

Participated in *Program on "Memory Formation in Matter"* held at Kavli Institute for Theoretical Physics, University of Santa Barbara, USA during Jan 2 – Jan 19, 2018. Talk on "Deformation Response of Glasses"

Participated in *5th Indian Statistical Physics Community Meeting* held at TIFR-ICTS, Bangalore, India during Feb 16 – Feb 18, 2018. Talk on "Glassy liquids: response to thermal gradient"

Date, G.

Visited VIT University, Vellore on Nov 1, 2017. Gave a lecture on *Relativity in Global Positioning System* under the Expert Lecture Program of VIT.

Digal, Sanatan D.

Participated in *Workshop on High Energy Physics Phenomenology XV* held at IISER, BHOPAL during Dec 17 – Dec 23, 2017.

Gun, S.

Visited University of Paris VI during Jun 5 – Jul 28, 2017. Academic collaboration.

Participated in *Number Theory: Arithmetic, Diophantine and Transcendence* held at IIT Ropar during Dec 22 – Dec 26, 2017. Organizer

Visited TIFR during Feb 5 – Feb 9, 2018. Academic collaboration

Jacob, Ashwin

Participated in *Recent Advances in Parameterized Complexity workshop* held at Grand Beach Hotel, Tel Aviv, Israel during Dec 3 – Dec 7, 2017. rapctelaviv.weebly.com

Visited Ben Gurion University, Beersheba, Israel during Dec 10 – Dec 15, 2017. Visited Dr. Meirav Zehavi

Janani, R.

Participated in *Dynamics of Complex Systems - 2017* held at ICTS, Bengaluru during May 10 – May 25, 2017.

Participated in *Winter School on Quantitative Systems Biology 2017* held at ICTS, Bengaluru during Dec 4 – Dec 22, 2017.

Participated in *Aspects of Gene and Cellular Regulation* held at IMSc, Chennai during Jan 12 – Jan 13, 2018.

Participated in *National Conference on Technological Empowerment of Women* held at Vigyan Bhawan, New Delhi during Mar 8 – Mar 9, 2018.

Jayakrishnan, M.

Visited University of Bergen, Norway during Sep 3 – Nov 29, 2017.

Jayakumar, R.

Participated in *ATMW Schubert Varieties (2017)* held at The Institute of Mathematical Sciences (IMSc), Chennai, India during Oct 23 – Nov 4, 2017.

Participated in *Annual Foundation School - I (2017) - Kozhikode* held at Kerala School of Mathematics,Kozhikode, Kerala, India during Dec 4 – Dec 30, 2017. Conducted 16 hours of tutorials in Algebra in Annual Foundation School-I (2017).

Participated in *Conference on Quantum Groups Noncommutative Geomentry* held at NISER Bhubaneswar, Odisha, India during Jan 15 – Jan 19, 2018.

Participated in *IST Complex Analysis and Analytic Number Theory (2018)* held at School of Mathematical Sciences, SRTM University, Nanded, Maharashtra, India. during Jan 29 – Feb 10, 2018. Conducted 16 hours of tutorials in Complex Analysis in IST Complex Analysis and Analytic Number Theory (2018).

Visited SRTM University on Feb 9, 2018. Gave a talk at School of Mathematical Sciences, SRTM University, Nanded, Maharashtra,India, on Russell's paradox and Universal set.

Krithika, R.

Visited The University of Bergen, Bergen, Norway during Sep 1 – Nov 30, 2017. Research Collaboration

Kumar, Balesh

Visited Harish-Chandra Research Institute, Allahabad during Jul 22 – Aug 8, 2017.

Participated in *Number Theory: Arithmetic, Diophantine and Transcendence* held at IIT Ropar during Dec 22 – Dec 25, 2017. Gave a talk titled "On Doi-Naganuma and Shimura liftings".

Visited Kerala School of Mathematics, Calicut during Feb 12 – Feb 24, 2018.

Lodaya, Kamal

Participated in *15th Asian logic conference* held at Daejeon, Korea during Jul 10 – Jul 14, 2017. Gave an invited talk on "Between two- and three-variable logic on word models".

Participated in *16th Formal Methods Update* held at IIT Mandi during Jul 17 – Jul 18, 2017. Gave a talk on "Between two- and three-variable logic on word models".

Participated in *Representation in AI school* held at IIT Mandi during Jul 19 – Jul 21, 2017. Gave a talk on "Description logics".

Participated in *19th Calcutta Logic Circle meeting* held at Dept of Pure Mathematics, University of Kolkata during Oct 13 – Oct 15, 2017. Gave a talk on "So many logics go so many different ways".

Participated in *Workshop on Probabilistic reasoning and formal methods* held at IIT Kanpur on Dec 11, 2017.

Participated in *37th FSTTCS conference* held at IIT Kanpur during Dec 12 – Dec 14, 2017.

Visited School of Engineering and Applied Science, Ahmedabad University on Mar 12, 2018. Gave a talk on "The origin of computer science".

Visited TIFR Mumbai on Mar 13, 2018.

Visited IIT Goa and BITS (Goa campus) during Mar 14 – Mar 15, 2018. Gave a talk on "The origin of computer science".

Mahajan, Meena B.

Participated in *CSL 2017: 26th EACSL Annual Conference on Computer Science Logic* held at Stockholm University during Aug 20 – Aug 24, 2017. Gave an invited talk titled "Arithmetic Circuits: An Overview"

Participated in *Dagstuhl Seminar on Recent Trends in Knowledge Compilation* held at Leibniz Centre for Informatics, Dagstuhl, Germany during Sep 17 – Sep 22, 2017.

Visited School of Computing, University of Leeds, UK during Sep 22 – Oct 6, 2017. This visit was for research collaboration under the ongoing IRSES project CORCON.

Participated in *Workshop on Probabilistic Reasoning and Formal Methods* held at IIT Kanpur on Dec 11, 2017. pre-FSTTCS workshop.

Participated in *FSTTCS* held at IIT Kanpur during Dec 12 – Dec 14, 2017.

Participated in *Dagstuhl Seminar on Proof Complexity* held at Leibniz Centre for Informatics, Dagstuhl, Germany during Jan 28 – Feb 2, 2018. Gave a talk titled "Are short proofs narrow? QBF Resolution is not so simple"

Visited Technical University, Berlin during Feb 3 – Feb 6, 2018. Gave a talk titled "Lower bound techniques for QBF proof systems" in the 'Methods for Discrete Structures' seminar.

Participated in *35th International Symposium on Theoretical Aspects of Computer Science STACS* held at Caen, France during Feb 28 – Mar 3, 2018. As an invited plenary speaker, gave a talk titled "Lower Bound Techniques for QBF Proof Systems".

Participated in *Workshop on Algebraic Complexity Theory WACT* held at University Paris-Diderot, Paris, France during Mar 5 – Mar 9, 2018. Gave an invited talk titled "(Min,+) Formulas, Max, and Shortest Paths"

Visited Max Planck Institute for Informatics, Saarbrucken, Germany during Mar 10 – Mar 22, 2018. Gave a talk titled "Short proofs with simple arithmetic?" on 16 March 2018.

Menon, Gautam I.

Participated in *Workshop on Mathematical Models for Infection and Immunity* held at Indian Institute of Science, Bengaluru during Apr 6 – Apr 8, 2017. Presented an invited talk on "An agent-based model for diseases in Indian populations"

Participated in *EMBO school on Experimental and Theoretical Approaches to Cell Mechanics* held at Raman Research Institute and National Centre for Biological Sciences, Bengaluru during Apr 24 – Apr 28, 2017. Presented a set of pedagogical lectures on "Fluctuations in Biophysics" to an international group of students at this EMBO school

Participated in *UGC-sponsored Refresher Course for College Teachers* held at Madras University during May 23 – May 24, 2017. Presented a lecture on "Statistical Mechanics"

Participated in *Correlation and Disorder in Classical and Quantum Systems* held at ICTS, Bengaluru during May 29 – Jun 2, 2017. Gave an invited talk on "The Peak Effect, Revisited"

Participated in *Dynamics of Complex Systems* held at ICTS, Bengaluru during Jun 18 – Jun 23, 2017. Gave two talks, one on "Nuclear Mechanics"and one on "Describing Cell-Substrate Detachment under Shear"

Participated in *Workshop on Infectious Disease Modelling* held at CMC, Vellore during Sep 13 – Sep 15, 2017. Gave two invited talks on "Network and Agent-based Models for Infectious Diseases" as part of this event, organized by CMC Vellore and supported by the Fogarty Centre of NIH, USA.

Participated in *Structure across Scales* held at NCBS, Bengaluru during Oct 7 – Oct 8, 2017. Presented an invited talk on "Nuclear Architecture at the Largest Scales"

Visited Department of Chemical engineering, Indian Institute of Science during Oct 26 – Oct 27, 2017. Presented a seminar on "Modelling Stem Cell Mechanics"

Visited TIFR, Mumbai during Dec 6 – Dec 8, 2017. Visited the group of Prof. Sandhya Koushika at TIFR in connection with a collaboration omn axonal transport

Participated in *CompFlu-2017* held at IIT Madras, Chennai during Dec 18 – Dec 20, 2017. Presented an invited talk on "Cell-substrate de-adhesion under fluid shear"

Participated in *Current Trends in Intracellular Transport and Molecular Motors* held at TIFR, Mumbai and IIT, Mumbai during Dec 21 – Dec 23, 2017. Presented an invited talk on "Models for motor-driven axonal transport"

Participated in *ICTS at Ten* held at ICTS, Bengaluru during Jan 4 – Jan 8, 2018. Chaired the Biophysics session at this meeting organized to celebrate 10 years of the establishment of ICTS-TIFR.

Visited Institut Curie, Paris during Feb 1 – Feb 4, 2018. Visited Prof. Jean-Francois Joanny at the ESPCI for discussions. Also visited the Curie Institute and presented a seminar on "A first-principles approach to nuclear architecture".

Participated in *Emergent Phenomena in Classical and Quantum Systems* held at SNBNCBS, Kolkata during Feb 28 – Mar 2, 2018. Gave an invited talk on "Modelling Stem Cell Mechanics". Also chaired a panel discussion on future research and directions in condensed matter physics and statistical mechanics.

Visited TIFR, Mumbai during Mar 13 – Mar 16, 2018. Visited the group of Sandhya Koushika at the Department of Biological Sciences, TIFR, Mumbai in connection with an on-going experiment-theory collaboration

Participated in *Annual Talks, Computational Biology Group* held at IMSc, Chennai on Mar 22, 2018. The Computational Biology group held its first public Annual Talks series, covering the research of all its members.

Participated in *Golden Jubilee Lecture and Dissemination and Orientation Program* held at Habitat Centre, New Delhi during Mar 28 – Mar 29, 2018. Attended this event as part of the orientation for Shastri Mobility Fellowship awardees

Menon, Shakti N.

Participated in *8th Bangalore school on Statistical Physics* held at International Center for Theoretical Sciences (ICTS) during Jun 28 – Jul 14, 2017.

Murthy, M.V.N.

Visited JSS College, Mysore during May 2 – May 5, 2017. Short Course (6 Lectures) on Relativistic Quantum Mechanics

Participated in *Science Academies Lecture Workshop on Advances in Particle Physics (supported by the three academies IAS, NAS and INSA)* held at Bishop Moore College, Mavelikkara, Kerala during Jul 12 – Jul 14, 2017. Convenor, Delivered three lectures on Symmetries and classification of elementary particles.

Participated in *Lecture workshop on "Topology and Quantum Mechanics" (supported by the three academies IAS, NAS and INSA)* held at P B Siddhartha College of Arts and Science, Vijayawada, AP. during Feb 9 – Feb 10, 2018. Delivered two lectures on "Fractional Exclusion Statistics and Calogero Sutherland Model".

Participated in *Lecture workshop on Quantum Theory of Angular Momentum (Supported by the three academies IAS, NAS and INSA)* held at T K M College of Arts and Science, Kollam, Kerala during Mar 14 – Mar 16, 2018. Delivered 6 lectures on "Rotation Group and its representations".

Nath, Avijit

Participated in *ATMW Schubert Varieties* held at IMSc Chennai during Oct 23 – Nov 4, 2017.

Varuni, P.

Visited Homi Bhabha Centre for Science Education, TIFR, Mumbai during Mar 9 – Mar 11, 2018. As part of the Vigyan Pratibha program, aimed at extended nurture of talent in Science and Mathematics for students in classes VIII to IX, I was involved in at Resource Generation Camp (RGC) for Biology for Class IX.

Pathak, Dhruv

Visited ICTS, Bengaluru during Jul 17 – Jul 28, 2017. Summer School on Gravitational-Wave Astronomy

Visited NCRA, Pune during Sep 12 – Sep 18, 2017. PTA observations at GMRT

Visited NCRA,Pune during Nov 18 – Nov 22, 2017. PTA observations at GMRT

Participated in *Pulsar Astronomy with uGMRT Boot-Camp* held at BITS Pilani, Hyderabad Campus during Jan 3 – Jan 6, 2018. Lectures and hands on sessions with different softwares important for pulsar timing analysis

Participated in *Multi Wavelength Neutron Star Workshop* held at BITS Pilani, Hyderabad Campus during Jan 7 – Jan 8, 2018. Gave a talk on "Dynamical contributions in the rate of change of the period of radio pulsars "

Prasad, Amritanshu

Participated in *International conference on algebra, discrete mathematics, and applications* held at Dr. Babasaheb Marathwada University, Aurangabad, Maharashtra during Dec 9 – Dec 11, 2017. Invited talk.

Participated in *83rd annual conference of the Indian Mathematical Society* held at Sri Venkateswara University, Tirupati during Dec 12 – Dec 15, 2017. Delivered the 28th Srinivasa Ramanujan Memorial Award Lecture

Raghavan, K. N.

Participated in *Summer Workshop for MSc students and college teachers* held at Kerala School of Mathematics, Kozhikkode during Apr 1 – Apr 5, 2017. Resource person

Visited National Institute of Technology, Calicut on Apr 4, 2017. Gave a colloquium talk

Visited Jawaharlal Nehru University, Dehli on Apr 6, 2017. Gave a colloquium talk.

Visited IGNOU, Delhi on Apr 7, 2017. Attended expert committee meeting to design a course in algebra.

Visited Harish-Chandra Research Institute, Allahabad during Apr 15 – Apr 18, 2017. Attended a meeting of the Board of Studies, Mathematical Sciences, of HBNI. Gave a colloquium talk.

Visited K. S. Rangasamy College of Arts and Science (Autonomous), Tiruchengode, Namakkal District, Tamilnadu during May 4 – May 6, 2017. Convener and resource person of Academies' Lecture Worskhop on Algebra

Participated in *Internship Programme conducted by Pie Mathematics Association* held at Arputharaj Matriculation Higher Secondary School, Choolaimedu, Chennai on May 13, 2017. Gave two lectures on linear algebra to the interns

Participated in *9th Summer training program in mathematics* held at Ramanujan Institute for Advance Study in Mathematics during May 16 – May 24, 2017. Conducted six sessions of lectures and tutorials on topics in linear algebra and algebra

Participated in *Madhava Competetion Nurture Camp* held at Indian Statistical Institute, Bangalore Centre during Jun 5 – Jun 6, 2017. Gave two lectures and conducted two tutorials for the participants of the camp

Visited Stella Maris College, Chennai on Jul 27, 2017. delivered the Dr. J. Thangamani Endowment Lecture

Visited Benares Hindu University during Dec 14 – Dec 16, 2017. As co-organizer of a topics symposium on Algebraic Groups in TIMC-AMS conference

Raman, Venkatesh

Visited IIT Jodhpur during Apr 17 – Apr 26, 2017. Gave some lectures on parameterized complexity

Participated in *ACM-Chennai Turing Award Lectures* held at IMSc Chennai on Sep 21, 2017. Gave a talk on 'Contributions of D.E. Knuth'

Visited PSG Arts College, Coimbatore on Sep 22, 2017. Gave a talk on 'A basic introduction to Algorithms'.

Participated in *Faculty Development Training Programme on Design and Analysis of Algorithms* held at St. Joseph's College of Engineering, Chennai during Dec 4 – Dec 11, 2017. Gave three lectures

Participated in *ACM-India Annual Event* held at Persistent Systems, Nagpur during Feb 15 – Feb 17, 2018.

Visited PSG College of Technology, Coimbatore on Mar 12, 2018. Gave a talk on 'Selection Problems and Adversary Lower Bounds'.

Ramanujam, R.

Visited LORIA, Nancy, France during May 1 – Jun 25, 2017. Gave a colloquium on "Dynamics of large games".

Participated in *Dynamic Epistemic Logic* held at LORIA, Nancy, France during May 9 – May 13, 2017. Gave a talk on "Agency in epistemic logics".

Participated in *Dagstuhl Workshop on Epistemic Planning* held at Schloss Dagstuhl, Germany during Jun 5 – Jun 9, 2017. Gave a keynote talk on "Distributed presentations of multi-agent systems".

Participated in *FSTTCS 2017* held at IIT, Kanpur during Dec 11 – Dec 15, 2017. Was Program Co-chair.

Samal, Areejit

Visited Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany during May 20 – Jun 30, 2017. Visit to continue collaboration within the Max Planck Partner Group on Mathematical Biology

Visited ICTP, Trieste, Italy during Jul 1 – Aug 12, 2017. Simons Associate

Participated in *India International Science Festival 2017* held at Anna University, NIOT, CSIR-CLRI, CSIR-SERC, IIT Madras during Oct 13 – Oct 16, 2017. Presented Poster in Industry-Academia Interaction Session

Participated in *2017 IISA International Conference on Statistics* held at Hyderabad, India during Dec 27 – Dec 30, 2017. Invited Speaker

Participated in *Symposium on Data Analytics in Bioinformatics* held at SASTRA University, Thanjavur on Feb 3, 2018. Invited Speaker

Participated in *Network Analysis in Biology* held at NIRRH, Mumbai, India during Feb 26 – Feb 27, 2018. Invited Speaker

Visited Vellore Institute of Technology (VIT) on Mar 16, 2018. Invited talk

Sankaran, Parameswaran

Participated in *Workshop on K theory* held at Indian Statistical Institute, Bengaluru during Dec 26, 2016 – Dec 6, 2017. Gave five lectures on 'Computations in K-theory'.

Participated in *International Conference on Mathematics and its Applications* held at Ramjas College, New Delhi during Apr 26 – Apr 28, 2017. Gave a talk on 'Cohomology of locally symmetric spaces'.

Participated in *Summer Training Programme for MSc Students* held at Ramanujan Institute, University of Madras, Chennai during May 19 – May 23, 2017. Gave a series of lectures on group theory.

Participated in *TEW-ECE Workshop for College teachers* held at IMSc during May 23 – May 26, 2017. Gave four lectures on complex analysis.

Visited Presidency University, Kolkata during Jun 27 – Jun 30, 2017. Gave a talk on the 'Geometry of the upper half space'.

Participated in *National Seminar on Topology and its Applications* held at Bharathiyar University PG Extension Centre, Perundurai during Jul 13 – Jul 14, 2017. Gave a talk on Topology of surfaces.

Participated in *Refresher course in algebra* held at Kerala School of Mathematics, Kozhikode during Sep 7 – Sep 10, 2017. Gave a series of lectures on Galois theory.

Participated in *'Analytica'* held at St Xavier's College, Kolkata during Sep 12 – Sep 13, 2017. Gave two lectures, one on hyperbolic geometry and one on transcendental numbers.

Participated in *Workshop on topology of manifolds and group actions* held at Delhi University, New Delhi during Nov 9 – Nov 22, 2017. Gave a special lecture on 'rotation numbers'.

Participated in *International conference on topology and geometry, in honour of Prof T B Singh* held at Delhi University, New Delhi during Nov 23 – Nov 24, 2017. Gave a talk on 'generalized Dold manifolds'.

Participated in *Seventh East Asian Conference on Algebraic Topology* held at IISER, Mohali during Dec 1 – Dec 6, 2017. Gave a talk on 'Topology of generalized Dold manifolds'.

Participated in *Seventh East Asian Conference on Algebraic Topology* held at IISER, Mohali. during Dec 2 – Dec 6, 2017. Gave a talk on 'Generalized Dold Manifolds'.

Participated in *Indo-Russian Celebration workshop* held at IISER Mohali during Dec 7 – Dec 8, 2017. Gave a talk on 'Twisted conjugacy in PL homeomorphism groups of the circle'.

Participated in *Annual Meeting of the Indian Mathematical Society* held at Sri Venkateswara University, Tirupathi during Dec 11 – Dec 13, 2017. Gave a talk on 'Twisted conjugacy in Houghton groups'.

Participated in *Science Academies' Workshop for College Teachers* held at Sarada Arts and Science College for Women, Karur during Jan 1 – Jan 3, 2018. Gave three lectures on matrices

Participated in *International Conference in Mathemamatical Analysis and Models* held at Jadavpur University, Kolkata during Jan 9 – Jan 12, 2018. Gave a talk on 'quasi-isometric invariants and rigidity.'

Sathiapalan, Balachandran

Participated in *Quantum Physics: Fields, Particles and Information Geometry* held at Dublin, Ireland during Jan 22 – Jan 26, 2018. Gave a talk on "Holographic Form of Wilson RG"

Saurabh, Saket

Participated in *Recent Advances in Algorithms 2017* held at St. Petersburg Department of V.A. Steklov Institute of Mathematics of the Russian Academy of Sciences during May 22 May 28, 2017. One of the invited lecturer. Gave four talks on 'Longest Paths in Graphs: Parameterized Algorithms'.

Visited Indian Statistical Institute (ISI), Kolkota during Dec 31, 2017 – Jan 3, 2018. Gave a talk in their distinguished lecture series on 'Algorithms and Architecture'.

Participated in *SODA 2018* held at New Orleans, USA during Jan 6 – Jan 10, 2018. Gave talks.

Participated in *ITCS 2018* held at Cambridge, Massachusetts, USA during Jan 10 – Jan 14, 2018. Gave a

talk.

Visited Indian Institute of Technology, Gandhinagar (IITGN) during Feb 17 Feb 24, 2018. Visited Dr. Neeldhara Misra for research purposes. Also gave a talk there.

Sharma, Vikram

Visited University of Reunion, Reunion, France during Oct 23 – Nov 2, 2017. Attended PANO meeting

Participated in *FSTTCS and Workshop on Lattices* held at IIT, Kanpur during Dec 11 – Dec 15, 2017. Chaired a session

Sinha, Sitabhra

Participated in *Discussion Meeting on Mathematical Models of Infection, Immunity and Inflammation* held at Indian Institute of Science, Bangalore during Apr 5 – Apr 7, 2017. Gave invited talk on "Cross-reactivity and extinction in ensemble of T-cell receptor (TCR) clonotypes: Ecological dynamics of exploitative competition between species"

Participated in *Discussion Meeting on Nonequilibrium Dynamics: Diffusion, Populations, and Aging* held at TCIS Hyderabad during Jun 30 – Jul 1, 2017. Gave invited talk on "Patterns, Broken Symmetries and Computation: Emergent complexity in collective dynamics of diffusively coupled oscillatory media"

Participated in *13th Econophysics Colloquium and FENS 2017* held at University of Warsaw, Warsaw during Jul 5 – Jul 7, 2017. Gave invited talk on "Is it rational for Homo Economicus to be nice to others? The co-action solution resolves social dilemmas"

Visited Department of Bioinformatics, Friedrich Schiller University, Jena, Germany during Jul 9 – Jul 12, 2017. Gave two invited talks on "Cancer Module-omics: Analyzing the network of cancer diseases and genes reveals movers and shakers of the disease" and "Emergence of voluntary vaccination behavior in a population of rational agents".

Visited Frankfurt Institute of Advanced Studies, Frankfurt, Germany during Jul 13 – Jul 15, 2017. Gave invited talk on "Loss of structural balance in the network of cross-correlations characterizing a financial market signals the onset of major economic crisis"

Visited Indian Institute of Science Education and Research, Tirupati on Aug 18, 2017. Gave invited talk on "Patterns, Broken Symmetries and Computation"

Visited Indian Institute of Management, Ahmedabad during Aug 24 – Aug 29, 2017. Gave invited seminar talk titled "Can we infer the "laws" of finance from big data ?"

Visited Department of Applied Mathematics, University of Calcutta, Kolkata during Nov 6 – Nov 8, 2017. Gave invited lecture on computational neuroscience

Participated in *One-day symposium on "100 years of Bose Institute: Acharya J C Bose and Beyond"* held at Bose Institute, Kolkata on Nov 21, 2017. Gave invited talk on "Memory, Intelligence and Computation without Brains"

Participated in *International Symposium on Systems, Synthetic Chemical Biology (SSC2017)* held at Bose Institute, Kolkata during Dec 5 – Dec 7, 2017. Gave invited talk on "Memory in MAPK Cascade"

Participated in *Research Training School in Physics (RTSP 2018)* held at Department of Physics, Cochin University of Science and Technology, Kochi on Mar 12, 2018. Gave invited talk on the Nonlinear Dynamics of Synchronization and Pattern Formation

Participated in *Conference on conference Cross-Disciplinary Applications of Complex Networks* held at Shiv Nadar University, Greater Noida, UP during Mar 22 – Mar 24, 2018. Gave invited talk on "Can social networks promote socially responsible behavior among selfish individuals? Emergence of voluntary vaccination in a population of rational agents"

Srivastav, Priyamvad

Visited the Institut de Mathmatiques de Bordeaux during May 08, 2017 to May 21, 2017 and the Institut de Mathmatiques de Marseille from May 22, 2017 to Jun 03, 2017 under the CEFIPRA project 5401-A.

Participated in the conference *Prime Numbers and Automatic Sequences : Determinism and Randomness* from May 22 - 26, 2017 held at CIRM, Marseille.

Gave a talk at the *International conference on Algebra and Analysis*, held at the Savitribai Phule Pune university during December 19-22, 2017.

Gave a talk at the *National Conference on "Algebra, Analysis and Number Theory"* held at North Maharashtra University, Jalgaon, Maharashtra during 13-14 January, 2018.

Subramanian, C. R.

Participated in *13th Annual ADMA Conference on Discrete Mathematics.* held at SSN College of Engineering, Kalavakkam, Chennai on Jun 8, 2017. Gave an Endowment talk on "Concentratration of some invariants in random digraphs".

Participated in *ACM-SIAM Symposium on Discrete Algorithms (SODA-2018)* held at New Orleans, Louisian, USA during Jan 7 – Jan 10, 2018. (Co-located with ANALCO-18 and SoSA-2018.)

Participated in *SIAM Meeting on Analytic Algorithmics and Combinatorics (ANALCO-2018)* held at New Orleans, Louisiana, USA during Jan 8 – Jan 9, 2018. Presented our accepted work on "On Induced Paths, Holes and Trees in Random Graphs".

Participated in *SIAM Sympsium on Simplicity in Algorithms (SoSA-2018)* held at New Orleans, USA, Louisiana on Jan 10, 2018. (Co-located with SODA-2018 and ANALCO-2018.)

Visited Department of Computer Science, Louisiana State University, Baton Rogue, USA during Jan 12 – Jan 26, 2018. Had interactions with a few members of the department and gave a talk on "Concentration of some invariants in random graphs and digraphs".

Visited Department of Mathematics, Faculty of Science and Humanities, SRM Institute of Science and Technology, Kattankulathur, Chennai on Feb 9, 2018. Inaugurated the National Level Math Fest ALTITUDES-18 (for undergraduate students) and gave an inaugural talk on Mathematics and its role in exact sciences.

Participated in *International Conference on Algorithms and Discrete Applied Mathematics (CALDAM-2018)* held at Indian Institute of Technology, Guwahati during Feb 15 – Feb 17, 2018. Was a PC member of CALDAM-2018 and chaired a session of CALDAM-2018. Was also a member of the committee that decided on student presentation prizes.

Vemparala, Satyavani

Participated in *Complex Fluids* held at IIT Madras, Chennai, India during Dec 18 – Dec 20, 2017.

Participated in *Recent Advances in Molecular Simulations* held at IISc, Bangalore, India during Feb 8 – Feb 11, 2018.

Participated in *5th Indian Statistical Physics Community meeting* held at ICTS, Bangalore, India during Feb 16 – Feb 18, 2018.

Viswanath, Sankaran

Visited IIT Madras on Apr 4, 2017. Gave a talk in the discrete mathematics seminar.

Vivek Ananth, R. P.

Participated in *Dynamics of Complex Systems - 2017* held at International Centre for Theoretical Sciences (ICTS), Bangalore during May 10 – May 25, 2017.

Participated in *International Symposium on Systems, Synthetic Chemical Biology (SSC 2017)* held at Bose Institute, Kolkata during Dec 5 – Dec 7, 2017. Presented a poster titled "Systems modeling of protein secretion system in model filamentous fungus".

Participated in *Aspects of Gene and Cellular Regulation (AOGCR 2018)* held at The Institute of Mathematical Sciences (IMSc), Chennai during Jan 12 – Jan 13, 2018. Presented a poster titled "Comparative systems analysis of the secretome of the opportunistic pathogen Aspergillus fumigatus and other Aspergillus species".

Participated in *Mini-symposium on research in Tuberculosis* held at The Institute of Mathematical Sciences (IMSc), Chennai on Jan 19, 2018.

Participated in *Network analysis in biology* held at National Institute for Research in Reproductive Health (NIRRH), Mumbai during Feb 26 – Feb 27, 2018. Provided hands-on training to the participants of the workshop.

5.4 Visitors from Other Institutions

Antonie Meyer	2.4.17 - 11.4.17	University Paris East, Cedexz
Didier Caucal	2.4.17 - 20.4.17	University Paris East, Cedexz
Rohit Dhir	3.4.17	SRM university
Jean-Marc Deshouillers	1.4.17 - 9.4.17	University of Bordeaux
Deepak Vaid	5.4.17 - 12.4.17	NITK, Surathkal
Roy Joshua	13.4.17 - 5.5.17	Ohio State University, Columbus, USA
Kalyan Bidhan Sinha	22.4.17 - 30.4.17	JNCASR, Bangalore
Madhusudana Rao	105.17 - 17.5.17	Jawahar Barati College, Kavali
Adhikari S.D.	13.5.17 - 27.5.17	HRI, Allahabad
Manickam M.	15.5.17 - 25.5.17	Kerala School of Mathematics, Kozhikode
Anjali Modi	10.5.17 - 13.5.17	Surat Medical College
Keshav Vaishnav	11.5.17 - 13.5.17	Surat Municipal Corporation
Gautam Mandal	8.5.17 - 11.5.17	TIFR, Mumbai
Sailu Yellaboina	11.5.17 - 12.5.17	CR Rao AIMSCS, Hyderabad
Aritra Banik	10.5.17 - 20.5.17	IIT Jodhpur
Anurag Tripathi	3.5.17 - 19.5.17	IIT Hyderabad
Chinmay Das	5.6.17 - 7.7.17	University of Leeds, Leeds, United Kingdom
Debabrata Goswami	5.6.17 - 17.6.17	IIT Kanpur
Ramij Rahaman	17.5.17 - 3.6.17	University of Allahabad
Somnath Jha	4.6.17 - 17.6.17	IIT Kanpur
Johal R.S.	1.6.17 - 13.6.17	IISER Mohali

Pushkar Jagalekar	28.5.17 - 16.6.17	Vishwagarma Inst. Of Tech. Pune
Samir Kunkri	11.6.17 - 24.6.17	Mahadebananda Mahavidyalaya, Barrackpore, West Bengal
Dilip Kumar Maiti	4.6.17 - 24.6.17	Vidyasagar University, Midnapur
Bhanukiran Parabathini	26.6.17 - 1.7.17	Mahindra Eciole Centrale, Hyderabad
Sandeep K Goyal	18.6.17 - 1.7.17	IISER, Mohali
Subinay Das Gupta	25.6.17 - 1.7.17	Univeristy of Calcutta
Priyotosh Bandyopadhyay	25.6.17 - 5.7.17	
Ranabir Chakrabarti	3.7.17 - 2.10.17	
Sandipan Sengupta	12.6.17 - 5.7.17	IIT Kharagpur
Venkatesh R.	19.6.17 - 23.6.17	IISc, Bangalore
Debajyoti Choudhury	25.5.17 - 14.7.17	University of Delhi
Sanjib Sabha Pandit	17.7.17 - 19.7.17	RRI, Bangalore
Sachin Subhash Sharma	9.7.17 - 22.7.17	IIT, Kanpur
Guru Prasad Kar	20.7.17 - 27.7.17	ISI, Kolkata
Soma Sanyal	31.7.17 - 6.8.17	University of Hyderabad
Muthukumar M.	31.7.17 - 4.8.17	University of Masschussets, USA
Balachandran A.P.	4.8.17 - 25.8.17	Syracuse Univeristy, USA
Satti Srinivasa Rao	15.8.17 - 20.8.17	Seoul University
Sinnou Davis	8.8.17 - 17.10.17	Univ. Pioneet Curie
Purabi Mukherji	15.8.17 - 22.8.17	INSA Research Scientist
Krishnaswamy S.	16.8.17 - 24.8.17	Madurai

Kumar Murty V.	23.8.17 - 2.9.17	University of Toranto
Eric Laenen	26.8.17 - 28.8.17	IISc, Bangalore
Dileep Jatkar	20.8.17 - 27.8.17	HRI, Allahabad
James Patrick	1.9.17 - 30.11.17	INSA, USA
Sivakumar M.	1.9.17 - 30.6.18	University of Hyderabad
Soma Dutta	30.8.17 - 2.9.17	Warsaw, Poland
Arijit Ghosh	20.8.17 - 23.8.17	ISI, Kolkata
Raja M.	21.9.17 - 22.9.17	Genotypic Technologies, Bangalore
Krishnamurthy S.	6.9.17 - 26.9.17	Madurai
Bosco Emmanuel	1.4.17 - 31.8.17	Visiting Sr. Professor
Ajit Bhand	25.9.17 - 29.9.17	IISER, Bhopal
Kavitha Ranganathan	7.9.17 - 9.9.17	Manipal
Sasidevan V.	11.10.17 - 14.10.17	Cochin University, Kerala
Swarup Poria	3.10.17 - 20.10.17	University of Calcutta, Kolkata
Sasidevan V	11.10.2017 - 14.10.2017	Cochin University , Kerala
Samir Kunkri	09.10.17 - 22.10.17	Barrackpara, Kolkatta
Krishnaswamy S.	09.10.17 - 13.10.17	Madurai
Ashoka Sen	11.10.2017 - 17.10.2017	HRI, Allahabad
Daniel Lokshtanov	23.10.2017 - 28.10.2017	University of Bergan, Norway
Phillippon P.	29.10.2017 - 11.11.2017	CNRS
Hidenori Sonoda	5.11.2017 - 26.11.2017	Kobe University

Pruisken A.M.M.	16.10.2017 - 17.11.2017	University of Asmterdem
Krishnaswamy S.	23.10.2017 - 3.11.2017	Madurai
Sasidevan V.	15.11.2017 - 16.11.2017	Cochin University of Science Technology
Zbigniew R Struzik	15.11.2017 - 22.11.2017	University of Tokya, Japan
Subhashish Banerjee	22.11.2017 - 26.11.2017	IIT, Jodhpur
Bhanukiran Perbathini	27.11.2017 - 5.12.2017	Mahindra Ecole Central, Hyderabad
Soham Biswas	11.12.2017- 15.12.2017	Universided de Guadalajoin Jaliso, Mexico
Shyamashree Upadhyay	11.12.2017 - 16.12.2017	IIT Guwahati
Krishna R Kalari	18.12.2017 - 18.12.2017	Mayo Clinie, United States
Saradha Natarajan	14.12.2017 - 16.12.2017	DAE Centre, Mumbai
Amarijit Sani	21.12.2017 - 22.12.2017	Brookhaven National Labs, USA
Xavier Viennot	17.12.17 - 18.3.18	CNRS, Bordeaux
Adhikari S.D.	26.12.2017 - 5.1.2018	formely at HRI, Allahabad
Ramakrishnan B.	26.12.2017 - 1.1.2018	HRI, Allahabad
Shalom Eliahou	26.12.2017 - 5.1.2018	France
Arun K. Pati	15.11.2017 - 3.12.2017	HRI, Allahabad
Arun K. Pati	22.12.2017 - 4.1.2018	HRI, Allahabad
Vijayalakshmi M	9.1.2018 - 12.1.2018	IBAB, Bangalore
Deshouillers Jean	12.1.2018 - 10.2.2018	Mare, University of Bordeaux
Shanta Laishram	15.1.2018 - 19.1.2018	ISI, Delhi
Tapas Chatterjee	14.1.2018 - 21.1.2018	IIT, Ropar
Amit Singh	19.1.2018 - 20.1.2018	IISc, Bangalore

Vinay Nandicoori	19.1.2018 - 20.1.2018	NII, Delhi
Dhiraj Kumar	19.1.2018 - 20.1.2018	ICGEB, Delhi
Mohan Chintamani	18.1.2018 - 21.1.2018	University of Hyderabad
Mrinal Nandi Das	23.1.2018 - 27.1.2018	ISI, Kolkatta
Kaushal Verma	22.1.2018 - 25.1.2018	IISc, Bangalore
Indranil Biswas	22.1.2018 - 23.1.2018	TIFR, Mumbai
Indranil Biswas	29.1.2018 - 1.2.2018	TIFR, Mumbai
Prabal Paul	18.1.2018 - 21.1.2018	BITS - Pilani, Goa
Sujit Sarkar	25.1.2018 - 31.1.2018	Poornaprajna Institute of Science Research
Bhaduri R.K.	18.1.2018 - 5.2.2018	Mc Master University, Hamilton, Canada
Krishnaswamy S.	8.1.2018 - 26.1.2018	Madurai
Prashant Baba	2.2.2018 - 11.2.2018	Technical University, Germany
Parasarathi Majumdar	29.1.2018 - 2.2.2018	Belur
Krishnaswamy S.	5.2.2018 - 16.2.2018	Madurai
Manas Kulkarni	31.12.2017 - 3.1.2018	ICTS, Bengaluru
Gyan Prakash	4.2.2018 - 10.2.2018	HRI, Allahabad
Sumilan Banerjee	11.2.2018 - 12.2.2018	IISc, Bangalore
Kunal K. Mukherjee	5.1.2018 - 4.11.2018	IIT, Madras
Amilcar Eacheco	7.2.2018 - 18.2.2018	UFRG, Brazil
Emil Saucan	15.2.18 - 24.2.18	Brande College, Karniel
Sagar Chakraborty	13.2.18 - 15.2.18	IIT, Kanpur

Nilendra Deshpande	18.2.18 - 23.2.18	Univ. of Oregon, USA
Winfried Kohnan	21.2.18 - 24.2.18	Univ. of Heidelberg
Antonio Gonlaler	15.2.18 - 17.2.18	Madrid
Bhaskar Saha	17.2.18 - 20.2.18	St. Xavier's College
Hari Dass N.D.	23.1.18 - 30.1.18	TIFR, Hyderabad
Kumar Murty V.	21.2.18 - 1.3.18	Univ. of Toronto, Canada
Mahesh Kakde	1.3.18	King's College, London
Sujit Sarkar	8.3.18 - 10.3.18	Poornaprana Inst. of Sci. Res.
Samsbubhro Bandyopadhyay	5.3.18 - 9.3.18	Bose Institute, Kolkata
Venkatesh R.	1.3.18 - 2.3.18	IISc, Bangalore
Balachandran A.P.	11.3.18 - 10.6.18	Syracuse University
Sridhar Hannenhalli	14.3.18 - 15.3.18	IISc, Bangalore
Jacobo Toran	9.3.18 - 23.3.18	University of Ulm, Germany
Saumia P.S.	27.3.18 - 25.4.18	JINR, Dubna, Russia

VISITORS FROM OTHER INSTITUTIONS - POST DOCTORAL FELLOWS

Arghya Mandal	3.4.2017 - 29.4.2017	IIT Bombay
Nitin Willams	10.4.2017 - 13.4.2017	University of Helsinki, Finland
Soumalya Joardar	22.4.2017 - 30.4.2017	JNCASR, Bangalore
Chittaranjan Hens	23.4.2017 - 26.4.2017	Bar- Ilan Univ, Israel
Soumya Sadhugan	22.4.2017 - 29.4.2017	PRL, Ahmedabad
Soumya S. S	3.5.2017 - 5.5.2017	IIT Bombay
Rohan Raghavan Poojary	20.5.2017 - 31.5.2017	TIFR Colaba, Mumbai

Sandipan De	29.5.2017 - 3.6.2017	ISI, Bangalore
Panjay Sheorin	16.5.2017 - 31.5.2017	Centre for Theoretical physics, New Delhi
Chandam Maity	25.5.2017 - 8.6.2017	ISI, New Delhi
Pranabendu Misra	5.6.2017 - 13.6.2017	University of Bergen
Yogeshwar Prasad	5.6.2017 - 7.7.2017	IISc, Bangalore
Sourav Tarafder	20.6.2017 - 30.6.2017	St. Xavier College, Kolkatta
Arya S.	26.6.2017 - 30.6.2017	IMSc, Chennai
Rishi Vyas	3.7.2017 - 8.7.2017	Ben Gurion University, Israel
Suchetana Sadhukhan	17.7.2017 - 23.7.2017	IIT, Kharagpur
Satyajit Guin	17.7.2017 - 29.7.2017	IISER, Mohali
Modid Asad	18.7.2017 - 28.7.2017	NIT, Patna
Keerti Choudhary	26.7.2017 - 23.9.2017	IIT, Kanpur
Victor Mukherjee	10.8.2017 - 13.8.2017	Weizmann Institute of Science, Israel
Aditya Gilra	7.8.2017 - 9.8.2017	EPFL, Switzerland
Bimla	19.8.2017 - 30.8.2017	IMSc, Chennai
Lakshmi S. Mohan	25.8.2017 -2.9.2017	PLI, Ahmedabad
Sudarkodi Venkatesan	6.9.2017 - 5.12.2017	IIT, Kanpur
Aswin Balasubramanian	7.9.2017 - 13.9.2017	University of Hansburs
Sandipan De	28.8.2017 - 9.9.2017	ISI, Bangalore
Amit Mukherjee	4.9.2017 - 16.9.2017	ISI, Kolkatta
Usha Keshar Sangale	3.10.2017 - 8.10.2017	SRTM University, Nanded
Sreejith	3.10.2017 - 9.10.2017	University of Walsaw

Ashwij Mayya	11.10.2017 - 10.11.2017	IIT Madras
Saronath Halder	11.10.2017 - 10.1.2018	Bose Institute, Kolkatta
Debmalya Das	08.10.2017 - 16.10.2017	HRI, Allahabad
Mohit Kumar Jolly	29.10.2017 - 31.10.2017	Rice University, Delhi
Rahul Dandekar	1.11.2017 - 31.1.2018	ICTP, Italy
Arita Biswas	30.10.2017 - 4.11.2017	IACS, Kolkatta
Usha K. Sangale	2.11.2017 - 4.12.2017	SRTM University, Nanded
Manabendra	7.11.2017 - 10.11.2017	Nath Bera, Spain
Sandamini Nayak	5.11.2017 - 13.11.2017	
Zbigniew R Struzik	15.11.2017 - 23.11.2017	University of Tokya, Japan
Vivek Mishra	18.11.2017 - 1.12.2017	Gk Ridge National Laboratory
Arunprasath V	20.11.2017 - 12.12.2017	
Kamlakshya Mahatab	6.12.2017 - 11.12.2017	Norway
Sandipan De	4.12.2017 - 6.12.2017	ISI, Bangalore
Rohan Sharma	11.12.2017 - 14.12.2017	IIT Jodhpur
Some Sankar Bhattacharya	14.12.2017 - 29.12.2017	ISI, Kolkatta
Sankar Deep Chakraborthy	7.12.2017 - 23.12.2017	NIIT, Japan
Nitin Saurabh	13.12.2017 - 23.12.2017	Czech Republic
Kabir Ramola	18.12.2017 - 20.12.2017	Brandels University
Ravi Kunjwal	13.12.2017 - 22.12.2017	Perimeter Institute, Canada
Tanmay Singal	16.12.2017 - 26.12.2017	Hantang University, South Korea
Gaurav Rattan	1.1.2018 - 5.1.2018	Aachen University, Germany

Pinaki Banerjee	30.12.2017 - 3.1.2018	ICTS, Bangalore
Subramani M.	4.1.2018 - 27.1.2018	HRI, Allahabad
Kushi Anand	17.1.2018 - 19.1.2018	IISc, Bangalore
Anupama Sharma	15.1.2018 - 29.1.2018	University of Michigan
Selvaganapathy J.	22.1.2018 - 21.3.2018	BITS Pilani, Goa
Raju Roy Choudhary	22.1.2018 - 26.1.2018	Naples University, Brazil
Akanksha Agarwal	10.1.2018 - 1.3.2018	University of Bergen, Norway
Ayon Patra	5.2.2018 - 15.2.2018	IISc, Bangalore
Arita Biswas	12.2.2018 - 16.2.2018	Indian Assoc. for cultivation of Science, Kolkatta
Manoj Kumar Mandal	18.2.2018 - 23.2.2018	University of Catholique De lourain, Belgium
Anil Kumar C. P.	26.2.2018 - 28.2.2018	CSTEP, Bangalore
Eshita Mazumdar	26.2.2018 - 28.2.2018	Tinanjin, China
De Debmalya Das	3.3.2018 - 9.3.2018	HRI, Allahabad
Rekha Biswal	14.3.2018 - 15.3.2018	Universite laval, Canada
Sankar Basu	20.3.18 - 23.3.18	University of Delhi

VISITORS FROM OTHER INSTITUTIONS - DOCTORAL FELLOWS

Pradeep Kumar N	1.4.17 - 30.6.17	IIT Jodhpur, Rajasthan
Ankita Roy	28.3.17 - 15.5.17	IISER, Bhopal
Nidhi Purohit	1.1.17 - 30.4.17	Amity University, UP
Richa Tripathi	1.5.17 - 12.5.17	IIT Gandhi Nagar, Gujarat
Krishna Praveen Yaramarthy	12.5.17 - 7.7.17	IIT Guwahati
Vishaka Dutta S.	28.4.17 - 10.5.17	NCBS, Bangalore

Sathish Kumar. P	30.4.17 - 30.7.17	University of Madras, Chennai
Anjala M.B.	3.5.17 - 18.7.17	IIT Madras
Solingyur Zimik Kachi	8.5.17 - 12.5.17	IISc Bangalore
Richa Mishra	15.5.17 - 30.7.17	BITS Pilani, Rajasthan
Pratibha Choudhary	12.5.17 - 23.5.17	IIT Jodhpur
Manish Kumar Pandey	10.5.17 - 25.5.17	HRI, Allahabad
Tanmoy Sarkar	25.4.17 - 25.5.17	IIT Bombay
Usha K. Sangale	2.5.17 - 4.6.17	SRTM University, Nanded
Ayan Mukhopadhyay	3.5.17 - 19.5.17	IIT Hyderabad
M. Lakshman Teja M.	28.5.17 - 15.7.17	IISER, Pune
Satvika B.	24.5.17 - 30.4.18	IISER, Pune
Atulya M.S.	15.5.17 - 15.12.17	PSG College of Technology, Coimbatore
Vaishali S.	15.5.17 - 15.12.17	PSG College of Technology, Coimbatore
Akshaya R.	1.6.17 - 30.11.17	PSG College of Technology, Coimbatore
Pooja K.	1.6.17 - 25.11.17	PSG College of Technology, Coimbatore
Appilineim Kushal	19.6.17 - 24.6.17	IISc, Bangalore
Nidhi Purohit	25.4.17 - 31.7.18	Amity University, UP
Pankaj Pundir	1.6.17 - 30.6.17	IIIT, Chittoor
Adhithya	27.6.17 - 4.7.17	IIT, Hyderabad
Kunal Mazumdar	18.7.17 - 21.7.17	IISER, Pune
Prakruti Burra	1.7.17 - 15.5.18	BITS, Hyderabad
Roopini V.	1.7.17 - 15.7.17	University of Madras

Junaid Akhter	6.6.17 - 24.7.17	Aligarh Muslim University
Muthusamy R.	29.6.17 - 29.7.17	IISER, Trivandrum
Richa Tripathi	7.8.17 - 11.8.17	IIT Gandhi Nagar
Rian Neogi	1.7.17	NIIT University, Rajasthan
Mahul Pandey	22.8.17 - 25.8.17	IISc, Bangalore
Renjan Rajan John	1.8.17 - 31.10.17	
Tuhin Subhra Mukherjee	11.10.17 - 16.10.17	West Bengal
Kushal A.	11.10.17 - 14.10.17	IISc, Bangalore
Sunil Singh Shah	25.10.17 - 10.11.17	HNB Garwal University
Rudranarayan Padhan	6.11.17 - 12.11.17	NIT Rourkela
Kushal A.	15.11.17 - 16.11.17	IISc, Bangalore
Rachita K. Kumar	18.11.17 - 18.12.17	Sastra University
Sk. Jahanur Hoque	16.8.17 - 10.9.17	
Subathra Vjayakumar	1.12.17 - 5.7.18	Sastra University
Sagar Bildain	15.12.17 - 31.12.17	BITS Pilani
Richa Tripathi	15.12.17 - 26.12.17	IIT Gandhi Nagar
Sulakhana Choudhury	11.12.17 - 26.12.17	IISER, TVM
Prakruthi Burra	1.1.18	BITS Hyderabad
Namitha Suresh	4.1.18 - 30.4.18	BITS Pilani
Geet Rakala	8.1.18 - 12.1.18	TIFR, Mumbai
Ranjith V	5.1.18 - 11.1.18	University of Cagliari, Italy
Ekta	17.1.18	JGU Mainz Germany

Pratibha Choudhary	7.1.18 - 5.5.18	IIT Jodhpur
Somnath Shee	17.1.18 - 25.1.18	IISc, Bangalore
Nimisha Pahoja	17.1.18 - 17.3.18	IISc Bangalore
Meena T	5.2.18 - 4.5.18	Idhaya College of Women, Kumbakonam
Aditya Kabra	23.1.18 - 20.4.18	IISER, Pune
Sreejith, R.P.	10.2.18 - 25.2.18	University of Kerala
Somnath Shee	13.2.18 - 16.2.18	IISc, Bangalore
Jitender Pratap	20.2.18 - 25.2.18	HRI, Allahabad
Soumyakanti Bose	23.2.18 - 4.3.18	SN Bose National Science for Basic Sciences, Kolkata
Aravinth Balaji R	1.3.18 - 31.5.18	Periyar University
Jay Ajitbhai Sandesara	24.1.18 - 5.3.18	University of Durham
Aishwarya S.	25.3.18 - 27.3.18	SJCE, Mysore
Sreejith R.P.	21.3.18 - 31.3.18	University of Kerala
Meghana M. Reddy	19.3.18 - 20.4.18	IIIT Bangalore

Chapter 6

Infrastructure

6.1 Computer Facilities

Enhancement of Computer Facility during 2017-18

- The new Laptops were issued to newly joined faculty and those faculty requested for replacement of laptops which are older than 4 years. The following Macbook Air 13 , Lenovo Yoga 720 , Dell XPS 15 , Macbook Pro 15 , Macbook Pro 13 , Lenovo laptops are distributed.
- Two motorized projection screens installed for replacing the existing obsolete and damaged screens in lecture hall 123 and Chandrasekar hall
- 58 Dell Optiplex desktops replaced with the desktops of obsolete and older than 7 years.
- 3 A3 laserjet multi-function Ricoh monochrome printers with access control by using RFID card reader and 3 new entry level A4 laserjet multi-function printers as replacements are ordered.
- The existing 40 Mbps Internet bandwidth service is renewed with higher capacity of 42 Mbps through the service provider M/s. Bharti Airtel.
- Obsolete and non working LAN switches are replaced with new ones in the following locations: Ramanujan Auditorium, Main Building(F15), New Guest House and Old Guest House.

Activities :

Jointly organised *Intel S/W tools workshop* on June 15, 2017 with Intel, India. IMSc users and others from Institution in and around Chennai participated.

Dr.G. Subramoniam, Scientific Officer-F acted as an external expert for setting up of Cloud Data center with HPC facility at Anna University, Chennai during Oct-Dec 2017

Mr.B. Raveendra Reddy, Scientific Officer-F visited IISER, Mohali on Nov 28, 2017 as a part of panel of experts set up to review the computer center and associated facilities. Also, attended the JEST local organising committee meeting on Oct 16, 2017 at IGCAR Kalpakkam

Mr. T. Vigneshkumar, Technical Assistant(Systems) has been recruited in the place of Mr. Jahir Hussain who resigned the position earlier under the project.

After the successful installation of PoS Canteen billing(Cash-less) System, it was planned for the full automation of IMSc Office functionalities with task management through Open ERP (ODOO). For this activity, Mr. E. Nambirajan and Ms. P. K. Sreelakshmi have been recruited as Technical Assistant (Systems-ERP) under the project.

6.2 The Library

The Institute Library holds a total collection of 73780 books and bound periodicals as on March 31, 2018. This includes an addition of 895 volumes during the current year April 2017 - March 2018. The NBHM has recognized this Institute library as the Regional Library for Mathematics. An average of about 4000 outside users in a year from colleges, universities and research institutions from different parts of the country make use of the library facilities for their academic and research information needs.
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 back-file 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.

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. VECC Kolkata has extended their support by providing linux based software applications to use RFID systems. 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.

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Basic Books, New Delhi
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