The

Institute of Mathematical Sciences

Annual Report &

Audited Statement of Accounts

March 2019- April 2020

The Institute of Mathematical Sciences

Chennai

Annual Report and Audited Statement of Accounts

April 2019 - March 2020

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Director's Note

I am happy to present the annual report of the Institute for 2019-2020 and put forth the distinctive achievements of its members during the year along with a perspective for the future.

During the period April 2019 - March 2020, there were 144 students pursuing their PhD and 42 scholars pursuing their post-doctoral programme at IMSc.

Spread through this period, the Institute organized or co-sponsored several workshops and conferences. The *First IMSc discussion meeting on extreme QCD matter* held during September 16 - 21, 2019 brought together senior scientists to deliver a set of pedagogic lectures on the current state-of-the-art, open problems and challenges in the area of hot and dense QCD matter. The annual meeting of the International Pulsar Timing Array (IPTA) was organized during June 10 - 21, 2019 by its Indian arm, of which IMSc is a part.

An NCM sponsored workshop on *Combinatorial Models for Representation Theory* was organised in IMSc during November 4 - 16, 2019 and saw active participation from Ph.D students and postdocs from across the country. An ACM-India Summer School on *Graphs and Graph Algorithms* and a meeting on *Recent Trends in Algorithms* were both organised during the year.

We note with a lot of satisfaction that our outreach programmes have expanded in scope and reach during this year. Our regular events such as the *Teachers Enrichment Workshop*, *Vigyan Pratibha Chennai Regional Teachers Workshop*, *Summer School Students Workshop*, *Facets*, *kaNita-kAnakam*, *Enriching Mathematics Education* and *Science at the Sabha* continued to draw enthusiastic participants across the spectrum - students, teachers, and the general public. In addition, new events were organised this year such as the *TNSF Chithirai FEST-I*, *Topics in Biology* and *Excitement in Science*. In the run-up to, and during, the annular solar eclipse of December 26 2019, many institute members worked with local science popularization organizations in various public activities such as distributing masks and spreading awareness about eclipses. The institute also organised some one-off public lectures on *Using ancient DNA to understand Indian history*, *Logic for*

non-persons?, *The Cryosphere and Climate of the Earth*, *A Symplectic World View* and *Science Communication and Education whose Science, for whom?*. The outreach related activities in the Institute are the initiative of several institute 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.

Research productivity of the members of the Institute has been excellent throughout the year. Several high-quality publications have been reported in national and international journals, and some of the research work carried out has also been presented in international conferences.

A total of 15 students were awarded PhD degrees, 12 students have submitted their PhD theses. Six students were awarded MSc by Research degrees, under the supervision of our faculty.

There are several ongoing collaborations between research groups of IMSc and other institutions, both national and international. Among these, we mention a few. Arecibo 327 MHz Drift Pulsar Survey (AO327) is an international effort to discover pulsars and transients using the Arecibo radio telescope (USA). The institutes involved are Naval Research Laboratory USA, University of New Mexico USA, West Virginia University USA, IMSc India (Manjari Bagchi) and Max-Planck-Institut fur Radioastronomie Bonn Germany. IMSc is also part of another such effort, using the uGMRT in Pune, along with collaborators from NCRA- TIFR Pune, SINP Kolkata, IUCAA Pune, RRI Bangalore, NISER Bhubaneswar, University of California Berkeley (USA), and ASTRON (The Netherlands).

IMSc is now an international research laboratory for the Indo-French Program in Mathematics for four years. The Institute is part of an R&D Networked joint Center involving partners at Jawaharlal Nehru Centre for Advanced Scientific Research (Bengaluru), Brandeis University (USA), National Centre for Biological Sciences (Bengaluru) and Northeastern University (USA), to pursue theoretical and computational research on the localization of pathways by which stress propagates in disordered, soft matter and biological systems. A new CEFIPRA funded project on Modeling Soft Glass flow

from micro to macro scale is a collaboration with the Universit Grenoble Alpes, Grenoble, France. As part of the ongoing Max Planck Partner Group in Mathematical Biology, IMSc has been collaborating with MPIMIS Leizig on the study of biological networks.

During 2019-2020, a total of 35 lecture courses were conducted at the Institute.

We are proud to note the awards and honors bestowed on our faculty for their contributions: Amritanshu Prasad was elected Fellow of the Indian Academy of Sciences 2019. Dishant Pancholi was awarded The Shanti Swarup Bhatnagar Prize for Science and Technology in Mathematical Sciences for 2019. Saket Saurabh, was elected Fellow of the Indian Academy of Sciences 2019. R. Ramanujam was awarded the The Indira Gandhi Prize for popularization of science for 2020. Biplab Paul, a recent graduate student in Mathematics, has been awarded the JS'PS' post-doctoral fellowship in Japan. Roohani Sharma, a senior research fellow (graduate student) in Theoretical Computer Science was offered a Lisa Meitner Award postdoctoral fellowship for excellent women computer scientists at the Max Planck Institute for Informatics, that allows her to pursue independent research.

The last year also witnessed a sad event for the Institute. Prof. S.K. Joshi, former Chairman of the IMSc Executive Council and member of the IMSc Governing Board, passed away on May 15, 2020. The Institute deeply mourns his demise and places on record its appreciation for his contributions as Chairman of the Executive Council, a position which he held for over two decades.

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

June, 2020 V. Arvind

Contents

1 The Institute

The Institute of Mathematical Sciences (IMSc), founded in 1962, is a national institution for fundamental research in the Mathematical and Physical Sciences.

The Institute is funded by the Department of Atomic Energy of the Government of India. Institute members work primarily in the areas of Mathematics, Theoretical Computer Science, Theoretical Physics and Computational Biology.

The Institute is governed by a Governing Board and an Executive Council. Academic personnel at the Institute are grouped as Faculty, Post-Doctoral Fellows, Junior Research Fellows and Senior Research Fellows. The academic programmes are ably supported by an administrative set-up. The Director is assisted by the Faculty in academic matters and by the Registrar in financial and administrative matters.

Out of a sanctioned strength of 61, at present, 54 faculty members are in position. This year there were 42 post-doctoral fellows from all over the world pursuing research at IMSc. In addition, there are about 41 scientific personnel at various levels working here on different projects. The number of doctoral students (JRFs & SRFs) is 144 this year. The Institute has 35 members of non-academic staff which include Scientific Staff, and Administrative and Accounts Staff.

IMSc has an outstanding scientific library, an excellent computing environment including a tera-flop class cluster computer and a dedicated high-speed network. The Institute hosts several national and international scientific/academic conferences/workshops and meetings every year.

This report briefly describes the programmes and activities of the Institute as well as its achievements in the past year. More details are available in the detailed annual report.

1.1 Governing Board

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

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

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

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

Prof. **Amitava Raychaudhuri**,
Former Director, HRI, Allahabad
Professor Emeritus, University of Calcutta,
Kolkata
(**Member**)

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

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

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

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

Selvi. **Apoorva**, IAS
Principal Secretary to Government,
Secretariat, Fort St. George, Chennai
(**Member)**

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

1.2 Executive Council

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

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

Prof. **Amitava Raychaudhuri**,
Former Director, HRI, Allahabad
Professor Emeritus, University of Calcutta, Kolkata
(**Member**)

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

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

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

Selvi. **Apoorva**, IAS
Principal Secretary to Government,
Secretariat, Fort St. George, 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. K. N. Vyas, Chairman, Atomic Energy Commission & Secretary to Govt. of India, Department of Atomic Energy, CSM Marg, Mumbai

(Co-Chairman, Governing Board)

Dr. Kamlesh Nilkanth Vyas is a Mechanical Engineering graduate from MS University, Vadodara. After completion of the training in the 22nd Batch of the BARC Training School in 1979, he joined the Fuel Design Development Section of the Reactor Engineering Division of BARC. Dr. Vyas has worked for design analysis of nuclear reactor fuels. He was also responsible for design development of a novel fuel for strategic applications. He has worked extensively in thermal hydraulics and stress analysis of critical reactor core components. Dr. Vyas, as an engineer, has played a key role for completion of strategic projects. Dr. Vyas has also participated in design analysis of the Test Blanket Module planned to be installed in ITER, France. Dr. Vyas has been conferred several awards, which include Indian Nuclear Society Outstanding Service Award 2011, Homi Bhabha Science and Technology Award 2006, and DAE Awards in the years 2007, 2008, 2012 and 2013. He is also a Fellow of the Indian National Academy of Engineers.

Dr. K. N. Vyas was Director, Bhabha Atomic Research Centre, before he has taken over the charge of Secretary, Department of Atomic Energy and Chairman, Atomic Energy Commission on 20.09.2018.

Prof. 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 Sri" 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, Professor Emeritus, University of Calcutta, Kolkata.

(Member, Governing Board & Executive Council)

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

Dr. P. Duraisamy, Vice Chancellor, University of Madras, Chennai

(Member, Governing Board)

Dr. Duraisamy is a former HOD of the 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)

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

(Member, Governing Board & Executive Council)

Selvi. Apoorva, IAS, Principal Secretary to Government, Secretariat, Higher Education Dept., Government of Tamilnadu, Chennai

(Member, Governing Board & Executive Council)

Prof. Manindra Agrawal, Department of Computer Sciences and Engineering, Indian Institute of Technology, Kanpur

(Member, Executive Council)

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

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.

1.2.2 Director's Advisory Committees

Academic Coordinators Committee

Satyavani Vemparala	Physics
Sundar. S	Mathematics
Subramaniam C R	TCS

Annual Report Committee

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

Approval Coordinators

Srihari Gopalakrishna	Physics
Srinivas, K.	Mathematics
Meena Mahajan	TCS
Sitabhra Sinha	Computational Biology

Events / Outreach

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

Colloquium & Seminar

Nemani, V. S.	Physics
Dishant Pancholi	Mathematics
Vikram Sharma	TCS

Associateship Programme

Arvind, V.	Chair
Venkatesh Raman	TCS
Srinivas, K. &	
Pralay Chatterjee	Mathematics
Mukul Laad	Physics

Alumni Committee

Partha Mukhopadhyay	Chair
Meena Mahajan	
Sanoli Gun	
Pinaki Choudhuri	(as CC-Chair)
Paul Pandian	Library
Raveendra Reddy, B.	

Computer Media & Web Committee

Pinaki Choudhuri	Chair
Venkatesh Raman	
Raghavan, K. N.	
Rahul Siddarthan	
Satyavani Vemparala	
Sayantan Sharma	
Subramoniam, G.	SO`F' (Systems)
Raveendra Reddy, B.	SO`F' (Systems)
A Student Representative	(nominated by the chair)

Internal Complaints Committee (Gender Bias Redressal)

Indumathi, D.	Chair
Rajesh Ravindran	
Sanoli Gun	
Vishnu Prasad, S.	Registrar
Indra	(Administrative Officer)
Geetha, V.	(External Member)
One Student representative	(Nominated by the Chair)

Grievance Redressal Committee

Meena Mahajan	Chair
Amritanshu Prasad	
Sanatan Digal	
Sujay Ashok	

Guest House Advisory Committee

Pralay Chatterjee	Chair
Ravindran, V.	
Saket Saurabh	
Vishnu Prasad, S.	Registrar
A student representative	(Nominated by the chair)

Hostel Faculty Counselor

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

Manjari Bagchi	Chair
Nita Sinha	
Vikram Sharma	

Housing & Up-Keep

Ravindran, V.	Chair
Pinaki Chaudhuri	
Chandrashekar, C. M.	
Vishnu Prasad, S.	Registrar
Indra, R.	Administrative Officer

Library Committee

Amritanshu Prasad	Chair
Subramanian, C. R.	
Sitabhra Sinha	
Chandrashekar, C. M.	
Manjari Bagchi	
Paul Pandian	S/O`F' (Library)
Chandrashekhar, K.	(Student Member)

JEST Coordinators

Rajesh Ravindran	Physics (JEST)
Pralay Chatterjee	Mathematics (NBHM)
Saket Saurabh	TCS (JEST)

HBNI Coordinators

Amritanshu Prasad	Mathematics	Dean, Student Affairs
Sibasish Ghosh	Physics	Dean, Physical Sciences
Sanatan Digal	Physics	Associate Dean, Physical Sciences
Vijay Kodiyalam	Mathematics	Dean, Mathematical Sciences
Gautam I. Menon	Computational Biology	Dean, Life Sciences

National Science Day Committee

Raghavan, K. N.
Ravindran, V.
Vikram Sharma
Sushmita Venugopalan

Official Language Implementation Committee [OLIC]

Arvind, V.	Chair
Srinivas, K.	
Saket Saurabh	
Nita Sinha	
Vishnu Prasad, S.	Registrar
Vinay Vaibhav	Student Member

PDF Committees

Srinivas, K. & Pralay Chatterjee	Mathematics
Manjari Bagchi	Physics HEP
Satyavani Vemparala & Sibashish Ghosh	Physics LEP
Sitabhra Sinha & Ajit C. Balram	

Summer Programme Co-ordinators

Venkatesh Raman	TCS
Dishant Pancholi	Maths
Prof. Pinaki Chaudhuri	Physics

Refurbishment Committee

Saket Saurabh	Chair
Anirban Mukhopadhyay	
Partha Mukhopadhyay	
Chandrasekar, K.	Ex-Chief Architect, IGCAR
Vishnu Prasad, S.	Registrar
Sundar, M.	S/O `C' (Civil)
Mohan, S.	S/O `E' (Electrical)

Right to Information Act [RTI]

Venkatesh Raman	Appellate Authority
Vishnu Prasad, S.	Public Information Officer

Space Planning & Allocation Committee

Arvind, V.	Chair
Amritanshu Prasad	
Indumathi	
Hassan, S. R.	
Chandrashekar, C. M.	
Subramaniam, C. R.	
Vishnu Prasad, S.	Registrar

Tender Committee

Satyavani Vemparala	Chair
Hassan, S. R.	

Sports/GYM Committee

Vikram Sharma

Partha Mukhopadyay

Sundar, S.

Dr. Manjari Bagchi

Mr. Rakesh Netha - Cricket
(Student member)

Mr. Pranendu Darbar - Foot ball & Tennis
(Student member)

Mr. Mrigendra Singh - Table Tennis
(Student member)

Mr. Anupam Sarkar - Badminton
(Student member)

Institute Seminar Day

Viswanath, S.

Vikram Sharma

Areejit Samal

Sayantan Sharma

Science at the Sabha Committee

Rahul Siddharthan

Viswanath, S.

Vishnu Prasad, S.

1.3 Faculty

Computational Biology

Menon, Gautam I.

Samal, Areejit

Siddharthan, Rahul

Sinha, Sitabhra

Mathematics

Chakraborty, Partha Sarathi

Chatterjee, Pralay

Gun, Sanoli

Iyer, Jaya N.

Kodiyalam, Vijay

Mohari, Anilesh

Mukhopadhyay, Anirban

Pancholi, Dishant Mayurbhai

Prasad, Amritanshu

Raghavan, K. N.

Roy, Indrava

Sankaran, P.

Srinivas, K.

Sundar, S.

Sushmita Venugopalan

Viswanath, S

Physics

Adhikari, Ronojoy

Ashok, Sujay K.

Bagchi, Manjari

Balram, Ajit C.

Chandrashekar, C.M.

Chaudhuri, Pinaki

Digal, Sanatan

Ghosh, Sibasish

Gopalakrishna, Shrihari

Hassan, Syed Raghib

Hazra, Dhiraj Kumar

Indumathi, D.

Laad, Mukul S.

Menon, Gautam I.

Mukhopadhyay, Partha

Nemani, Venkata Suryanarayana

Pius, Roji

Rajesh, Ravindran

Rama, S. Kalyana

Ramachandran, Ganesh

Ravindran, V.

Sathiapalan, Balachandran

Sayantan Sharma

Shankar, R.

Siddharthan, Rahul

Sinha, Nita

Sinha, Rahul

Sinha, Sitabhra

Vemparala, Satyavani

Theoretical Computer Science

Arvind, V.

Mahajan, Meena

Raman, Venkatesh

Ramanujam, R.

Saivasan, Prakash

Saurabh, Saket

Sharma, Vikram

Subramanian, C.R.

1.4 Honorary Members

Balasubramanian, R.

Baskaran, G.

Rajasekaran, G.

Simon, R.

1.5 Scientific Staff

Subramoniam G.

Raveendra Reddy B.

Paul Pandian M.

Mohan S.

Usha Devi P.

Sundar M.

Maruthu Pandiyan B.

1.6 Administrative & Accounts Staff

Vishnu Prasad S.
Registrar

Gayatri E.
Accounts Officer

Indra R.
Administrative Officer

Vasudevan, T.V.

Parthiban, V.

Ashfack Ahmed, G.

Geetha, M.

Padmanabhan, T.

Prema, P.

Jayanthi, S.

Baskaran, R.

Balakrishnan, J.

Moorthy, E.

Radhakrishnan, M. G.

Shankaran, K.P.

Seenivasa Raghavan N

Usha Otheeswaran

Archana Shukla

Babu, B.

Johnson, P.

Gopinath, S.

Amulraj, D.

Janakiraman, J.

Munuswamy, N.

Rajasekaran, N.

Ramesh, M.

Ravichandran, N.

Tamil Mani, M.

1.7 Project Staff

Project Staff (Non-Academic)

Balachander M.

Gayathri S.

Hari Priya T.V.

Hemamalini A.

Imran Khan H.

Jayakumar P.

Karthikeyan B.S.

Karthikeyan M.

Kirubananth P.

Krishna Balaji R.

Kavyaa Kumaravel

Mangala Pandi P.

Manikandan Sambasivam

Moovendan M.

Narmatha S.

Parthasarathi N.

Prashanna K.

Rajkumar S.

Rethinasamy D.

Sadhana R.

Sakthivel Murugan E.

Shalieni D.

Sivasubbu Raj B.

Sreelakshmi P.K.

Srinadh G.

Srinivasan G.

Sree Raj T.P.

Thennarasu S.D.

Vaideeswaran Vimalraj J.

Vinoth Babu M.

Project Staff (Scientific/Academic)

Gajendra Singh Badwal

Harish, K.

Janaki Raghavan

Md. Izhar Ashraf

Shakthi N. Menon

Soumya Easwaran

Sudharshan A.

Surendra Singh Badwal

Varuni Prabhakar

Vinod Kumar T.

1.8 Post Doctoral Fellows

Computational Biology

Nayana Mukerjee

Om Prakash

Sushmita Ghosh

Mathematics

Abishek Juyal

Amit Kumar Singh

Anbu Arjunan

Anuj Jakhar

Balesh Kumar

Chandranandan Gangopadhyay

Jyotirmoy Ganguly

Kathiravan, T.

Neha Prabhu

Selvaraja S.

Soumya Dey

Suratno Basu

Usha Keshav Sangale

Veekesh Kumar

Physics

Abhiram Kaushik B

Amit Mukherjee

Arghya Chattopadhyay

Arpan Das

Arpita Choudhary

Arunprasath V.

Asweel Ahemed A Jaleel

Bala Subramanian P.N.

Bijoy Daga

Chandreyee Roy

Chandrima Paul

Gautam Sharma

Karthick H.S

Prasad V.V.

Rahul Dandekar

Samapan Sikdar

Shreyansh Shankar Dave

Srimoy Bhattacharya

Subhroneel Chakrabarti

Suman Dutta

Theoretical Computer Science

Anupam Mondal

Gurumuruhan Ganesan

Pallavi Jain

Purbita Jana

Vibha Sahlot

1.9 Ph.D Students

Computational Biology

Ajay Subbaroyan

Ajaya Kumar Sahoo

Chandrani Kumari

Chandrashekar K. A.

Devanand T.

Farhina Mozaffer

Janani R.

Pavitra S.

Rakshika Lakshmi, A.

Reshma M

Ria Ghosh

Sreevidya T.S

Sunayanaa Sridharan

Vadnala Rakesh Netha

Vivek Ananth R.P.

Mathematics

Ankur Sarkar

Aritra Bhattacharya

Avijit Nath

Biplab Paul

Dhananjaya Saha

Digjoy Paul

Jayakumar R.

Jyothsnaa S.

Karthick Babu C.G.

Krishanu Roy

Manas Mandal

Manav Gaddam

Mrigendra Singh Kushwaha

Nabanita Roy

Namitha C.H

Neelam

Oorna Mitra

Piyasa Sarkar

Pranendu Darbar

Priyamvad Srivastav

Rashi Sanjay Lunia

Ratheesh T.V

Rupam Karmakar

Sathish Kumar, V.

Siddheswar Kundu

Snehajit Misra

Sridhar P. Narayanan

Sruthy Murali

Sunil L Naik

Tanmoy Bera

Saurav Holme Choudhury

Ujjal Das

Physics

Abinash Kumar Nayak

Ajjath A.H.

Akhil Antony

Amir Suhail

Amit Kumar

Amlan Chakraborty

Anand Pathak

Anirban Karan

Anjali Kundalpady

Ankita Chakrabarti

Anupam A.H.

Anupam Sarkar

Aparajitha Karthikeyan

Aparna Sankar

Apurba Biswas, G.

Arindam Mitra

Arjun Hariharan

Arkajyoti Manna

Arpan Kundu

Bhargava B.A.

Dheeraj Kumar Mishra

Dhruv Pathak

Dipanjan Mandal

Garima Rani

Gopal Prakash

Himanshu Badhani

Hitesh Garg

Jilmy P. Joy

Jyotijwal Debnath

Kamal Tripathi

Koyena Bose

Mahaveer Prasad

Mamale Vinod Suryakant

Manish

Mohammad Shabbir

Nishant Gupta

Pavan Dharanipragada

Pooja Mukherjee

Prabhat Butola

Prafulla Oak

Prateek Chawla

Prashanth Raman

Prathik Cherian J.

Prem Kumar

Pritam Sen

Raghvendra Singh

Ravi T

Ria Sain

Ravi Shanker

Sabiar Shaikh

Sabyasachi Chowdhuri

Sahil

Sanjoy Mandal

Saroj Prasad Chhatoi

Sayantan Ghosh

Semanti Dutta

Shibasis Roy

Shilpa Kastha

Shivam Gola

Shivani Singh

Soumya Sur

Soumen Podder

Sourav Ballav

Subhankar Khatua

Sujoy Mahato

Surabhi Tiwari

Subashri, V.

Sushovan Mondal

Sumit Shaw

Tanmay Mitra

Tanmay Saha

Tanmoy Sengupta

Toshali Mitra

Umang A. Dattani

Vaibhav Pathak

Varun Gupta

Vignesh, B.

Vigneshwar N.

Vigneshwaran K.

Vinay Vaibhav

Theoretical Computer Science

Abhishek Sahu

Abhimanyu Choudhury

Abhranil Chatterjee

Anantha Padmanabha M.S.

Arindam Biswas

Ashwin Jacob

Gaurav Sood

Jayakrishnan M.

Lawqueen Kanesh

Niranka Banerjee

Prafullakumar Prabhakar Tale

Ramit Das

Roohani Sharma

Rian Neogi

Sanjukta Roy

Souvik Saha

Yogesh Dahiya

1.10 Summer Students

Every summer, a small number of students from Institutes/Universities across India come to our Institute to work on various learning/research projects with one of our faculty members for a period of four to six weeks. The following students visited the institute during Apr, 2019 - Mar, 2020.

Computational Biology

Pavithra Elumalai, PSG College of Tech, Coimbatore

Yogesh.S, IISER, Kolkata

Reethu Anand.A, SASTRA University, Tanjore

Shiva Ramakrishna.S, SASTRA University, Tanjore

Mathematics

Sanyam Gupta, IISER, Berhampur

Sreejani Chaudhury, University of Hyderabad

Gurieenkaur Nanda, IISER, Bhopal

Vignesh S, ISI Kolkata

Aishwarya S. Dabhole, Fergusson College , Pune

Swathi Sucharita, Central University of Orissa, Orissa

Ujjwal K.R. Sana, CMI, Chennai

Kiran, D, IISER Bhopal

Supriya P.I., PSG College of Technology, Coimbatore

Sourav Ghosh, CMI, Chennai

Amrutha B Nair, IISER, Thiruvananthapuram

Physics

Abhaya S Hedge, IISER Thiruvanathapuram

Deepthi P.G., Central University of Tamilnadu, Thiruvarur

Gourab Pal, IIT Madras

Khyati Jain, BITS, Goa

Sarvesh Srinivasan, BITS Pilani

Sree Ganesh Kumar Reddy, NIT Rourkela

Abhishek Kumar, NISER, Bhubaneshwar

Aakash Marthanadan, IIT Mumbai

Suyog Garg, IITDM Kancheepuram

Aditya Vaswani, BITS Pilani

Anagha K.V., NIT Calicut

Dolly Nambi, IISER, Thiruvanathapuram

Swaparjith K.S, IISER Mohali

Ashwath N. Madhusudan,IISER Pune

Sayantan Maity, IISER, Kolkata

Anandu R.S, IIT Punjab

Anubhab Sur, IISER Kolkata

Pavan, NISER, Bhubaneshwar

Reena Joseph, Madras Christian College, Chennai

Anandavijayan, Chandranathan NISER, Bhubaneswar

Debopam Goswami, Scottish Church College, Calcutta

Harihar Pradhan, NISER, Bhubaneshwar

Amrutha C.V., Azim Premji University, Banglore

Vishal Pandey, Banaras Hindu University

Budharaju Sasank, IISER,Mohali

Pratyush Kullepara, BITS, Goa

Ranadeep Roy, IISER Tirupathi

Samay H.N., IIT Madras, Chennai

Theoretical Computer Science

Srishti Agarwal, Ashoka University, Sonepat

Anmol Agrawal, Shri Shankaracharya Group of Inst., Bhilai

Madhumitha Kundu, ISI,Kolkata

Navish Kumar, IIT, Kharagpur

Ananth Krishna Duggirala, CMI,Chennai

Ganesh, G, Amirtha Vishwa Vidyapeetham, Coimbatore

Pasupuleti Rekha,SSN college of engineering ,Chennai

Rajhesh, R, PSG college of Technology, Coimbatore

Adarsh Srinivasan, IISER, Pune

Rahul, B.S, BITS Pilani

1.11 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, 2019 - Mar, 2020.

Mathematics

Sen, Smith, BITS GOA

Raavali, Nookala, NIT Rourkela

Sahoo, Lalatendu Bidyadhar, NIT Rourkela

Physics

Gupta, Divyanshu, BITS Pilani (Goa)

Rigby, Elizabeth, Oberlin College and Conservatory, USA.

Chwalik, Erica, West Virginia University, USA Vaswani, Aditya, BITS Pilani, Rajasthan

Kuzhively, Disha, graduated from NISER Bhubaneswar in 2019

Theoretical Computer Science

Ayyagiri, Saveri S., Sastra University, Thanjavur

Suresh, Nishank, Shiv Nadar University

2 Academic Activities and Programs

2.1 Research Activities and Highlights

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

Computational Biology

The field of computational biology lies at the intersection of biological phenomena and measurements, physics, applied mathematics and large-scale computation. The interests of the Computational Biology group at the Institute encompass computational genomics, networks in biology, biophysics, systems biology, infectious disease modelling, computational neuroscience and large-scale molecular dynamics simulations of biologically relevant phenomena.

An earlier model for phototaxis in cyanobacteria, the motion of bacteria away from or towards a source of light, is extended to understand the behaviour of such bacteria when bacterial colonies are exposed to complex light input. Collective effects are emphasized in the model, since these bacteria are known to interact and exert forces on each other through extensions called type-IV pili. The agent-based model reproduces most features of what is experimentally seen. It points out that, at the level of colony shapes alone, it is hard to distinguish between various proposed mechanisms for how bacteria integrate information and make decisions regarding motion, precisely because such motion is collective.

In 2019-2020, 4 articles were published in peer reviewed journals.

First PhD in Computational Biology

Established in 2013, the Computational Biology group is the youngest at IMSc and consists of an enthusiastic group of faculty, post-docs and students who work on a variety of interdisciplinary topics.

Ankit Agrawal is the first student to complete a Ph.D in Computational Biology from IMSc, Chennai. He defended his thesis on July 18, 2019. His thesis advisors are Gautam Menon and Rahul Siddharthan. He worked on nuclear architecture with Gautam Menon and on the detection of transcription factor binding motifs with Rahul Siddharthan. After submitting his thesis, Ankit is a postdoctoral fellow at the Weizmann Institute of Science, Israel, and is working on biophysics and image analysis of cell packings.

Image 1: Computational Biology- Ankit Agarwal's Ph.D. Defence, 18th July 2019

A Community Resource Documenting Experimental Evidence on Hormone-Disrupting Environmental Chemicals

A. Samal and his students have developed a digital resource called Database of Endocrine Disrupting Chemicals and their Toxicity profiles (DEDuCT) which contains a manually curated list of 686 Endocrine Disrupting Chemicals (EDCs) compiled from 1796 scientific research articles with experimental evidence of endocrine disruption, specific to humans or rodents. EDCs are a group of chemicals of emerging concern, omnipresent in the environment, that are known to cause adverse effects by interfering with the human endocrine system.

There has been growing interest in unraveling the endocrine disrupting mechanisms upon EDC exposure. In this direction, the research team has designed a detailed pipeline to identify such chemicals based on experimental evidence in published literature. In addition, the team has compiled the adverse effects and the dosage levels at which each of these effects were observed upon EDC exposure. The EDCs are classified based on the type of supporting experimental evidence, their environmental source, and chemical classification.

DEDuCT also contains information about chemical structure, physicochemical properties, molecular descriptors, predicted ADMET properties and target genes for potential EDCs. A network-centric analysis using DEDuCT revealed a lack of correlation between chemical structures and target genes of EDCs. In sum, this work highlights the future challenges in developing computational predictive models for identifying the adverse effects of EDCs. This large-scale compilation of EDCs will facilitate future research on systems-level understanding of endocrine-mediated effects upon exposure. DEDuCT is freely accessible at -

https://cb.imsc.res.in/deduct/

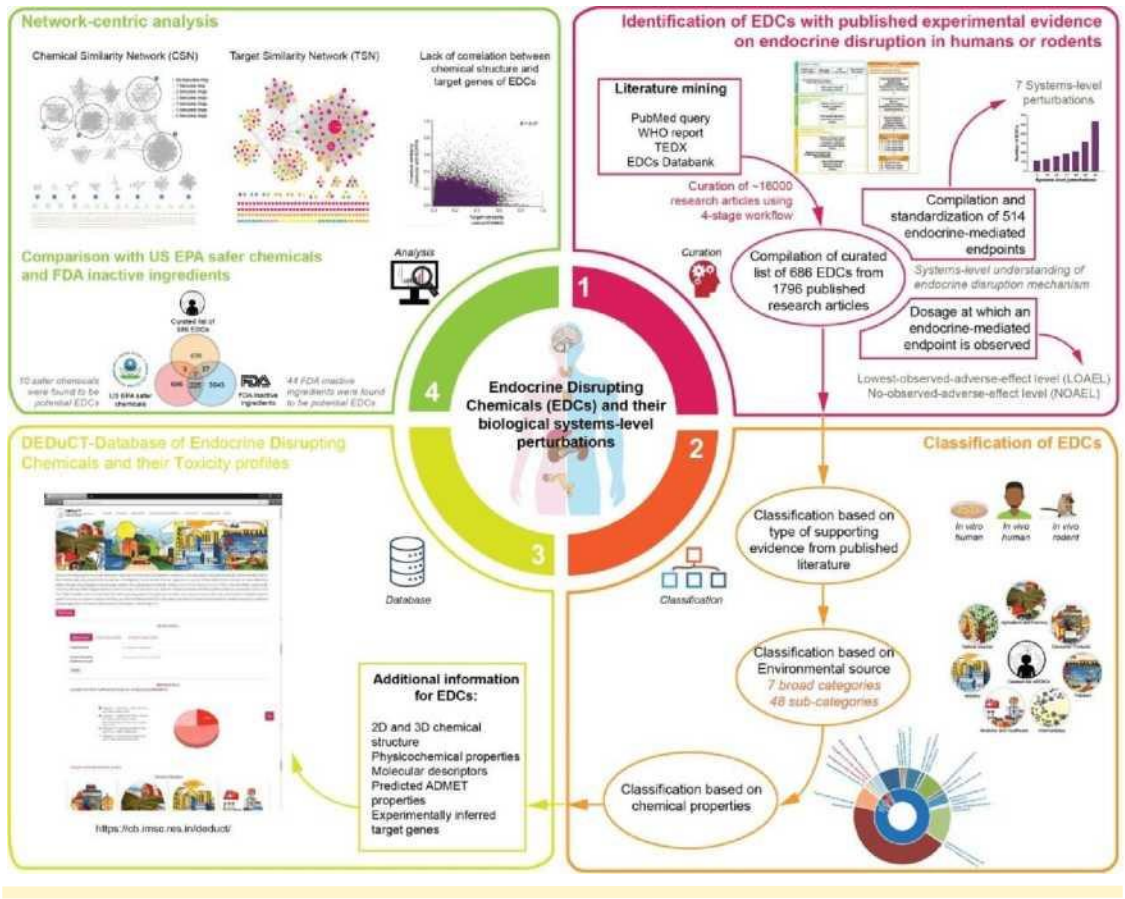

Image 2: Schematic figure summarizing the work on Endocrine Disruptors

This work was published in the journal Science of the Total Environment. Further the work has been covered by national and international media such as Hindustan Times, India Science Wire, ChemicalWatch, European Trade Union Institute and ACS Chemical Engineering news.

Mathematics

The Mathematics group has wide ranging interests. These specializations are conveniently grouped together under broad headings. A very brief description is provided below:

In 2019-2020, 23 articles were published in peer reviewed journals.

Algebra: Algebra is the study of the properties of mathematical structures involving "algebraic" operations such as addition and multiplication. One of the main motivations to study algebraic structures is to analyze geometric objects such as curves and surfaces via the algebra of functions defined on them. Aspects of algebra being studied at IMSc involve algebraic geometry (study of loci of solutions of polynomial equations), algebraic groups (groups of matrices), and the theory of knots.

[**Vijay Kodiyalam, D. S. Nagaraj, K. N. Raghavan.**]

Algebraic Geometry: This branch of mathematics is a study of the solution set of a finite set of polynomials in several variables. The total degrees of the polynomials and the number of polynomials play an important role in determining the geometry of the solution set. This subject has rich interactions with mathematical physics and other areas.

[**Jaya Iyer, D. S. Nagaraj**]

Lie Groups:

The theory of Lie groups deals with the groups of symmetries of continuous mathematical objects. It is one of the most important areas of Mathematics. It is used widely in almost all major branches in Mathematics and in many branches in Physics.

[**Pralay Chatterjee**]

Number Theory:

Number theory is concerned mainly with the way prime numbers are distributed in the set of natural numbers. This area has rich interactions with many other branches of mathematics including algebra, complex analysis and geometry. There are also applications to cryptography.

[**K. Srinivas, Anirban Mukhopadhyay, Sanoli Gun**]

Operator algebras:

This subject may loosely be described as the study of 'infinite-dimensional matrices'. It was introduced by von Neumann in order to address some problems arising from quantum mechanics. Even today, it is intimately tied to various branches of physics as well as to other areas of pure mathematics, such as knot theory.

[**Vijay Kodiyalam, V. S. Sunder, Partha Sarathi Chakraborty**]

Non-commutative Geometry:

Geometry can be loosely defined as the study of cycles and their intersection properties in some suitable homology theory. Noncommutative geometry of Alain Connes is no exception. It is the study of some special cycles in the unbounded picture of Kasparov's K-homology. This subject tries to extend the reach of differential geometry in the setting of operator algebras. Noncommutative geometry interacts with various branches of Mathematics like discrete groups, topology etc. It also interacts with mathematical physics.

[**Partha Sarathi Chakraborty, Indrava Roy**]

C* dynamical systems and non-commutative probability theory:

The subject studies an automorphism group action on C* algebras and its asymptotic behaviour of stationary states with additional symmetries that arise naturally in a given mathematical or physical problems of interest. It uses intuition of non-commutative probability theory and powerful methods of functional analysis to study various ergodic properties of the automorphism group action.

[**Anilesh Mohari**]

Representation theory:

Groups are algebraic structures that arise as symmetries of physical or mathematical objects. Representation theory studies properties of abstract groups via their matrix representations. Representation theory enables many group-theoretic problems to be reduced to problems in matrix algebra, which is very well-understood.

[A. Prasad, K. N. Raghavan, P. Sankaran, S. Viswanath]

Topology:

Topology may be described as geometry with or without a notion of distance. It aims to study properties of these objects, of which curves and surfaces are well-known examples, which are invariant under 35 deformations. The subject has wide applications within mathematics as well as in physics.

[P. Sankaran, Sushmita Venugopalan, Dishant Panchol]

The Mathematics group are involved in a number of research and educational activities under various specializations, some of which are highlighted below.

Algebra

Understanding the tensor product of two irreducible finite dimensional representations of a complex semisimple Lie algebras is a very important problem that has been studied intensely by mathematicians for the past 75 years. The celebrated conjecture of Parthasarathy-Ranga Rao-Varadarajan from the 1960s and its extensions by Kostant, Verma, Kumar and Montagard were the subject of recent research by members of the mathematics group at IMSc. Significant new results were obtained employing the “path model”, a powerful combinatorial tool first formulated by Littelmann in the 1990s.

Using the decomposition rule, we establish a lower bound for multiplicities of PRV components in Kostant- Kumar modules, thereby generalising simultaneously the KPRV and the refined PRV theorems of Kumar.

Algebraic Number Theory

Lenstra introduced the notion of Euclidean ideal classes to study number fields with cyclic class groups. In particular, he showed that the class group of a number field with unit rank of at least one is cyclic if and only if it has a Euclidean ideal class where the only if part is conditional on the Extended Riemann hypothesis.

An unconditional version of the above result has been proven for a family of Abelian extensions with unit rank at least 3. This strengthens an earlier result of Murty and Graves.

It is an inherent feature of this theme that the number fields with small unit rank are more difficult to handle.

In a paper "On existence of Euclidean ideal classes in real cubic and quadratic fields with cyclic class group", by S. Gun & J. Sivaraman, the authors show that same assertion holds for a family of real cubic (respectively quadratic) fields with cyclic class groups with at most one (respectively two) exceptions.

An important problem in algebraic number theory is to study whether a polynomial over rationals is irreducible or not. If not, then what can be said about the degrees of its irreducible factors? A general criteria to find a lower bound for each irreducible factor (over rationals) of a given polynomial with integer coefficients is given.

Differential Geometry

Sushmita Venugopalan of IMSc was a co-organizer of the conference titled '*Novel Vistas in Vortices*' in the Simons Center for Geometry and Physics, New York. Vortices are gauge-theoretic objects that originated in the study of super-conductors. Research in the last two decades has uncovered connections between vortices and various aspects of symplectic geometry and representation theory. This conference succeeded in bringing together a community of mathematicians and physicists spread across many countries. The details of the conference can be accessed at the following URL:
http://scgp.stonybrook.edu/archives/29486

Koszul duality and the alternating Schur algebra

The polynomial representation theory of a full matrix group is a fundamental problem of algebra and leads to a deep understanding of tensor spaces as well as symmetric functions. About 100 years ago, Issai Schur classified the building blocks of such representations by relating them to representations of permutation groups. Work done at IMSc by Amritanshu Prasad and Shraddha Srivastava in collaboration with T Geetha of IISER Thiruvananthapuram, set out to understand Schur's theory when restricted to even

permutations. This led to the discovery of a beautiful connection with Koszul duality, a fundamental duality on the polynomial representations of a full matrix group.

Modular forms

Suppose for all but finitely many primes p, we are given an elliptic curve E_p defined over a finite field F_p of p elements. A criterion has been derived for the existence of an elliptic curve E defined over for which the reduction of E modulo p is isogenous to E_p for all p.

Non Commutative Geometry

Higson-Roe sequence for transformation groupoids:

Coarse Geometry investigates the large-scale structure of geometric objects. Building on earlier ideas of Gromov, Lawson and others, John Roe developed an axiomatic approach to study coarse structures (sometimes also referred as uniform or bornological structures), with the goal of extending classical index theoretic results on compact manifolds, to the non-compact setting. A particularly striking application in the context of coarse geometry, is a K-theoretic generalization of a classical theorem of Gromov-Lawson on the index-theoretic obstruction for the existence of a metric of positive scalar curvature.

In joint work with M.T. Benameur, we have extended, in a systematic way, the seminal results of N. Higson and J. Roe on the construction of the analytic surgery sequence for discrete groups, to the case of étale transformation groupoids. In particular, we give generalizations of the Paschke-Higson duality theorem as well as new secondary index classes that are invariants of foliations and laminations. In the process, we also develop a coarse analogue of a deep result of Pimsner-Popa-Voiculescu. Two papers on this area are scheduled to appear in the Journal of Noncommutative Geometry.

Novikov's Theorem in Higher Dimensions?

A foliation is an equivalence relation in a manifold whose equivalence classes are embedded submanifolds of codimension one. Novikov's theorem says that a taut foliation on a three-manifold does not have any Reeb components. Thus, the class of taut foliations on three manifolds has a certain rigidity. For higher dimensional manifolds, the existence of a strong symplectic form has been proposed as an analog for tautness in order to achieve similar rigidity. It was conjectured (about ten years ago) that strong symplectic foliations would satisfy an analogue of Novikov's theorem. However, this turned out to be false, and in an article 'Novikov's theorem in higher dimensions?' [arXiv 1907.05876] IMSc mathematician S. Venugopalan constructs a counter example.

Representation Theory

Polynomial representations of general linear groups can be viewed as modules for the Schur algebra. This algebra is the commutant for the action of the symmetric group on tensor space by permuting the tensor factors. Schur-Weyl duality relates these representations to representations of the symmetric group.

The commutant of the alternating group on tensor space, called the alternating Schur algebra, was studied. This algebra is a $\mathbf{Z}/2\mathbf{Z}$-graded algebra, its 0th graded part being the classical Schur algebra S. It's 1th graded part is an (S, S) bimodule S^-. The functor $M \leftrightarrow S^- \otimes M$ was defined as the Koszul duality functor on the category of S-modules. Under Schur-Weyl duality, this functor corresponds to multiplication by the sign characater of a representation of the symmetric group. This definition was shown to be consistent with a more abstract notion of Koszul duality defined by Krause on the category of strict polynomial functors.

A combinatorial interpretation of the structure constants of this algebra was used to study properties of Koszul duality.

Multivariate polynomials give rise to class functions on all symmetric groups by substituting for the ith variable the number of cycles of size i in a permutation. A simple formula for computing the Schur inner product of such class functions was obtained. The restriction problem seeks to determine how an irreducible representation of GL_n decomposes when restricted to its subgroup of permutation matrices. Multivariate polynomials giving rise to characters of such restrictions were computed. Together with the formula for Schur inner products, restriction coefficients were computed. This is a new approach to the restriction problem.

Topology

Application of topology to complex networks:

Topological data analysis (TDA) is an emerging field which employs tools from combinatorial and algebraic topology to study the 'shape' of data. In particular, it reveals higher-order patterns within the data that remain hidden to classical methods of investigating the structure of data.

In network science, capturing such higher-order patterns is a key challenge. High-volume data that emerges from large networks such as Facebook, can therefore be studied using TDA.

The main tool in TDA is 'Persistent homology', which has its origins in the field of algebraic topology and is used to capture the 'global' structures that are present in an object. The computation of persistent homology is further rendered more efficient by the use of discrete Morse theory, which is a purely combinatorial way of studying the underlying topology of the object. An interdisciplinary collaboration between Indrava Roy in

Mathematics group and Areejit Samal in the Computational biology group, along with Harish Kannan (project assistant to Areejit Samal) of the institute has led to the development of a new method to investigate such higher-order structures in complex networks using TDA. Specifically, the team has developed a new method to study persistent homology in unweighted networks based on discrete Morse theory. Informally, this method produces an efficient algorithm to obtain a discrete Morse function that not only helps to capture the higher-order relations in an unweighted network, but can also be used in the lossless compression of such data. In addition to capturing the topology of the network, this function is then used to compute the persistent homology of the network in an efficient manner.

The team has employed this new method to explore persistent homology of several unweighted model and real-world networks. They show that the persistence diagrams can distinguish between the topology of different types of model and real networks. A manuscript on this work appeared in the journal Scientific Reports.

Physics

The Theoretical Physics group subsumes a very broad spectrum of specializations. These are conveniently grouped under a smaller number of headings. A very brief description is provided followed by the names of faculty members currently working in these areas.

In 2019-2020, 65 articles were published in journals and conference proceedings.

- **High Energy Physics:** Sub-nuclear constituents of nature and their properties is well summarized by the *Standard Model*. This model describes the strong and electro-weak interactions. The research involves both elaboration of the model as well as constructing theories that go beyond it.

  The following grouping refers to different aspects that are being pursued at IMSc.

  - Particle Physics Phenomenology:

    The phenomenological aspects of physics at existing and future colliders are studied with a view to test the Standard Model and seek possible signals of New Physics (or Physics beyond the Standard Model), a particular focus being data and results currently coming out of the Large Hadron Collider (LHC) at CERN in Geneva [**Shrihari Gopalakrishna, V. Ravindran and Rahul Sinha**]

    Predictions of various scattering processes at colliders are being calculated using perturbative QCD, which deals with the strong forces in the standard model. Quantum loop contributions tomultileg processes are being included to improve the accuracy of the predictions.

[**D. Indumathi and V. Ravindran**]

Several experiments worldwide are studying the physics of "beauty mesons" (B-physics) in order to explain the observed CP-violation (the dominance of matter over antimatter). Such studies are also important in the search for physics beyond the Standard Model.
[**Rahul Sinha**]

Neutrinos are very weakly interacting particles which have recently been found to possess a mass. There is involvement in the national proposal to build a *Indian Neutrino Observatory* (INO), and in global efforts using *neutrino factories* to elucidate the possibility of CP violation in neutrinos, and determining the mass ordering. Theoretical studies of neutrino masses and mixings are pursued.
[**D. Indumathi, M.V.N. Murthy, Nita Sinha, G. Rajasekaran (Professor Emeritus)**]

Most of the matter in the Universe is "dark". Beyond the standard model candidates for this dark matter are being investigated. Experiments are going-on world-wide to detect this dark matter. IMSc group has interpreted the unexplained Kolar events seen in the Kolar experiments 50 years ago as due to dark matter particles.
[**D. Indumathi, Shrihari Gopalakrishna, M. V. N. Murthy, G. Rajasekaran (Professor Emeritus)**]

- Non-Perturbative QCD:

  This deals with widely believed properties of strong forces such as "color confinement", "color superconductivity" and "chiral symmetry breaking". The main themes of research are the QCD phase diagram and exotic transport properties of QCD matter far away from equilibrium. In particular we are looking for signals of QCD (chiral) critical point from first principles lattice gauge theory calculations and understanding the degrees of freedom and the symmetries across the deconfinement transition. Moreover the effects of topological transitions in QCD matter both in and away from equilibrium is studied using lattice techniques which can provide us with crucial insights about the mechanism of deconfinement and chiral symmetry breaking. Exotic phases of QCD matter at very high baryon densities like color superconducting phases and its properties are also another theme of research within our group.
  [**Sanatan Digal, Sayantan Sharma**]

- Gravitational Physics:

  Einstein's theory of gravity has a bearing on the theory of our cosmos and also predicts exotic objects such as neutron stars and black holes. Rotating neutron stars (pulsars) constitute important observational probes of the strong gravity regime. Astrophysics of pulsars, classical general relativity and one of its quantum versions

namely, loop quantum gravity are pursued at IMSc. IMSc members are also interested in the theory and observations of gravitational waves.
[**Manjari Bagchi, Ghanashyam Date, Romesh Kaul**]

- Astrophysics:

  Astrophysics is in one sense an inter-disciplinary science, where the knowledge in various other areas of physics including particle physics, gravitational physics, statistical physics, etc can be tested and enhanced. IMSc has recently expanded its area of research in astrophysics. So far only pulsar astrophysics is being pursued at IMSc. In addition to gravitational physics, pulsars are also useful to understand the state of matter at extreme densities, evolution of stars, properties of interstellar medium, etc.
  [**Manjari Bagchi**]

- Quantum Field Theory:

  This provides a general theoretical framework for the quantum theory of fields. Apart from the perturbative analyses of quantum field theories used in the theory of scattering processes, their non-perturbative aspects are crucial for a more complete understanding. There are many different types of quantum field theories such as Conformal Field Theories, Topological Field Theories, Non-commutative Field Theories, Lattice Gauge Theories etc.
  [**Sanatan Digal, Romesh Kaul**]

- String Theory:

  In the quest for a unified framework to understand and unify all interactions, string theory is the leading candidate. At IMSc the focus has been on the loop variables approach, dualities in string theory and supersymmetric gauge theory, the AdS/CFT correspondence, brane physics including cosmology and black hole entropy.
  [**Sujay K. Ashok, S. Kalyana Rama, Partha Mukhopadhyay, Balachandran Sathiapalan, Nemani V. Suryanarayana**]

- **Condensed Matter Physics:**

  Condensed matter physics deals with the understanding of the diverse properties exhibited by the materials in nature; for example, the resistivity of materials can vary over about 20 orders of magnitude depending on the material. Condensed matter physics attempts to understand these behaviour in terms of simpler models which can then be studied using a variety of theoretical and computational tools.

  - High Temperature Superconductivity:

At very low temperatures, several materials undergo a transition into a superconducting state, in which an electrical current flows without resistance.
The properties of materials which superconduct at somewhat higher temperatures, the high- temperature superconductors, is one of the most active areas of research today, since it raises many theoretical questions of principle and has important implications for technology.
[**Mukul Laad, Gautam I. Menon, G. Baskaran (Raja Ramanna Fellow)**]

- Correlated Electronic Systems, Magnetism and the Quantum Hall Effect:

  The interactions between electrons is responsible for magnetism. Such interactions are key to several unusual electronic states. Understanding this problem better would impact our understanding of a host of recently discovered materials with unusual properties.
  [**R. Ganesh, Syed Raghib Hassan, Mukul Laad, A. K. Mishra, R. Shankar and G. Baskaran (Raja Ramanna Fellow)**]

- Soft Condensed Matter Physics:

  Soft condensed matter refers to physical systems in which the energy scales required to create sizeable deformations are comparable to temperature. Thus, such systems can exhibit a remarkable variety of complex flow behaviour as well as equilibrium phases under relatively modest perturbations. The physics of glasses is also an active area of research.
  [**Gautam I. Menon, Pinaki Chaudhuri, Satyavani Vemparala**]

- **Statistical Mechanics:**

Statistical mechanics provides a foundation for thinking about the collective behaviour of large numbers of interacting particles. The behaviour of systems out of thermal equilibrium is of particular interest, featuring problems such as fracture in disordered materials, hysteresis in magnets and surface growth, shock propagation in granular systems, earthquake dynamics and stability of masonry wall.

Given the generality of the approach of statistical mechanics, it finds application in a huge range of fields, including study of phase transition and critical phenomena, statistical physics of spin systems, disordered systems such as percolation problem, spin glass and glass, statistical physics of surfaces and networks, granular systems, statistical mechanics of fracture in materials and breakdown in threshold activated systems, turbulence in liquids, the modeling of biological systems and even explaining socio-economic distributions such as that of income or stock price fluctuations. Cold

fermionic atoms at unitarity and their equation of state leading to universal thermodynamics is a field of active study in recent years.
[Purusattam Ray, R. Rajesh, Gautam I. Menon, M. V. N. Murthy, Sitabhra Sinha, Satyavani Vemparala]

- **Quantum Statistics:**

  A theory of generalized Fock spaces is formulated. This theory underlies the different forms of quantum statistics such as ''infinite", Bose-Einstein and Fermi-Dirac statistics. The theory is based on a three-tiered structure consisting of Fock space, statistics and algebra. This generalized formalism not only unifies the various forms of statistics and algebras, but also allows the construction of new forms of quantum statistics as well as many algebras of creation and destruction operators. Some of these are new algebras for infinite statistics, q-statistics and its many avatars, a consistent algebra for fractional statistics, null statistics or statistics of frozen order, 'doubly-infinite statistics, many representations of Orthostatistics, Hubbard statistics and its variations.
  [A. K. Mishra and G Rajasekaran (Professor Emeritus)]

- **Theoretical fluid mechanics:**

  The theoretical study of the mechanics and statistical mechanics of fluids using classical field theories is an area of research that has been revitalised by the necessity to understand fluid flows at scales that span a few microns (as in biofluids and in microfluidic devices) to few thousands of kilometers (as in geophysical flows). Intelligent numerical approximations to the nonlinear governing equations, combined with their computational solutions, are able to shed insight into this fascinating area of theoretical physics. Research from IMSc in the area has appeared in prestigious international journals, including Physical Review Letters and PNAS, been featured in numerous news items, and has led to the establishment of a start-up company for commercializing computational models of fluid flow.
  [Ronojoy Adhikari]

- **Non-linear Dynamics and Complex Systems:**

  Nonlinear phenomena is ubiquitous in complex systems all around us - e.g., from the cell to society - which are characterized by a large number of interacting elements exhibiting emergence of surprising systems-level behavior that is absent in any of its components. The richness of the collective behavior could come about either through strong nonlinearity in the local dynamics of the elements and/or from the non-trivial

topology of the network connecting them. Nonlinear systems exhibit surprising and complex effects that would never be anticipated by a scientist trained only in linear techniques. Prominent examples of these include bifurcation, chaos, and solitons. Surprisingly, diverse non-linear dynamical systems exhibit remarkably similar, sometimes even universal behaviour. Nonlinear science has applications to a wide variety of fields, from mathematics, physics, biology, and chemistry, to engineering, economics, and medicine.
[Sitabhra Sinha]

- **Quantum Physics:**

  This is a grouping of areas not subsumed under the above headings and contains the following specializations.

  - Quantum Optics:

    Broadly, this area refers to the study of quantum states of light. At IMSc, the focus in this area has been on specifically non-classical (quantum) aspects of radiation. Other related interests are geometric phases, Wigner distribution functions for finite dimensional Hilbert spaces etc.
    [Sibasish Ghosh, R. Simon]

  - Quantum Entanglement, Quantum Information Theory:

    Classical states have definite attributes while quantum states can exist as "superpositions" and have non-classical (probabilistic) attributes. This feature affects aspects of information science such as coding/decoding, transmission, computing etc. Aspects of quantum information theory in the context of finite dimensional as well as infinite dimensional quantum state spaces are being studied.
    [V. Arvind, C. M. Chandrashekar, Sibasish Ghosh, R. Simon]

- **Interdisciplinary research:**

  There is an ongoing effort, not belonging to any of the areas above, of an interdisciplinary nature in such diverse areas like the study of indus script and seals, historical monsoon shifts, modeling of tsunamis, movement of Himalayan glaciers, modeling Indian musical instruments, etc.
  [M V N Murthy, R Shankar, Sitabhra Sinha]

Some of the academic activities of the Physics group are highlighted below.

Astrophysics & Cosmology

An effort is going on to build an "Indian Pulsar Timing Array" which will join the "International Pulsar Timing Array" to detect nano-Hertz gravitational waves. Observations using GMRT and ORT have been performed.

The International Pulsar Timing Array (IPTA) consortium consists of established Pulsar Timing Array (PTA) efforts, that include the European Pulsar Timing Array (EPTA), the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), and the Parkes Pulsar Timing Array (PPTA) as well as the emerging efforts like the Indian Pulsar Timing Array (InPTA), South African Pulsar Timing Array and the Chinese Pulsar Timing Array. The IPTA consortium aims to detect gravitational waves using an ensemble of millisecond pulsars located in our Galaxy. To nurture the collaborative nature of the IPTA consortium, annual meeting is held in different continents. This year, the annual meeting of the IPTA was held in Pune, India between June 10 to 21, 2019.

The first week (June 10 - 14, 2019) was a school for students, where lectures and hands on experiments by international experts were arranged. This part was hosted by NCRA-TIFR. The second week (June 17 - 21, 2019) was the conference week, and was held in the Orchid Hotel, Pune. It was a very successful meeting. The conference week was attended by 90 scientists throughout the globe (26 Indians working in India, 12 Indian students and post-docs abroad, and 52 foreign nationals). There were presentations by scientists on their research results as well as policy making discussions for the IPTA. There was a dedicated session on diversity and equity, lead by Prof. Ketki Ranade and Prof. Shewli Kumar from Tata Institute of Social Sciences, Mumbai.

Image 3: Annual Meeting of the IPTA, 10th-21st June 2019, Pune

IMSc members had pivotal roles in organising both of the weeks. Dhruv Pathak, Phd student in IMSc was part of the Scientific Organising Committee of the student workshop (the first week) and the Scientific Organising Committee of the conference week was chaired by Manjari Bagchi, faculty member of the theoretical physics group of IMSc. Additionally, Arpita Choudhury, DST-WOSA postdoctoral fellow at IMSc attended the meeting. Bagchi and Pathak presented their research work and Choudhury presented a collaborative work done by the InPTA team. Pulsar surveys to discover new pulsars are being undertaken using the upgraded GMRT as well as Arecibo radio telescopes. The effects of velocity and accelerations of pulsars in their observed derivatives and second derivatives of periods are being studied.

Magnetars are neutron star with very high magnetic fields (around 10^{10} Tesla). Magnetars usually emit persistent X-rays, but no radio pulsations. However, there are two magnetars that emit occassional radio pulses. XTE J1810-197 is one of these. Since December-2018, this is in a radio emitting phase. This source is being monitored using the Giant Metrewave Radio Telescope. Interesting spike like features in the radio pulses have been seen. Similar features have been seen in mysterious cosmological Fast Radio Bursts for which magnetars (out of our Galaxy) are one probable sources. This similarity is interesting.

This study has been recently published in the Astrophysical Journal Letters. This work has received media attention and has been highlighted in space.com

(https://www.space.com/magnetar-clues-mystery-fast-radio-bursts.html)

Classical and Quantum Gravity, Black Holes, Cosmology

In 1970‘s, W.G. Dixon completed a programme initiated by Myron Mathisson of describing the motion of an extended, but compact object in an arbitrary, but fixed background spacetime M. In this approach the dynamics is given by equations along an average worldline that resembles a generalised form of Newton‘s laws for rigid body motion. The generalised force and torque appearing in these equations are given by coupling of background gravity with a set of infinite number of multipole moments of the object. In Dixon‘s computation a derivative appears which can be interpreted as a natural connection on *TM*. In an ongoing work, attempt is being made to make the bundle structure more manifest in the problem. In another ongoing work, Dixon‘s construction is being used to study dynamics of a small string in M.

Condensed Matter Physics

Condensed matter theory with an emphasis on the physics of the fractional quantum Hall effect and topological insulators.

Using extensive computations, we have studied both equilibrium and out-of-equilibrium behaviour of disordered materials like glasses, emulsions etc.

Motivated by recent experiments and also mean field predictions related to how glassy systems respond to quenched disorder, we have studied the response of a model two-dimensional colloidal glass former to an externally imposed spatially random potential. The external field induces the onset of the glassy dynamics at increasingly smaller field roughness, with increasing packing fraction of the particulate assembly, and the existence of aging processes within the glassy regime is also observed.

Furthermore, along the axis of increasing field roughness, the dynamical slowdown is not correlated to the hexatic order within the supercooled regime. In the context of non-equilibrium properties of glassy materials, we have probed response of a model glassy forming system to an externally applied thermal gradient.

In the first study, we have shown that near the glass transition temperature, where the structural relaxation time becomes very long, the measured thermal conductivity decreases with increasing age. Second, the thermal conductivity of the disordered solid obtained at low temperatures is found to depend on the cooling rate with which it was prepared. For the cooling rates accessible in simulations, lower cooling rates lead to lower thermal conductivity. Our analysis links this decrease of the thermal conductivity with increased exploration of lower-energy inherent structures of the underlying potential energy landscape.

In the next study, for the same model system, we have studied the Soret effect, i.e., the flow of matter caused by a temperature gradient. The transport processes associated with this effect are thermal diffusion and interdiffusion. While interdiffusion processes exhibit a drastic slowing down when approaching the glass transition, thermal diffusion appears to be a fast process even in the glass.

We show that the Soret effect becomes more pronounced in the vicinity of the glass transition, due to the decoupling between thermal diffusion and interdiffusion as well as the chemical ordering in the considered LJ mixture. This is reflected in the occurrence of large concentration gradients, nonlinear concentration profiles, and long-lived nonstationary structures.

To understand the mechanical response of amorphous materials having defects in the form of inclusions, we have studied the yielding response, in the athermal quasistatic limit, of a model system having inclusions in the form of randomly pinned particles. We show that,

with increasing pinning concentration, the plastic activity becomes more spatially localized, resulting in smaller stress drops, and a corresponding increase in the magnitude of strain where yielding occurs. We demonstrate that, unlike the spatially heterogeneous and avalanche led yielding in the case of the unpinned glass, for the case of large pinning concentration, yielding takes place via a spatially homogeneous proliferation of localized events.

Our continued interest in studying the rheology of emulsion-like granular systems, led us to investigate the steady-shear rheology of a model adhesive dispersion in the dense regime. We vary the range of the attractive interparticle forces as well as the strength of the dissipation. We observed that for large dissipative forces, the rheology is governed by the Weissenberg number and displays Herschel-Bulkley form. Decreasing the strength of dissipation, the scaling with Weissenberg number breaks down and inertial effects show up. The stress decreases via the Johnson-Samwer law, where thermal effects are exclusively due to shear-induced vibrations. During flow, particles slide past each other such that their relative velocities are primarily directed tangentially to the particle surfaces. This tangential channel of energy dissipation and its suppression leads to a discontinuity in the flow curve and an associated discontinuous shear-thinning transition.

We set up an analogy with frictional systems, where the phenomenon of discontinuous shear-thickening occurs. In both cases, tangential forces, frictional or viscous, mediate a transition from one branch of the flow curve with low tangential dissipation to one with larger tangential dissipation.

Explaining the Ubiquity of Complex Patterns

A recent paper published by scientists from IMSc shows that patterns seen in processes as diverse as chemical reactions, a cell undergoing division, and interactions between populations of predators and prey, can arise through the same fundamental mechanism. All of these systems (and more) consist of many oscillators, each trying to suppress the activity of its neighbors - a phenomenon that can be termed as lateral inhibition in analogy to the similar mechanism in operation in sensory systems. Although one may see a dazzling range of patterns that vary over space as well as in time, these can be traced to effectively two basic patterns - one which shows patterns frozen in time, and the other in which the oscillators are organized into clusters of synchronous activity.

Mathematical Physics

In the area of mathematical physics, there has been work done in the derivation of non-linear differential equations satisfied by automorphic forms of Hecke groups, which are

discrete subgroups of $SL(2,R)$. The work was motivated by the appearance of Hecke groups as symmetries in certain supersymmetric gauge theories, and the associated automorphic forms made an appearance in the low energy effective actions of these theories. While the motivation for the work came from physics, the work in is purely mathematical. It was found that the automorphic forms satisfy generalized Ramanujan relations and that it was possible to associate non-linear differential equations to each Hecke group that are higher order generalizations of the Chazy equation.

It was shown that the solution to the non-linear equation in each case is a quasiautomorphic weight-2 Eisenstein series and its orbit under the group action.

Non-perturbative Quantum field theory

The main foucs of the group was to study and develop new theoretical tools for understanding novel non- perturbative physics in quantum field theories. These include detailed study of the Z3 metastable states in PNJL model, topological vortices in complex scalar field theories with oscillating metric background, the onset of plasma instabilities in strongly coupled quantum electrodynamics, the role of topological objects near the chiral crossover transition in QCD. Another important focus was to relate ab-initio theoretical calculations of fluctuations and correlations of conserved quantum numbers in thermal QCD to the recent state-of-the art experimental data from the STAR experiment, for the first time, finding a consistent agreement between the two.

Particle Physics

The discovery of the Higgs boson at the CERN Large Hadron Collider and the knowledge of its mass allowed us to ask if the Higgs vacuum state is stable or not. It was argued by other groups that for the measured values of the Higgs couplings, the vacuum state is not stable but can quantum mechanically tunnel into a deeper true vacuum. The particle properties will be very different if this were to happen. But the life-time for such a tunneling event to happen is much larger than the age of the Universe. We show that if new fermions beyond the standard model are coupled to the Higgs, the vacuum can either become unstable or can become absolutely stable depending on the coupling values.

The effects of vectorlike fermions (VLFs) on the stability of the Higgs electroweak vacuum, using the renormalization group improved Higgs effective potential was studied. The scale at which the effective Higgs quartic coupling becomes zero and goes negative, signaling vacuum instability was computed. For cases where the vacuum is metastable, the probability of quantum tunneling from the false electroweak vacuum into a deeper true

vacuum in our Hubble volume was computed by numerically solving for the bounce configuration in Euclidean space-time and computing the bounce action for it.

Statistical Mechanics

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 granular gas in two dimensions within the well-mixed limit. It is shown that there are two universal regimes depending on how the system is driven. In the more generic universal regime, the distribution is a gaussian with logarithmic corrections. In the second universal regime, the distribution is an exponential with additional logarithmic corrections. Both of these are in contradiction to well accepted results based on phenomenological modelling. Data from experiments are re-analysed to show that they may be reinterpreted to fall into one of the two universality classes. The results are mad more rigorous in one dimension, and has also been extended to the case of binary gases.

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 a system of hard cubes on a three dimensional cubic lattice. By implementing a Monte Carlo algorithm with a cluster move, it is possible to access densities close to full packing. It is shown that the system undergoes three phase transitions with increasing density, contrary to what was seen and expected up to now.

Shock propagation in conservative as well as dissipative systems has been a topic of interest for a long time. Well-known examples include the spread of disturbance after a nuclear explosion. The solution for the radial distribution of pressure, density, temperature and flow velocity fields in a blast wave propagating through a medium at rest, following an intense explosion, starting from hydrodynamic equations, is one of the classic problems in gas dynamics.

However, there is very little direct verification of the theory and its assumptions from simulations of microscopic models. Here, the results and assumptions of the hydrodynamic theory are compared with results from large scale event driven molecular dynamics simulations of a hard sphere gas in three dimensions. It is found that the predictions for the radial distribution of the thermodynamic quantities do not match well with the numerical data.

The theory is improved by replacing the ideal gas law with a more realistic virial equation of state for the hard sphere gas. While this improves the theoretical predictions, it still fails to describe the data well.

To understand the reasons for this discrepancy, the different assumptions of the hydrodynamic theory are tested within the simulations. A key assumption of the theory is the existence of a local equation of state. This assumption is validated by showing that the local pressure, temperature and density obey the equation of state for a hard sphere gas. However, the probability distribution of the velocity fluctuations has non-gaussian tails, especially away from the shock front, showing that the assumption of local equilibrium is violated. This, along with neglect of heat conduction, could be the possible reasons for the mismatch between theory and simulations.

Extensive simulations have been performed to probe the induced phase transitions in the model cell membranes when membrane active agents interact with them. The simulations were setup with the membrane active protein Nogo-66 with dimyristoylphosphocholine (DMPC) membranes and the protein-membrane interactions were shown to remodel the membrane and induce interdigitation in the DMPC membrane.

This phase change is seen to occur only when the temperature is close to the main transition temperature of the membrane (Tm) and only in the presence of the protein. No similar interdigitation of the membrane lipids was observed temperatures well above Tm in the presence of the protein.

Also, in protein-free simulations, no interdigitation of the membrane lipids was found both at temperatures near or well above Tm indicating that the observed effect is caused by the interactions of Nogo-66 with the membrane. Analysis of the simulations suggest protein-membrane interactions, even if transient, alter the lifetimes of lipid head defects and can potentially alter the effective Tm and cause interdigitation.

This study emphasize the importance of membrane active proteins and their interactions with membranes leading to phase transitions which would affect other membrane related processes such as domain formation.

To understand the effects of addition of different salts on the kinetics and dynamics of early-stage aggregated structures of steric zipper peptides in water, detailed molecular dynamics simulations have been employed. The simulations reveal that the chemical identity and valency of cation in the salt play a crucial role in aggregate dynamics and morphology of the peptides. Sodium ions induce the most aggregated structures, but this is not replicated equivalently by potassium ions which are also monovalent. Divalent magnesium ions induce aggregation but to a lesser extent than that of sodium, and their interactions with the charged peptides are also significantly different. The aggregate morphology in the presence of monovalent sodium ions is a compact structure with

interpenetrating peptides, which differs from the more loosely connected peptides in the presence of either potassium or magnesium ions.

The different ways in which the cations effectively renormalize the charges of peptides are suggested to be the cause of the differential effects of different salts studied here. These simulations underscore the importance of understanding both the valency and nature of salts in biologically relevant aggregated structures.

A spherically confined neutral polymer in the presence of crowding particles was studied to investigate the polymer shapes and conformations as a function of the strength of the attraction to the confining wall, solvent quality, and the density of crowders. The conformations of the polymer under good solvent conditions are weakly dependent on crowder particle density, even when the polymer is strongly confined.

In contrast, under poor solvent conditions, when the polymer assumes a collapsed conformation when unconfined, it can exhibit transitions to two different adsorbed phases, when either the interaction with the wall or the density of crowder particles is changed. One such transition involves a desorbed collapsed phase change to an adsorbed extended phase as the attraction of the polymer towards the confining wall is increased. Such an adsorbed extended phase can exhibit a second transition to an ordered adsorbed collapsed phase as the crowder particle density is increased. The ordered adsorbed collapsed phase of the polymer differs significantly in its structure from the desorbed collapsed phase. We revisit the earlier understanding of the adsorption of confined polymers on attractive surfaces in light of our results.

An invited book chapter summarizing our long-time efforts on biomimetic antimicrobial polymers in general and on our work on methacrylate-based polymers in particular has been written. Following a brief summary of the physiochemical features of methacrylate AMPoly, and the most significant developments in their design as potent antimicrobial agents, special emphasis is laid on recent insights gained using computer simulations on their mechanism of microbial membrane recognition, invasion, and subsequent destabilization.

Do we need a new kind of physics for understanding social behavior?

The enterprise of trying to explain different social and economic phenomena using concepts and ideas drawn from physics has a long history. Statistical mechanics, in particular, has been often seen as most likely to provide the means to achieve this, because it provides a lucid and concrete framework for describing the collective behavior of systems comprising large numbers of interacting entities. Several physicists have, in recent years, attempted to use such tools to throw light on the mechanisms underlying a plethora of

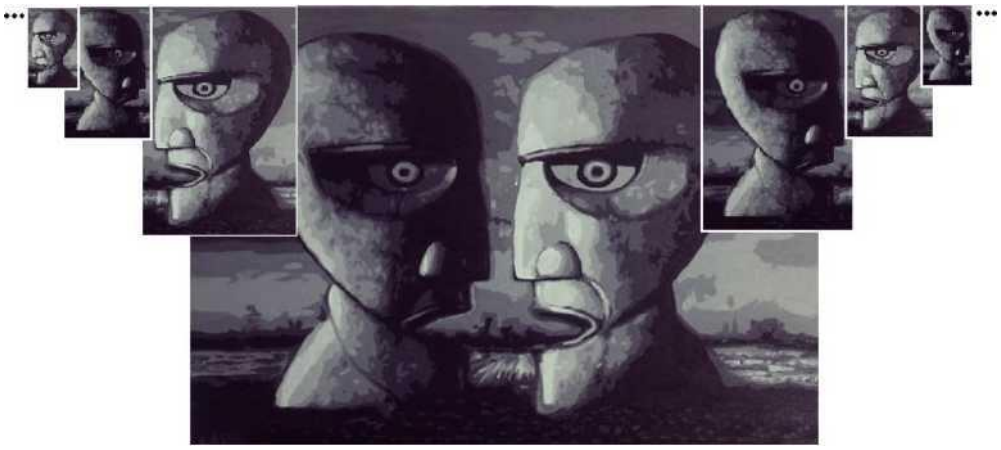

Image 4: EconoPhysics-A New kind of Physics for understanding Social Behaviour

socioeconomic phenomena. These endeavors have led them to develop a community identity - with their academic enterprise being dubbed as “econophysics” by some.

However, the emergence of this field has also exposed several academic fault-lines. Social scientists often regard physics-inspired models, such as those involving spins coupled to each other, as over-simplifications of empirical phenomena. At the same time, while models of rational agents who strategically make choices based on complete information so as to maximize their utility are commonly used in economics, many physicists consider them to be caricatures of reality.

A recent essay written by IMSc scientists which will be appearing in a book to be published by Springer shows that while these contrasting approaches may seem irreconcilable there are in fact many parallels and analogies between them. In addition, the scientists suggest that a new formulation of statistical mechanics may be necessary to permit a complete mapping of the game-theoretic formalism to a statistical physics framework.

As the essay puts it, “This may indeed turn out to be the most significant contribution of “econophysics”.

String Theory

Research in string theory at IMSc encompasses various aspects of gravity and quantum field theory, including holography, supersymmetric gauge theories, perturbative string theory and also topics in mathematical physics such as integrable systems.

Starting from the Exact Renormalization Group equation of a boundary conformal field theory it is shown that one can obtain Holographic Renormalization Group equations in some simple cases. This goes some distance towards a derivation of the AdS/CFT correspondence, also called “holography”.

In a paper the fixed point Wilson action for the critical O(N) model in 4 — e dimensions is written down in the e expansion to order e^2. It is obtained by solving the fixed point Polchinski Exact Renormalization Group equation (with anomalous dimension) in powers of e. This is an example of a theory that has scale and conformal invariance while having a finite UV cutoff. The energy momentum tensor for this theory is also constructed (at zero momentum) to order e^2. This is done by solving the Ward identity for the bare action to leading order in powers of the momentum, and then evolving down to the lower scale as a composite operator using exact RG equations. It is verified that the trace of the energy momentum tensor is proportional to the violation of scale invariance as given by the exact RG (i.e. 0- function) and that at the lower scale the energy momentum tensor is traceless (to the required order in e), thus ensuring scale and conformal invariance of the IR fixed point theory. Covariant string bits model has been constructed. This can be viewed as a lattice regularisation of the bosonic non-linear sigma model with an arbitrary curved target space.

It has been shown that the model admits a remnant of the local Diff X Weyl symmetry and isometries of the target space as global symmetries. Classical BRST construction has been performed. Work is in progress to investigate quantum consistency. In a parallel investigation the new lattice approach is being applied to higher dimensional Poincare invariant quantum field theories. Three dimensional supersymmetric gauge theories were studied. It had been shown by various groups that partition functions and indices of such three dimensional theories can be obtained by performing gluing operations on some basic building blocks called holomorphic blocks. These satisfy q-difference equations and it was shown that various non-trivial properties of these blocks could be derived by applying exact WKB methods to the q-difference operators that annihilate the blocks. It is likely that these new methods could be generalized to more complicated situations where traditional physics methods prove inadequate.

Various aspects of two dimensional quantum gravity coupled to minimal and non- minimal matter were studied. A particular focus was a derivation of open/closed string duality by using the Kontsevich matrix model description of the system. By integrating out off-diagonal degrees of freedom associated to one source eigenvalue in the matrix model, an open/closed topological string partition function was derived. This allowed a match between the resulting open partition function with the generation function derived in the mathematics literature. The open/closed partition function was also related to a wavefunction of the KP integrable hierarchy.

Systemic Risk: Frustration Suggests Imminent Depression

A recent article published by scientists at IMSc suggests that measuring the level of frustration, a concept central to the physics of disordered systems, in financial markets can

give warning about the build-up of systemic risk, which, left unchecked can lead to a catastrophic failure of the economy. Unlike previous studies focusing on relatively short periods that possibly include only one extreme event, the article looks at the evolution of the largest financial market of the world for close to a century.

Theoretical Computer Science

Theoretical computer science is mainly concerned with the mathematical structure of computations (as distinct from software development). Various aspects of computation are studied by the group at IMSc. A very brief description of these specializations is provided in this section.

In 2019-2020, 22 articles were published in peer reviewed journals and conference proceedings

- **Algorithms and Data Structures:**

  The main goal of this area is the design of efficient methods for solving various computational problems and developing methods for analyzing their performance in terms of the resources used (eg. time, space) and the quality of the solution. It also involves developing means of storing information, with small space requirements, and supporting efficient access and update operations. It also involves designing and analyzing algorithms which are efficient on the average under some distributional assumptions over input instances. Another important problem in this area is to develop algorithms for numerical computation minimizing error propagation. It also includes designing and analyzing ways to quickly update a solution when the input undergoes a small local change, without building the solution from scratch.
  [V. Arvind, Meena Mahajan, Venkatesh Raman, Saket Saurabh, Vikram Sharma, C. R. Subramanian]

- **Computational Algebra and Geometry**

  This area is the study of designing algorithms for various fundamental algebraic and geometric prob¬lems. Implementing such algorithms has always been challenging due to robustness issues. One aim is to overcome this issue as efficiently as possible.
  [Vikram Sharma]

- **Computational Complexity:**

  Broadly speaking, computational complexity theory is the study of bounds on resources such as time and space required for solving computational problems. The theory aims

at a classification of problems into various complexity classes defined by resource bounds and seeks to separate them by proving lower bounds and upper bounds on resources required by the problems.
[V. Arvind, Meena Mahajan]

- **Design of Efficient and Succinct Data Structures**:

  Succinct storage and efficient access and update of data that are supplied to and/or generated by an algorithm plays an important role in making it more efficient. This calls for developing means for designing and analyzing tools for succinct storage and efficient access of information.
  [Venkatesh Raman]

- **Game theory and security:**

  With the advent of the worldwide web as a platform of computation, traditional models of distributed systems are being re-examined, incorporating not only co-operation but conflict as well. This brings in game theoretic considerations and information security aspects, raising new questions of interest.
  [R. Ramanujam]

- **Graph theory and Combinatorics:**

  This area is the mathematical study of discrete objects with applications to various branches of Computer Science. It uses tools from various branches of mathematics such as probability theory, algebra, etc.
  [Venkatesh Raman, Saket Saurabh, C. R. Subramanian]

- **Logic and Formal models of computation:**

  This area is concerned with three main aspects: developing and comparing different mathematical models of computation, developing and analyzing different tools for logical reasoning as well as applying them to computational processes and the connection between automata, Petri nets and algebras on the one hand and logic and program expressions on the other.
  [Prakash Saivasan, R. Ramanujam]

- **Parameterized and Exact Computation:**

  Parameterized Computation is the study of computational problems based on the feasibility of designing algorithms for problems where one allows the dependence of running time on the size of a small part of the input to be arbitrary but require the dependence on the remaining large part be polynomially bounded. It also involves designing such algorithms. Exact computation is the study of computational problems based on the feasibility of designing algorithms within various degrees of even exponential dependence of the running time on the size of the input.
  [V. Arvind, Meena Mahajan, Saket Saurabh, Venkatesh Raman, C.R. Subramanian]

- **Probabilistic Combinatorics**

  This is the study of analyzing random discrete structures for their typical properties. It also involves applying this paradigm to resolve existential questions related to discrete structures like graphs. It also involves designing and analyzing algorithms with respect to their typical performance when applied to random structures.
  [C.R. Subramanian]

Below are some of the research activities the IMSc Theoretical Computer Science group is involved in:

Automata, Logic and Concurrency

Notions of equilibria are central not only to game theory but also computational social choice theory and voting systems, and most algorithmic problems in these areas can be seen as computation of fixed-points of suitably defined operators. We suggest the extension of first order logic with monadic least fixed-point operators and counting is appropriate for a variety of these problems, and present a model checking algorithm for the logic, An important aspect of security theory is the study of algebraic properties of encryption algorithms and how they impact security verification. When encryption is distributive over pairing, as we have in the case of blind pairs, the associated Dolev-Yao theory is generally hard, and becomes non-elementary for Abelian group operators. An intermediate theory of associative distributive encryption has been presented, which is elementary but yet DEXPTIME-complete.

Term-modal logics are closely related to First order modal logics. These are of great interest for infinite state systems but are typically undecidable, hence it is a challenge to find decidable fragments. The two variable fragment of term-modal logic has been identified as a decidable one. The proof proceeds by constructing a new normal form as well as a novel inductive construction generalizing the one for two variable first order logic.

Algorithms and Data Structures

Prof Pavol Hell, a renowned graph theorist from Simon Fraser University,Canada, visited IMSc during November 27th to 30th, and in conjunction with the visit, a two day workshop was organized with the title, 'Graphs, Structures and Algorithms' on November 28th and 29th. The meeting had 13 talks by experts from IIT Madras, IISc Bangalore, IIT Hyderabad, Chennai Mathematical Institute and Indian Statistical Institute Chennai apart from Prof Pavol Hell and students and faculty of IMSc. It had over 50 participants from IMSc, IIT Madras, CMI and other institutions in Chennai.

For a graph G and a positive integer d, a set S is a fair set with the fairness factor *d* if for every vertex in G, at most d of its neighbours are in S. In the n-Fair Vertex Deletion problem, the aim is to find in a given graph a fair set S of minimum size such that G — S satisfies the property n. In a study, the authors initiate a systematic study on various Fair Vertex Deletion problems under various parameterizations.

In list-coloring, each vertex is given a list of allowed colors with which it can be colored. It has been shown that, given a graph of n vertices with each vertex having a list of size *n* — *k*, there is an algorithm which is FPT with respect to k that determines whether there is a coloring that respects the lists.

Set Cover is one of the well-known classical NP-hard problems. The conflict-free version of the Set Cover problem has been studied. Here we have a universe U, a family F of subsets of U and a graph G_F on the vertex set F and we look for a subfamily F' C F of minimum size that covers U and also forms an independent set in G_F. The authors initiate a systematic study of the problem in parameterized complexity by restricting the focus to the variants where Set Cover is fixed-parameter tractable (FPT). They give upper bounds and lower bounds for conflict-free version of the Set Cover with and without duplicate sets along with restrictions to the graph classes of G_F.

Computational Complexity

For quantified Boolean formulas (QBF) there are two main different approaches to solving: conflict-driven clause learning (QCDCL) and expansion solving. The underlying proof systems are compared, and it is shown that expansion systems admit strictly shorter proofs than QCDCL systems for formulas of bounded quantifier complexity, thus pointing towards potential advantages of expansion solving techniques over QCDCL solving.

The first result shows that *tree-like* expansion systems allow short proofs of QBFs that are a source of hardness for QCDCL, i.e. tree-like VExp+Res is strictly stronger than tree-like Q-Resolution.

The second result shows that *dag-like* Q-Resolution proofs of QBFs with bounded quantifier complexity can be efficiently transformed into VExp+Res proofs. This is theoretical confirmation of experimental findings by Lonsing and Egly, who observed that

expansion QBF solvers often outperform QCDCL solvers on instances with few quantifier alternations.

2.2 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. The following list includes in addition to Publications reported by members, Publications extracted from sources like Mathscinet, iNSPIRE/HEP, etc., which are duly verified by the members.

Computational Biology

Karthikeyan Bagavathy Shanmugam, Janani Ravichandran, Karthikeyan Mohanraj, Vivek Ananth R.P., and Areejit Samal.
A curated knowledgebase on endocrine disrupting chemicals and their biological systems-level perturbations.
Science of The Total Environment, **692**, 281-296, 2019.

Harish Kannan, Emil Saucan*, Indrava Roy, and Areejit Samal.
Persistent homology of unweighted complex networks via discrete morse theory.
Scientific Reports, **9**, 13817, 2019.

Maria Augusta Horta*, Nils Thieme*, Yuqian Gao*, Kristin E. Burnum-Johnson*, Carrie D. Nicora*, Marina A. Gritsenko*, Mary S. Lipton*, Karthikeyan Mohanraj, Leandro Jose de Assis*, Liangcai Lin*, Chaoguang Tian*, Gerhard H. Braus*, Kartherine A. Borkovich*, Monika Schmoll*, Luis F. Larrondo*, Areejit Samal, Gustavo H. Goldman*, and J Philipp Benz*.
Broad substrate-specific phosphorylation events are associated with the initial stage of plant cell wall recognition in neurospora crassa.
Frontiers in Microbiology, **10**, 2317, 2019.

Om Prakash.
Algorithm for extraction of sub-structure from co-crystallized PDB ligand for selective targeting. 2020.
(Preprint: bioRxiv 2020.02.02.931436; doi: https://doi.org/10.1101/2020.02).

Om Prakash.
Algorithm for theoretical mapping of bio-strings for co-expression: bridging genotype to phenotype. 2020.
(Preprint: bioRxiv 2020.03.05.979781; doi: https://doi.org/10.1101/2020.03.).

Om Prakash.
Intra-molecular Electro-potential Circuit ElectroNegatrode: Hypothesis, algorithm implementation for universal indicative rule towards activity of biomolecules.
2020.
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2.3 Teaching Programmes

An integral part of sustained research activity is training future generations of scientists and mathematicians. At IMSc this is done by supervising postgraduate and doctoral level thesis work. Motivated and bright students at the graduate and post-graduate level are selected every year through a national level Joint Entrance Screening Test followed by an interview. The selected students receive a fellowship throughout their tenure. They undergo one or two years of course-work, followed by doctoral thesis work under the guidance of a faculty member.

During 2019-2020, the student strength was 144, with 32 in Mathematics, 79 in Physics, 17 in Theoretical Computer Science, 16 in Biological Physics and Computational Biology.

16 PhD students obtained their Doctoral Degree, and 12 students obtained Master's Degree, during this period. Also 12 students have submitted their doctoral theses, and 4 master's students from other institutions have been supervised by our IMSc faculty, during this year.

A total of 35 courses in all disciplines were taught at IMSc, during 2019-2020.

Apart from this main training activity, IMSc also offers the opportunity of learning to a few students during the summer vacation period. These students spend up to 6 weeks doing projects with faculty members. The faculty also supervises short-term projects during other periods. A total of 63 students availed these opportunities during 2019-2020.

2.4 Degrees Awarded

Doctoral Degrees Awarded during 2019 - 2020

Computational Biology

Name	Thesis Title	Thesis Advisor(s)	University
Ankit Aggarwal	Nuclear architecture from chromosomes to motifs	Gautam I. Menon	HBNI

Mathematics

Name	Thesis Title	Thesis Advisor(s)	University
Avijth Nath	Topology of Generalized Dold Manifolds	Parameswaran Sankaran	HBNI
Pranendu Darbar	Correlation of multiplicative functions	Anirban Mukhopadhyay	HBNI
Biplab Paul	Arithmetic of Hecke eigenvalues of Siegel modular forms	Sanoli Gun	HBNI
Priymvad Srivastav	An alternate Vaughan's Identity in the ternary goldbach problem	Sanoli Gun	HBNI
Jyothsnaa Sivaraman	On Euclidean ideal classes in Abelian extensions	Sanoli Gun	HBNI

Physics

Name	Thesis Title	Thesis Advisor(s)	University
Anirban Karan	Probing some beyond standard model scenarios in different sectors of flavour physics	Rahul Sinha	HBNI
Arnab Priya Saha	Soft graviton theorems in higher spacetime dimensions	Kalyana Rama	HBNI
Dipanjan Mandal	Entropy driven phase transitions in hard core lattice gases	R. Rajesh	HBNI
R. Rathul Nath	Two field models of Inflationary and bouncing scenario	Balachandran Sathiapalan	HBNI

Sagnik Chakraborty	Phenomenological and foundational aspects of non-markovianity	Sibasish Ghosh	HBNI
Sanjay Mandal	Search for sterile neutrinos at colliders	Nita Sinha	HBNI
Tanmay Mitra	Adaptive dynamics of intra- and inter- cellular networks: Emergence of memory and learning in cell signaling and immune system.	Sitabra Sinha	HBNI
Anvy M. Tom	Attractive interactions in similarly charged polyelectrolytes	S. Vemparala & R. Rajesh	HBNI

Theoretical Computer Science

Name	Thesis Title	Thesis Advisor(s)	University
Anantha Padmanabha	Propositional term modal logic	R. Ramanujam	HBNI
N.P. Swaroop	New results in bounds for positiveness of polynomial	Vikram Sharma	HBNI

Doctoral Theses Submitted during 2019-20

Computational Biology

Name	Thesis Title	Thesis Advisor(s)	University
Devanand T	Allosteric effects in protein dynamics and their interactions with membranes	Satyavani Vemparala	HBNI

Mathematics

Name	Thesis Title	Thesis Advisor(s)	University
Nabanita Ray	Projective bundle and blowup	Sanoli Gun	HBNI
Narayanan P A	Eignevalue Statistics of Higher Rank Anderson Model on the Canopy Tree	Vijay Kodiyalam	HBNI
Sohan Lal Saini	Topics in planar algebras and their presentations	Vijay Kodiyalam	HBNI
Snehajit Misra	New results in bounds for positiveness of polynomial	Sanoli Gun	HBNI

Physics

Name	Thesis Title	Thesis Advisor(s)	University
Ankita Chakrabarti	Quantum Geometry of correlated Many Body states	S. R. Hassan	HBNI
Jilmy P. Joy	Shock propagation in dilute inelastic and elastic media	R. Rajesh	HBNI
N. Vigneshwar	Entropy driven phase transitions in hard core lattice gas models in three dimensions	R. Rajesh	HBNI
Prafulla Oak	Holographic and exact RG beta function computations of the Sine – Gordon model	Balachandran Sathiapalan	HBNI
Shilpa Kastha	Gravitational waves rom compact binary coalescences: test of general relativity and astrophysics	Manjari Bagchi	HBNI
Prashanth Raman	Positive Geometry of Scalar Theories	Nemani Venkata Suryanarayana	HBNI
Dheeraj Kumar Mishra	Thermodynamic corrections due to an invariant ultraviolet scale and its implications	Sibasish Ghosh	HBNI

Master's Degrees Awarded during 2019-20

Physics

Name	Thesis Title	Thesis Advisor(s)	University
Anupam Sarkar	Randomness in a quantum system, it's extraction and application	C.M. Chandrashekar	HBNI
Arindram Mitra	Incompability in Quantum information processing: An operational point of view	Manjari Bagchi	HBNI
B.A. Bhargava	Collective excitation in emergent lattices	R. Ganesh	HBNI
Sahil	Studies in weak measurements, entanglements, Information,	Sibasish Ghosh	HBNI

	scrambling, open systems and all that		
Soumya Sur	Investigations into Quantum spin liquids and Superconductor- Inductor phase transition	Mukul S. Laad	HBNI

Master's Theses during 2019-20

External Master's Theses

The following is the list of Master's theses of various students from other institutes, under the supervision of IMSc faculty.

Mathematics

Name	Thesis Title	Thesis Advisor(s)	University
K. Seethalakshmi	A Chinese Remainder Theorem for Partitions	Amritanshu Prasad	IISER Pune
Divya Chopra	Euclidean algorithm in Number Fields	K. Srinivas	Central University of Rajasthan, Rajasthan

Theoretical Computer Science

Name	Thesis Title	Thesis Advisor(s)	University
Mitali Thatte	Survey of Algorithms for Different Matchings	Amritanshu Prasad	IISER Pune
Divya Chopra	Euclidean algorithm in Number Fields	K. Srinivas	Central University of Rajasthan, Rajasthan

2.5 Collaborative Projects

Institute members are also involved in joint projects with colleagues from other national and international institutes. The following projects are ongoing:

Arecibo 327 MHz Drift Pulsar Survey (AO327)
[ongoing]

AO327 has been running using the Arecibo radio telescope (USA) since 2010. To date, the survey has discovered 87 pulsars and transients (http://www.naic.edu/ deneva/drift-search). Papers have been published reporting results of this survey. This collaboration has 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.

Indian Pulsar Timing Array (InPTA) experiment
[ongoing]

Pulsar Timing Array (PTA) uses an ensemble of pulsar clocks in an attempt to detect Gravitational Waves (GW) from a stochastic background resulting from a superposition of an ensemble of super- massive black hole binary systems (BSMBH). The Indian PTA (InPTA) experiment is going on since 2015 using the 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, IIT-Hyderabad, West Virginia University (USA), ASTRON (The Netherlands), IMSC Chennai (Manjari Bagchi, Dhruv Pathak). IMSc faculty M. Bagchi is a member (out of three) of InPTA steering committee. M. Bagchi is also the chair of the scientific organising committee of the meeting of the Interrnational Pulsar Timing Array to be held in June 2019 in Pune.

Indo-French Program in Mathematics, IFPM

IMSc is now an international research laboratory for ”Indo-French Program in Mathematics, IFPM” for four years. This program facilitates exchange of mathematical ideas between these two countries.

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.

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.

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 inter- disciplinaire 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.

Survey for Pulsars and Fast Transients with the upgraded GMRT: A Pilot Study *[ongoing]*

A pilot survey to discover new for pulsars and radio transients using the upgraded GMRT (uGMRT) is ongoing. More than 100 hours of observations have been performed and data analysis is ongoing. So far, two new pulsars have been discovered. The results have been presented at various national conferences by various team members. 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), and ASTRON (The Netherlands), etc. GMRT is operated by NCRA-TIFR, Pune

2.6 Scientific Meetings and Visitor Program

The academic members of the Institute typically participate extensively in a large number of national and international scientific meetings.

An important aspect of research is interaction with peers. IMSc makes it possible for the scientific community of India by organising national and international scientific meetings. The Institute contributes towards such activities either by sponsoring them fully or partially.

In this year, the following conferences were organized or co-sponsored by the Institute. –

- Conference on Topology, Geometry, and Related Topics, (May 27 - May 28, 2019)
- First IMSc discussion meeting on extreme QCD matter, (Sep 16 - Sep 21, 2019)
- ATM Workshop on Combinatorial Models for Representation Theory, (Nov 4 - Nov 16, 2019)
- Computational Thinking in Schools (CTiS) 2019, (Apr 20, 2019)
- Eleventh Summer Training Programme in Mathematics, (May 8 - May 28, 2019)
- NCM Workshop on Combinatorial Models for Representation Theory, (Nov 4 - Nov 16, 2019)
- Instructional School for Teachers (NCM event), (Jun 3 - Jun 15, 2019)
- IPTA 2019 Conference, (Jun 10 - Jun 21, 2019)
- Recent Trends in Algorithms, (Feb 16 - Feb 19, 2020)

The annual activities included the following: –

- Annual K.S. Krishnan Meeting on Quantum Matter and Quantum Entanglement –
- Institute Seminar Week

Institute members and visitors discuss their work during weekly seminars. During 2019-2020, about 276 such seminars were held at IMSc.

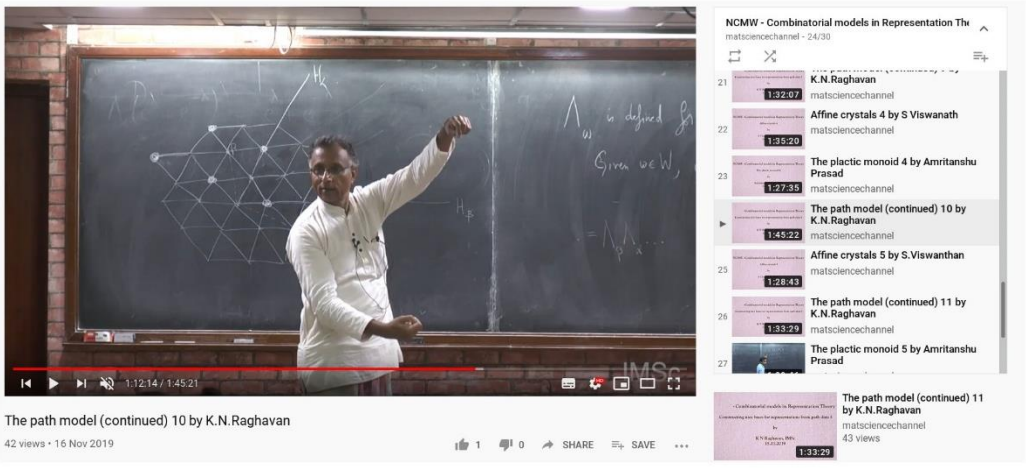

Image 5: NCM Workshop on Combinatorial Models for Representation Theory, 4 - 16 Nov, 2019

Outreach Activities

Apart from engaging in high quality research and training activities, the Institute also recognizes its responsibility towards enhancing its interactions with society at large. Currently, this occurs through two programs: –

Associateship program: 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. During 2019-2020, 2 faculty members from different organisations have visited the Institute as associateship visitors.

Science Popularization: The Institute organizes Popular Science Lectures from time to time to keep the public informed as well as to enthuse the younger generation. IMSc outreach activities include a range of workshops and programs that bring students and teachers into direct contact with research scientists. Throughout the year, many eminent researchers and educators who visit our campus also give public lectures on various topics. One of our most recent outreach initiatives, "Science at the Sabha", is an annual event for the general public featuring talks on current scientific research.

Many IMSc members also give talks in schools, colleges, clubs etc in their individual capacities. In this year, the following conferences were organized by the Institute, towards outreach activities.

- TNSF Chithirai FEST-I : (6th - 8th May 2019)
- Summer Camp for college students – Summer School Students Workshop: (14th - 22nd May 2019)
- Teacher's Enrichment Workshop: (20th - 25th May 2019)
- Indian Women in Science
- Facets: (8th - 9th July 2019)
- Annular Solar Eclipse Planning Workshop: (20th - 21st July 2019)
- Vigyan Pratibha Chennai Regional Teachers Workshop (2019-2020: I): (9th-11th September 2019)
- Annual Solar Eclipse Planning meeting: (15th Sept 2019)
- Public lecture: A Symplectic World View: (15th October 2019)
- kaNita-kAnakam: (24th Oct 2019)
- Enriching Mathematics Education: (8th Nov 2019)
- Public lecture: Using ancient DNA to understand Indian history: (11th Nov 2019) –
- Topics in Biology: (21st Nov 2019)
- Teachers Enrichment Workshop: (25th - 30th Nov 2019)
- Excitement in Science: (30th Nov 2019)
- Annular Solar Eclipse : (26th December 2019)

- Science at the Sabha: (16th Feb 2020)
- Public Lecture: The Cryosphere and Climate of the Earth: (22nd Feb 2020)

Details of the events are available at http://www.imsc.res.in/outreach/

TNSF Chithirai FEST-I :

6th - 8th May 2019 This is part of the efforts to popularize science to the general public and students who are pursuing science as their career and to fill the gap between what students are acquiring through the curriculum and what it is required. A Summer Camp was organised at Anna Centenary Library, Kotturpuram, Chennai, on June 15, 2019, hosting “Popular Science Lecture Series VIII, LHC and Detection of Higgs Boson.

The event was co-organised by The Institute of Mathematical Sciences, Indian Institute of Technology Madras, Anna Centenary Library Tamil Nadu Science Forum.

Summer Camp for college students:

About 50 students from various local colleges attend a 3 day science workshop including talks on a range of topics from physics to evolution. (Co-organised by The Institute of Mathematical Sciences, Indian Institute of Technology Madras and Tamil Nadu Science Forum)

Organizer: R Ramanujam

Summer School Students Workshop:

14th - 22nd May 2019 Week-long summer science workshop for high school students IMSc students and post-docs ran a 9-day summer workshop for students from class XI. We designed and ran activity and interactive problem sessions for school students on various topics in mathematics and science. About 30 students attended the workshop.

Organizers: Sushmita V, Varuni P

Teacher's Enrichment Workshop: **20th - 25th May 2019** –

Linear Algebra and Calculus on Rn: (A workshop for mathematics teachers of Arts and Science colleges)

Organizer: Sanoli Gun

Image 6: Summer School Students Workshop, 14-22 May 2019

Exhibitions:

The "Indian Women in Science" exhibition was displayed at TCS Ignite, Periyar Science and Technology Center, and at the Central University of Tamil Nadu, Thiruvarur. The "From Learning to Doing: Science, Education and Public Service in Chennai" exhibition was displayed at TCS Ignite and Chennai Mathematical Institute.

Image 7: Indian Women in Science Exhibition

Facets: 8th - 9th July 2019

Facets is the Institutes's outreach program for advanced undergraduate and postgraduate students of mathematics. This two day program is intended for mathematics students to interact with professional mathematicians working in various fields. This year too, in addition to academics, the program featured mathematicians in industry as well as in the field of education. The program also featured a career panel where students asked questions to panelists. This year, around 200 students attended this program.

Organizers: Sushmita V, Varuni P. Speakers: Karen Haydock (HBCSE), R. Rajesh, R. Ramanujam, S. Sunder, Swarna Srinivasan (Ignite TCS), S. Viswanath, Vijay Ravikumar

Annular Solar Eclipse Planning Workshop: 20th - 21st July 2019

Organizers: Ramanujam R, Varuni P Co-organizers: IMSc, Public Outreach and Education Committee of the Astronomical Society of India (ASI-POEC), Vigyan Prasar (DST)An Annular Solar Eclipse (ASE) will be visible on the morning of 26 December 2019 in India, with the annular track passing from southern Karnataka, northern Kerala through central Tamil Nadu. IMSc hosted a two-day workshop for institutions and organizations to plan outreach activities surrounding this Annular Solar Eclipse. The mass campaigns during past solar eclipses in India are unique in their range and reach. This is a 2-day Nucleation Meeting on the ASE, for the southern states which will be in the path of the annularity. The workshop aimed to collate a list of resource material with responsibilities for their creation, translation and production (all under Creative Commons) and arrive at a shared set of strategies to get as many people as possible to see the eclipse safely. We hope that these plans will also be adapted for the ASE that will occur on 21 June 2020, whose path will cross northern India.

Organizers: Ramanujam R, Varuni P Co-organizers: IMSc, Public Outreach and Education Committee of the Astronomical Society of India (ASI-POEC), Vigyan Prasar (DST)

Vigyan Pratibha Chennai Regional Teachers Workshop (2019-2020: I): 9th-11th September 2019

IMSc organized a 3-day regional teachers workshop for the Vigyan Pratibha program, a Government of India program to nurture of talent in Science and Mathematics among VIII - X students. In addition to the resource people from Homi Bhabha Centre for Science Education (HBCSE), Mumbai, IMSc members also had sessions for the teachers. The workshop was attended by 25 teachers from central schools (KV, JNV and AECS) in the southern region.

Organizers: R. Ramanujam, Varuni P. Speakers: Chaitanya Ursekar (HBCSE), R. Ramanujam, Prateek Chawla, Rohini Karandikar (HBCSE), Subashri V, Swapna Narvekar (HBCSE), Varuni P.

Annual Solar Eclipse Planning meeting: 15th Sept 2019

A follow-up meeting for the Annular Solar Eclipse (ASE) planning attended by 20 resource people from the southern region.

Organizer: Ramanujam R

Co-organizers: IMSc, Public Outreach and Education Committee of the Astronomical Society of India (ASI-POEC), Vigyan Prasar (DST).

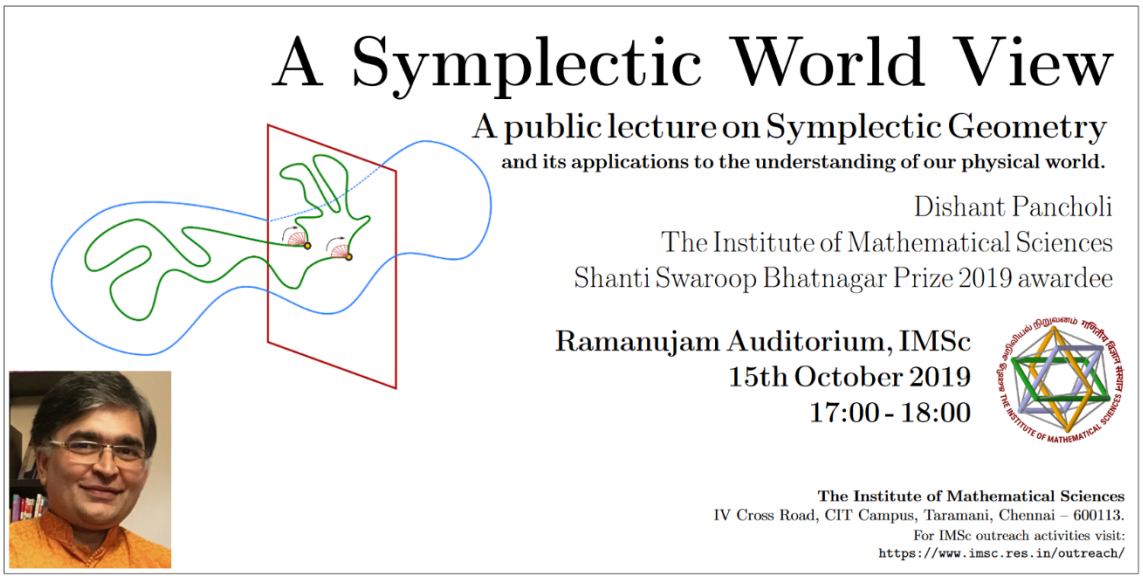

Image 8: Public lecture: A Symplectic World View: 15th October 2019

Public lecture: A Symplectic World View: 15th October 2019

Prof. Dishant Pancholi, IMSc Shanti Swaroop Bhatnagar Prize 2019 awardee delivered a public lecture on "Symplectic Geometry and its applications to the understanding of our physical world".*Image 9: kaNita-kAnakam (24th Oct 2019)*

kaNita-kAnakam: 24th Oct 2019

This is the 3rd year of IMSc's outreach program for school children in Tamil. The workshop was aimed at students of class VIII - XII. The program included Mathematics activities conducted by IMSc members for students to engage with topics more interactively. About 100 students from various government and corporation schools from the area attended the program.

Organizers: Amritanshu Prasad, Varuni P. Speakers: R. Baskaran, S. Viswanath, R. Ventakesh (IISc).

Image 9: Public lecture: kaNita-kAnakam: 24th Oct 2019

Enriching Mathematics Education: 8th Nov 2019

This is the 8th edition of IMSc's outreach program for school teachers. This year, the workshop has focused on the use of Geogebra as an exploration tool for students. The program was attended by 25 teachers from various Chennai schools.

Organizers: Varuni P, S. Viswanath

Speakers: Aaloka Kanhere (HBCSE)

Hosted by: Balasubramanian V (SSN College)

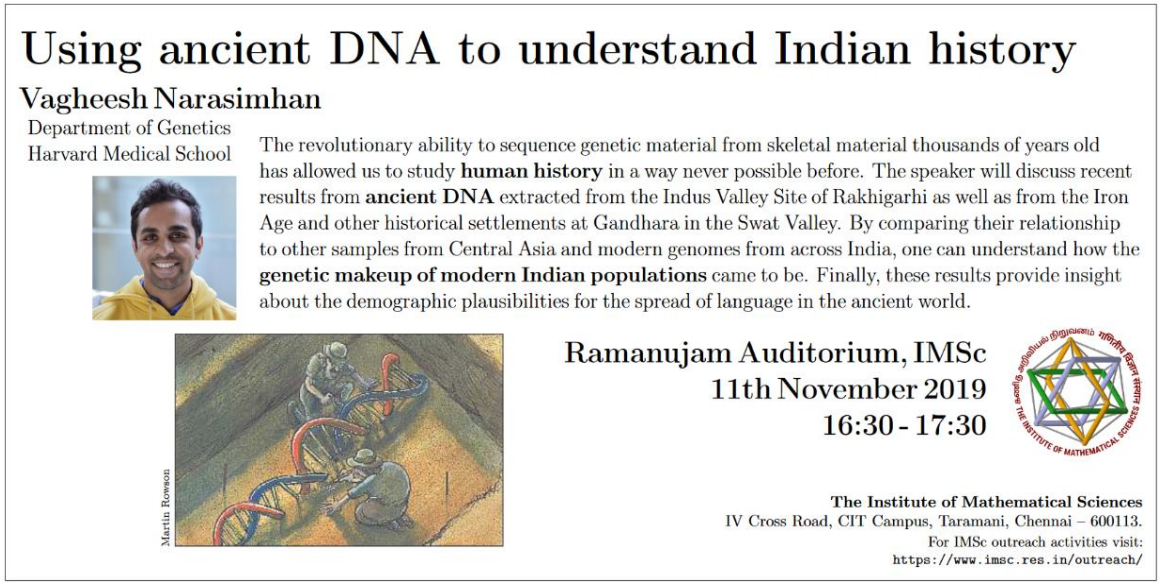

Image 10: Public lecture: Using ancient DNA to understand Indian history, 11th Nov 2019

Public lecture: Using ancient DNA to understand Indian history: 11th Nov 2019

Vagheesh Narasimhan Department of Genetics, Harvard Medical School, gave a public lecture on how the genetic makeup of modern Indian populations came to be.

Topics in Biology: 21st Nov 2019

This is the 1st of the institutes outreach program for advanced undergraduate (BSc) and postgraduate (MSc) students of biology and related fields. This year, the program focused on Evolution and Ecology. The program was attended by 20 people from various local institutions.

Organizers: Rahul Siddarthan, Varuni P

Speakers: Analabha Basu (NIBMG, Kalyani), Geeta R (Rtd, Delhi University), Manjari Jain (IISERMohali), Nandini Rajamani (IISER-Tirupati), Robin Vijayan (IISER-Tirupati)

Teacher's Enrichment Workshop: 25th - 30th Nov 2019

Workshop for mathematics teachers of Engineering colleges. This week-long workshop was aimed at mathematics teachers in Engineering colleges, to enable them to revisit and update content knowledge specifically focusing on Algebra, Linear Algebra, and Cryptography. The program was attended by 40 teachers who 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. The workshop was held as a 'Teachers Enrichment Workshop of the National Centre for Mathematics (NCM)', Workshop for mathematics teachers of Engineering colleges.

Organizer: K. Srinivas Speakers: K. N. Raghavan, Pralay Chatterjee, K. Srinivas.

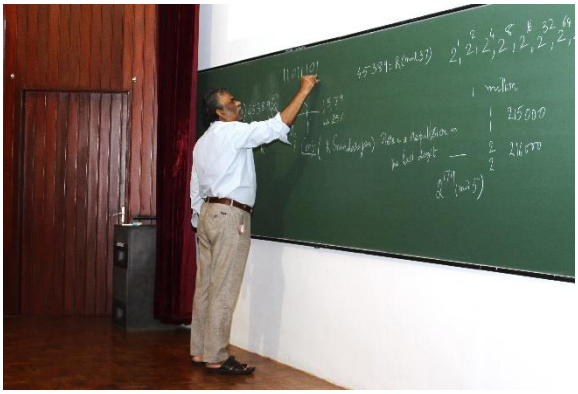

Image 9: Excitement in Science, 30th Nov 2019

Excitement in Science: 30th Nov 2019

A series of lectures on Science to celebrate Silver Jubilee year of the International Academy of Physical Sciences (IAPS). The program was attended by 100 students from various local colleges.

Organizers: Ashok Kumar Mishra, K. N. Raghavan

Speakers: Balasubramanian Ramachandran, Madhavan Mukund (CMI), G. Rajasekaran, K. Ramesha (CSIR-CECRI), Sitabhra Sinha (IMSc).

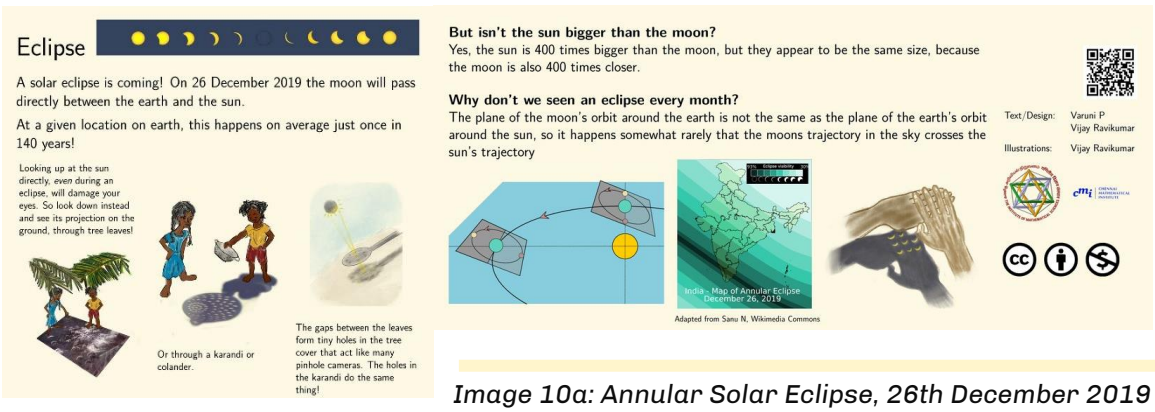

Image 10a: Annular Solar Eclipse, 26th December 2019

Annular Solar Eclipse: 26th December 2019

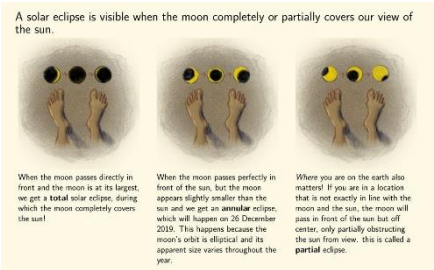

Image 10b: Annular Solar Eclipse, 26th December 2019

An Annular Solar Eclipse (ASE) was visible on the morning of 26 December 2019 in India, with the annular track passing from southern Karnataka, northern Kerala through central Tamil Nadu. Solar eclipses are of huge public interest and provide an exceptional opportunity to promote science and scientific temper among the people, as well as challenge the myths surrounding the topic. The mass campaigns during past solar eclipses in India are unique in their range and reach. IMSc members worked with local science popularization organizations in various public activities surrounding the ASE including distributing masks and spreading awareness about eclipses. DSC images: Himanshu Badani at Govt. Arts College, Ooty Other images: Ariel Huber at Govt. High School, Manathavady, Kerala.

Public Lecture: Logic for non-persons?: (7th Jan 2020), By Rohit Parikh, City University of New York, USA

A public lecture on logic and reasoning in babies, animals and groups was organised at the institute. The talk focussed on two themes:

1. To what extent is the reasoning of animals and children logical? What do they think?
2. To what extent can we regard groups: corporations, or political parties, etc. as individuals to whom we can assign goals and beliefs? In other words, how far can we extend the notion of an individual?

For the first part, the speaker referred to experiments in animal behaviour and what we know about the thinking of animals and children. For the second part, he spoke about issues in game theory and in states of knowledge, and subsequent coordinated action arising from communication.

Science at the Sabha: (16th Feb 2020)

Science at the Sabha, IMSc's annual flagship outreach program, was held as usual at the Madras Music Academy on Sunday, 16th February. The program, which is free and open to all features talks aimed at anyone with an interest in science, irrespective of age or background. The program this year the program also featured a poster exhibition: "Deep History Sites of the Indian Subcontinent" highlighting some important prehistoric sites in

the Indian subcontinent. It attracted around 1000 people and was extensively covered in the press and media.

Image 11: Science at the Sabha, 16 February 2020

Organizers: Rahul Siddharthan, Varuni P, S. Viswanath

Speakers: Shannon Olsson (NCBS), Harinath Chakrapani (IISER Pune), V Madhurima (CUTN), R. Ramanujam (IMSc)

Photos: https://ekalavya.imsc.res.in/node/3897, https://ekalavya.imsc.res.in/node/3898

Public Lecture: The Cryosphere and Climate of the Earth: (22nd Feb 2020) By R. Shankar, IMSc

This lecture, addressing issues of climate change, was co-organized with the Tamil Nadu Science Forum as a part of its Popular Science Lecture series (PSL-17). The ice on earth, the cryosphere, is inextricably tied up with the climate of the earth. It affects and is affected by life on earth. This talk addressed this aspect along with several related questions. The main themes of the talk were: What caused the ice ages? How did they affect the sea level? Why is this interplay of great concern today? What is the evidence that the climate is changing at an “unnaturally” fast rate today? Closer home, what is the role of the ice in the Himalaya in the water cycle? How will the current rapid rate of climate change affect the flow of the rivers of North India? How will it affect the sea level? What will be the effect of the sea level rise on coastal regions like Chennai?

Visitors

Research is often a collaborative activity and is boosted by a vibrant visitor program. The Institute hosts a large number of short term and long-term visitors. During the year 2019-20, 409 scientists have visited the Institute. The list of visitors to the Institute during this period is listed below

Faculty Visitors

Abrahim	IISER,Pune
Adhikari, S.D	RKMVERI, Howrah
Ajit Bhand	IISER,Bhopal
Akhilesh, P	Kerala School of Mathematics
Akshaa Vatwani	IIT Gujarat
Amit Chakraborty	Central Univ. of Rajasthan
Andreas Osterloh	Univ. of Duisburg-Essen, Germany
	Angeles
Arghya Majee	Max Planck Inst. for Intelligent Systems, Germany
Aritra Baink	NISER, Bhubaneshwar
Arun Pakmakanti	Toronto Univ.
Ashish Srivastav	BARC, Mumbai
Balachandran, A.P	Syracuse Univ., Syracuse
Benjamin Grinstein	Univ. of California, San Diego
Biswa Jyothi Saha	Univ. of Hyderabad, Hyderabad
Christian Schmidt	Bielefield Univ.
Debhajyothi Choudhry	Univ. of Delhi, Delhi
Deshouillers	Bordeaux, France
Dhiraj Kumar	ICGEB, Delhi
Dileep Jatkar	HRI, Allahabad
Diptimoy Ghosh	IISER, Pune
El Houcein El Abdalaoui	Univ. de Rouen
Fahad Panolan	IIT, Hyderabad
Farhat Habib	INMOBI, Bangalore
Hai Yang Cheng	Academia Sinica, Taiwan
Heim, B	Gu Tech, Oman
Hitesh J Changlani	Florida State Univ.
Hossein Movasati	IMPA, Rio de Janeiro, Brasil
Indranil Mazumdar	TIFR, Mumbai

Jacabo Toran	Univ. of ULM, Germany
Jean Marc D	Univ. of Bordeaux
Jean Marc Deshouillers	Univ. of Bordeaux, France
Johannes Koebler	Humboldt Univ., Berlin
John Bechhoefer	Simon Fraser Univ.
Joseph Samuel	RRI,Banglore
Kasi Viswanadhan, G	IIISER,Bermapur
Kaustav Sanyal	JNCASR, Bangalore
Koushik Ray	IACS, Kolkata
Kumaraguru	
Larry Rolen	Vanderbit Univ.
Leelavathi Narlikar	CSIR, National Chemical Lab, Pune
Lunfried Kohnen	Univ. of Heidelberg
Madhurima	Central Univ. of Tamilnadu, Thiruvarur
Manoj Changat	Univ. of Kerala, Tiruvanantha--puram
Marc-Hubert Nicole	Inst. de Mathematiques de Luminy
Medhuri E Kumar	IIT,Guwahati
Mihir Kumar Chakraborty	IIEST Shibpur
Minedupawan Depa	JINR,Dubna, Russia
Mubeena, T	Government College Kasaragod, Kerala
Mukund Ramakrishnan	IISER Brahampur
Nagaraj, D.S	IISER, Tirupathi
Najmul Haque	NISER, Bhubaneswar
Naveen Surendran	IIST, Trivandrum
Nilendra Ganesh Deshpande	Univ. of Oregon
Oesterle Joseph	Sorbenne Univ.
Palash Pal	Univ. of Calcutta
Pampa Paul	Presidency Univ., Kolkata
Parimala Raman	Emory Univ., USA
Pavol Hell	Fraser Univ., Canada
Petr Golovoch	Univ. of Bergen, Norway
Phillippon, P	Univ. of Paris VI
Ponnurangam	IIT, Delhi
Pranav Pandit	ICTS, Bangalore
Pruisken, A.M.M	Univ. of Amsterdam, Netherlands
Pushan Majumdar	IACS, Kolkata

Pushpita Ghosh	TIFR, Hydrabad
Ragavendran, V.	Kalasalingam Univ., Srivilliputhur
Raghavendra, K	Kalasalinagam Univ.
Raja Raman, R	New Delhi
Raja, S	IIT, Tirupati
Rajeev S. Bhalrao	IISER Pune
Rajiv Vasantrao Gavai	TIFR, Mumbai
Ram Murthy, M	Queens Univ., Canada
Rama Devi, P.	IIT Bombay
Ramakishnan, B	HRI, Allahabad
Ramare Oliver	CNRS- Maths Department
Ramesh, V.P	Central Univ. of Tamilnadu, Thiruvarur
Ramesh, V.P	Univ. of Hyderabad
Ramij Rahman	Presidency Univ., Kolkata
Ranjitha, K	IIT, Bangalore
Roy Joshua	Ohio State Univ., USA
Sabeshwar Paul	IISER,TVM
Sachin Subhash Sharma	IIT,Kanpur
SachinSubhash Sharma	IIT Kanpur
Samir Kunin	Mahabanada college, Barackpur
Sandeep K. Goyal	IISER, Mohali
Sankha S Basu	IIT Delhi
Santhosh Kumar Das	IIT Goa
Saptarshi Mandal	Inst. of Physics, Bhubaneshwar
Satadar Ganguly	ISI, Kolkata
Saumia, P.S	BLTP -JINR, Dubina, Russia
Saumia, P.S	Joint Inst. for Nuclear Research
Sebastin Ferenczi	Inst. De Mathematiques De, France
Shaji, N	TM Jacob Memorial College, Ernakulam
Shakir Ali	Aligharh Muslim Univ.
Shyam Sundar, R.K	IIT, Mumbai
Somnath Jha	IIT,Kanpur
Sonia Garcha	CSPathshala, Pune
Sonia Sen	TIGS Centre, Bangalore
Sree Krishna Dani	CEBS, Mumbai
Sreejith	IISER, Pune
Stephan Baier	RKMVERI, Howrah
Stephen Spallone	IISER, Pune
Steven Spallore	IISER, Pune
Subhashish Banarjee	IIT, Jodhpur
Subinoy Das	IIA, Bengaluru

Sudipto Pal Chowdury	Morgan Stanley, Mumbai	Vasudharani Devanathan	IISER,Tirupathi
Sujan Sengupta	IIA, Bangalore	Venkat Guruswamy	Carnegie Mellon Univ., Pennsylvania
Sujit Sarkar	PPISR, Banglore		
Sukumar Das Adhikari	Ramakrishna Univ., Belur	Venkatesan Guruswami	Carnegie Mellon Univ., Pennsylvania
Sunil Chandran, L	IISc, Bangalore		
Sunitha, V	IICT, Gujarat	Venkatesh, R	IISc, Banglore
Supurna Sinha	RRI, Banglore	Vikram Soni	JNU, New Delhi
Sushmitha Gupta	NISER, Bhubaneshwar	Vinay Nandicrooz	NIT, Delhi
Swapan Kumar Majhi	Achhrupam Memorial College, Purulia	Vinod Chandran, N.V	Univ. of Nebraska, USA
		Vishwas Venkatesh	IIT, Palakkad
Swarup Poria	Univ. of Calcutta	Vivawani Roy Chowdhury	Univ. of California, Los
Tavenas Sebastien, R	Univ. Savoie Mont Blanc, France	Vivek Kumar Yadav	IIT, Banglore
		Yashodhan Hatwalne	RRI, Banglore
Teodor Knapik	Univ. of New Caledonia	Yuri Bilu	Univ. of Bordeaux
Thangadurai, R	HRI, Allahabad	Yuta Suzuki	Nagoya Univ., Japan
Thomas Konnad	Univ. of KwaZulu-Nata, South Africa		
Vaitheeshwaran, G.S.	Univ. of Hyderabad		

Post Doctoral Visitors

Abhishek Iyer	INFN, Naples	Ameya Vaze	Ivory Dental Clinic, Indore
Akshata Shenoy, H.	Univ. of Geneva		
		Anilban Polley	Columbia Univ.

Anirban Karan	IIT, Hydrebad
Ankit Agarwal	Weizmann Inst. of Sciences, Israel
Ankita Chakrabarti	Former IMSc Research Scholar
Anup Biswanath	Dixit, Canada
Anupama Sharma	Univ. of Michigan, USA
Anvy Moly Tom	Korea Inst. of Advanced Study, South Korea
Aprameyo Pal	Univ. of Duisberg
Aravinda, S	ISI, Kolkata
Archit Somani	Technion, Israel
Arghya Mondal	TIFR, Mumbai
Arindam Das	Osaka Univ.
Arnab Priya Saha	HRI, Allahabad
Arun Kumar, G	IISER, Mohali
Ashmita Das	IIT, Guwahati
Ashutosh Rai	Charles Univ., Czech Republic
Ashwathy, N.	JNCASE, Bangalore
Aswin Balasubramanian	Astro-Physics Rutgess Univ.
Azizul Hoque	HRI, Allahabad
Balagopal	Scarland Univ., Germany
Bimla Danu	Dulius Maximilians Univ.
Biswajith Karmakar	PRL, Ahmedabad
Chandan Maity	IISER, Mohali
Chandrachur Chakraborty Chandreyee Roy	Kavli Inst. for Astronomy and SNBNCBS, Kolkata
Chandrima Paul	Sikkim Univ.
Dipanjan Mandal	TIFR, Hyderabad
Diptapriyo Manjumdar	Univ. of London
Eshita Mazumdar	ISI, Bangalore
Gaurav Prakash Shrivastav	TU Vienna
Gopal Chandru Himadri Barman	IIT, Jodhpur Dept. Of Physics, Zhejiang Univ.
Himadri Shekar Dhar	Imperial College, London
Indrajit Ghosh	ISI, Kolkata
Iyyappan, I.	IISER, Mohali
Javid Ahamad Naiko	IIT, Jodhpur
Kannabiran Seshasayanam	CAE Saclay, France
Kiran Yadav	Central Univ. of Rajasthan
Krishnakumar Sabapathy	Toronto, Canada
Madhusudhan Raman	TIFR, Mumbai
Mallesham K.	ISI, Kolkata
Manoj Kumar Mandal	Univ. of Padova
Marc Vinyals	Technion, Israel
Minati Biswal	Inst. of Physics, Bhuvaneshwar
Mohd Suhail Rizvi	CNRS, France

Nabanita Ray	TIFR, Mumbai
Naveen S. Prabhakar	TIFR, Mumbai
Neeraj	IIT, Bombay
Nikhil S. Karthick	BNL, Upton, Newyork, USA
Niladri Sarkar	Leiden Univ.
Nilanjan Sircar	Morgan Stanley, Mumbai
Nirupam Dutta	JATNI, Odisha
Nishad Bharat	Univ. of Campinas, Brazil
Nithin Jonathan Paul Williams	Univ. of Helsinki, Finland
Nitin Saurabh	MPII, Germany
Omkar Srikrishna	Seoul National Univ., South Korea
Panch Ram	Jawaharlal Nehru Univ., New Delhi
	Peking Univ.
Prafulla S. Oak	IACS, Kolkata
Prajwal Yash	IIST, Trivandrum
Pranabendu Misra	MPII
Pranendu Darbar	ISI, Kolkata
Prasad, V.V.	Weizmann Inst. of Science, Israel
Prasanna Kumar Dhani	INFN, Florance
Pratyush	ENS Lyon
Priyamvad Srivastav	HRI Allahabad
Priyanka Chakraborty	Univ. of Kolkata
Projesh Kumar	IISC, Banglore
Prosenjit Kundu	NIT, Durgapur
Pulak Banerjee	Paul Scherrer Inst.
Rahul Srivastava	AHEP, IFIC
Ramakrishnan Natesan	Univ. of Pennsylvania
Rameez Raja	HRI, Allahabad
Ranadeep Roy	IISER, Tirupati
Ranjith V	PPISR, Banglore
Ranjith Venkatrama	Univ. of Cagliari, Italy
Ravi Kunjwal	Perimeter Inst., Canada
Saikat Sur	IIT, Kanpur
Samyadeb Bhattacharya	SNBNCBS, Kolkata
Sandeep Aashish	IISER, Bhopal
Sandeep Chowdhary	IISER, Pune
Sandipan De	ISI, Banglore
Sanga Mitra	NIH, USA
Sanjoy Mandal	Sainik School, Bhuvaneshwar
Sardar	
Shilpa Kastha	AEI, Hannover, MPI, Germany
Snehajit Misra	TIFR, Mumbai
Solomon Owerre	Perimeter Inst.
Soumya Bhattacharya	IIT, Kharagpur
Soumya Kanti Bose	IISER, Mohali
Sthitadhi Roy	Univ. of Oxford, UK
Subhadip Chakraborti	ICTS, Banglore
Subhrajit Madak	IISER, Kolkata

Subramani	HRI, Allahabad	Tanmay Mitra	HCIR, Germany
Subramani, M	HRI, Allahabad	Tanmay Modak	National Taiwan Univ.
Sudip Kumar Garain	Korea Astronomy and Space Science, South Korea	Taushif Ahmed	KIT, Germany
		Yasir Ameen, P.A	IISER, Mohali
Sunando Patra	IIT, Guwahati		
Sweta Kumari	Technion, Israel		

Doctoral Visitors

Aanjaneya Kumar	IISER, Pune	Anwesh Chakrabarti	SNBNCBS, Kolkata
Adersh N.K	TKM College of Arts & Sciences, Kolam	Arjit Mukherjee	Univ. of Hyderabad
Aishwarya Suryakant Dabhole	Fergusson, Pune	Ashwath Narayana Madhusudan	IISER, Pune
Akansha Agarwal	BEN-Gurion Univ., Israel	Asweel Ahmed, A Jaleel	Pondicherry Univ.
Amit Kumar Singh	IIT, Madras	Avijit Nath	Former IMSc student
Amruta Chandrashekar	Azim Premji Univ.	Avishek Basu	TIFR – NCRA, Pune
Amrutha, B Nair	IISER, Thiruvanantha--puram	Budaraju Sasane	IISER, Mohali
Ananth Krishna Duggirala	CMI, Kelambakkam	Chiranjib Mukhopadhyay	HRI, Allahabad
Anbu Arjunan	Kelambakkam	Debabrata Deb	IIEST, Shibpur
Ankit Aggarwal	ULB, Brussels, Belgium	Deepthi, P G	Central Univ. of Tamilnadu
Ankita Budhraja	IIS, Bhopal	Devanand T.	Former Reseach Scholar, IMSc
Ankita Chakrabarthi	Former IMSc student	Dharmesh Jain	SINP, Kolkata

Dheeraj Kumar	Former Research Scholar, IMSc
Dibyajyoti Mohanta	Dept. Of Physics
Ganesh, G	Amrita Vishwa Vidyapeetham
Garima Agarwal	IISER, Pune
Gautam Sharma	HRI, Allahabad
James Ferguson	Univ. of Zurich
Madumita Kundu	ISI, Kolkata
Meduri Chakravartula Kumar	IIT, Guwahati
Mohan, R	ISI, Bangalore
Namitha, C.V	Pondicherry Univ., Kalapet
Navish Kumar	IIT, Kanpur
Neha Malik	IISER, Pune
Nimmal Narendra	IIT Hyderabad
Nithin, R.	Anna Univ.
Partha Nandi	SNBNCBS, Kolkata
Pavithra Elumalai	PSG College, Coimbatore
Prafulla Shrikant	Former Reseach Scholar, IMSc
Pranandu Darbar	ISI, Kolkata
Pratik Tarafdar	SNBNCBS, Kolkata
Priyamvad Srinivastav	HRI, Allahabad
Rajesh, G.	Anna Univ.
Ram, S	IIIT, Bangalore
Richa Tripathi	IIT, Gandhi Nagar
Sanchit Srinivastava	IISc, Thiruvananth--apuram
Sanchita Sharma	IISC, Bangalore
Sandeep, M	Kerala School of Mathematics
Saswati Dhara	IIT, Bombay
Sayan Kumar Pal	SNBNCBS, Kolkata
Seethalakshmi, K	IISER, Pune
Shauri Chakraborty	SNBNCBS, Kolkata
Shoumay Dutta	SNBNCBS, Kolkata
Shriya Pai	Univ. of Colorado, Boulder
Shuvam Kant Tripathi	IISER, Pune
Siddhesh Satish	Padral, Univ. of Mumbai
Smith Sen	BITS, Pilani
Sreejith, M.M	Kerala School of Mathematics
Sukanya Pandey	IISER, Pune
Suman Kumbhakar	IIT, Bombay
Suman Mandal	Newyork Univ.
Sundar Ram, S	JNCASR, Bangalore
Sundheer Kumar,	IISER, Pune
Supriya, P.I	PSG College, Coimbatore
Surajit Kalita	IIT, Bangalore
Suyog Garg	IITDM

Tanmoy Pandit	IISER, Mohali	Wataru Takeda	Nagoya Univ.
Veekesh Kumar	HRI, Allahabad		
Vibhuti Bhushantha	ISRO, Ahmedabad		

Non-Doctoral Visitors

Abhaya Seetaram	Thiruvanantha--puram	Disha J Kuzhively	NISER, Bhubaneswar
Abhishek Kumar	NISER, Bhubaneswar	Divya, S	TNAU, Coimbatore
Abiya, R	IISER, Tirupathi	Divyanshu Gupta	BITS, Pilani
Adersh, V.K	TKM College of Arts & Science	Evanjalee, A	Anna Univ.
Aditya Lonkar	IIT, Madras	Gourab Pal	IIT, Madras
Aditya Vaswani	BITS, Pilani	Hareesh, J	BITS, Goa
Aman Agarwal	KK Birla Goa Campus, Goa	Harikar Pradhar	NISER, Bhubaneswar
Amandeep	IIT, Rourkela	Harini Sudha, J.G	IISER, Pune
Amartya Muthal	ISI, Bangalore	Kalyani, S	Univ. of Madras
Anagha, K V	NIT, Calicut	Karthika, R	Anna Univ.
Anmol Agrawal	Shri Shankaracharya, Bhilai	Khyati Jain	BITS, Goa
Aparna, S.R	Chennai	Kiruthiga, A	Anna Univ.
Arpan Das	IOP, Bhubaneswar	Komal Diwakar	DBS College, Dehradun
Avinandan Das	CMI, Kelambakkam	Lalatendo Bidyadhar Sahoo	NIT, Rourkela
Chandan Kumar Jana	ICTS, Bangalore	Madhumita Kundu	ISI, Kolkata
Debapom Goswami	Univ. of Calcutta	Mattam Pottimgari Sree Ganesh Kumar Reddy	NIT, Rourkela
Deepashree, U	Anna Univ.	Mitali Rawat	Pathshala, C S (Pratham)

Mitali Rawat	Whitehal Jr.
Mohit Gupta	ICTS-TIFR, Bengaluru
Murugesan, K	Bharathidasan Univ.
Muthupandian, S	SAS College
Nidhi Purohit	ENS de Lyon (France)
Nikhil Ramesh	BITS, Goa
Nishan, K	Shiv Nadar Univ
Nishant, Gaurav	IGNO Univ.
Nookala Ravali	NIT, Rourkela
P. Fahad	Cochin Univ,
Palak Singla	Central Univ. of South Bihar
Parth Rajauria	IISER, Tirupati
Pragati Gupta	IISc, Bengaluru
Pratyush Kumar, K	BITS, Pilani
Ranadeep Roy	IISER, Tirupati
Ranganatha, B.R	IISER, Tirupati
Rithika Sharma	Central Univ. of Rajasthan
Sampa Dey	IIT, Madras
Sanchit Srivastava	IISER, Thiruvanantha--puram
Sandeep Chowdhary	IISER, Pune
Sarath Jyothsna, R	PSG College of Tech.,Coimbatore
Sarvesh Srinivasan	Birla Inst. of Technology & Sciences
Sathish Kumar, P	Univ. of Madras
Saveri Sumadyuti Ayyagari	Sastra Univ., Tanjavur
Shivami, V	BITS, Ranchi
Shri Poornima, R	Anna Univ.
Shri Vishalini, R	Anna Univ.
Siddharth Paliwal	IISc, Bangalore
Sravya, P	IISER, Pune
Srikara, S	IISER, Pune
Sudharsan, V	PSG College of Tech., Coimbatore
Sukanya Pandey	IISER, Pune
Suyeet Bhalerau	IISER, Pune
Tamil Maran, C	TNAU, Coimbatore
Ujjwal Kumar Sana	CMI, Kelambakkam
Vivek Anand	Pennsylvania State Univ
Yeshwanth Sripathy	Amrita Vishwa Vidyapeetham, Coimbatore

3. Infrastructure

The Institute has excellent facilities required for cutting-edge research. The two main facilities are the Library and the Computing Environment. The Institute also has an on-campus hostel for students and a guest house for short term and long term visitors. Recreational facilities are also available. The state of the art, 200 seater Ramanujan Auditorium provides the venue for conferences and other public events of an academic nature.

3.1 Computer Facilities Enhancement of Computer Facility during 2019-20

- New laptops were issued to newly inducted faculty and to those faculty on demand for which the laptops are older than 4 years. Macbook book Pro 13, Macbook Pro 16 and Lenovo Thinkpad - P1 were distributed.
- Obsolete and non working LAN switches are replaced with new ones in the following locations: New Guest House, Server room, Library building 2nd and 3rd Floor.
- Portable media hardware viz., A/V Mixer, Preview monitor, Recorder, Streamer, etc., with a DataVideo GO 650 Studio, 4 Channel HD portable Video production studio with accessories and additional 2 in¬put expansion interface ports for the existing DataVideo SE-2800 are installed as a backup solution for the media activity.

Activities:

- Mr. P.Mangala Pandi, Project Technical Assistant(HPC) is relieved from the project on June 4, 2019
- Mr. Imrankhan, H., Project Technical Assistant(HPC) joined under the project Management of IMSc IT Infrastructure: Computing Media, Web : 2019-2022 with effect from the forenoon of 11/09/2019.
- Mr. Imrankhan, H., Project Technical Assistant(HPC) has attended “SETS - National Workshop on Introduction to Quantum Computing” organised by SETS, Chennai during Feb 20-22, 2020.
- 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). Visitor request form module is completed and trial run under process.

3.2 The Library

The Institute Library holds a total collection of 75349 books and bound periodicals as on March 31, 2020. This includes an addition of 574 volumes during the current year April 2019 - March 2020. 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 backfile collection of journals contents from Volume 1 from some of the major publishers like Elesevier under DAE consortium, Springer, World Scientific, Wiley, deGruyter, Cambridge University Press, Turpion, IOP Publishing and Annual Reviews Electronic Backvolume collection.

Access to online journals is restricted to members of the Institute.

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.

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

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

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

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

Acknowledgment:

The Library gratefully acknowledges the donation of valuable books, journals and other reading materials

Arvind, V., IMSc
Kalyana Rama, IMSc
Kamal Lodaya, IMSc
Meena Mahajan, IMSc
Narayanan, P.A., IMSc
Pallavi Jain, IMSc
Parameswaran Sankaran, IMSc
Prashanth Raman, IMSc
Thinniyam Ramanathan, IMSc
Vigneshwar, N., IMSc
Kesavan S, IMSc
Rajasekaran G, IMSc
Jegannathan, R.
NBHM
Vijay Nambisan Trust

4. IMSc Cultural Association, Sports & Games

As the Institute focuses deeply on academic excellence and advancement, and strives to make science accessible and relatable to the general public, it also encourages a number of community-building activities on-campus. These include the IMSc Cultural Association (ICA), which provides a space for members to explore the various cultures of India, and the Sports and Games Activities, which encourage team values and help students and faculty stay active.

Image 12: Program organised by IMSc Cultural Association 2019-20

Image 13: Cricket Team (February - March 2020), 2019-2020, IMSc, Chennai

Image 14: Badminton Tournament, 2019-2020, IMSc, Chennai

Image 15: Badminton Winners, 2019-2020, IMSc, Chennai

Image 16: Badminton Runners, 2019-2020, IMSc, Chennai

Image 17: Chess Winners, 2019-2020, IMSc, Chennai

Image 18: Chess Players, 2019-2020, IMSc, Chennai

Image 19: Chess Tournament, August 2019, IMSc, Chennai

Image 20: Football Teams, 2019-2020, IMSc, Chennai

Image 21: Football Match, April 2019

5. Audited Statement of Accounts for the Year 2019-2020

As per clause 29 of the Constitution and By - Laws of the Institute, the Accounts of the Institute shall be audited by Professional Chartered Accountants as prescribed by the law. The audit of the Accounts of the Institute for the Financial Year 2019-20 was taken up and complied by Professional Auditors M/s R. Balachandran & Co., Chennai - 600 035. The Report of the Auditors and the Audited Statement of Accounts including the Provident Fund Accounts for the year 2019-20 are attached herewith for reference

R. BALACHANDRAN & CO.
CHARTERED ACCOUNTANTS

R. BALACHANDRAN
B.A., B.L., F.C.A., A.C.S., DIRM (ICAI), DISA(ICA)

Flat 3B, IIIrd Floor, Block III, Bajaj Apartments,
4, Nandanam Extn. 1st, Main Road,
Nandanam, Chennai - 600 035. Ph: 044-4858 7686
Cell: 94442 58090 (D) 98843 50000
Email: rbalaca@gmail.com / rbksr@rediffmail.com

INDEPENDENT AUDITOR'S REPORT

REPORT ON THE FINANCIAL STATEMENTS

I have audited the financial statements of M/s. The Institute of Mathematical Sciences (herein after called "The Society"), comprising Balance sheet as at 31st March 2020, Receipts and Payments and the Income and Expenditure for the year then ended, and the relevant schedules to the financial statements.

In my opinion and to the best of my knowledge and according to the explanations given to me, the aforesaid financial statements give the information required in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India.

a) In the case of the Balance Sheet, of the state of affairs of the Society as at 31st March, 2020.

b) In the case of the Income and Expenditure Account, of the Excess of Expenditure over Income for the year ended on that date.

BASIS FOR OPINION

I conducted my audit in accordance with the Standards on Auditing (SAs) issued by ICAI. My responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of my report. I am Independent of the Society in accordance with the code of Ethics Issued by ICAI and I have fulfilled my other ethical responsibilities in accordance with the code of Ethics. I believe that the audit evidence I have obtained is sufficient and Appropriate to Provide a basis for my opinion.

MANAGEMENT'S RESPONSIBILITY

The management of the Society is responsible for the preparation of these financial statements that give true and fair view of the financial position, financial performance in accordance with the accounting standards. This responsibility includes the design, implementation and maintenance of internal control relevant to preparation and fair presentation of the financial statements that give true and fair view and are free from material misstatement, whether due to fraud or error.

AUDITOR'S RESPONSIBILITY

My responsibility is to express an opinion on these financial statements based on my audit. I conducted my audit in accordance with the standards on auditing issued by Institute of Chartered Accountants of India. Those Standards require that I comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

R. BALACHANDRAN & CO.
Flat 3B, Block - III Bajaj Apts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35
Chartered Accountants

R. BALACHANDRAN & CO.
CHARTERED ACCOUNTANTS

R. BALACHANDRAN
B.A., B.L., F.C.A., A.C.S., DIRM (ICAI), DISA(ICA)

Flat 3B, IIIrd Floor, Block III, Bajaj Apartments,
4, Nandanam Extn. 1st, Main Road,
Nandanam, Chennai - 600 035. Ph: 044-4858 7686
Cell: 94442 58090 (D) 98843 50000
Email: rbalaca@gmail.com / rbksr@rediffmail.com

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Society's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances but not for the purpose of expressing an opinion on the effectiveness of the said internal controls. An Audit includes examining the evidence supporting the amounts and disclosures in the financial statements on a test basis. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by Society, as well as evaluating the overall presentation of the financial statements.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my audit opinion

Place: Chennai
Date :

For R.Balachandran & Co
Chartered Accountants
Firm No.323S

R. BALACHANDRAN & CO. Flat 3B, Block - III Bajaj Arts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35 Chartered Accountants

R.Balachandran
Chartered Accountant
M.No. 026980
UDIN: **20026980AAAADK2145**

The Institute of Mathematical Sciences, Chennai

BALANCE SHEET AS AT 31st MARCH 2020

(All amounts in Rs.)

PARTICULARS	Schedule No. as per the Common Format of accounts	CURRENT YEAR	*PREVIOUS YEAR*
CAPITAL FUND AND LIABILITIES			
CAPITAL FUND ACCOUNT	1	-63,05,08,645	*-30,55,26,802*
EARMARKED/ENDOWMENT FUNDS	3	16,12,909	*15,15,039*
CURRENT LIABILITIES AND PROVISIONS	7	1,24,56,34,344	*96,44,91,807*
TOTAL		*61,67,38,608*	*66,04,80,044*
ASSETS			
FIXED ASSETS	8	54,74,27,461	*42,13,39,991*
INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS	9	16,12,909	*15,09,107*
CURRENT ASSETS, LOANS AND ADVANCES	11	6,76,98,238	*23,76,30,946*
TOTAL		*61,67,38,608*	*66,04,80,044*
SIGNIFICANT ACCOUNTING POLICIES	24		
NOTES ON ACCOUNTS	25		

Place : Chennai
Date:

Flat 35, Block - III, Bajaj Apts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai-35. Chartered Accountants

[E. GAYATRI]
ACCOUNTS OFFICER

[S. VISHNU PRASAD]
REGISTRAR

[V. ARVIND]
DIRECTOR

The Institute of Mathematical Sciences, Chennai

Income and Expenditure Account for the year ended 31st March, 2020

(All amounts in Rs.)

PARTICULARS	Schedule No. as per the Common Format of accounts	Current Year	Previous Year
INCOME			
Interest Earned	17	7,16,580	*2,43,378*
Other Income	18	1,80,92,160	*2,00,09,239*
Grant ± in ± Aid	22	39,56,10,293	*39,17,32,588*
TOTAL (A)		**41,44,19,033**	*41,19,85,205*
EXPENDITURE			
Establishment Expenses	20	29,11,06,561	*27,59,77,575*
Other Administrative Expenses etc	21	46,60,07,599	*36,73,48,589*
Depreciation		9,59,76,423	*7,01,91,033*
TOTAL (B)		**85,30,90,583**	**71,35,17,197**
Deficit transferred to Capital Fund Account		**-43,86,71,550**	*-30,15,31,992*

R. BALACHANDRAN & CO.
Flat 3B, Block - III, Bajaj Apts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35
Chartered Accountants

Place : Chennai
Date:

[E. GAYATRI]
ACCOUNTS OFFICER

[S. VISHNU PRASAD]
REGISTRAR

[V. ARVIND]
DIRECTOR

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31-03-2020

(All amounts in Rs.)

PARTICULARS	Current Year		Previous Year
SCHEDULE: 1 - CAPITAL FUND:			
Balance as at the beginning of the year	**-30,55,26,802**		
Add : Capital Expenditure incurred during the year	36,27,17,520		
Add: Surplus / (Deficit) Transferred from Grant-in-Aid reserve as in Schedule no. 13	-24,90,27,813		
Add: Surplus / (Deficit) transferred from I & E account for the year	-43,86,71,550	**-63,05,08,645**	*-30,55,26,802*
BALANCE AT THE YEAR END		**-63,05,08,645**	*-30,55,26,802*

PARTICULARS	Current Year			Previous Year
SCHEDULE: 13 -GRANT-IN-AID RESERVE :	**Capital**	**Revenue**	**Total**	***Total***
D.A.E.., Govt. of India				
Balance as at the beginning of the year	**0**	**0**	**0**	***0***
Add : Grant received during the year	1,31,00,000	49,62,00,000	**50,93,00,000**	***52,14,00,000***
Less: Revenue Expenditure incurred during the year	-1,05,20,763	-38,50,89,530	**-39,56,10,293**	***-39,17,32,588***
Less: Capital Expenditure incurred during the year	-32,03,23,801	-4,23,93,719	**-36,27,17,520**	***-10,20,62,315***
Less: (Surplus)/Deficit Transferred to Capital Fund account	31,77,44,564	-6,87,16,751	**24,90,27,813**	***2,76,05,097***
BALANCE AT THE YEAR END	**0**	**0**	**0**	***0***

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31-03-2020

(All amounts in Rs.)

Particulars	Name of the Fund			Current Year	*Previous Year*
SCHEDULE: 3 - EARMARKED/ENDOWMENT FUNDS	**Apalat Trust Fund**	**Prof. Alladi Ramakrishnan Endowment Fund**	**Prof. Nag Memorial Fund**	**TOTAL**	***TOTAL***
a) Opening balance of the funds	**8,20,799**	**86,027**	**6,08,213**	**15,15,039**	**13,63,138**
b) Additions to the Funds :					
i. Grants / Contributions	0	0	0	0	0
ii. Income from Investments / Savings Bank A/C	58,280	6,002	33,588	97,870	2,08,986
TOTAL (a+b)	**8,79,079**	**92,029**	**6,41,801**	**16,12,909**	15,72,124
c) Utilisation/Expenditure towards objectives of funds					
i. Revenue Expenditure					
- Scholarships / Awards.	0	0	0	0	57,085
- Other expenses	0	0	0	0	0
TOTAL (C)	**0**	**0**	**0**	**0**	**57,085**
NET BALANCE AS AT THE YEAR -END (a+b -c)	**8,79,079**	**92,029**	**6,41,801**	**16,12,909**	**15,15,039**

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31-03-2020

(All amount in Rs.)

Particulars	Current Year	*Previous Year*
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS		
A. CURRENT LIABILITIES		
1. Sundry Creditors	0	0
2. Received and Refundable for projects/conferences/programmes/schemes	6,29,887	6,66,751
3. Statutory Liabilities:		
a) Income Tax, Sales Tax & Prof. Tax	29,306	67,033
4. Other Liabilities	2,93,47,489	3,98,25,429
TOTAL (A)	**3,00,06,682**	**4,05,59,213**
B. PROVISIONS		
1. Provision for Pension	*1,09,32,57,586*	80,82,47,643
2. Provision for Gratuity	*5,43,66,016*	5,18,23,114
3. Provision for Leave Encashment	*6,80,04,060*	6,38,61,837
TOTAL (B)	**1,21,56,27,662**	**92,39,32,594**
TOTAL (A+B)	**1,24,56,34,344**	***96,44,91,807***

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31-03-2020

(All amounts in Rs.)

SCHEDULE 8 - FIXED ASSETS (Capital)	GROSS BLOCK				DEPRECIATION					NET BLOCK	
Description	Cost/valuation as at 01-04-19	Additions during 2019-20	Deductions during 2019-20	Cost/Valuation as at 31-03-20	Rate under WDV method	As at 01-04-19	For the year 2019-20	Deductions during 2019-20	Total upto 31-03-20	As at 31-03-20	*As at 31-03-19*
A. FIXED ASSETS :											
1. LAND											
a) Freehold	**65,26,500**	0	0	**65,26,500**	0%	**0**	0	0	**0**	**65,26,500**	*65,26,500*
2. BUILDING :											
a) Office Buildings	**14,36,39,066**	31,69,08,786	0	**46,05,47,852**	10%	**8,04,71,071**	3,80,07,678	0	**11,84,78,749**	**34,20,69,103**	*6,31,67,995*
b) Residential Buildings	**1,33,77,773**	0	0	**1,33,77,773**	5%	**95,97,365**	1,89,020	0	**97,86,385**	**35,91,388**	*37,80,408*
3. PLANT MACHINERY & EQUIPMENT	**6,87,82,233**	0	0	**6,87,82,233**	15%	**4,49,53,558**	35,74,301	0	**4,85,27,859**	**2,02,54,374**	*2,38,28,675*
4. VEHICLES	**10,800**	0	0	**10,800**	15%	**10,040**	114	0	**10,154**	**646**	*760*
5. FURNITURE, FIXTURES	**2,09,16,165**	7,45,384	0	**2,16,61,549**	10%	**1,55,59,144**	6,10,241	0	**1,61,69,385**	**54,92,164**	*53,57,021*
6. OFFICE EQUIPMENT	**48,93,595**	5,96,313	0	**54,89,908**	15%	**31,53,634**	3,50,441	0	**35,04,075**	**19,85,833**	*17,39,961*
7. COMPUTER/PERIPHERALS	**26,56,32,542**	12,43,998	0	**26,68,76,540**	40%	**25,29,03,282**	55,89,303	0	**25,84,92,585**	**83,83,955**	*1,27,29,260*
8. ELECTRIC INSTALATIONS	**4,02,48,827**	8,29,320	0	**4,10,78,147**	10%	**2,92,68,630**	11,80,952	0	**3,04,49,582**	**1,06,28,565**	*1,09,80,197*
9. BOOKS & JOURNALS	**3,61,11,773**	0	0	**3,61,11,773**	25%	**3,48,07,609**	3,26,041	0	**3,51,33,650**	**9,78,123**	*13,04,164*
TOTAL CURRENT YEAR	**60,01,39,274**	**32,03,23,801**	**0**	**92,04,63,075**		**47,07,24,333**	**4,98,28,091**	**0**	**52,05,52,424**	**39,99,10,651**	**12,94,14,941**
Previous year	*58,92,42,664*	*1,08,96,610*	***0***	*60,01,39,274*		*44,82,58,310*	*2,24,66,023*	***0***	*47,07,24,333*		
B. CAPITAL, WORK - IN - PROGRESS										**19,61,522**	*0*
TOTAL (Capital)										**40,18,72,173**	***12,94,14,941***

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31-03-2019

(All amounts in Rs.)

SCHEDULE 8 - FIXED ASSETS(Revenue)	GROSS BLOCK				DEPRECIATION					NET BLOCK	
Description	Cost/valuation as at 01-04-19	Additions during 2019-20	Deductions during 2019-20	Cost/Valuation as at 31-03-20	Rate under WDV method	As at 01-04-19	For the year 2019-20	Deductions during 2019-20	Total upto 31-03-20	As at 31-03-20	*As at 31-03-19*
A. FIXED ASSETS :											
1. LAND											
a) Freehold	1	0	0	1	0%	0	0	0	0	1	*1*
2. BUILDING :											
a) Office Buildings	7,69,494	0	0	7,69,494	10%	7,46,473	2,302	0	7,48,775	20,719	*23,021*
b) Residential Buildings	0	0	0	0	5%	0	0	0	0	0	*0*
3. PLANT MACHINERY & EQUIPMENT	44,79,778	0	0	44,79,778	15%	33,67,698	1,66,812	0	35,34,510	9,45,268	*11,12,080*
4. VEHICLES	19,36,771	0	0	19,36,771	15%	17,72,515	24,638	0	17,97,153	1,39,618	*1,64,256*
5. FURNITURE, FIXTURES	1,14,33,691	5,542	0	1,14,39,233	10%	70,50,017	4,38,922	0	74,88,939	39,50,294	*43,83,674*
6. OFFICE EQUIPMENT	20,28,245	14,819	0	20,43,064	15%	17,01,619	51,217	0	17,52,836	2,90,228	*3,26,626*
7. COMPUTER/PERIPHERALS	5,31,488	0	0	5,31,488	40%	5,31,097	156	0	5,31,253	235	*391*
8. ELECTRIC INSTALATIONS	80,17,001	26,48,659	0	1,06,65,660	10%	47,73,126	5,89,253	0	53,62,379	53,03,281	*32,43,875*
9. BOOKS & JOURNALS*	65,10,02,533	3,97,24,699	0	69,07,27,232	25%	51,12,27,106	4,48,75,032	0	55,61,02,138	13,46,25,094	*13,97,75,427*
10. OTHER FIXED ASSETS	2,80,550	0	0	2,80,550	0%	0	0	0	0	2,80,550	*2,80,550*
TOTAL CURRENT YEAR	68,04,79,552	4,23,93,719	0	72,28,73,271		53,11,69,651	4,61,48,332	0	57,73,17,983	14,55,55,288	*14,93,09,901*
PREVIOUS YEAR	*58,93,16,182*	*9,11,65,705*	*2,335*	*68,04,79,552*		*48,34,46,902*	*4,77,25,010*	*2,261*	*53,11,69,651*		
B. CAPITAL WORK - IN - PROGRESS										0	*14,26,15,149*
TOTAL (Revenue)										14,55,55,288	*29,19,25,050*
Total (Capital + Revenue)	1,28,06,18,826	36,27,17,520	0	1,64,33,36,346		1,00,18,93,984	9,59,76,423	0	1,09,78,70,407	54,74,27,461	42,13,39,991

* An amount of Rs.1,11,96,621/- included under additions during the year 2019-20 towards procurement of online subscription of journals.

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31-03-2020

(All amounts in Rs.)

Particulars	Current Year	*Previous Year*
SCHEDULE: 9-INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS		
1. Apalat Fund	*8,79,079*	*8,22,962*
2. Prof. Alladi Ramakrishnan Endowment Fund	*92,029*	*86,145*
3. Prof. Subhahis Nag Memorial Fund	*6,41,801*	*6,00,000*
TOTAL	**16,12,909**	***15,09,107***

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31-03-2020

(All amounts in Rs.)

Particulars	Current Year	*Previous Year*
SCHEDULE: 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.		
A. CURRENT ASSETS:		
1. Cash balances in hand (including cheques/drafts and imprest)	51,844	*66,893*
2. Bank Balances :		
a) With Scheduled Banks :		
-On Current Accounts - Institute	4,87,21,706	*3,39,98,946*
- Projects/Schemes	450	*450*
TOTAL (A)	**4,87,74,000**	***3,40,66,289***
B. LOANS, ADVANCES AND OTHER ASSETS		
1. Advances and other amounts recoverable in cash or in kind or for value to be received :		
a) On Capital Account: Advance to Contractors/ suppliers	49,36,428	*38,90,715*
b) Prepayments	1,00,182	*2,44,676*
c) Loans & Advances to Staff	4,36,159	*2,87,316*
d) Deposits	60,62,707	*18,94,95,336*
e) STD- LC Margin Money	0	*4,21,200*
2. Income Accrued :		
a) On Investments from Earmarked/Endowment Funds	63,025	*68,957*
b) On Loans and Advances	83,023	*1,98,497*
c) On EB Deposits	11,01,689	*3,92,624*
3. Receivables - Project / Programmes	2,21,593	*2,42,385*
- Others	59,19,432	*83,22,951*
TOTAL (B)	**1,89,24,238**	*20,35,64,657*
TOTAL (A+B)	**6,76,98,238**	***23,76,30,946***

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31-03-2020

(All amounts in Rs.)

Particulars	Current Year		Previous Year	
SCHEDULE 22-GRANT-IN-AID	**CAPITAL**	**REVENUE**	**CAPITAL**	**REVENUE**
1) Grant-in-Aid from DAE	1,05,20,763	38,50,89,530	1,49,02,627	37,68,29,961
3) Grant-in-Aid from Govt. of TN	0	0	0	0
TOTAL	**1,05,20,763**	**38,50,89,530**	***1,49,02,627***	***37,68,29,961***

(All amounts in Rs.)

Particulars	Current Year	*Previous Year*
SCHEDULE 17-INTEREST EARNED		
1) On Term Deposits	3,925	0
2) On Advances to staff members		
a) On HBA	0	0
b) On Car Advance	0	0
c) On Motor-Cycle Advance	594	1,134
d) On Personal Computer Advance	2,327	264
e) On LTC advances	669	0
3) On Electricity Board Deposits	7,09,065	2,41,980
TOTAL	**7,16,580**	***2,43,378***

(All amounts in Rs.)

Particulars	Current Year	*Previous Year*
SCHEDULE 18-OTHER INCOME		
1) CHSS Subscription	31,00,452	26,77,444
2) Licence Fee	1,44,204	1,53,835
3) Guest House Accommodation Charges	29,84,370	24,25,939
4) Guest House Canteen Receipts	68,90,998	86,83,858
5) Xeroxing Receipts	3,427	6,181
6) Sale of Tender Forms	69,650	44,500
7) Miscellaneous Receipts	1,41,403	19,95,949
8) Profit on Sale of Old Items (Assets)	2,93,200	2,261
9) Project overheads on ongoing Projects	16,987	0
10) CPF Management Contribution lapsed to Management	44,47,469	40,19,272
TOTAL	**1,80,92,160**	***2,00,09,239***

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31-03-2020

(All amounts in Rs.)

Particulars	Current Year		Previous Year	
SCHEDULE 20-ESTABLISHMENT EXPENSES	CAPITAL	REVENUE	CAPITAL	REVENUE
1) Pay & Allowances (Academic Staff)	0	14,71,26,304	0	15,42,27,828
2) Post Doctoral Fellowship	0	1,73,39,591	0	1,22,14,221
3) Junior Research Fellowship	0	5,64,37,109	0	4,30,75,005
4) Pay & Allowances (Admin. Staff)	1,02,90,044	4,39,83,287	92,13,391	4,15,29,157
5) Staff Welfare Expenses	0	87,78,216	0	81,21,322
6) Employees Service / Retirement Benefits	0	71,52,010	0	75,96,651
TOTAL	**1,02,90,044**	**28,08,16,517**	**92,13,391**	**26,67,64,184**

(All amounts in Rs.)

Particulars	Current Year		Previous Year	
SCHEDULE 21 ± OTHER ADMINISTRATIVE EXPENSES	CAPITAL	REVENUE	CAPITAL	REVENUE
1) Visiting Scientist Programme Expenses	0	79,72,197	18,14,086	66,40,489
2) Summer Student Programme Expenses	0	6,36,126	0	6,55,223
3) Conferences / Symposia / Workshop Expenses	2,30,719	17,18,703	7,13,179	24,60,466
4) Contribution paid to other Institutions / Agencies	0	4,88,410	4,10,000	10,44,000
5) Participation in Conferences	0	74,11,652	14,05,892	63,61,613
6) Internet Connectivity Charges	0	3,77,482	0	5,13,853
7) Online Journals, Newspapers & Magazines [Library]	0	0	2,98,954	0
8) Travel Expenses	0	39,38,990	1,05,999	48,02,516
9) Rent, Rates & Taxes	0	4,05,425	0	3,59,178
10) Electricity Charges	0	2,46,20,304	0	2,50,09,287
11) Water Charges	0	19,16,016	0	27,55,967
12) Printing & Stationery	0	7,03,596	4,341	10,03,206
13) Postages	0	1,76,064	8,42,157	1,97,399
14) Telephone Charges	0	9,76,949	0	11,17,175
C/F	**2,30,719**	**5,13,41,914**	**55,94,608**	**5,29,20,372**

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31-03-2020

(All amounts in Rs.)

Particulars	Current Year		Previous Year	
SCHEDULE 21- OTHER ADMINISTRATIVE EXPENSES Contd...	CAPITAL	REVENUE	CAPITAL	REVENUE
B/F	2,30,719	5,13,41,914	55,94,608	5,29,20,372
15) Security Services	0	1,09,58,466	0	1,19,79,563
16) Advertisement Charges	0	30,45,627	0	28,02,171
17) Entertainment & Hospitality Charges	0	11,96,992	0	13,69,214
18) Catering Expenses	0	84,18,575	0	97,42,664
19) Guest House/Hostel Maintenance	0	33,25,411	0	33,30,140
20) Audit Fees	0	1,47,500	0	88,500
21) Actuarial/Legal Fees	0	23600	0	29,396
22) Bank Charges	0	212	0	6,770
23) Repairs & Maintenance	0	2,56,44,940	57,545	2,67,27,401
24) Contingent & Miscellaneous Expenses	0	1,69,776	37,083	10,69,586
25) Provision for Pension	0	33,53,92,099	0	22,59,38,299
26) Provision for Gratuity	0	1,19,39,990	0	1,16,21,576
27) Provision for Leave Encashment	0	1,41,71,778	0	1,40,33,701
TOTAL	2,30,719	46,57,76,880	56,89,236	36,16,59,353

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31-03-2020

SCHEDULE 24 - SIGNIFICANT ACCOUNTING POLICIES

1. ACCOUNTING CONVENTION

The financial statements are prepared on the basis of historical cost convention, unless Otherwise Stated and on the accrual method of Accounting.

2. FIXED ASSETS

2.1 Fixed Assets of the Institute are acquired out of grants from the Government of India. Funds utilized for acquisition of assets are shown under Capital Fund.

2.2 Fixed Assets are stated at cost of acquisition inclusive of inward freight, duties and taxes and incidental and direct expenses related to Acquisition.

2.3 Value of assets assigned to the Institute free of cost by Tamil Nadu Government (6.5 acres of land) brought into books of accounts with a Nominal value of Re.1/-

2.4 Books & Periodicals include online journals also.

3. DEPRECIATION

3.1 Depreciation is provided on written down value method as per rates specified in the Income Tax Act, 1961 except Library Books and Journals includes online Journals which are depreciated @ 25% and Computers / Peripherals @40%

3.2 No Depreciation is charged to Prof.Chandrasekar's Bust shown under Fixed Assets at a cost of Rs.2,80,550/- as it is similar to archaeological Item.

3.3 Depreciation has been charged for the full year on addition made during the Year.

4. INVENTORIES

Consumables, stationery etc. are charged off to the Revenue in the year of Purchase.

5. INVESTMENTS

5.1 Investments are valued at cost. Income on investments are accounted on accrual Basis.

5.2 Term Deposits with Banks are classified under Current Assets if the duration of the deposits is less than one year and under Investments if the duration is more than one year.

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31-03-2020

SCHEDULE 24 - SIGNIFICANT ACCOUNTING POLICIES contd..

6. GOVERNMENT GRANTS/SUBSIDIES

Recurring (Revenue) and Non Recurring (Capital) grants received from DAE, Govt. of India and Recurring (Non-Plan) Grants received from Government of Tamil Nadu have Been treated as follows:

6.1 The grants are accounted for on realization basis.

6.2 That portion of Capital and revenue Funds utilized for Revenue Expenditure is taken to Income & Expenditure account as Income.

6.3 That portion of Capital and Revenue Funds utilized for Capital Expenditure is treated as Capital Fund.

6.4 The balance available under Capital & Revenue Grants is exhibited as carried forward balance in the Liabilities side of the Balance Sheet.

7. Externally Funded Project

The grants received in respect of Externally Funded Projects are kept under separate interest bearing bank accounts from the financial year 2018-19 onwards. The interest earned are being shown in the consolidated statement of externally funded projects.

8. FOREIGN CURRENCY TRANSACTIONS

Transactions involving in foreign currencies are accounted at the exchange rate prevailing on the date of transaction. The Foreign currency assets and liabilities are restated at exchange rates prevailing at the end of the year and the resultant gain or loss is recognised in the Income and Expenditure Account.

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31-03-2020

SCHEDULE 24 - SIGNIFICANT ACCOUNTING POLICIES contd..

9. RETIREMENT BENEFITS.

Provision for Pension, Gratuity and Leave Encashment wherever applicable made are provided on actuarial valuation as at each year end. Since the retirement benefits are supported by the Grant-in-Aid every year, no separate fund is maintained for this specific purpose.

R. BALACHANDRAN & CO. Chartered Accountants Flat 3B, Block - III Bajaj Apts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35

Place : Chennai
Date:

[E. GAYATRI]	[S. VISHNU PRASAD]	[V. ARVIND]
ACCOUNTS OFFICER	REGISTRAR	DIRECTOR

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31-03-2020

SCHEDULE 25 - NOTES ON ACCOUNTS

1. CURRENT ASSETS, LOANS AND ADVANCES

The current assets, loans and advances have a value on realization in the ordinary course equal to the aggregate amount shown in the Balance Sheet.

2. Externally Funded Project

The grants received in respect of Externally Funded Projects are kept under separate interest bearing bank accounts from the financial year 2018-19 onwards. The interest earned are being shown in the consolidated statement of externally funded projects.

3. No Grant in aid received from Government of Tamil Nadu during the year 2019-20 and a reminder has already been submitted to this effect.

4. CONFIRMATION OF BALANCES

The balances under Sundry Creditors, Advances and Deposits are subject to Confirmation. Physical Verification of fixed assets is being carried out by the Institute during the year and reconciliation of physical balance and book balance report is pending.

5. Corresponding opening figures of accounts have been regrouped and rearranged wherever necessary and amount in rupees has been rounded off To the nearest integer.

6. Schedules 1,3,7,8,9,11,13,17,18,20,21 and 22 are annexed to and form an integral part of the Balance Sheet as at 31.3.2020 and the Income and Expenditure Account for the Year Ended on that date.

The Institute of Mathematical Sciences, Chennai

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31-03-2020

SCHEDULE 25 - NOTES ON ACCOUNTS contd...

7. Physical Verification of Library Books was carried out by the Institute during the year 2016-17 and reconciliation of physical balance and book balance was done during 2016-17 and the value of missing books was written off as per the procedures during 2016-17.

8. Provision for Pension, Gratuity & Leave Encashment was calculated through Actuarial Valuation which worked out to Rs.36.15 crores as per AS15.

9. As per the common format of accounts as envisaged by Ministry of Finance, Controller General of Accounts endorsed by DAE, this Institute is following the common format of accounts in respect of Central Autonomous Bodies, the Schedules have been re-numbered this year and Schedule Nos.2,4,5,6,10,12,14,15,16,19 & 23 which have no transaction are Treated as "NOT APPLICABLE".

10. Goods and Service Tax we are awaiting the guidance from the Department about applicability of Autonomous Institutions in the purview of GST However, IMSc registered with GST authorities, TDS on GST Registration no as 33AAATT6815G1DT

11. Since IMSc is registered as a Society under Society's Registration Act of TN 1860, submission of every year's annual report & Balance Sheet along with necessary documents is under process.

12. Actuarial valuation for Provision for retirement benefits like Pension, Gratuity and Encashment of EL has been made by M/s. Mithra Consultants, Delhi amounting to Rs.36,15,03,867/-.

13. Separate bank account is being maintained for Provident Fund account in the name of "Director, The Institute of Mathematical Sciences ".However no separate PAN number is available for the particular PF a/c. as PAN Number is common for IMSc, TDS deducted on PF deposits also reflected in 26AS of IMSc a/c.

R. BALACHANDRAN & CO. Chartered Accountants — Flat 3B, Block - III, Bajaj Arts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35

Place : Chennai
Date:

[E. GAYATRI]	[S. VISHNU PRASAD]	[V. ARVIND]
ACCOUNTS OFFICER	REGISTRAR	DIRECTOR

The Institute of Mathematical Sciences, Chennai

Receipts and Payments for the year ended 31 March, 2020

(All amounts in Rs.)

RECEIPTS			PAYMENTS		
Particulars	**Current Year**	**Previous Year**	**Particulars**	**Current Year**	**Previous Year**
I. OPENING BALANCE:			**I. Expenses**		
a) Cash Balances	66,893	**65,316**	a) Establishment Expenses	5,65,74,058	**6,56,52,493**
			b) Other Administrative Expenses	17,60,49,062	**14,64,73,448**
b) Bank Balances					
(i) Current Accounts					
SBI, Adyar - Revenue a/c	2,70,33,641	**3,45,73,086**			
SBI, Adyar - Capital a/c	68,052	**2,56,62,675**	**II. Earmarked Fund related expenditures**	0	**0**
BOI, Adyar - Project a/c	450	**450**			
BOI, Advar	68,49,228	**63,352**	**III. Payments made against funds for various Projects/Programmes/Scheme**	0	**1,15,443**
SBI Online A/c	48,024	**9,851**			
(ii) Term Deposits	0	**0**			
Term Deposits - Earmarked Funds	4,21,200	**0**	**IV. Plan Expenditure (Revenue & Capital)**	2,10,65,998	**8,98,75,065**
			V. Other Payments	26,46,57,599	**32,34,71,338**
II. Project / Programme / Scheme Receipts	0	**1,15,443**			
III. Grants Received			**VI. CLOSING BALANCE:**		
a) From DAE, Govt. of India (Capital)	1,31,00,000	**6,41,00,000**	a) Cash Balances	51,844	**66,893**
b) From DAE, Govt. of India (Revenue)	49,62,00,000	**45,73,00,000**			
			b) Bank Balances		
IV. Interest Received			(i) Current Accounts		
a) On Bank Deposits	3,925	**0**	SBI, Adyar - Revenue a/c	4,28,58,885	**2,70,33,641**
b) On Advances to Employees	0	**0**	SBI, Adyar - Capital a/c	23,03,810	**68,052**
c) On Earmarked Fund Investments	0	**0**	BOI, Adyar - Project a/c	450	**450**
			BOI, Adyar	35,07,541	**68,49,228**
V. Other Income			SBI Online A/c	51,469	**48,024**
a) CHSS Subscription	13,45,742	**10,20,940**			
b) Licence Fee	3,840	**1,920**	(ii) Term Deposits		
c) Guest House Accommodation charges	14,08,810	**11,62,689**	Term Deposits - Earmarked Funds	0	**0**
d) Guest House/ Canteen Receipts	23,07,876	**33,44,182**	Term Deposits – LC Margin Money	0	**4,21,200**
e) Xeroxing Receipts	3,427	**6,181**			
f) Miscellaneous Receipts	29,792	**17,19,049**			
g) Sale of old items	2,93,200	**0**			
h) Sale of Tender forms	69,650	**0**			
VI. Other receipts	1,78,66,965	**7,09,30,141**			
TOTAL	**56,71,20,716**	**66,00,75,276**	**TOTAL**	**56,71,20,716**	**66,00,75,276**

The Institute of Mathematical Sciences, Chennai

Provident Fund and New Pension Scheme Account

BALANCE SHEET AS AT 31ST MARCH, 2020

(Amount in Rs.)

LIABILITIES		Current year	*Previous Year*	ASSETS	Current year		*Previous Year*
MEMBERS ACCOUNT				**BANK BALANCE**			
I) Provident Fund Account:				SB A/C, Adyar Branch - PF A/c	19,13,552		
Opening Balance	10,54,56,547			SB A/C, Adyar Branch – NPS A/c	5,46,168	**24,59,720**	*2,29,067*
Add: - Sub/Transfer/Refunds	2,50,10,965						
- Interest Credited	78,23,221			**INVESTMENTS - PF A/c**			
	13,82,90,733			With Banks	9,29,93,518	**9,29,93,518**	*10,41,17,374*
Less: Adv/Withdrawals/Transfer	4,00,46,982						
Closing Balance	**9,82,43,751**			**INVESTMENTS – NPS A/c**			
II) New Pension Scheme Account:				With Banks	44,24,364	**44,24,364**	*40,99,655*
Opening Balance	42,39,650						
Add: - Sub/Transfer/Refunds	4,99,760						
- Interest Credited	4,23,268			**INTEREST ACCRUED BUT NOT RECEIVED ON**			
	51,62,678			--- PF a/c	96,53,067		
Less: Adv/Withdrawals/Transfer	-			--- NPS a/c	37,767	**96,90,834**	*90,85,946*
Closing Balance	**51,62,678**	**10,34,06,429**	*10,96,96,197*				
SURPLUS / DEFICIT ACCOUNT							
PF account :-							
Surplus as per previous year	77,61,139						
Less : Deficit transferred from income and Expenditure account	-14,44,753	**63,16,386**	**77,61,139**				
NPS account :-							
Surplus as per previous year	74,706						
Less: Deficit transferred from Income And Expenditure a/c	-2,29,085						
		-1,54,379	*74,706*				
Total		**10,95,68,436**	*11,75,32,042*	**Total**		**10,95,68,436**	*11,75,32,042*

Place : Chennai
Date:

R. BALACHANDRAN & CO. Chartered Accountants
Flat 3B, Block - III, Bajaj Arts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35

[GAYATRI E]
ACCOUNTS OFFICER

[S VISHNU PRASAD]
REGISTRAR

[V ARVIND]
DIRECTOR

The Institute of Mathematical Sciences, Chennai

Provident Fund and New Pension Scheme Account

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH,2020

(Amount in Rs.)

EXPENDITURE	Current Year		Previous Year	INCOME	Current year		Previous Year
To INTEREST				By INTEREST			
- Credited to PF members	78,23,221			- Savings Bank Account - PF A/c	1,06,036		
- Credited to NPS members	4,23,268	82,46,489	*86,39,365*	- Savings Bank Account – NPS A/c	10,519	1,16,555	*3,45,726*
				- Earned and accured on Invesments PF a/c	62,72,432		
To Record Keeping Charges		6,650	*6,806*	- Earned and accured on Invesments NPS a/c	1,90,314		
						64,62,746	*76,32,195*
To Deficit trfd.to Balance Sheet (PF a/c)		-14,44,753	*-5,71,415*				
To Deficit trfd.to Balance Sheet (NPS a/c)		-2,29,085	*-96,835*				
Total		65,79,301	*79,77,921*	**Total**		65,79,301	*79,77,921*

R. BALACHANDRAN & CO. Flat 3B, Block - III, Bajaj Arts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35. Chartered Accountants

Place : Chennai
Date:

[GAYATRI E]
ACCOUNTS OFFICER

[S VISHNU PRASAD]
REGISTRAR

[V ARVIND]
DIRECTOR

The Institute of Mathematical Sciences, Chennai

Provident Fund and New Pension Scheme Account

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDED 31ST MARCH,2020

(Amount in Rs.)

RECEIPTS	Current year		Previous Year	PAYMENTS	Current year		Previous Year
OPENING BALANCE				**PAYMENTS TO MEMBERS**			
Provident Fund A/c							
SBI, Adyar, SB A/C		2,10,147	*20,64,513*	Settlement on Termination of Service	2,20,61,558		
Investments		8,11,68,493	*9,09,54,102*	Amount Withdrawn by members	17,41,918		
				Refundable Advances	12,54,822		
New Pension Scheme A/c						2,50,58,298	*2,46,71,349*
SBI, Adyar, SB A/C		18,920	*21,405*	**TRANSFERRED TO NPS**			
Investments		37,31,092	*32,75,970*	**TRUSTEE ACCOUNT**			
				- Members	1,26,32,324		
MEMBERS SUBSCRIPTION				- Interest Credited to Members	0	1,26,32,324	*1,12,72,056*
Provident Fund A/c							
- CPF/GPF Members	1,40,42,430			Record Keeping charges (NPS)	6,739	6,739	*6,806*
- Loans/withdrawals Refunded	0	1,40,42,430	*1,46,09,340*	Payable to ISI KOLKATTA	5,098	5,098	
New Pension Scheme A/c				**EMPLOYER'S CPF CONTRI.**			
- NPS Members	65,80,445	65,80,445	*58,60,636*	REFUNDED			
				- IMSc Account	44,47,469	44,47,469	*40,19,272*
MANAGEMENT CONTRIBUTION							
Provident Fund A/c							
- CPF Members	0						
Contribution receivd from UNOHYD -JAYANIYER		3,17,365	*8,54,160*	**CLOSING BALANCE**			
TDS Receivables		28,600		**Provident Fund A/c**			
New Pension Scheme A/c				- SBI, Adyar	19,13,552	19,13,552	*2,10,147*
- NPS Members	65,80,445	65,80,445	*58,60,636*	- Investments	6,51,03,659	6,51,03,659	*8,11,68,493*
INTEREST RECEIVED ON							
Provident Fund A/c				**New Pension Scheme A/c**			
Savings Bank Account - PF	1,06,036			- SBI, Adyar	5,46,168		
Investments - PF	6,49,907	7,55,943	*15,87,146*	- Investments	37,31,092	42,77,260	*37,50,012*
New Pension Scheme A/c							
Savings Bank Account	10,519	10,519	*10,227*				
Investments	0	0	-				
Total		11,34,44,399	12,50,98,135	**Total**		11,34,44,399	12,50,98,135

R. BALACHANDRAN & CO. Chartered Accountants, Flat No. 11, Block - III, Bajaj Arts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35

Place : Chennai
Date:

[GAYATRI E]
ACCOUNTS OFFICER

[S VISHNU PRASAD]
REGISTRAR

[V ARVIND]
DIRECTOR

The Institute of Mathematical Sciences, Chennai

Consolidated statement of External Projects Receipts and Payments accounts for the year ended 31 March, 2020

Sl.	NAME OF THE PROJECT	RECEIPTS					
		Opening balance on Savings Bank a/c	Grant-in-Aid	Regi./Exam Fees	Advance Received	Interest On SB a/c	TOTAL
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1	DAE – SRC Outstanding Investigator Awards SCH. Prof Ronojoy Adhikari	51,92,629				1,94,544	53,87,173
2	DST – SERB DISTINGUISHED FELLOWSHIP – PROF G BASKARAN	1,12,108				3,267	1,15,375
3	DST – SERB DISTINGUISHED FELLOWSHIP – PROF R SIMON	15,55,330				50,774	16,06,104
4	DST – STARTUP GRANT NEXT GENERATION METABOLIC DR AREEJIT SAMAL	4				1,047	1,051
5	DST – J C BOSE FELLOWSHIP PROF V S SUNDER	0				6,061	6,061
6	DST – J C BOSE FELLOWSHIP PROF ROMESH K KAUL	10,632				373	11,005
7	DST – SWARNAJAYANTHI FELLOWSHIP DR AMRITANSHUPRASAD	3,82,649	4,00,000			14,194	7,96,843
8	DST – SWARNAJAYANTHI FELLOWSHIP DR PARTHASARATHI CHAKRABORTY	1,13,860				3,957	1,17,817
9	GOOGLE INC AWARD DR RONOJOY ADHIKARI	4,35,821				15,028	4,50,849
10	IFCPAR MOD SOFT MIC PROF PINAKI HCAUDHURI	6,43,017				13,203	6,56,220
11	IFCPAR SUMS OF THE PROF PROF R BALASUBRAMANIAN	38,884				1,316	40,200
12	ITRA De-Congesting India's trans. networks using Mobile devices – Prof Sitabhra Sinha	3				19	22
13	JAWHARLAL NEHRU FELLOWSHIP PROF S R S VARDHAN	26,29,458				90,460	27,19,918
14	Max Planck Partner Group – IMSC- DR AREEJIT SAMAL	21,06,807				57,579	21,64,386
15	NNMCB VIDEO RECORDING – PROF SITABHRA SINHA	1,38,199				4,794	1,42,993
16	SERB – RAMANUJAN FELLOWSHIP – DR AREEJIT SAMAL	1,80,000	6,00,000			9,341	7,89,341
17	SERB – RAMANUJAN FELLOWSHIP – DR C M CHANDRASHEKAR	93,687	6,70,000			11,451	7,75,138
18	TPSC	1,498				52	1,550
19	INSA SRINIVASAN RAMANUJAN RESEARCH PROF R BALASUBRAMANIAN	1,99,671	12,00,000			14,752	14,14,423
20	NBHM SOUTHERN REGIONAL LIBRARY MEETING PROF K N RAGHAVAN	4,87,176			1,65,796	13,497	6,66,469
21	DST SERB NATIONAL FELLOWSHIP DR PALLAVI JAIN – N PDF	74,411			50,000	3,086	1,27,497
22	DST SERB NATIONAL FELLOWSHIP DR SHRADDHA SRIVASTAVA – N PDF	2,89,841				8,798	2,98,639
23	INDO GERMAN MAX PLANCK TRAVEL GRANT PROF AREEJIT SAMAL	72				1	73
24	WATERLOO ALGORITHAMS COOL PROF C M CHANDRASHEKAR	1,73,935	16,95,048			14,414	18,83,396
25	INDO – ITALIAN PRE. PHY LHC V RAVINDRAN	2,32,255				8,034	2,40,289
26	NCM TEW WORKSHOPS	95,673	4,60,966			4,575	5,61,214
27	DST PRECISION THEORY LARGE COLL. PROV V RAVINDRAN	7,50,805		62,000		22,070	8,34,875
28	SERB – Explicit formulas for a class of general L functions Dr K Srinivas	5,488	2,20,000			573	2,26,061
29	SERB – Lagrangian floer Theory - Dr Sushmita Venugopalan	1,54,150				4,283	1,58,433
30	SERB GO .GE. ET GR. AND AP TO HR IN THE PROF INDRAVA ROY	2,24,610				7,602	2,32,212
31	DBT – Mechanobiology of cell adhesion and cytoskeleton under dynamic Dr G I Menon	7,49,425				25,719	7,75,144
32	DAE – RAJA RAMANNA FELLOWSHIP – PROF ROMESH K KAUL	1,06,472	12,37,109			13,266	13,56,847
33	DST JC BOSE FELLOWSHIP PROF R BALASUBRAMANIAN	14,26,853				49,155	14,76,008
34	INDIA I EMBO SYM. REG . EL PROF RAHUL SIDDHARTHAN	3,62,876	16,12,981	1,941		23,527	20,01,325
35	SERB-VAJRA FACULTY SCHEME PROF C M CHANDRASHEKAR	1				197	198
36	DAE – VIGYAN PRATIBHA	99,68,233			50,00,000	3,12,902	1,52,81,135
37	Women Scientist Scheme A (WOS-A) fellowship to Dr Arpita Choudhary	6,89,460				13,461	7,02,921
38	SERB RAMANUJA N FELLOWSHIP – DR SAYANTAN SHARMA	7,60,000				23,678	7,83,678
39	SERB TARE PRJECT DR SUNITHA V – DR AREEJIT SAMAL	3,35,000				9,581	3,44,581
40	SERB GSC GAME THEORY DR SITABHRA SINHA	2,20,000				6,288	2,26,288
41	SERB AF COEFFICIENTS M FORMS – DR SANOLI GUN	2,20,000				5,158	2,25,158
42	SERB TARE PROJECT DR SWAPAN KUMAR MAJHI – DR V RAVINDRAN	3,35,000				8,368	3,43,368
43	MHRD-SPARC DR SANOLI GUN	0	99,985			1,441	1,01,426
44	MHRD-SPARC DR AMRITANSHU PRASAD	0	99,985			1,211	1,01,196
45	QITPD-ICPS Dr C M CHANDRASEKHAR	0	14,50,000		2,42,980	17,540	17,10,520
46	QITPD-ICPS Dr SIBASISH GHOSH	0	14,50,000			29,910	14,79,910
47	DST-SWARNAJAYANTHI FELLOWSHIP DR SAKET SAURABH	0	24,51,800			46,207	24,98,007
48	NBHM-M.A/M.Sc AND Ph.D sCHOLARSHIP TEST	0	14,00,000	25,41,500		17,633	39,59,133
	TOTAL	3,14,95,995	1,50,47,874	26,05,441	54,58,776	11,84,387	5,57,92,473

R. BALACHANDRAN & CO. Chartered Accountants, Flat 3B, Block 1, Rajaji Apts., 7/4, Nandanam Extn. Main Road, Nandanam, Chennai - 35

Place : Chennai
Date:

[E. GAYATRI]
ACCOUNTS OFFICER

[S. VISHNU PRASAD]
REGISTRAR

[V. ARVIND]
DIRECTOR

The Institute of Mathematical Sciences, Chennai

Consolidated statement of External Projects Receipts and Payments accounts for the year ended 31 March, 2020

Sl.	NAME OF THE PROJECT	PAYMENTS				
		Revenue Expenditure	Capital Expenditure	Refund of Unspent Balance	Closing Balanace On Bank accounts	TOTAL
		Rs.	Rs.	Rs.	Rs.	Rs.
1	DAE – SRC Outstanding Investigator Awards SCH. Prof Ronojoy Adhikari	0	0	0	53,87,173	53,87,173
2	DST – SERB DISTINGUISHED FELLOWSHIP – PROF G BASKARAN	1,13,058	0	0	2,317	1,15,375
3	DST – SERB DISTINGUISHED FELLOWSHIP – PROF R SIMON	23,670	0	0	15,82,434	16,06,104
4	DST – STARTUP GRANT NEXT GENERATION METABOLIC DR AREEJIT SAMAL	1,051	0	0	0	1,051
5	DST – J C BOSE FELLOWSHIP PROF V S SUNDER	18	0	0	6,043	6,061
6	DST – J C BOSE FELLOWSHIP PROF ROMESH K KAUL	18	0	0	10,987	11,005
7	DST – SWARNAJAYANTHI FELLOWSHIP DR AMRITANSHUPRASAD	4,11,201	0	0	3,85,642	7,96,843
8	DST – SWARNAJAYANTHI FELLOWSHIP DR PARTHASARATHI CHAKRABORTY	0	0	0	1,17,817	1,17,817
9	GOOGLE INC AWARD DR RONOJOY ADHIKARI	0	0	0	4,50,849	4,50,849
10	IFCPAR MOD SOFT MIC PROF PINAKI HCAUDHURI	5,78,045	0	0	78,175	6,56,220
11	IFCPAR SUMS OF THE PROF PROF R BALASUBRAMANIAN	0	0	0	40,200	40,200
12	ITRA De-Congesting India's trans. networks using Mobile devices – Prof Sitabhra Sinha	22	0	0	0	22
13	JAWHARLAL NEHRU FELLOWSHIP PROF S R S VARDHAN	0	0	0	27,19,918	27,19,918
14	Max Planck Partner Group – IMSC- DR AREEJIT SAMAL	14,06,814	0	0	7,57,572	21,64,386
15	NNMCB VIDEO RECORDING – PROF SITABHRA SINHA	0	0	0	1,42,993	1,42,993
16	SERB – RAMANUJAN FELLOWSHIP – DR AREEJIT SAMAL	4,84,660	23,852	0	2,80,829	7,89,341
17	SERB – RAMANUJAN FELLOWSHIP – DR C M CHANDRASHEKAR	3,42,699	14,363	0	4,18,075	7,75,138
18	TPSC	0	0	0	1,550	1,550
19	INSA SRINIVASAN RAMANUJAN RESEARCH PROF R BALASUBRAMANIAN	12,24,948	0	0	1,89,475	14,14,423
20	NBHM SOUTHERN REGIONAL LIBRARY MEETING PROF K N RAGHAVAN	1,65,797	0	0	5,00,673	6,66,469
21	DST SERB NATIONAL FELLOWSHIP DR PALLAVI JAIN – N PDF	1,08,250	0	0	19,248	1,27,497
22	DST SERB NATIONAL FELLOWSHIP DR SHRADDHA SRIVASTAVA – N PDF	2,90,282	0	0	8,358	2,98,639
23	INDO GERMAN MAX PLANCK TRAVEL GRANT PROF AREEJIT SAMAL	73	0	0	0	73
24	WATERLOO ALGORITHAMS COOL PROF C M CHANDRASHEKAR	6,06,291	0	0	12,77,105	18,83,396
25	INDO – ITALIAN PRE. PHY LHC V RAVINDRAN	15,667	0	0	2,24,622	2,40,289
26	NCM TEW WORKSHOPS	5,48,047	0		13,168	5,61,214
27	DST PRECISION THEORY LARGE COLL. PROV V RAVINDRAN	5,71,987	0	0	2,62,887	8,34,875
28	SERB – Explicit formulas for a class of general L functions Dr K Srinivas	1,26,347	0	0	99,714	2,26,061
29	SERB – Lagrangian floer Theory - Dr Sushmita Venugopalan	1,49,556	0	0	8,877	1,58,433
30	SERB GO .GE. ET GR. AND AP TO HR IN THE PROF INDRAVA ROY	14,319	0	0	2,17,894	2,32,212
31	DBT – Mechanobiology of cell adhesion and cytoskeleton under dynamic Dr G I Menon	5,589	0	0	7,69,555	7,75,144
32	DAE – RAJA RAMANNA FELLOWSHIP – PROF ROMESH K KAUL	12,96,153	0	0	60,694	13,56,847
33	DST JC BOSE FELLOWSHIP PROF R BALASUBRAMANIAN	0	0	0	14,76,008	14,76,008
34	INDIA I EMBO SYM. REG . EL PROF RAHUL SIDDHARTHAN	17,04,370	0	0	2,96,955	20,01,325
35	SERB-VAJRA FACULTY SCHEME PROF C M CHANDRASHEKAR	197	0	0	1	198
36	DAE – VIGYAN PRATIBHA	51,29,170	0	0	1,01,51,965	1,52,81,135
37	Women Scientist Scheme A (WOS-A) fellowship to Dr Arpita Choudhary	5,57,017	50,000	0	95,904	7,02,921
38	SERB RAMANUJA N FELLOWSHIP – DR SAYANTAN SHARMA	68,460	0	0	7,15,218	7,83,678
39	SERB TARE PRJECT DR SUNITHA V – DR AREEJIT SAMAL	63,683	0	0	2,80,898	3,44,581
40	SERB GSC GAME THEORY DR SITABHRA SINHA	0	0	0	2,26,288	2,26,288
41	SERB AF COEFFICIENTS M FORMS – DR SANOLI GUN	1,66,435	0	0	58,723	2,25,158
42	SERB TARE PROJECT DR SWAPAN KUMAR MAJHI – DR V RAVINDRAN	1,72,461	0	0	1,70,907	3,43,368
43	MHRD-SPARC DR SANOLI GUN	1,00,008	0	0	1,418	1,01,426
44	MHRD-SPARC DR AMRITANSHU PRASAD	73,366	0	0	27,830	1,01,196
45	QITPD-ICPS Dr C M CHANDRASEKHAR	8,08,320	9,01,830	0	370	17,10,520
46	QITPD-ICPS Dr SIBASISH GHOSH	1,19,790	2,97,786	0	10,62,334	14,79,910
47	DST-SWARNAJAYANTHI FELLOWSHIP DR SAKET SAURABH	2,00,073	1,19,582	0	21,78,352	24,98,007
48	NBHM-M.A/M.Sc AND Ph.D SCHOLARSHIP TEST	22,68,994	0	0	16,90,139	39,59,133
	TOTAL	1,99,16,908	14,07,413	0	3,44,68,152	5,57,92,473

Place : Chennai
Date:

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[E. GAYATRI]
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