Indian Institute of Space Science and Technology

# ANNUAL REPORT

## 2020-2021

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*2020-2021*


Indian Institute of Space Science and Technology

Declared as Deemed to be University under Section 3 of the UGC Act, 1956

An autonomous institute under Department of Space, Govt. of India

Valiamala P O, Thiruvananthapuram - 695 547, Kerala

www.iist.ac.in

# Vision & Mission

## *Vision*

To be a world class educational and research institution contributing significantly to the Space endeavours.

## *Mission*

- Create a unique learning environment enriched by the challenges of the Space Programme.
- Nurture the spirit of innovation and creativity.
- Establish Centres of Excellence in niche areas.
- Provide ethical and value based education.
- Promote activities to address societal needs.
- Network with national and international institutions of repute.

# Key Functionaries

**Dr. B. N. Suresh**
Chancellor

**Dr. K. Sivan**
President, IIST Governing Body
Chairman, IIST Governing Council
Secretary, DoS /Chairman, ISRO

**Dr. Vinay Kumar Dadhwal**
Director &
Chairman, Board of Management

**Prof. Y V N Krishna Murthy**
Senior Professor & Registrar

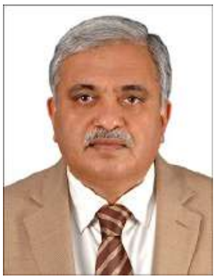
**Prof. A. Chandrasekar**
Dean
(Academic & Continuing Education)

**Prof. Raju K. George**
Dean
(Research & Development, IPR)

**Prof. Kuruvilla Joseph**
Dean
(Student Activities,
Student Welfare & Outreach Programme)

# CONTENTS

# FOREWORD >>> Dr. V. K. Dadhwal, Director



The year 2020-21 has been one of the most difficult time periods for the entire world and the institute also faced tremendous difficulties due to the pandemic. It was a challenge to continue the academic and research activities without compromising the quality under these extreme conditions. The faculty, students and staff came together and acted in unison to meet these challenges. I would like to present this Annual report with a sense of hope and belief in the human spirit to tide over the pandemic.

The academic activities were completely transformed using the appropriate online platforms and an open-source learning management system was adopted. The regular examinations and evaluations were also conducted online. However, the research activities took a hit with students staying at home and unable to do experimental work.

The leadership of our institute helped us to make suitable decisions to tide over the unpredictable situation. Even in this difficult time, the institute could complete some of the infrastructure projects and contribute significantly to the research activities. IIST continued its good position in the NIRF ranking in the current year as well at 40th position in the engineering category.

We have several collaborative projects with ISRO centres and the Advanced Space Research Group (ASRG) is spearheading the development of the systems necessary for bringing the institute closer to the ISRO centres in a mutually beneficial way.

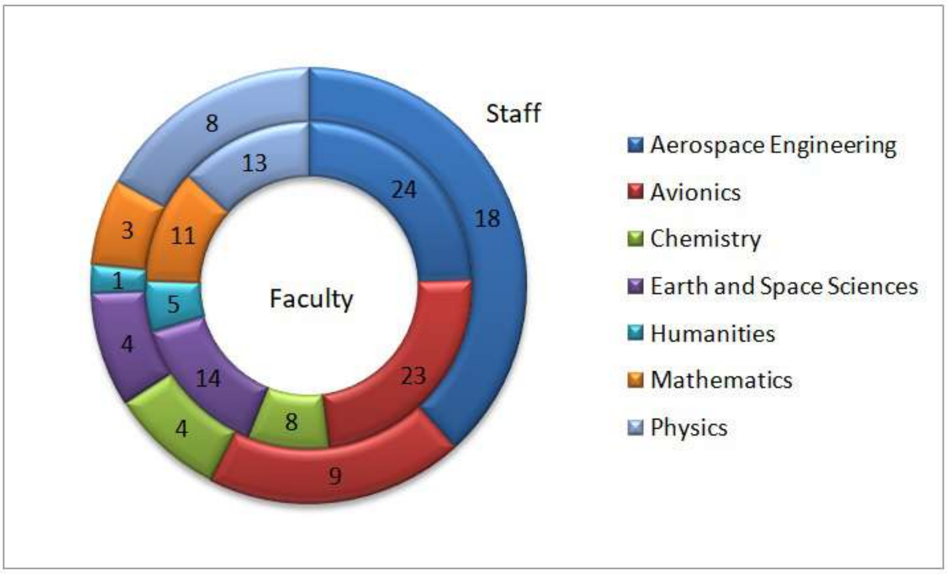
IIST graduated 118 BTech, 20 Dual Degree, 70 MTech and 17 PhD candidates in the 8th convocation conducted on 16th December, 2020. The Institute admitted 149 BTech, 135 MTech and 54 PhD students this year. ISRO offered placement for 100 BTech and dual degree graduates.

The institute wishes to charter a new path of growth by harvesting the benefits of the academic foundations and research. It would be imperative for us to augment the capacity building in terms of infrastructure and human capital to strive towards a world class institution of higher learning. We also look forward to the opening – up of the space sector and yearn to play a much bigger role in the future and hope to gain the status of the Institute of National Importance soon.

# IIST AT A GLANCE 2020-21

## Departments and its Strength

| Department | Academic Faculty | Technical/Scientific Staff |
|---|---|---|
| Aerospace Engineering | 24 | 7 |
| Avionics | 23 | 14 |
| Chemistry | 8 | 5 |
| Earth and Space Sciences | 14 | 13 |
| Humanities | 5 | 2 |
| Mathematics | 11 | 0 |
| Physics | 13 | 10 |




## Administration

| | |
|---|---|
| Officers | 13 |
| Administrative staff | 9 |

# Students Strength as on 31.03.2021

## B.Tech.

| Course | 2017 | 2018 | 2019 | 2020 | Total |
|---|---|---|---|---|---|
| Aerospace Engineering | 57 | 60 | 66 | 64 | 247 |
| Electronics & Communication Engineering (Avionics) | 53 | 60 | 65 | 61 | 239 |
| Engineering Physics | - | 19 | 22 | 20 | 61 |
| Total | 110 | 139 | 153 | 145 | 547 |

## M.Tech. / Master of Science

| Course | 2018 | 2019 | 2020 | Total |
|---|---|---|---|---|
| Machine Learning and Computing | - | 7 | 9 | 16 |
| Optical Engineering | - | 5 | 6 | 11 |
| Solid State Technology | - | 5 | 5 | 10 |
| Materials Science and Technology | - | 7 | 7 | 14 |
| Aerodynamics and Flight Mechanics | - | 7 | 10 | 17 |
| Thermal and Propulsion | - | 6 | 7 | 13 |
| Structures and Design | 1 | 8 | 4 | 13 |
| Control System | - | 7 | 8 | 15 |
| Digital Signal Processing | - | 7 | 9 | 16 |
| RF and Microwave Engineering | - | 5 | 8 | 13 |
| VLSI and Microsystems | - | 7 | 7 | 14 |
| Power Electronics | - | 5 | 8 | 13 |
| Geoinformatics | 1 | 5 | 10 | 16 |
| Earth System Science | - | 6 | 9 | 15 |
| Astronomy and Astrophysics | - | 4 | 7 | 11 |
| **Total** | **2** | **91** | **114** | **207** |

## Dual Degree

| Course | 2016 | 2017 | Total |
|---|---|---|---|
| Optical Engineering | 4 | 7 | 11 |
| Solid State Physics | 4 | 5 | 9 |
| Earth System Science | 4 | 4 | 8 |
| Astronomy and Astrophysics | 4 | 4 | 8 |
| **Total** | **16** | **20** | **36** |

## Ph.D

| Department | Full Time | Part Time |
|---|---|---|
| Aerospace Engineering | 31 | 18 |
| Avionics | 48 | 13 |
| Chemistry | 11 | 12 |
| Earth and Space Sciences | 36 | 4 |
| Humanities | 9 | 3 |
| Mathematics | 19 | 2 |
| Physics | 29 | 4 |
| **Total** | **183** | **56** |

# Other Details

| | |
|---|---|
| Post Doctoral Scholars | 3 |
| No. of Research Projects | 68 |
| No. of Journal Papers | 236 |
| No. of Conference Papers | 50 |
| No. of PhD Thesis Accepted | 17 |
| No. of Patents | 11 |

| | |
|---|---|
| Placement (B. Tech- ISRO) | 90 |
| Placement(M. Tech- Placement Cell) | 16 |
| MoUs signed | 5 |
| New Books/E-books/Reports added in the library | 3225 |

# RTI Status

From April, 2020 to March, 2021 (Decentralised the processing of applications under RTI and CPIO, IIST has been disseminating the information directly to the applicants)

| Application Received | Information given | Appeal | CIC Hearing |
|---|---|---|---|
| 28 | 28 | 02 | Nil |

# Vigilance Status

Number of Vigilance Cases: NIL

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# THE INSTITUTE


AEROSPACE BLOCK

# 1. THE INSTITUTE

Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram, Kerala is a Deemed to be University under Section 3 of the UGC Act 1956, established by Department of Space (DoS), Government of India, in 2007. The institute has moved to its fourteenth year by establishing the phase I of the originally conceived plan. IIST covers the whole spectrum of undergraduate and postgraduate programmes in different branches of Technology and Science streams with a focus to space science & technology. The academic programmes have been envisioned to strengthen the fundamentals, experience the realities through practical work, and enhance the knowledge and understanding in the areas relevant to the Aerospace sector. The institute provides an academic perspective to the activities of ISRO by retaining a symbiotic relationship through several sponsored projects, planning and review processes. The students of the Institute get several opportunities of internships and employment at various centres of ISRO.

The Institute recognizes the importance of research in developing future technologies and applications of space research. IIST encourages all its faculty members to guide and supervise young scholars for the PhD programme as well as for Post-Doctoral programmes. The major theme of our research portfolio is the application of cutting - edge science to generate new technology. The style of research in IIST is both theoretical as well as richly experimental, and the institute has set up state-of-the-art facilities in all departments to support its research activities. The Institute is focused on strong interdisciplinary and collaborative work both within the various departments and across the various centres of ISRO, which will help to generate excellent technologies responding to the need of local, national and global interest. IIST envisages to be a global leader in the areas of science and technology related to Aerospace sector in the days to come by capacity building in terms of infrastructure and human capital. IIST also has a number of international collaborations, both as MOU at the level of institute and faculty-to-faculty collaboration.

## NIRF 2021

National Institutional Ranking Framework (NIRF) set up by the Ministry of Human Resource Development (MHRD), Government of India to rank institutions in various categories ranked IIST as **40th in the Engineering category in year 2021** among all Engineering institutions in the country.

## ARIIA 2021

Atal Ranking of Institutions on Innovation Achievements (ARIIA) is an initiative of Ministry of Human Resource Development (MHRD), Govt. of India to systematically rank all major higher educational institutions and universities in India on indicators related to "Innovation and Entrepreneurship Development" amongst students and faculties. The ranking is based on seven parameters with certain weightages. IIST was ranked in **Band A under the category** of Government and Government aided Universities.

## STATUTORY BODIES OF THE INSTITUTE

# 1. The Governing Body

| | |
|---|---|
| K. Sivan | Secretary, DOS /Chairman ISRO<br>President |
| M. Maheshwar Rao | Joint Secretary & FA,DOS |
| R. Umamaheswaran | Scientific Secretary<br>ISRO Headquarters |
| S. Somanath | Director, VSSC |
| V. Narayanan | Director, LPSC |
| D.K.Das (till 31.12.2020)<br>Nilesh M Desai (from 01.01.2021) | Director, SAC |
| Santanu Chowdhury (till 31.12.2020)<br>Raj Kumar (from 01.01.2021) | Director, NRSC |
| Vinay Kumar Dadhwal | Director, IIST<br>Secretary |

# 2. IIST Governing Council

| | |
|---|---|
| K. Sivan | Secretary, DOS /Chairman ISRO<br>Chairperson |
| M Maheshwar Rao | Joint Secretary & FA,<br>DOS |
| Chintamani Manohar Sane<br>(till 29.10.2020)<br>G. Jayanthi (from 02.11.2020) | Joint Secretary (Finance), DOS – Invitee |
| R. Umamaheswaran | Scientific Secretary<br>ISRO Headquarters |
| Vinay Kumar Dadhwal | Director, IIST<br>Secretary |

# 3. IIST Board of Management

| | |
|---|---|
| Vinay Kumar Dadhwal | Director, IIST<br>Chairman |
| M Maheshwar Rao | Joint Secretary & FA<br>Department of Space |
| R. Umamaheswaran | Scientific Secretary, ISRO<br>Headquarters |
| V. Narayanan | Director, LPSC |
| Santanu Chowdhury (till 31.12.2020)<br>Raj Kumar (from 01.01.2021) | Director, NRSC |
| Partha Pratim Chakraborti | Director, IIT Kharagpur |
| Bhaskar Ramamurthi | Director, IIT Madras |
| A. Ajayaghosh | Director, NIIST |
| Anil Bharadwaj | Director, PRL |
| A. Chandrasekar | Dean (Academics and CE), IIST |
| Kuruvilla Joseph | Dean (SA, SW and OR), IIST |
| Raju K Gorge | Dean (R & D and IPR)<br>Outstanding Professor<br>Department of Mathematics, IIST |

| | |
|---|---|
| N Sabu | Professor<br>Department of Mathematics, IIST |
| Anoop C S | Associate Professor<br>Department of Avionics, IIST |
| Y. V. N. Krishna Murthy | Registrar, IIST<br>Secretary |

## 4. IIST Finance Committee

| | |
|---|---|
| Vinay Kumar Dadhwal | Director, IIST<br>Chairman |
| M. Maheshwar Rao | Joint Secretary, FA<br>Department of Space |
| Bijay Kumar Behera | Director, BEA<br>ISRO Headquarters |
| A. Chandrasekar | Dean Academics and CE |
| Raju K. George | Dean (R&D and IPR)<br>IIST |
| Y. V. N. Krishnamurthy | Registrar, IIST |
| Sivanandan G | Sr. Head Accounts / IFA<br>LPSC, Valiamala |
| R. Hari Prasad | Finance Officer - Member Secretary |

## 5. IIST Academic Council

| | |
|---|---|
| Vinay Kumar Dadhwal | Director, IIST |
| A. Chandrasekar | Dean, Academic & Continuing Education |
| Raju K. George | Dean, Research & Development and<br>Intellectual Property Rights |
| Kuruvilla Joseph | Dean, Student Activities, Students<br>Welfare & Outreach |
| K. Sudhakar | Former Professor, IIT Bombay |
| K. R. Ramakrishnan | Former Professor, IISc Bangalore |

| | |
|---|---|
| A. Ajayaghosh | Director, NIIST Trivandrum |
| K. Kurien Issac | Senior Professor<br>Department of Aerospace Engineering |
| C. S. Narayanamurthy | Senior Professor<br>Department of Physics |
| Aravind V | Professor & Head<br>Department of Aerospace Engineering |
| Deepak Mishra | Professor & Head<br>Department of Avionics |
| K. Prabhakaran | Professor & Head<br>Department of Chemistry |
| Samir Mandal | Associate Professor & Head<br>Department of Earth and Space Sciences |
| Lekshmi V. Nair | Associate Professor & Head<br>Department of Humanities |
| N. Sabu | Professor & Head<br>Department of Mathematics |
| Umesh R. Kadhane | Professor & Head<br>Department of Physics |
| A. Salih | Professor<br>Department of Aerospace Engineering |
| Deepu M | Professor<br>Department of Aerospace Engineering |
| B. S. Manoj | Professor<br>Department of Avionics |
| N. Selvaganesan | Professor<br>Department of Avionics |
| Nirmala Rachel James | Professor<br>Department of Chemistry |
| Sandhya K Y | Professor<br>Department of Chemistry |
| Anandmayee Tej | Professor<br>Department of Earth and Space Sciences |
| Rama Rao Nidamanuri | Professor<br>Department of Earth and Space Sciences |

| | | |
|---|---|---|
| Anand Narayanan | \| | Professor<br>Department of Earth and Space Sciences |
| Sarita Vig | \| | Professor<br>Department of Earth and Space Sciences |
| K. S. S. Moosath | \| | Professor<br>Department of Mathematics |
| C. V. Anil kumar | \| | Professor<br>Department of Mathematics |
| Deepak T G | \| | Professor<br>Department of Mathematics |
| S. Murugesh | \| | Professor<br>Department of Physics |
| Anindya Dasgupta | \| | Assistant Professor<br>Department of Avionics |
| Gigy J Alex | \| | Assistant Professor<br>Department of Humanities |
| Y. V. N. Krishnamurthy | \| | Registrar, Secretary |

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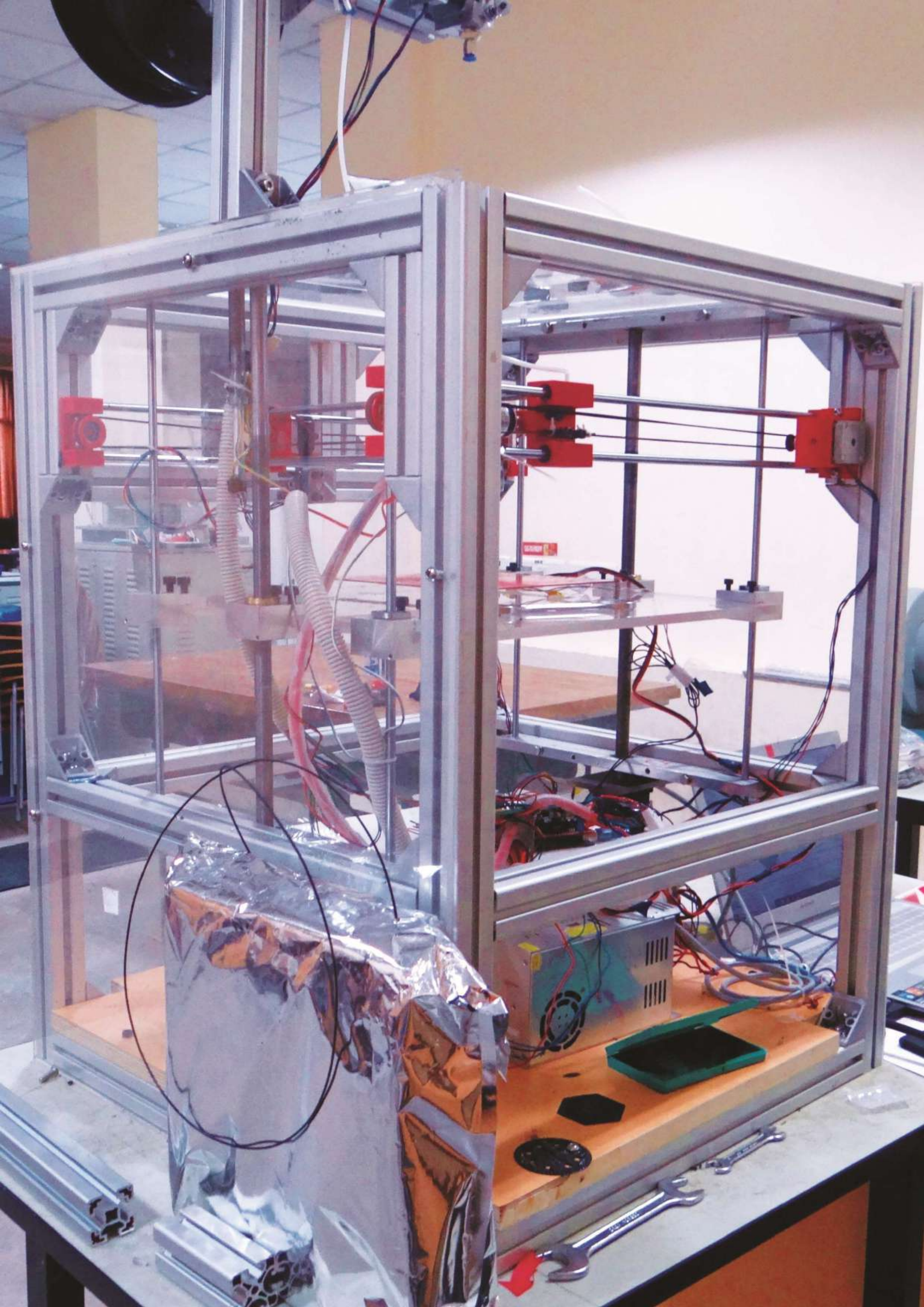
# ACADEMIC DEPARTMENTS



# 2. ACADEMIC DEPARTMENTS

The academic programmes of the institute are run by seven departments comprising of two engineering, four science and a humanities departments. Faculty members, Research Scholars, Laboratories and other relevant details of each department are as below.

## 2.1 Department of Aerospace Engineering

**IN NUMBERS**

24 Faculty Members
49 Research Scholars
43 M.Tech Students
07 Laboratory Staff/Technical Staff

Aerospace Engineering deals with the design and development of machines that can fly. These machines could be aircraft that fly within Earth's atmosphere such as gliders, fixed-wing aeroplanes and helicopters, or spacecraft that fly outside Earth'satmosphere.

The department offers one undergraduate degree (BTech) in Aerospace Engineering, three postgraduate degrees (MTech), and PhD programme. Aerospace engineering requires in-depth skills and understanding in physics, mathematics, aerodynamics, flight mechanics, propulsion systems and materials science. In the undergraduate programme, the students develop a basic understanding of these core areas. The postgraduate programmes are offered in three specialisations:

a) Aerodynamics and flight mechanics, b) Thermal and propulsion, c) Structures and design. These courses further strengthen the knowledge in the respective streams. The postgraduate courses give equal emphasis on research and design with the students having the option of taking advanced electives and design courses.

# Faculty & Core Research Areas

*Professor and Head of the Department*

**Aravind. V** | Laser Diagnostics, Combustion.
PhD (University of Florida, USA)

*Senior Professor*

**Kurien Issac K** | Kinematics, Dynamics and Robotics.
PhD (IIT, Madras)

*Adjunct Professor*

**Ramanan R V** | Space Missions: Optimal Trajectory / Manouvre Design. (superannuated 2020)
PhD (University of Kerala)

**Raveendranath P** | Advanced Finite Element Method.
PhD (IIT, Kharagpur)

*Professors*

**Abdusamad Alias Salih** | Numerical solution of multiphase flows.
PhD (IIT, Kharagpur)

**Deepu M** | Computational fluid mechanics, heat transfer and combustion.
PhD (NIT, Calicut)

*Associate Professors*

**Anup S** | Mechanics of biological and bioinspired composites.
PhD (IIT, Madras)

**Manoj T Nair** | Aerodynamics, Computational Fluid Dynamics.
PhD(IIT, Kanpur)

**Arun C O** | Structural mechanics, Computational Mechanics-Meshfree, methods, Finite element method, Stochastic mechanics, Structural reliability,Sloshing of liquid in tanks, Design of steel structures, Thin-walled structures etc.
PhD (IIT, Madras)

| | |
|---|---|
| **Bijudas C R**<br>PhD (IIT, Bombay) | Structural Health Monitoring |
| **Chakravarthy P**<br>PhD (IIT, Madras) | Processing maps for hot deformation, Flux assisted TIG welding |
| **Girish B S**<br>PhD (Anna University, Chennai) | Sequencing and scheduling issues in manufacturing systems and Air traffic management, vehicle routing and scheduling issues in supply chains. |
| **Manu K V**<br>PhD (IISc, Banglore) | Fluid Dynamics |
| **Pradeep Kumar P**<br>PhD (IIT, Bombay) | Two-phase flow and heat transfer, Electronic scale cooling in micro and macro |
| **Prathap C**<br>PhD (IIT, Delhi) | Fundamental and applied research in Combustion |
| **Praveen Krishna I R**<br>PhD (IIT, Madras) | Nonlinear Dynamics, Fluid Structure Interaction, Acoustics. |
| **Rajesh S**<br>PhD (University of Karlsruhe, Germany) | Optical and Laser Diagnostics, Combustion. |
| **Satheesh K**<br>PhD (IISc, Bangalore) | High Temperature Aerodynamics. |
| **Shine S R**<br>PhD (IIST, Thiruvananthapuram) | Heat Transfer in Space Applications. |
| **Sooraj V S**<br>PhD (IIST, Thiruvananthapuram) | Machining and Precision Manufacturing. |

**Vinoth B R** | Aerodynamics, Aeroacoustics, Unsteadyflows,
PhD (IIT, Kanpur) Flow instability, Experimentalmethods.

*Assistant Professors*

**Devendra Prakash Ghate** | Multidisciplinary optimisation.
PhD (University of Oxford, UK)

**Dhayalan** | Flight Dynamics, Aircraft SystemIdentification.
PhD (IIT, Kanpur)

**Mahesh S** | Jet/Swirl flame characteristics, Microcombustion.
PhD (IIT, Kanpur)

*Reader (on Contract)*

**Sam Noble** | Mechanical design, Optimal Design of mechanisms
M.Tech. (University of Kerala)

## Laboratory Facilities

Major lab facilities established under Department of Aerospace Engineering include

- Engineering workshop
- Strength of Materials Lab
- Engineering Drawing Lab
- Thermal and Propulsion Lab
- Fluid Mechanics Lab
- Heat Transfer Lab
- Computer Aided Design and Analysis Lab
- Metrology and Computer Aided Inspection Lab
- Manufacturing Processes Lab
- Materials Characterization lab
- Aerospace Structures Lab
- Aerodynamics Lab

- Flame Diagnostics Lab
- Flight Mechanics Lab
- Vibration Lab
- Health Monitoring Lab
- Micro Raman

The manufacturing processes lab and Engineering workshop under Department of Aerospace Engineering does effectively support many of the project and research related activities in IIST, encompassing all the departments in IIST.

Recently various equipment that were added to the laboratories include:
Electro-dynamic shaker units, Data acquisition system with software, Impacthammer, accelerometers, stereo microscope, condenser microphones, high speed LEDlight, tuned diode laser, high speed camera, dynamic and unsteady pressuretransducer, digital delay pulse generators and 6 workstations and A mini CNCplatform for lab scale testing/ experimentation purposes.


Vibration Lab


Micro Raman for Structural Measurement


Health Monitoring Lab

# 2.2 Department of Avionics

**IN NUMBERS**

23 Faculty Members

61 Research Scholars

00 Post Doctoral Fellows

71 M.Tech Students

14 Laboratory Staff/Technical Staff

The Department of Avionics ensures the deeper understanding on the fundamentals and advanced courses of Avionics with a special thrust to enhance research capability of students to undertake the challenges in the field of Avionics Engineering and allied areas. The department offers undergraduate course in Electronics and Communication with specialization in Avionics and post graduate courses in RF and Microwave Engineering, Digital Signal Processing, Control Systems, VLSI & Microsystems and Power Electronics. Moreover, the department also offers Ph.D. in various disciplines of Avionics/ Electrical/ Electronics/ Communication/ Computer Science Engineering/interdisciplinary areas. The department provides a vibrant and dynamic research ecosystem in the institute with expertise in all these areas.

## Faculty & Core Research Areas

### *Professor and Head of Department*

| | |
|---|---|
| **Deepak Mishra**<br>PhD (IIT, Kanpur) | \| Computer vision and graphics, image processing deep learning and artificial neural networks,biometrics, machine learning, soft computing, computational neuroscience, nonlinear dynamics. |

### *Adjunct Professor*

| | |
|---|---|
| **Sam K Zacharia**<br>Ph.D (IIST ,<br>Thiruvananthapuram) | \|Autonomous locomotion control of biped humanoid robot. Nonlinear mathematical modeling, compensator design and simulation of electro mechanical and electro |

hydraulic servo actuation systems and components. Digital autopilot design of launch vehicles and realization of mechatronic systems.

*Professors*

**Manoj B S**

PhD (IIT, Madras) | Computer networks, next generation Internet, ad hoc wireless networks, wireless mesh networks, wireless sensor networks, complex networks, cyber security, Internet of Things, Satellite Networks, Beyond 5G Networks, and Quantum Machine Learning.

**Selvaganesan N**

PhD (Anna University, Chennai) | Control system design, estimation theory, Biological modelling, fault diagnosis and fractional order control.

*Associate Professors*

**Anindya Dasgupta**

PhD (IIT, Kanpur) |Modelling and control of power Electronic (PE) converters, PE topologies and applications in distributed generation

**Anoop C S**

PhD (IIT, Madras) | Measurements and instrumentation, interface electronics, direct-digitizers, analog signal processing, biomedical electronic systems.

**Basudeb Ghosh**

PhD (IIT, Roorkee) | Computational electromagnetics, fractal, waveguide passive components, aperture antennas, Frequency Selective Surfaces (FSS), Electromagnetic Band Gap (EBG) structures, Substrate Integrated Waveguide

**Chinmoy Saha**

PhD (University of Calcutta) | Multifunctional UWB Antennas/

Reconfigurable Antennas. Antennas for SDR and CDR Applications. Dielectric resonator based WPT system.

**Harsha Simha M S** | Nonlinear dynamical systems and control.
PhD (IIT, Bombay)

**Lakshmi Narayanan R**
PhD (IIT, Madras) |Estimation, detection and signal processing algorithms.

**Palash Kumar Basu**
PhD (Jadavpur University, Kolkata) |Nanotechnology based Gas Sensor, THz devices, biosensor and flexible electronics.

**H Priyadarshnam**
PhD (IIT, Bombay) | Design, modeling and development of satellite systems and control systems.

**Rajeevan Puthan Purayil** | Power electronics – power converters – topologies and PWM techniques, control of multiphase drives, power quality,and renewable energy.
PhD (IISc, Bangalore)

**Rajesh Joseph Abraham**
PhD (IIT, Kharagpur) |Control systems and applications. Power systems control guidance and navigational control. Robust control and applications.

**Seena V** | NEMS Sensor Systems, CMOS-MEMS Sensors, Micro/Nanoelectronics, , Polymer MEMS
PhD (IIT, Bombay)

**Sheeba Rani J**
PhD (Anna University, Chennai) |Computer vision and pattern recognition, image analysis and understanding. Design and performance

evaluation of hardware solutions for signal and image processing techniques.

**Sooraj R**

PhD (GIST, South Korea) | Semiconductor optoelectronics and photonics, optical sensors, semiconductor nano-structures, optical interconnects and integrated circuits, photovoltaics, plasmonics.

**Sudharshan Kaarthik R**

PhD (IISc, Bangalore) | Power electronics, multilevel converters, electric drives, modulation andswitching techniques, power hardware in-the-loop emulation, grid connected systems, integrated battery chargers for EV, analog and digital circuit design.

### *Assistant Professors*

**Basudev Majumder**

PhD (IIT, Bombay) |Planar antenna and passive system design. Application of metamaterials and meta surfaces in antenna design. Reconfigurable antenna design.

**Chris Prema S**

PhD (IIST, Thiruvananthapuram) | Wideband spectrum sensing in CR, Multirate signal processing. Sub-nyquist techniques for spectrum sensing, Device to Device communication, efficient spectrum utilization for 5G communication

**Immanuel Raja**

PhD (IISc, Bangalore) | broad area of analog, mixed-signal and RF IC design. Developing low-power, efficient transmitters and receivers for RF communication

**Vani Devi M**

PhD (IIST, Thiruvananthapuram) | Signal processing in 5G communication- Massive MIMO channel estimation and decoding algorithm,

NOMA – SCMA receiver design, MIMO-OFDM system.
Joint Radar and communication system.
Error control coding – LDPC, TURBO decoder,
Polar code and real time RF communication in SDR.

| | |
|---|---|
| **Vineeth B S**<br>PhD (IISc, Bangalore) | Applied probability & stochastic processes, stochastic control and optimization for computing and communication systems, queueing theory, machine learning, performance analysis and optimization. |

## Laboratory Facilities

The department has excellent laboratory facilities and state-of-the-art software tools in various disciplines of Electrical Engineering, Electronics and Communications Engineering, and Computer Science and Engineering. These laboratories cater to the academic programs offered by the department at the undergraduate and postgraduate levels. Many post graduate laboratories in the department are equipped to support advanced research activities across various disciplines. The department has set up state of the art research facilities supporting advanced research for PhD, Post-Doctoral research programs and R&D projects across different thrust areas. Subsequent to the movement of the Department to Avionics Block at D3, the following teaching and instructional laboratories have been established. Many of these laboratories have also been augmented with additional facilities and upgrades.

### ❖ UG Laboratories:

| | |
|---|---|
| 1. Analog Electronics Lab | 2. Digital Signal Processing Lab |
| 3. Basic Electrical Lab | 4. ECAD Lab |
| 5. Basic Electronics Lab | 6. Instrumentation and Measurement Lab |
| 7. Computer Networks Lab | 8. Microprocessor and Microcontroller Lab |
| 9. Control System Lab | 10. Navigation Systems and Sensor Lab |
| 11. Digital Communication Lab | 12. Power Electronics Lab ( UG) |
| 13. Digital Electronics Lab | 14. RF and Microwave Lab (UG) |

## ❖ PG and Research Laboratories:

1. SSPACE Satellite ground station
2. Small Spacecraft Systems & Payload Centre (Electronics Fabrication & Research Lab)
3. Advanced Antenna Fabrication and Characterization Lab
4. Advanced Microwave Lab
5. Advanced Wireless Communication Research Lab
6. VLSI & Microsystems Lab
7. Micro/ Nanosystem characterization Lab
8. MEMS and Nano FAB Phase-1
9. NEM Sensor Systems Lab
10. Chemi Sens Lab (Gas Sensor and Bio Sensor Lab )
11. Internet of Things (IoT) Lab
12. Virtual Reality Lab
13. Image Processing/Computer Vision Lab
14. Communication Networks Lab
15. Power Electronics in Electrical Distribution System Laboratory
16. Power Electronics PG/Research Laboratory


Control Systems Lab
Digital Signal Processing Lab
Digital Communication Lab
Basic Electrical Lab


Navigation System Lab
Power Electronics (UG) Lab
Virtual Reality Lab
E-CAD Lab

# Research & Development laboratories

The department of Avionics has a strong focus on excellence in education through fundamental and applied research activities carried out by the faculty members and students. Hence the department is in the process of establishing various research laboratories to support these activities. Many post graduate laboratories in the department have also been equipped to support advanced research activities across various disciplines. Details of some of the laboratories are provided below: -

## NEMS and Opto – Nanoelectronics (NEMO)

Department of Avionics took the initiative towards development of an R&D ecosystem in the area of VLSI, Micro Electro Mechanical Systems (MEMS)/ Micro/Nanoelectronics/optoelectronics and sensors at IIST for academia, ISRO and other research organizations. Department has established laboratories and research facilities in the area of Micro-Electro Mechanical Systems (MEMS) and Micro/Nanoelectronics. These laboratories support the post graduate programme VLSI and Microsystems and research activities in the areas of micro/nano electronics, micro electromechanical systems (MEMS/NEMS), devices and technologies across all departments in IIST. Close collaborations have been established with many ISRO centres like IISU, VSSC, SCL and IPRC. These are either through formal collaborative projects for development of Micro/Nanosensors or service.

The following laboratories are being established as part of this activity.

- **VLSI & Microsystems Design Lab**

  - The VLSI design facility is equipped with high end computing facility, FPGA design kits (zynq , Virtex 7) with latest IDE softwares and state of art IC design design simulation tools.
  - Microsystems design facility is equipped with modelling, design and simulation tools for MEMS devices, Micro/Nanoelectronics devices and systems. (High end workstations, Coventorware and MEMS+ from Coventor,, Silvaco ATLAS and ATHENA TCAD, Sentaures TCAD 3D Process and Device TCAD from Synopsis, COMSOL Multiphysics etc.)

### ❖ Micro/Nanosystems characterization and NEMS Sensor Systems Lab

Micro/Nanosystems characterization and NEMS Sensor Systems laboratories have been established with characterization equipment for electrical and mechanical characterization of micro/nano-scale devices, VLSI and NEMS sensor systems with funding support from institute and research projects.


### ❖ MEMS an NanoFAB (Microfabrication laboratory)

MEMS/Micro/nanofabrication facility is for 4″ silicon wafer substrates with upgradability for 6″ wafers. Phase-1 of MEMS &NanoFAB has been established with the major equipments for MEMS and microfabrication processes such as deposition tools, photolithography mask aligner, plasma etch tools etc. with funding support from institute and research projects.

The Phase-II of MEMS &NanoFAB with 140 SQM Class 1000/Class 100 cleanrooms has also been designed and are in the process of commissioning.

Masters and PhD students carry out their academic and research projects in these laboratories. The research work under the umbrella of NEMO focus on the indigenous development of miniaturized low power/self-powered smart sensor systems. Metal oxide-based gas sensors, MEMS Accelerometers with ultra-low cross axis sensitivity, CMOS-MEMS Accelerometers, Nanomechanical Sensors, silicon photonics-based devices are just a few examples of miniature sensors/systems being developed. The research activities carried out by us could invite research funding through various sponsored projects from ISRO, Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Department of Biotechnology (DBT), ISRO Human Space Program (HSP) etc. Some of the recently completed and on-going projects are as follows:-

- MEMS Accelerometer with Ultra-Sensitive Transductions (**IIST-ISRO**)
- TMDCs based FETs for Nanomechanical Bio/chemical Sensor (**SERB/DST**)
- Passive and active optical waveguide for optical interconnects (**IIST Fastrack**)
- Nanomaterial Based Exosome Sensor for Cancer Prognostic(**DBT**)
- Polymer MEMS Sensor and energy harvester (**SERB Women Excellence Award/DST**)
- Design and implementation of SAR ADC (**IIST/ISRO**)
- Low power design of Flash ADC (**IIST/ISRO**)
- IRNSS Receiver (**MeiTY Project**)

## Power Electronics Research Lab

1. Power Electronics in electrical Distribution System Laboratory
2. Power Electronics PG/Research Laboratory

This lab incorporates the research work of B. Tech, M. Tech and PhD students in the area of power electronics and drives. Research works are done in the area of electric drives, multilevel inverters, multi-phase drives, grid connected systems, battery chargers, solid-state transformers, and high performance DC-DC converters.

Research for improved performance of drives through different control schemes such as Direct Torque Control and Space Vector based PWM schemes for five phase machines, six-phase and conventional three-phase machines have been implemented. Works based on innovative control of series and parallel connection of six phase permanent magnet machines are being carried out in the lab. Research on grid connected systems include sensorless control for single phase integrated battery charger and Integrated battery charger using three-phase supply with split phase induction machines. Multilevel inverters based on dodecagonal space vector modulation schemes using cascaded H-bridges were implemented. Research on power quality improvement using STATCOM with novel control techniques have been performed.

Project works on the control strategies for BLDC motors and Hub motors are also being carried out in the lab. Low power high efficiency isolated DC-DC power supply with both voltage control and current control mode was designed, built and tested in the lab. Distribution system based 1.5 kVA Solid state transformer hardware is being developed and currently some developed modules are under test. Furthermore, on-board electronics and Electrical Power System EPS for small satellites and payloads are designed and built in this lab.



## Chemi Sens Lab (Gas and Biosensor Lab)

The main activity of this lab is to carry research on gas sensor and biosensor. The facility is equipped with thr ee gas calibration facility which is upgrading to multi gas calibration facility to calibrate the gas sensors in different environment. The facility is also having material synthesis unit (nano materials) to develop gas sensors. Similarly, the lab is well equipped to carry the research activity in the field of biosensor. At the moment it is looking to develop first prototype for liquid biopsy of cancer. The upgradion is going on to include the cell culture facility.

The lab has a facility to characterize the gas sensor for four gases together. Now, the lab is upgrading to handle eleven gases including explosive and toxic volatile compounds. It is also having a facility to develop electrochemical sensors for various applications. Bio sensor Lab is a cell culture research lab (for PhD) purpose of this lab is for continuous growth of cancer cells and their utilization for studying the properties of its contents (protein/DNA/RNA). a study of extra cellular vesicles(that are released by the cancer cells) can also be performed in this lab.Gas sensor lab is equipped with instruments like gas calibration system, spectrometer, furnace; microwave synthesizer etc focuses on designing and characterization of gas sensors especially applicable for space missions.

Unidentified leakage of different toxic and explosive gases during the space missions can cause lot of harm to the space crew and flight and thus requires timely detection of such gases and immediate generation of warning. In gas sensor lab student works on optimization of the material for the sensors which will be used as the base for reaction between the sensor and the target gas. Secondly they also focus on designing of the sensors for maximum efficiency. Characterization of the sensor material done for detail and proper understanding of the physical and chemical properties.


## ChemiSens lab: Avionics Block

- Centralized sensor lab facility (125 sq m).
- Separate sections for material preparation and gas sensing.
- Separate section for Bio sensing activity
- The lab is upgrading to handle 11 gases at time.
- It will have a gas storage bay (65 sq m) out the building to accommodate 65 gas cylinders

## Rf and Microwave Research Lab

1. Advanced Antenna Fabrication and Characterization Lab
2. Advanced Microwave Lab

Microwave Lab of the Department of Avionics is equipped with state of the art facilities in frontier areas of microwave circuits and antennas across various electromagnetic spectrum and caters to the research activities of PhD and M.Tech. Students along with various other R&D projects. This lab caters to the various advanced research in diversified areas, like, advanced electromagnetics, antenna technology, microwave and mm-wave circuits, metamaterials, THz Technology, wireless power transfer, energy harvesting etc.

Figure-1: Glimpses of the selective major equipments and devises/antennas/system realized by the M.Tech. RF and Microwave students at IIST

Thanks to the availability of the well-equipped antenna fabrication facilities and high frequency measuring instruments in this laboratory, students get ample exposure on various practical experiments, hands-on experience and associated system aspects through various research projects of Department of Science and Technology, (Government of India), ISRO centres along with IIST projects. Various projects in collaboration with various ISRO Centres, executed in this lab are :

- Design and Implementation of a Helmet Antenna : Dr.Basudeb Ghosh (IIST)
- Design and Implementation of a Compact Wideband Microstrip Patch Antenna (Completed) (Dr.ChinmoySaha, IIST and Mr. Mukundan, VSSC)
- Design and implementation of Integrated Tri-Band Monopulse Auto-Tracking Feed for Remote Sensing Satellite Communications (Dr.ChinmoySaha, Dr.Basudeb Ghosh, IIST, S. S. Roy, T Naga Sekhar and G Baig, NRSC)
- SIW based Horn Antennas for MM wave Applications (IIST and SAC, Ahmadabad)
- Design of Photoconductive Antenna for THz Applications (IIST, SAC, Ahmadabad, IISER Trivandrum)

**Existing Computational and Characterization Facility in this lab:**

- Simulation softwares: Ansys HFSS, CST, FEKO, ADS
- Fabrication Facility: Mechanical (Drilling and Milling) based PC
- Measurement facility: VNA (Agilent PNA-X N5224A), Spectrum Analyzer, Signal Generator (Upto 40 GHz)

Figure-1 shows the glimpses of the some of the research equipment /facilities along with few selected prototypes developed by the PhD/ M.Tech. RF and Microwave Engineering students under the supervision of the faculty members of the group.

## Navigation System Laboratory

This lab was set up to provide hands-on training in the field of navigation Systems and sensors. Various experiments like calibration of inertial sensors such as servo accelerometers, MEMS accelerometers, Dynamically Tuned Gyroscopes, MEMS gyroscopes are performed in the lab. Navigation system level tests such as rate test, multi-position test, all attitude test, Hardware in loop tests are planned to be carried out in this lab. In addition, provisions for carrying out the simulation of an inertial navigation system are provided to impart training on different navigation algorithms in different navigation frames.

Major equipment such as servo accelerometer check-out system, DTG check-out system, 2-axis Angular Motion Simulation set up, 3-axis dividing head setup are available in the lab. Further, Navigation System packages which are used in the PSLV, GSLV Mk-3 are available for demonstration in the lab. Significantly, the lab has one of the first few deployed IRNSS receivers across the country, and two portable IRNSS receivers and ISRO-SAC in-house developed IRNSS simulator. This gives focus on satellite navigation receiver design for GPS, IRNSS(NAVIC) etc.

Satellite attitude control test setup

## IIST Systems and Networks Laboratory

Systems and Networks Lab (SNL) is one of the major research labs of the Department of Avionics, Indian Institute of Space Science and Technology. SNL focuses on research activities in the broader area of computer and communication networks. Major research areas include multihop wireless communication networks (e.g., Mobile Ad-hoc Networks (MANETs), Wireless Mesh Networks (WMNs), and sensor networks), Delay Tolerant Networks (DTNs), Software Defined Networks (SDNs), Satellite Networks, Internet of Things (IoT), network security, complex networks, graph signal processing, and quantum computing. As part of the research, a WMN testbed "IIST MeshNet" was set up to analyze the behavioral characteristics of multihop wireless networks.

At present, the advanced networking techniques such as SDN is integrated to wireless environments in order to analyze network control at finer levels. As far as

Internet of Things (IoT) is concerned, the lab includes different sensors specially to develop the concept of smart homes. The lab also equipped with an enterprise level network testbed to simulate different malware behaviors and, thereby, developing solution to detect and prevent them.

The resources available in SNL include:

- Network testbeds (Wireless Sensor Network testbed, Wireless Mesh Network testbed,Software-defined Wireless Mesh Network Testbed )
- Hardware (Alix3d3 boards, Inforce IFC 6410 board, Raspberry Pi boards (Pi3, Pi4, and PiZero), Intel Galileo GEN 2 for IoT applications, IRIS motes and sensors, Arduino UNO/NANO boards, Various types of IoT sensors Software, ● Network Simulator Software (e.g., Network Simulator - 2 (Ns-2), Ns-3,Global Mobile Simulator (GloMoSim), Stanford Enhanced GloMoSim, and OMNET++ Network Simulator)
- Sensor Simulator Software (e.g., MoteView, MoteConfig, Admin/Config ,Software for long-range sensors, and TinyOS sensor OS) ,Mesh Network Simulator Software (e.g., Voyage Linux OS for mesh, routers, MadWiFi Driver Software for Atheros chipset, OLSR/DSR/AODV ,Routing Protocols) ,NetSim Standard Version 10.2 and NetSim Standard Version 11

Advanced Wireless Communication Research Lab

The Advanced Wireless Communication Laboratory conducts research in the broad area of Wireless communications with focus on signal processing in the physical layer. Major research activities includes:

- Signal processing for Wireless communication systems
- Cognitive radio/dynamic resource allocation
- Full-duplex radio/Hardware-based modelling and signal processing techniques
- Software radio/USRP experimental implementation
- Hybrid beamforming for mm wave communication
- OFDM/OTFS system for joint radar and communication system
- MIMO OFDM system – channel estimation and decoding
- Radar signal processing

This lab consists of state of the art equipment and development tools that can be used for real time signal processing and communication. The existing hardware and software tools in the lab are:


Hardware

- Universal Software Radio peripheral Transceivers (USRP N210) – carrier frequency up to 6GHz and bandwidth 20 MHz
- Daughter card UBX 40, LFTX (DC-30MHz), LFRX(DC-30MHz)
- OCTOCLOCK-G 8-channel clock distribution module
- GPS Antenna
- VERT400 Antenna -144MHz, 400MHz,, 1200MHz
- Log periodic Antenna- 400MHz-1GHz, 850 MHz -6.5GHz
- ADALM PLUTO Analog device SDR 325MHz- 3.8GHz
- PXB Baseband generator and Channel Emulator N5106A
- EXA spectrum Analyzer 26.5GHz
- MXG Vector Signal Generator 6GHz

- RF Development Tool-AD9364 software development board AD-FMCOMMS4-EBZ
- Xilinx Zynq-7000 All programmable ZC706 Evaluation SoC

Software

- Matlab Software
- Agilent SystemVue Software
- Agilent VSA software

## 2.3 Department of Chemistry

IN NUMBERS

08 Faculty Members
23 Research Scholars
01 Post Doctoral Fellows
14 M.Tech Students
05 Laboratory/Technical Staff

Department of Chemistry is teaching in the undergraduate and postgraduate level where strong foundations are laid facilitating the design and development of novel materials and processes to meet future technological challenges. The department offers Chemistry courses (core as well as electives) for B.Tech programmes of the institute, M.Tech programme in Materials Science and Technology and PhD programs.

### Faculty & Core Research Areas

*Professor & Head of Department*

**Prabhakaran K**
PhD (CSIR-NIIST, University of Kerala) | High temperature materials, materials for environmental applications, ceramic powder processing

*Outstanding Professor, Dean (Student Activities)*

**Kuruvilla Joseph**
PhD(CSIR-NIIST, MG Univ., Kottayam) | Polymer nanocomposites for electronic and structural applications, Bio-nanosensors for biomedical applications, Elastomers and blends, Bio-composites.

*Professors*

| | | |
|---|---|---|
| **Nirmala Rachel James**<br>PhD (CSIR-NCL, Pune University) | \| | Step growth polymers, Polymers for medical applications, Hydrogels for tissue engineering. Nanofibers for biomedicalapplications, polysaccharide based nanomaterials for drug delivery applications, light emitting polymers, nanocomposites. |
| **Sandhya K Y**<br>PhD (CSIR-NIIST, University of Kerala) | \| | Electrochemical Energy storage and sensing, photocatalysis, Adsorption-Removal of pollutants from water. |

*Associate Professors*

| | | |
|---|---|---|
| **Gomathi N**<br>PhD (IIT, Kharagpur) | \| | Surface modification, nanomaterials, sensors. |
| **Jobin Cyriac**<br>PhD (IIT, Madras) | \| | Chemical Sensors, Nanomaterials, Mass Spectrometry. |
| **Sreejalekshmi K G**<br>PhD (University of Kerala) | \| | Computational and Synthetic Organic Chemistry. |
| **Mary Gladis J**<br>PhD (CSIR-NIIST, University of Kerala) | \| | Energy storage materials: Metal-Sulfur batteries and supercapacitors, Trace and ultratrace analysis. |

## Laboratory Facilities

Department of Chemistry has various facilities to support the project and research activities of IIST. Major laboratories established under department of chemistry are

Polymer processing lab
Nanomaterials lab
General chemistry lab
Inorganic chemistry lab
Material characterisation lab
Battery/OLED fabrication lab
Physical chemistry lab
Organic chemistry lab


Polymer processing lab

Nano materials Lab

# 2.4 Department of Earth and Space Sciences

**IN NUMBERS**

14 Faculty Members

40 Research Scholars

31 M.Tech Students and 11 M.S. Students

16 Dual Degree

13 Laboratory Staff/Technical Staff

The department is inter-disciplinary in nature, bridging gaps between technology and its application to fundamental research areas in physical sciences. The faculty of the department carry out research in four broad areas: (i) Astronomy & Astrophysics, (ii) Atmospheric Sciences, (iii) Geology and (iv) Remote Sensing. It offers two Dual degree Masters programs (Astronomy & Astrophysics, Earth System Science). It also offers post-graduate programs in Astronomy & Astrophysics, Earth System Science and Geoinformatics. In addition, PhD programs are offered in the main areas of research, namely, Astronomy & Astrophysics, Atmospheric Sciences, Geology and Remote Sensing.

## Faculty & Core Research Areas

*Associate Professor & Head of Department*

**Samir Mandal** | High Energy Astrophysics.

PhD (Jadavpur University, Kolkata)

*Outstanding Professor, Dean (Academics & CE)*

**A Chandrasekar** | Mesoscale modeling, data assimilation

PhD (IISc, Bangalore)

## *Professors*

| | |
|---|---|
| **Anandmayee Tej**<br>PhD (PRL, Ahmedabad<br>affiliated to Gujarat University) | High-mass star formation and their feedback on surrounding ISM, Particle acceleration in stellar systems, Exoplanets |
| **Rama Rao Nidamanuri**<br>PhD (IIT, Roorkee) | Hyperspectral and LiDAR remote sensing. |
| **Sarita Vig**<br>PhD (TIFR, Mumbai) | Massive star formation, Protostellar jets, Hots stars in globular clusters |
| **Anand Narayanan**<br>Ph D (Pennsylvania State University, USA) | Spectroscopic observations of galaxies and intergalactic medium |

## *Associate Professors*

| | |
|---|---|
| **Gnanappazham L**<br>PhD (University of Madras) | Remote sensing and coastal resources management, monitoring of mangroves using satellite data |
| **Govindan Kutty M**<br>PhD (IIT, Kharagpur) | Atmospheric Modelling, Data Assimilation, Predictability |
| **Jagadheep D**<br>PhD (Cornell University, USA ) | Massive star formation, 6.7 GHz methanol masers, HII regions |
| **Rajesh V J**<br>PhD (Yokohama National University, Japan) | Mineralogy, Igneous Petrology, Planetary Geology & Terrestrial Analogues for Planetary Exploration |
| **Resmi L**<br>PhD (IISc, Bangalore) | Gamma Ray Bursts, Gravitational Wave Astronomy, High Energy Astrophysics |

### *Assistant Professors*

**A M Ramiya**
PhD (IIST, Thiruvananthapuram)

| Automated processing of LiDAR point cloud, Applications related to natural and man-made resource management.

**P R Sinha**
PhD (TIFR Balloon Facility, Hyderabad affiliated to Pt. Ravi Shankar Shukla University, Raipur)

| Balloon-borne and ground-based measurements of aerosols, Aerosol-cloud interaction.

**Sayantani Ojha**
PhD (Savitribai Phule Pune University)

| Climate Modeling, Sea level variability, Air-Sea interaction processes

## Laboratory Facilities

Geology Lab

Astronomy & Astrophysics Lab

Atmospheric Science Lab

Remote Sensing Lab

The department has developed various facilities across sub-disciplines for research and Under Graduate / Masters courses.

### Atmospheric Science Lab

Atmospheric science lab is equipped with start-of-the art field instrumentation for the measurement of aerosol optical/physical properties and cloud microphysics along with meteorological variables for constraining important processes associated with aerosol-cloud interactions to develop robust aerosol models for air quality and climate research. These instruments are also extensively used for teaching courses. The lab also has the computing facilities for weather data processing and analyses.

### Astronomy & Astrophysics Lab

This group has set up an experimental and computational lab along with the Astronomical Observatory. A CCD characterisation experiment set-up is routinely used for the UG and PG courses. In addition, the lab is equipped with a blackbody, infrared photometer and a spectrograph, used in teaching and outreach. The lab includes computing facilities for Astronomical Data Analysis and Computational Astrophysics courses. Two telescopes, a 14-inch Cassegrain and a 8-inch Newtonian, are housed in the Observatory. These are extensively used for teaching and outreach.

### Geology Lab

The geology lab has a geological museum with a good collection of rock samples, ore minerals, rock forming minerals, precious and semi-precious minerals, and various faunal and floral fossils. The lab also has a variety of terrestrial analogue minerals and rocks to study the geological conditions and evolution of the Moon and Mars. 3D models of various geomorphological features are available to teach the basic geological concepts. The lab hosts an advanced petrological trinocular microscope (Nikon Eclipse LV100 optical microscope) and a dedicated petrological microscope equipped with heating freezing stages for the fluid inclusion research. The research on planetary geosciences includes processing and interpretation of satellite data from Moon and Mars for terrain morphology and spectral characterization of various rocks and minerals and terrestrial analogue sites for planetary exploration of the Moon and Mars. The softwares required for processing satellite images and other planetary planetary data are also available.

### Remote Sensing Lab

Remote sensing lab is installed with an updated set of remote sensing and image processing software for multispectral, hyperspectral and LIDAR data of field/ air/ space borne data and GIS softwares for 3D geospatial data analysis. Good amount of satellite data archive is available as a repository which is also used for the regular lab sessions, internships and projects of B. Tech and M Tech students. Further research activities on various fields of geospatial technology are supported by necessary field data collection equipments such as spectro-radiometer, Plant canopy analyser, Differential Global Positioning System, hyperspectral imager, Terrestrial Laser Scanner etc. benefiting the research scholars.

# 2.5 Department of Humanities

**IN NUMBERS**

**05 Faculty Members**
**01 Post Doctoral Fellow**
**12 Research Scholars**
**02 Laboratory / Technical Staff**

The Humanities department plays a unique and distinctive role in IIST where the ethos of science and technology prevails. The department tries to bring in a holistic education that necessitates the study of the language, management and social sciences so that the application of the sciences for the improvement of the quality of life is accompanied by humanitarian and social concerns. In addition to the carefully designed undergraduate programs (core as well as electives), the department offers opportunities and facilities for the pursuit of research in Economics, English, Management and Sociology.

## Faculty & Core Research Areas

*Associate Professor & Head of Department*

| | |
|---|---|
| **Lekshmi V Nair**<br>PhD (University of Kerala) | Science, Technology and Society, Study of Marginalized Communitie |

### *Associate Professors*

| | |
|---|---|
| **Ravi V**<br>PhD (IIT, Delhi) | \| Operations Management, Supply Chain Management, Quantitative modelling, General Management |
| **Babitha Justin**<br>PhD (University of Hyderabad) | \| Gender and Travel, Cultural Studies |
| **Shaijumon C S**<br>PhD (University of Kerala) | \| Technology diffusion and development, Space Economics and Development Economics, Macro Economy, Climate change and Economic development |

### *Assistant Professor*

| | |
|---|---|
| **Gigy J Alex**<br>PhD (M G University) | \| Cultural Studies, Gender Studies, Science Fiction |

## Laboratory Facilities

**Audio Visual Lab**

The Audio Visual Lab is intended to be utilized for creating audio and video modules, study materials, to create content generation for lectures (both online and offline), documentaries, etc, by the faculty members, students and the administrative fraternity of the Institute.

It has

- Multiple Camera Setup
- Support equipment
- Editing Facilities
- Multicolor backdrop chroma curtain
- DVD Authoring facilities for Programme distribution

The main objectives of the AV Lab are: • Creation of courseware video lectures in line of Stanford 'Openclassroom', MIT 'Opencourseware', IIT-M initiative NPTEL, Virtual Labs of MHRD, etc • Hardspots graphics/animation/video creation: Multimedia enriched Audio Visual Learning • Enhancing Communication Skills of the students by Multimedia Feedback system (MFS) • Content and Materials Development • Recording of Interviews, talks of Dignitaries, expert lectures, etc • Offline lecture content: To Create a Virtual Learning Environment at IIST for Societal needs (to study the impact of satellite communication in the society)

**Language Lab**

Department of Humanities has a multimedia-based language lab for enhancing the language proficiency of students. Currently, we make use of the language learning software provided by Orell Digital language lab and Edutech. These language teaching and learning tools are effectively structured to enhance the listening, speaking, reading, and writing (LSRW) skills of the students. A batch of forty students can attend the lab per session. The language learning space is structured like two semicircles where the students will work on their individual computers and the work will be monitored by the teachers PC. There is an open space for the performance of students like role plays and other language lab exercises. They can give their individual and team presentations also in the lab.

## 2.6 Department of Mathematics

**IN NUMBERS**

11 Faculty Members

21 Research Scholars

16 M Tech Students

Department of Mathematics offers courses at undergraduate and postgraduate level for Aerospace and Avionics Engineering branches. Department also runs an

M.Techprogramme in Machine Learning and Computing. Research in the department mainly focus on various areas of pure as well as applied mathematics, including Control Theory, Numerical analysis, Partial Differential Equations, Commutative Algebra, Machine Learning, Differential Geometry, Stochastic Modelling & Analysis, Queuing Theory and Time Series Analysis etc. Faculty members have strong research collaboration with reputed Indian institutions such as IITs and IISc etc. and international institutions include: Monash University, Australia, University of Concepcion, Chile and University of Bio-Bio, Chile. Moreover, the department is also actively engaged in other activities like organizing training/nurture programmes in mathematics for undergraduate/postgraduate students as well as seminars/workshops by renowned scientist from various parts of the world.

## Faculty & Core Research Areas

### *Professor & Head of Department*

| | |
|---|---|
| **Sabu N**<br>PhD (University of Madras) | Partial Differential Equations, Homogenization. |

### *Outstanding Professor, Dean (Research & Development and IPR)*

| | |
|---|---|
| **Raju K George**<br>PhD (IIT, Bombay) | Mathematical Theory of Control, Machine Learning, Industrial Mathematics |

### *Professors*

| | |
|---|---|
| **Anilkumar C V**<br>PhD (CUSAT) | Nonlinear Dynamics and Chaos, Time series Analysis. |
| **Subrahamanian Moosath K S**<br>PhD (University of Hyderabad) | Differential Geometry and Applications. |
| **Deepak T G**<br>PhD (CUSAT) | Probability theory and Stochastic processes. |

### *Associate Professors*

| | |
|---|---|
| **Kaushik Mukherjee**<br>PhD (IIT, Guwahati) | Numerical Analysis of Singularly Perturbed Differential Equations. |

| | |
|---|---|
| **Prosenjit Das**<br>PhD (Indian Statistical Institute, Kolkata) | Commutative Algebra and its applications to Affine Algebraic. |
| **Sarvesh Kumar**<br>PhD (IIT, Bombay) | Computational Partial differential equations, finite element methods, finite volume methods, virtual element methods. |
| **Natarajan E**<br>PhD (IIT, Madras) | Numerical analysis. |
| **Sumitra S**<br>PhD (Sheffield University, England) | Machine Learning, Data Mining. |

*Assistant Professor*

| | |
|---|---|
| **Sakthivel K**<br>PhD (Bharathiar University, Coimbatore) | Control and Inverse Problems of Partial Differential Equations |

## Laboratory Facilities

The following laboratory facilities are available to support the teaching programme for the undergraduate and post graduate students of IIST department.

Programming Lab

M.Tech Machine Learning and Computing Lab

The detailed information about the above mentioned Labs are furnished below:

### Programming Lab

- 55 Desktop Computers with Internet facility.
- Dual Operating Systems (Windows and Linux).

- C, C++, MATLAB courses.

**Machine Learning and Computing Lab**

- A High-end GPU Workstation, 2 x 8 Core Intel Xeon Processor with 256 GB RAM, 3.2 Ghz Speed, 25MB Cache, NVIDIA GTX 1080 8GB Graphics, NVIDIA Tesla K80 24GB GPU and 24 inch LED Monitor.
- 4 High-end Workstations, 8 Core Xeon Processor with 80 GB RAM, 2.4 Ghz Speed, 20MB Cache, NVIDIA Quadro K4200 Graphics and 24 inch LED Monitor.
- A brain computer interface with 16 channel EEG recording unit.
- Artificial Neural Networks, Pattern recognition and Machine Learning, Modelling and Simulation Lab courses.
- 10 desktops with Intel i5 3.2 GHz CPU and 4 GB RAM.

# 2.7 Department of Physics

**IN NUMBERS**

13 Faculty Members
33 Research Scholars
21 M. Tech
20 Dual Degree
10 Laboratory / Technical Staff

The Department of Physics offers a five-year dual-degree programme where the students receive a B.Tech. in Engineering Physics and a Master of Science in Solid State Physics or Master of Technology in Optical Engineering. The department also offers independent M. Tech. programs in Solid State Technology and in Optical Engineering. The members of the department are actively involved in research in diverse areas of physics, which is supported by a flourishing Ph. D. programme.

## Faculty & Core Research Areas

*Professor & Head of Department*

**Umesh R Kadhane** | Atomic and Molecular Physics.
PhD (Tata Institute of Fundamental Research, Mumbai Affiliated to University of Mumbai )

*Senior Professor*

| | |
|---|---|
| **Narayanamurthy C S**<br>PhD (IIT, Madras) | Applied and Adaptive Optics. |

*Associate Professors*

| | |
|---|---|
| **Apoorva Nagar**<br>PhD (Tata Institute of Fundamental Research, Mumbai) | Nonequilibrium Statistical Mechanics and Biological Physics. |
| **Kuntala Bhattacharjee**<br>PhD (Institute of Physics, Bhubaneshwar Affiliated to Utkal University) | Experimental condensed matter physics. |
| **Jinesh K B**<br>PhD (University of Twente, Netherlands)<br>PhD (Leiden University, Netherlands) | Semiconductor and device physics. |
| **Murugesh S**<br>PhD (University of Madras) | Nonlinear dynamics: Integrable systems and solitons. Applications to spintronics. |
| **Solomon Ivan J**<br>PhD (Institute of Mathematical Sciences, Chennai Affiliated to Homi Bhabha National Institute) | Classical Optics, Quantum Optics, Quantum Information. |
| **Sudheesh Chethil**<br>PhD (IIT, Madras) | Quantum Information, Quantum Optics and Nonlinear Dynamics. |
| **Jayanthi S**<br>PhD (IISc, Bangalore) | Nuclear Magnetic Resonance, pulse sequence development and applications. |
| **Naveen Surendran**<br>PhD (Institute of Mathematical Sciences, Chennai) | Condensed matter theory. |

### *Assistant Professors*

**Ashok Kumar** | Experimental Quantum Optics

PhD (PRL, Ahmedabad Affiliated to Mohanlal Sukhodia University, Udaipur)

**Dinesh N Naik** | Spectrally resolved incoherent holography for space based imaging.

PhD (The University of Electro Communication, Tokyo)

**Sourin Mukhopadhyay** | Spectroscopic studies on correlated electrons systems.

PhD (Tata Institute of Fundamental Research, Mumbai)

## Laboratory Facilities

Atomic and Molecular Physics Lab

Modern Physics Lab

Applied and Adaptive Optics Lab

Electronic Materials and Devices Lab

Space-Technology Innovations Lab

Solid State Technology Lab

Electric Propulsion Diagnostic Lab

The following laboratories with state-of-the-art facilities support the research and teaching programmes of the department.

- Applied and Adaptive Optics
- Atomic and Molecular Physics
- Computational Physics
- Electronic Materials and Devices (EMERALD)
- General Physics
- Lasers and Photonics
- Modern Physics
- Optics
- Solid State Technology Lab
- Space Technology Innovations and Characterization Lab (STIC)
- Electric Propulsion Diagnostic Lab

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# ACADEMIC PROGRAMMES

# 3. ACADEMIC PROGRAMMES

The institute offers two undergraduate, a dual degree, fifteen post-graduate programmes and full-time/part-time PhD programmes.

The undergraduate program comprises of BTech in Aerospace Engineering and BTech in Electronics & Communication Engineering (Avionics), each with 66 seats annually and a dual degree program with BTech in Engineering Physics with 22 seats. Students of the Dual degree programme spend an additional fifth year to acquire either Master of Technology degree in Optical Engineering or Earth System Sciences, or Master of Sciences in Astronomy or Astrophysics or Solid State Physics.

## 3.1 Admission

The following are the enrolment details of the undergraduate programs offered by the institute and for the year 2020-21

| UG Programme | General | OBC | SC | ST | PD* General | PD OBC | EWS** | PMSSS*** | Total |
|---|---|---|---|---|---|---|---|---|---|
| Aerospace Engineering | 24 | 18 | 12 | 0 | 0 | 0 | 9 | 1 | 64 |
| Electronics & Communication Engineering (Avionics) | 29 | 16 | 11 | 0 | 0 | 0 | 7 | 0 | 63 |
| Dual Degree | 9 | 6 | 4 | 1 | 0 | 0 | 2 | 0 | 22 |

*Persons with Disabilities (PD)

**Economically Weaker Sections (EWS). As per government directive, the reservation for the EWS has been started from the academic year 2019-2020.

***

The institute currently offers 15 Master of Technology/Master of Science programs. Admissions to the programs are based on the performance in national level examinations such as GATE or JEST, followed by an interview. Category-wise details of students admitted during the reporting period across various M.Tech and Master of Science Programmes of IIST are as follows:

| Admission 2020-2021 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sl. No. | Name of the M.Tech. and Master of Science Programme | Gen | OBC | SC | ST | PD* General | EWS** | Sponsored from DOS/ISRO | Total |
| 1 | Thermal and Propulsion | 4 | 2 | 1 | 0 | 0 | 1 | 1 | 9 |
| 2 | Aerodynamics and Flight Mechanics | 5 | 2 | 2 | 0 | 0 | 1 | 0 | 10 |
| 3 | Structures and Design | 3 | 3 | 1 | 1 | 0 | 1 | 0 | 9 |
| 4 | RF and Microwave Engineering | 4 | 2 | 1 | 1 | 0 | 1 | 0 | 9 |
| 5 | Digital Signal Processing | 4 | 2 | 3 | 0 | 0 | 1 | 0 | 10 |
| 6 | VLSI and Microsystems | 5 | 3 | 2 | 0 | 0 | 0 | 0 | 10 |
| 7 | Control Systems | 4 | 2 | 1 | 1 | 0 | 1 | 0 | 9 |
| 8 | Power Electronics | 4 | 3 | 2 | 0 | 0 | 1 | 0 | 10 |
| 9 | Machine Learning and Computing | 4 | 2 | 1 | 0 | 1 | 1 | 1 | 10 |
| 10 | Materials Science and Technology | 4 | 2 | 1 | 0 | 0 | 0 | 1 | 8 |
| 11 | Earth System Sciences | 4 | 2 | 2 | 0 | 0 | 1 | 1 | 10 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 12 | Geoinformatics | 4 | 2 | 1 | 0 | 0 | 1 | 2 | 10 |
| 13 | Astronomy and Astrophysics | 6 | 1 | 1 | 0 | 0 | 0 | 0 | 8 |
| 14 | Optical Engineering | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 6 |
| 15 | Solid State Technology | 4 | 1 | 1 | 0 | 0 | 0 | 1 | 7 |
| Total | | 62 | 31 | 21 | 3 | 1 | 10 | 7 | 135 |

*Persons with Disabilities (PD)

**Economically Weaker Sections (EWS). As per government directive, the reservation for the EWS has been started from the academic year 2019-2020.

## Doctoral Programmes

To enhance research output, the institute continues to strengthen PhD programme. Admissions were held in January and July based on test and interview and is restricted to those candidates who qualified GATE/UGC/CSIR NET-JRF/JEST or equivalent exams. During this period, 44 students registered for PhD, the details of which are given below:

| Department | Full Time | Part-Time | Total |
|---|---|---|---|
| Aerospace Engineering | 6 | 3 | 9 |
| Avionics | 13 | 0 | 13 |
| Chemistry | 0 | 3 | 3 |
| Earth and Space Sciences | 12 | 2 | 14 |
| Humanities | 2 | 0 | 2 |
| Mathematics | 5 | 1 | 6 |
| Physics | 7 | 0 | 7 |
| **Total** | **45** | **9** | **54** |

# 3.2 Successful Completion Details of academic programs

118 BTech students, 20 Dual degree students, 67 MTech students and 3 Master of Science students graduated in the year 2020-21.

## 3.2.1 B.Tech

| Degree | Discipline | Number of Students Passed out |
|---|---|---|
| Bachelor of Technology | Aerospace Engineering | 59 |
| | Electronics & Communication Engineering (Avionics) | 59 |
| Dual Degree | B.Tech in Engineerng Physics + M.Tech in Earth System Science | 04 |
| | B.Tech in Engineerng Physics + Master of Science in Astronomy & Astrophysics | 06 |
| | B.Tech in Engineerng Physics + M.Tech in Optical Engineering | 04 |
| | B.Tech in Engineerng Physics + Master of Science in Solid State Physics | 06 |

## 3.2.2 M.Tech/Master of Science

| Degree | Discipline | Number of Students Passed out |
|---|---|---|
| Master of Technology | Aerodynamics and Flight Mechanics | 7 |
| | Structure and Design | 4 |
| | Thermal and Propulsion | 6 |
| | Control Systems | 7 |
| | Digital Signal Processing | 4 |
| | RF and Microwave Engineering | 3 |
| | VLSI and Microsystems | 7 |
| | Power Electronics | 6 |
| | Material Sciences and Technology | 6 |
| | Earth System Sciences | 4 |
| | Geoinformatics | 6 |
| | Machine Learning and Computing | 5 |
| | Optical Engineering | 2 |
| | Solid State Technology | 0 |
| Master of Science | Astronomy and Astrophysics | 3 |
| **Total** | | **70** |

## 3.2.3 Ph.D. Thesis accepted/ published (17)

Seventeen students had completed their Ph.D. programme and successfully defended their thesis the report period. (List is given in the order: Student name, Thesis title, Department, Guide(s) name, Date of defense)

1. **Randeep N C**
   Topological entanglement entropy and gapless Majorana edge modes in the three-dimensional Kitaev model.
   Physics / Dr. Naveen Surendran / 29-04-2020
2. **Arthi Aishwarya**
   Urban Growth Modeling using Cellular Automata based Machine Learning Techniques.
   Earth & Space Sciences / Dr. L Gnanapazham / 04-05-2020
3. **Gayathri G R**
   Mind and Space: A Study on Post-Traumatic Psychosocial Disabilities of Selected Malayalam Films of 1980s and 90s.
   Humanities / Dr. Babitha Justin / 08-05-2020
4. **Reshmi S**
   Investigation of Metal-Semiconductor Thin Films and Nano structures of Layered Materials
   Physics / Dr. Kuntala Bhattacharjee /14-05-2020
5. **Anu Kuriakose**
   (Trans) forming Space: Construction and Contestation of Transgender Identities in Selected Malayalam Films.
   Humanities / Dr. Gigy J Alex / 27-05-2020
6. **Sweta Dey**
   Modelling and Performance Analysis of Some Communication Related Queuing Systems.
   Mathematics / Dr. Deepak T G / 12-06-2020

7. **Neema P M**

   Chemical Sensing Applications of Luminescent MoS2 and WS2 based 2D Materials.

   Chemistry / Dr. JobinCyriac / 09-06-2020

8. **Praveen Wilson**

   Investigations on NaCl Particle Templating Method for the Preparation of Microcellular Carbon and Silicon Carbide Foams.

   Chemistry / Dr. K Prabhakaran / 15-06-2020

9. **Haritha H**

   Strategies to develop materials for lithium storage in high-performance lithium-sulphur batteries and pseudocapacitors.

   Chemistry / Dr. J Mary Gladis / 03-07-2020

10. **Vinitha M V**

    On the quantification and control of internal energy in energetic radiation interaction with PAHs.

    Physics / Dr. Umesh R Kadhane / 16-09-2020

11. **Mohan Kumar L**

    Investigations on the critical parameters influencing the properties and functional performance of ablative composites.

    Aerospac Engineering / Dr. P Chakravarthy / 18-09-2020

12. **Preetam Hazra**

    Resistive RAM and Neuromorphic Systems: Role of Ions and Interface States.

    Physics / Dr. Jinesh K B / 23-09-2020

13. **Suresh Kumar P**

    Modelling and Control of Inverted Magnetic Needle System: A New Problem in Control Theory.

    Avionics / Dr. Priyadarshnam / 30-09-2020

14. **Richu Sebastian C**

    Load Commutated Current Source Inverter Fed AC Motor Drives with Open-End Stator Windings.

    Avionics / Dr.Rajeevan P P / 23-11-2020

15. **Aneesh U**

    Study of Spectral Signatures and Accretion Dynamics of Black Holes During Outbursts

    Earth and Space Sciences / Dr. Samir Mandal / 27-11-2020

16. **Karthika S**

    Study of the Effect of Nonlocal Hopping and Resetting in Asymmetric Exclusion Process

    Physics / Dr. Apoorva Nagar / 08-03-2021

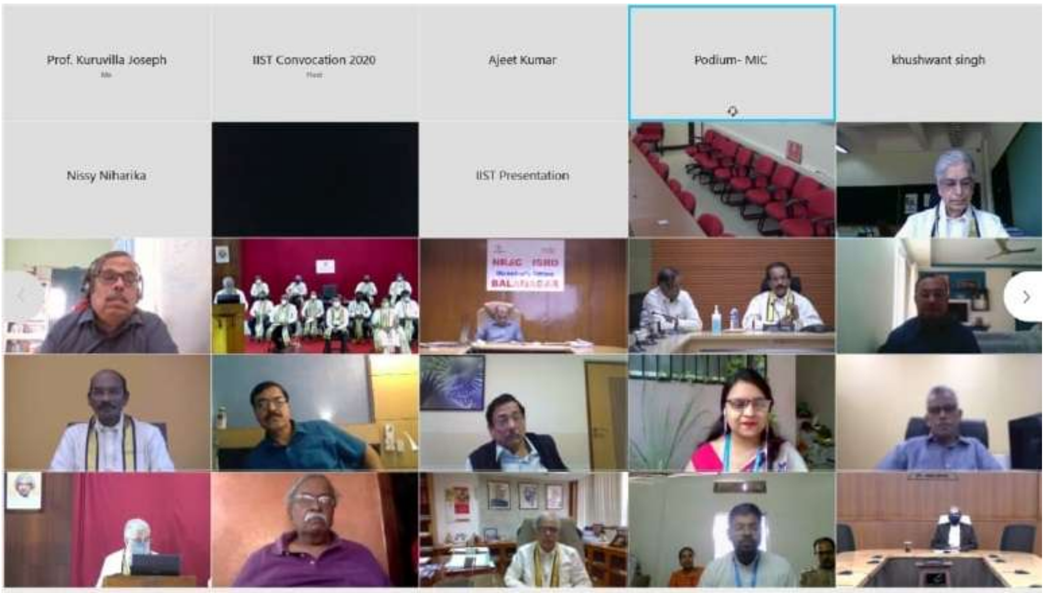
17. **Veena V S**

    A Solid State NMR Study of the Local Mobility of Water and Water Induced Dynamics of Linkers on Silica Surface

    Physics / Dr. Jayanthi S / 24-03-2021

## 3.3 Convocation

The 8th Convocation of IIST was held in an online mode on 16th December 2020. This year a total of 230 degrees were awarded in various disciplines.




Dr. Shekhar C. Mande, Director General, CSIR was the Chief Guest and delivered the Eighth IIST Convocation Address. Dr. B. N. Suresh, Hon′ ble, Chancellor, IIST declared the convocation open. Dr. V. K. Dadhwal, Director, IIST welcomed the dignitaries, graduating students and other invitees and presented report on IIST for 2019-20. Dr. K. Sivan, President, Governing Council, IIST, Secretary DOS and Chairman, ISRO addressed the graduating students. Dr. B. N. Suresh, Hon. Chancellor, IIST addressed the gathering which was followed by the address of the Guest of Honour, Shri. S. Somanath, Director, VSSC.

Dr Shekhar C. Mande delivering the 8th convocation address

Shri. Subham Saha (Avionics) and Shri. Kiran M Jayasurya (Master of Science in Astronomy & Astrophysics) bagged the gold medals for the toppers in U.G and P.G respectively. Cash Award and Excellence Certificate for the topper in B. Tech Aerospace Engineering was given to Shri. Dibya Kanti Golui. Ms. Kalepu Harsha Nikhitha B. Tech, ECE (Avionics) received the Cash Award and Excellence Certificate for best all-round performance in academics, co-curricular and extra-curricular activities.





Institute gold medals are given to the best academic performer of the undergraduate and postgraduate programs and excellence certificate and a cash award is given to the topper of the other BTech branch and also for the best outgoing student.

| | |
|---|---|
| Gold medal for the topper of all B Tech Branches<br><br>**Subham Saha** | Gold medal for the Topper of all PG specializations<br><br>**Kiran M Jayasurya** |
| Best academic score in Aerospace Engineering<br><br>**Dibya Kanti Golui** | Best all-rounder among UG graduates<br><br>**Kalepu Harsha Nikita** |

## 3.4 Placement

100 students, who have completed their BTech programme in IIST with a 7.5 and above CGPA are absorbed in the different centres of ISRO. Other BTech and MTech students are placed through the placement Cell of IIST.

### 3.4.1 ISRO Placement for BTech / Dual Degree

From the group of passing out BTech students,106 students (out of conferred degrees) were offered placement in ISRO in 2020.

ISRO/ DoS absorption data (2011-2020)

| Year | AE | AV | PS/EP | Total |
|---|---|---|---|---|
| 2011 | 41 | 54 | 22 | 117 |
| 2012 | 42 | 52 | 30 | 124 |
| 2013 | 39 | 54 | 29 | 122 |
| 2014 | 35 | 43 | 26 | 104 |
| 2015 | 44 | 45 | 13 | 102 |
| 2016 | 43 | 39 | 21 | 103 |
| 2017 | 39 | 42 | 23 | 104 |
| 2018 | 36 | 33 | - | 69 |
| 2019 | 42 | 38 | 26 | 106 |
| 2020 | 38 | 43 | 19 | 100 |
| **Total** | **403** | **434** | **204** | **1041** |

### 3.4.2 Non-ISRO Placement for UG, PG & Others

**List of Students placed Through IIST Placement cell**

**M.Tech Placement Cell Record for 2019 Batch:**

| SL NO | NAME OF THE COMPANY | NAME OF THE STUDENT | COURSE |
|---|---|---|---|
| 1 | M/s Tata Consultancy Services | Ankita Nayak | Machine Learning and Computing |
| 2 | M/s Tata Consultancy | Durgesh Kalwar | Machine Learning and |

| | | | |
|---|---|---|---|
| | Services | | Computing |
| 3 | M/s Tata Consultancy Services | Sombed Saha | Control System |
| 4 | M/s Agnikul Cosmos | Ajay Vincent Raj | Thermal and Propulsion |
| 5 | M/s Agnikul Cosmos | Dhiliban S | Materials Science and Technology |
| 6 | M/s Agnikul Cosmos | Harshith Reddy Vangala | Power Electronics |
| 7 | M/s Agnikul Cosmos | G G D Venkata Sai Pavan | Power Electronics |
| 8 | M/s Agnikul Cosmos | Akhil Sharma | Thermal and Propulsion |
| 9 | M/s Agnikul Cosmos | Srujana J | Materials Science and Technology |
| 10 | M/s Global Foundries | Sreedevi B | VLSI and Microsystems |
| 11 | M/s Newspace Research Technology | Mokshith SR | Power Electronics |
| 12 | M/s Continental Automotive | Janardhan Sarkar | Machine Learning and Computing |
| 13 | M/s Textron India | Vijay Kumar S | Structure and Design |
| 14 | M/s Textron India | Chandra Prakash Rawat | Structure and Design |
| 15 | M/s L&T | Dhanush Arul | Aerodynamics and Flight Mechanics |
| 16 | M/s Aadyah Aerospace | Christina K. | Digital Signal Processing |

| BTech Placement | | | |
|---|---|---|---|
| SL NO | NAME OF THE COMPANY | NAME OF THE STUDENTS | PACKAGE ( CTC ) Lakhs |
| 1 | M/s L&T | Ajay Sidharth | 7 |
| 2 | M/s Aadyah Aerospace | Abhishek Jaiswal | 3.06 |

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# RESEARCH & DEVELOPMENT

# 4. RESEARCH AND DEVELOPMENT

Research and Development (R&D) activities at IIST have kept up a brisk pace with time, even during the pandemic. The Office of Dean (R&D) continued to engage and facilitate research and development initiatives of IIST by administering and reviewing R&D projects, facilitating industry interactions, managing intellectual property and licensing activities, reviewing and finalizing R&D related agreements and contracts, supporting high-end research infrastructure, and disseminating R&D related information in various forums within and outside IIST. An Advanced Space Research Group (ASRG) also functions in IIST to facilitate the seamless integration of ideas, expertise, and know-how between IIST and ISRO and to catch up with the advances in the Indian Space Sector. Many new R&D projects and related activities were undertaken during the year 2020-21.

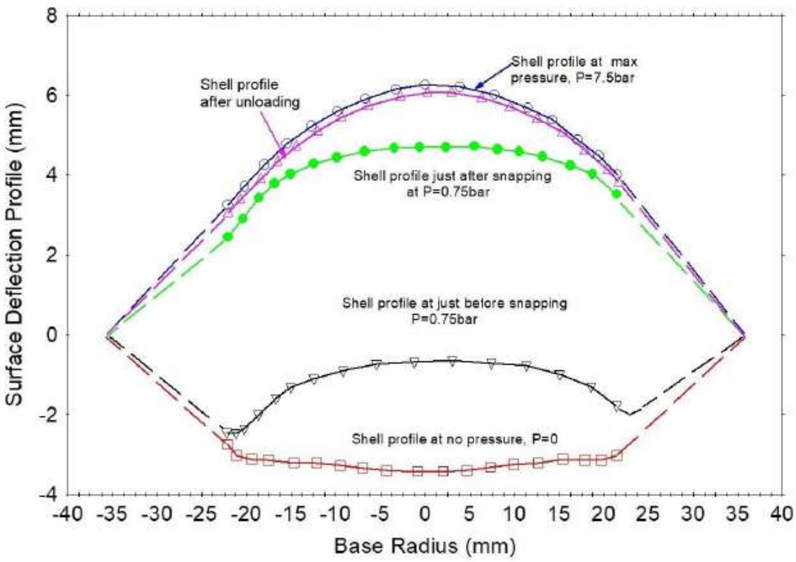
## 4.1 Snapshots of Research

### Department of Aerospace Engineering

### Dr. Anup S.

**Buckling behavior of a dished shallow shell- application in Cryogenic Engines**

The buckling behavior of a dished shallow shell - a shell similar to that of conical and spherical shells is investigated. These shells have a conical frustum with a flat



closed top. The specific objective of the research is the snap-through buckling behavior of a metallic dished shells which has applications as actuator elements in control components in space crafts, especially in cryogenic engines. To design these dished shallow shells, a through understanding of their buckling behavior is necessary. In this aspect, a non-liner Riks analysis using finite element method is conducted to analyse the snap through buckling and post-buckling analysis of such shells using commercial software ABAQUS. Parametric studies are also conducted to delineate the effect of various geometrical parameters on the critical buckling pressure. In addition, experiments are were carried out using 3D Digital Image Correlation technique (3D-DIC) to measure whole-field deflection and strains. The figure shows the deflection profile of such a shell from experimental results. Various material models were used for the numerical

*Figure: the deflection profile of a shell from experimental results*

investigations: Non-linear elastic, elastic-perfectly plastic and elasto-plastic. A perfectly elastic-plastic material model gave excellent comparison with experimental results. The results indicate that material plasticity has a significant role in the critical buckling pressure of such structures.

***Tripathi, S.M., Swain, D., Muthukumar, R., & Anup, S. (2020)*** *Investigation on Snap Through Buckling Behaviour of Dished Shells under Uniform External Pressure. ASME-Journal of Applied Mechanics, 1-31.*

## Dr. Aravind Vaidyanathan

### Effervescent Strut Injection for Scramjet Combustors

The scramjet engine requires a mechanism for quick and efficient mixing of fuel with a good flame holding mechanism. Of many other mechanisms proposed, Strut has been found to be one of the most promising hyper-mixers, offering enhanced mixing of fuel in the scramjet combustion chamber. In the present study, the internal geometry of the strut injector was modified to make it as an effervescent or aerated type injector (Figure 1).

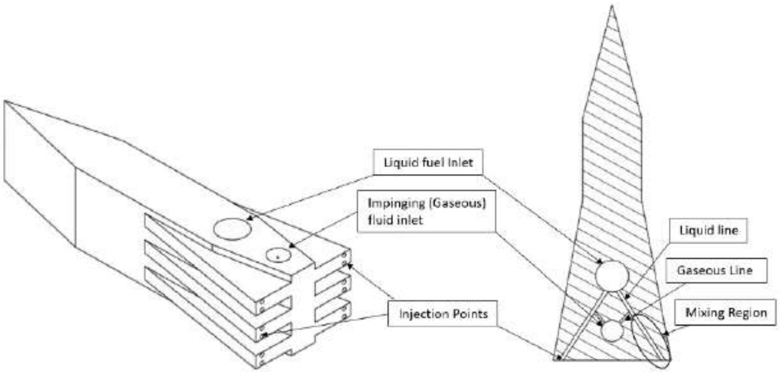



*Figure 1: Isometric and cross-section view of the Strut Injector*

So, to understand the improvement in the quality of atomization and finding the possibility of sustainable combustion inside the supersonic combustion chamber are the major objectives of this study. Theoretical calculation considering the dropletburning and evaporation model provides an overall idea of the maximum kerosene droplet diameter that can completely burn within the shortresidence time inside the combustion chamber available length.

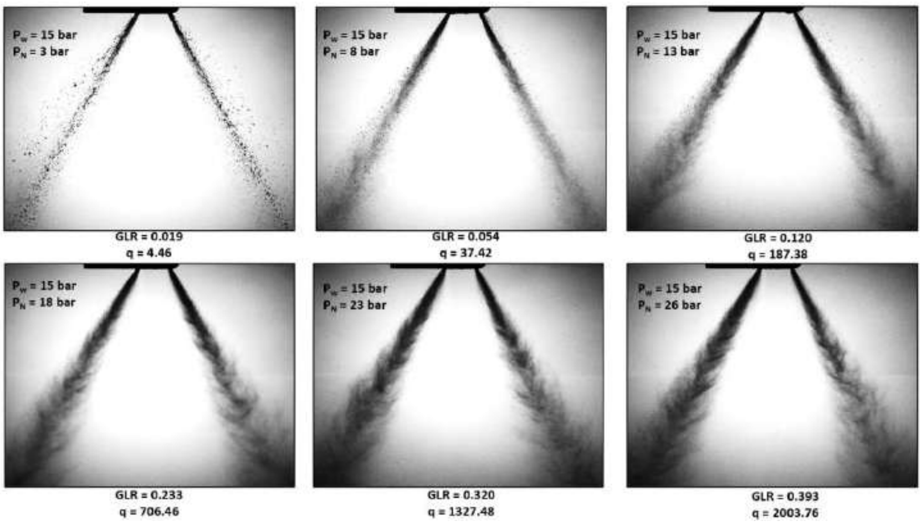



*Figure 2 : Shadowgraph images for understanding the improvement in atomization quality due tointernal impingement*

High-speed shadowgraphy images (Fig 2) were taken to analyze and understand the spray structure and jet spread angle due to the internal impingement of the secondary fluid. For understanding the two-phase flow interaction at the downstream of the injection process, Mie scattering imaging of the spray was conducted. The Normalized Spread Area revealed the advantageous effect of GLR and momentum flux ratio for the improvement in mixing efficiency for the actual flow condition. A statistical analysis of these Mie scattering images indicates the process of interaction between the injected fluids and the high turbulence region in the spray core. Also, the PDPA and LDV experiments were conducted to find out the atomized kerosene droplet diameter and velocity for a wide range of momentum flux ratio and GLR. The experiment recorded the smallest diameter of kerosene droplet around 12.21$\mu m$. The optimum condition for getting the smallest droplet diameter for a sustainable combustion inside the combustion chamber is one of the major findings of this study. It was also observed that, as the momentum flux ratio or GLR increases, there is a steep drop in droplet diameter size, but after a momentum flux ratio of 450 and a GLR value of 0.18, there is no significant change in the droplet diameter. The two-phase flow interaction in the mixing region may be one of the major reasons for this behaviour. So for understanding the spray interaction and flow transition process in a better way, a modal decomposition analysis on the spray region was also conducted and flow transition effects were identified.

*Chakraborty, M., Vaidyanathan, A., and Desikan, S.L.N., " Experiments on atomizaion and spray characteristics of an effervescent strut injector", Physics of Fluids, 33(1), 017103, 2021*

## Dr. Arun C. O.

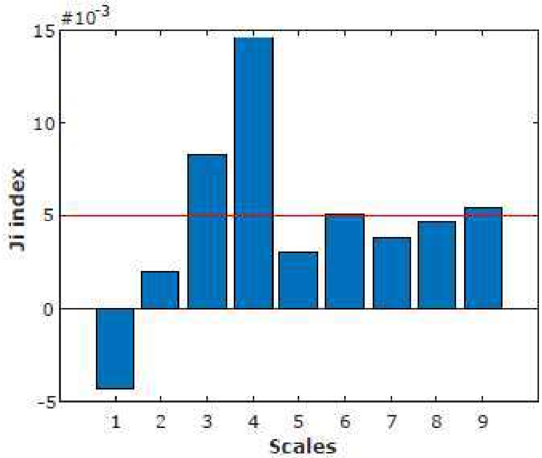
### Improved response function (IRF) based stochastic element free Galerkin method (SEFGM)

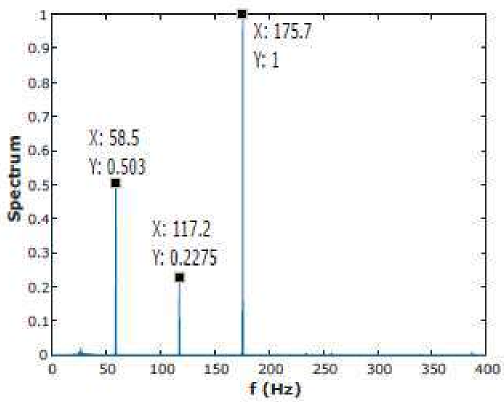
An improved response function (IRF) based stochastic element free Galerkin method (SEFGM) is proposed for the analysis of problems in elasto-statics, wherein Young's modulus is modelled as ahomogeneous random field. The proposed SEFGM approximates displacement as the sum of adeterministic part and a stochastic part. The stochastic part is modelled with the help of an IRF, which is a function of discretized set of random variables. Moving least square shape functions areemployed to discretize the random field. Utilizing Taylor series expansions of stiffness matrix andforce vector and IRF approximation of displacement, explicit expressions for system responses interms of random variables are derived. Stochastic informations of system responses are evaluatedby employing Monte Carlo Simulation (MCS) on the response function, which eliminates the need ofconstruction and simulation of system matrices at each set of sample generation. 1D and 2Dnumerical examples in elasto-statics are solved using proposed method. Results are validated withthose obtained by direct simulation of system of equations using MCS and also compared with othermethods like second order perturbation and ad-hoc response function based SEFGM. Normalizedcomputational times required for all the methods are also compared. It is found that the proposedis computationally efficient and can produce accurate results even for higher coefficient ofvariation of input random fields. The method is further extended for structural reliability analysis ofbeams and stochastic analysis of thin plates.

## Dr. Bijudas C. R.

### Health Monitoring of Rolling Element Bearings

An improved wavelet cross spectrum (IWCS) scheme is proposed for health monitoring of the rolling element bearing. The developed method takes the advantages of wavelet cross spectrum technique for feature extraction from non-stationary vibration signatures. The signals of rolling element bearing (REB) are first analysed by a continuous wavelet transform over selected scales corresponding to the bearing fundamental fault frequencies. In this improved scheme, the contributive bandwidth selection from Jarque-Bera (JB) statistic index is carried out with the assistance of an outlier technique.




Skariah, A., Pradeep, R., Rejith, R., &Bijudas, C. R. (2021). Health monitoring of rolling element bearings using improved wavelet cross spectrum technique and support vector machines. *Tribology International*, *154*, 106650.

## Dr. Chakravarty P.

### Additive manufacturing

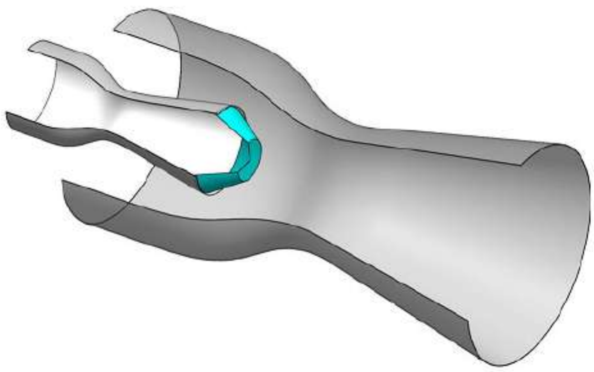
3D printed Inconel 718 was characterized for its microstructure and mechanical properties. The defects such as porosity, balling, cracks were analyzed using microscopic techniques and a qualitative relationship between the process parameters (scan speed, laser power) used during laser bed fusion process and the microstructure, phases evolved and the defects such as porosity, cracks, etc. was established. Mechanical properties such as hardness was also measured to corroborate the microstructural evolution that happened during additive manufacturing.

### Composites

Surface composites of aluminium was fabricated through friction stir processing and their damping capacity was assessed and correlated to the process parameters. The variation in the damping capacity was correlated to the microstructures.

## Dr. Deepu M.

### Numerical simulation of the shock transitions during off-design operation of a dual throat nozzle (DTN)



The single-stage-to-orbit (SSTO) reusable launch vehicle is an emerging cost-effective, reliable, and environmentally friendly space transportation concept. A single-stage operation from lift-off to orbit entry can set aside many involved complexities in the mission, such as staging and separation. Re-usability has an inherent advantage of cost-effectiveness, although the design of launch vehicle components and its refurbishment is expensive. The usage of conventional fixed expansion ratio nozzles for such applications leads to considerable losses. The dual throat nozzle (DTN) has an inner primary nozzle and an outer secondary nozzle. Hence, it is capable of expanding different propellant/oxidizer combinations. In most of the cases, a common oxidizer is used while two different propellant fuels are used in the inner and outer combustion chambers. Thus, the DTN is suitable for a tri-propellant engine. The DTN is the thrust generating part of a typical tri-propellant engine (TPE). A high-density fuel (usually RP1-LOX combination) is expanded through the secondary nozzle to meet a high thrust demand during lift-off. Whereas, a low-density, high specific impulse propellant combination (LH2-LOX) is used at higher altitudes to ensure maximum efficiency. In addition to this, the DTN can also simultaneously expand propellants from the primary and secondary chamber during its parallel burn mode of operation.

Numerical studies have been carried out to the shock transitions during the off-design operation of a dual throat nozzle has been carried out using an AUSM-based finite-volume solver. The conditions investigated in the study are encountered in the operation of a single-stage to-orbit rocket making use of the DTN, wherein the rocket engine thruster needs to be operated under varying backpressure conditions. The computations have been performed with the objective to study the flow field changes influenced by wall heat transfer and chamber pressure. The DTN flow field is unique as it exhibits complex flow features such as shock separation, the interaction of shock waves, shear layer mixing, and the formation of local recirculation regions. A detailed exposition of the flow physics of the DTN is carried out using computations, and the regular and Mach reflection configuration as well as the MR↔RR transitions have been well established.

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## Dr. Dhayalan R.

**Modeling, fabrication, control of fully automated unmanned aerial vehicles**

The current research work focuses on modeling, fabrication, control of fully automated unmanned aerial vehicles in small and micro class. Full automation involves proper system identification, flight dynamics and control. The system identification includes the conceptual design, fabrication, state measurements, flight tests and parameter estimation of the aerodynamic models. Further, the usage of a proper estimator corresponding to the flight vehicle and flight data is of paramount importance. A few classical methods such as Least Squares and Maximum Likelihood along with data driven methods like Neural and Fuzzy networks have been used for the parameter estimation. The flight dynamics of the corresponding flight vehicles are characterized by modelling the aerodynamics of the flight vehicles over a wide range of flight regimes. The estimated model can be used as a control variable for various algorithms. The control of UAVs are achieved by classical and state space methods. However the research involves the implementation of optimal control and neural-fuzzy based control logic. Contemporary designs such as VTOL, Tail sitter and High Altitude Soaring UAVs are considered for implementing the control and estimation algorithms. Multi-rotor UAVs have been fabricated and will be used for the purpose of aerial land surveys and high altitude surveillance.

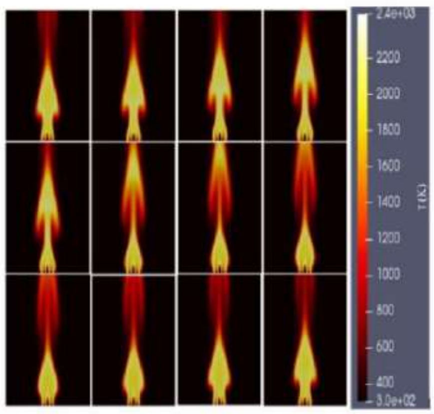
## Dr. Mahesh S.

### Buoyant Oscillations in Laminar Inverse Diffusion Flame

A tri-port burner has been designed and developed in IIST to study the buoyantoscillations in inverse diffusion flame (IDF) configuration.

- Preliminary studies on buoyant IDF established in tri-port burner indicate thebuoyant oscillation in inverse jet diffusion flame is very sensitive to the central airjet as compared to the outer annular air jet for a fixed annular fuel Reynoldsnumber.
- Buoyant oscillation frequency of tri-port burner stabilized IDF obtained throughnumerical simulations using LaminarSMOKE (opensource CFD solver) comparedwell with the experimental data.

**Oscillations of Buoyant IDF simulated using opensource CFD solver LaminarSMOKE**




Temperature contour of the flame with central air velocity 1.00 m/s and annular fuel velocity 0.15 m/s. Every snapshot has an interval of 0.01 seconds. The chronological order is from left to right in each row, from the top row to the bottom row.

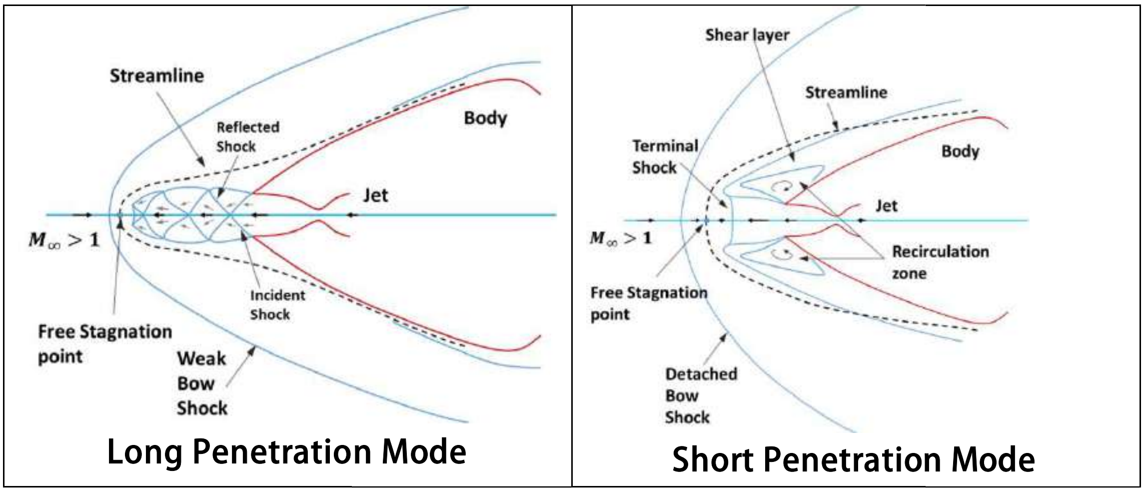
## Dr. Manoj T. Nair

### Combination of Counterflow Jet and Cavity for Heat Flux and Drag Reduction

The objective is to study a combination of counter-flowing jets and cavity for drag and heat load reduction and to find the performance of this combination at angles of attack.

It was observed that two different modes of jet interaction exist (a) short penetration mode (SPM) for lower jet total pressure; (b) long penetration mode (LPM) for higher jet total pressure. The conclusions from the study are

1. If drag reduction is the only objective, LPM mode should be preferred.
2. For both drag and heat load reduction, SPM mode should be preferred.
3. Presence of cavity is beneficial for total heat load reduction.
4. SPM would be preferred mode at non-zero angles of attack.

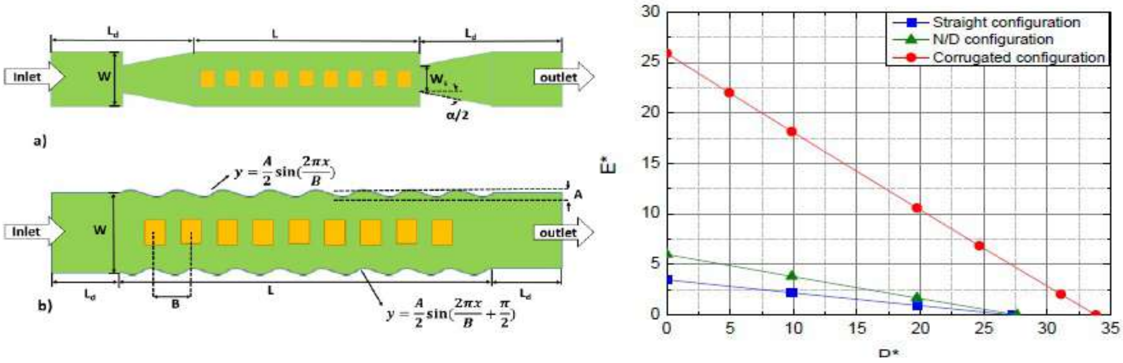



## Dr. Pradeep Kumar P.

### Internal Flow Cavitation

Experimental and numerical studies are ongoing in the area internal flow cavitation. With joint collaboration with Dr. Amrit Ambirajan, Department of Mechanical Engineering, IISc Bangalore, work is progressing in predicting radiative heat transfer through high temperature insulations. The work would be useful in understanding and improving the metallic thermal protection systems for space vehicles. Works are also going on in the area of micro scale heat transfer and fluid flow. A numerical study was presented by our student Shri Ajin Ghosh K.K at the 5$^{th}$

International Thermal and Fluid Conference, ASTFE, New Orleans, USA (held online) ,April 5-8, 2020. The paer was on the performance characterization of valveless travelling wave piezo electric micro wave pump[Paper No. TFEC-2020-32042]. The usefulness of such a device would be in controlled low flow rates in microchannels.



## Dr. Prathap C.

### Instrumental Investigation of Laminar Burning Velocity

The objective of the research was to understand the effect of change in the composition of combustible (CC)/ non-combustible components (NCC) on the unstretched laminar burning velocity (LBV), burned gas Markstein length ($L_b$) and Lewis number (Le) of premixed producer gas (PG)-oxygen mixtures. Design of composition and flame stability aspects based on Le are presented in part-1. PG comprised of CC($CH_4$:CO:$H_2$)+NCC($CO_2$:$N_2$) and the extent of variation was identified from 800 compositions reported in 123 research works. In this work, forty-five PG mixtures were studied where CC:NCC varied from 25:75–45:55, $CO_2$:$N_2$ from 0:100–100:0 and $CH_4$:CO:$H_2$ from 25:25:50–50:25:25. Spherical flame method was used to measure the LBV at 1bar, 300K and $\varphi$=0.8 in a 4.5L spherical chamber and the layout is shown below. Validation experiments were performed with (50%$H_2$+50%CO)-air mixtures and it compared well with the literature and computational data. Unstable mixtures identified by effective (volume-based model) and critical Lewis numbers corroborated well with the experimental burned gas Markstein length.

*MunirajaTippaa, M .Akash, Senthilmurugan Subbiah, ChockalingamPrathap (2021) A comprehensive study on laminar burning velocity and flame stability of oxy-producer gas mixtures. Part-1: Gas mixture composition and flame stability analysis based on Lewis number, Fuel, Volume 292, 119982*

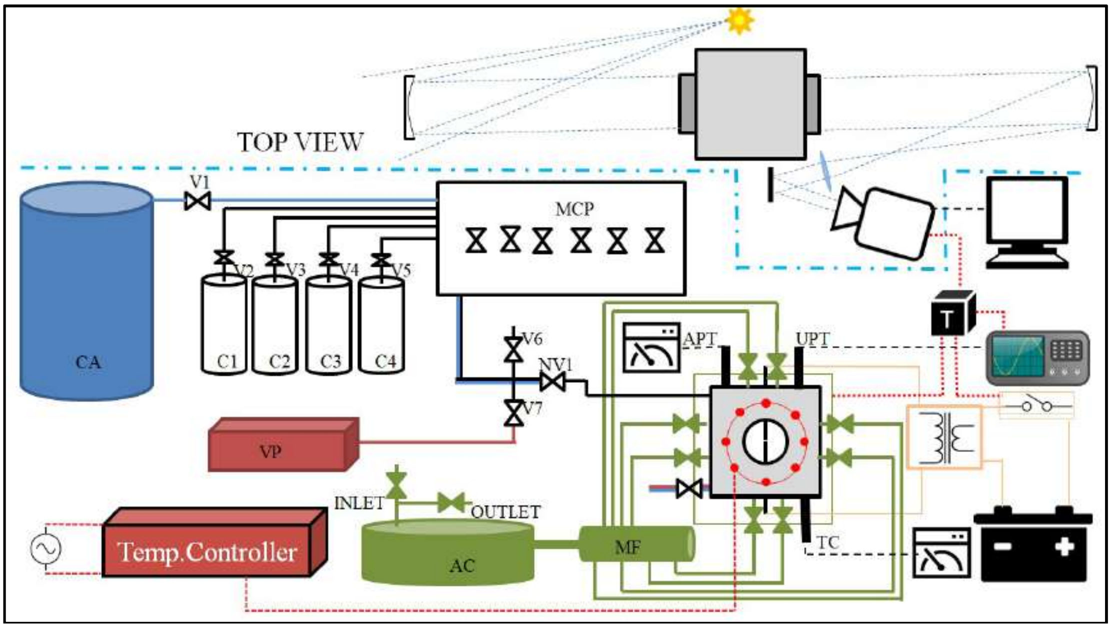



*Figure: Layout of the test facility with Z-type shadowgraph system*

## Dr. Praveen Krishna I. R.

### Stability analysis of a two-spool rotor system undergoing rub-impact

The main objective of the research is to determine the influence of rub parameters on the stability of a two-spool rotor system undergoing rub-impact. The parameters such as rotor–stator contact stiffness, coefficient of friction and clearance are varied for understanding their effects on the system response and stability. Moreover, the analysis is performed for two modes of rotor operations, namely co-rotation and counter-rotation, and determines their impacts on rotor–stator rubbing. A time variational method is employed to predict the nonlinear response of the system with a perturbation function applied at the steady-state solution points to investigate their stability. Two types of bifurcations, namely limit point and Neimark–Sacker bifurcations, are observed in the response by monitoring the Floquet exponents of the perturbed system. As the coefficient of friction is increased, the early onset of NS bifurcation has happened and the system enters into the quasi-periodic regime early. However, when the contact stiffness and clearance values are increased, the onset of NS bifurcation is delayed. It is also observed that the response characteristics of the co- and counter-rotating systems are entirely different. The separation between forward and backward whirling frequencies is reduced for the counter-rotating system due to the cancellation of gyroscopic moments. In addition, for the same set of parameters, the counter-rotating system enters into the quasi-periodic regime quickly once the disk starts rubbing.

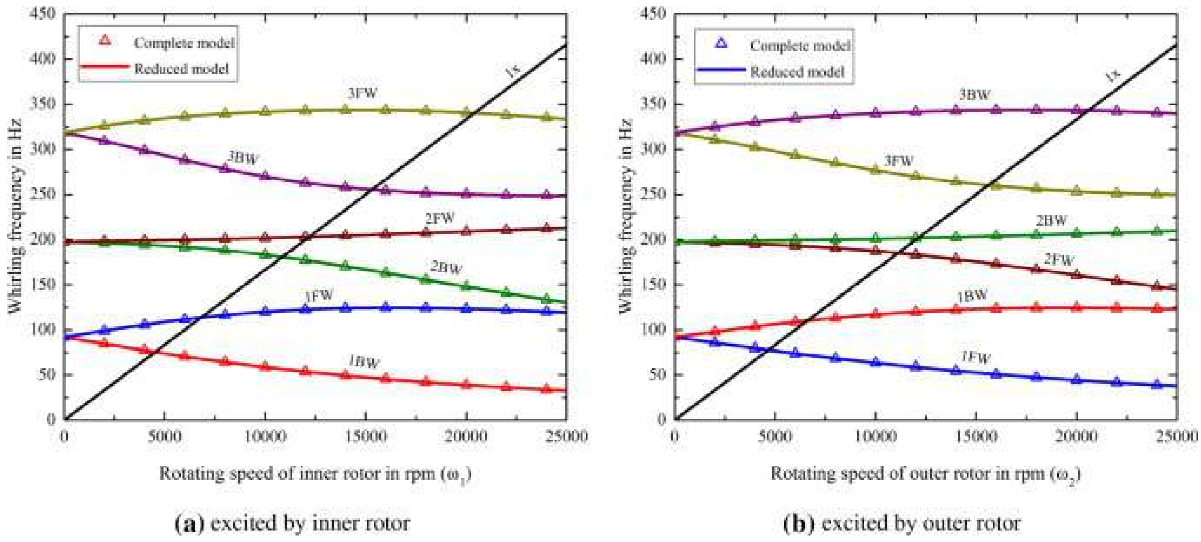



*Figure: Campbell diagram of the dual-rotor model (counter-rotation)*

***K. Prabith and I.R. Praveen Krishna (2021)*** *The stability analysis of a two-spool rotor system undergoing rub-impact, Nonlinear Dynamics, 104(2), 941-969.*

## Dr. Sam Noble

### Optical Torques for a Wheeled Rover

Analytical procedures for determining global minimum friction requirement for a six wheeled rover negotiating hard uneven terrain was one of the main work done. The main contributions of this work are (a) a comprehensive understanding of how solutions emerge for the problem of minimizing friction requirement of a six wheeled rover with zero and positive lower bounds on normal forces on wheels, and (b) development of two non-iterative algorithms which are capable of obtaining global minima. This was demonstrated by solving many problems. The two proposed algorithms are an order of magnitude faster than a generic powerful solver for NLP problems, and much easier to implement in a rover's controller.

## Dr. Shine S. R.

**Heat Transfer related to space applications, biological heat transfer, and computational hemodynamics**

Heat transfer related to space applications, biological heat transfer, and computational hemodynamics. Major works in space applications include film cooling of liquid rocket thrust chambers, liquid rocket engine cycle analysis, cryogenic two-phase flow, plume radiation modeling of solid rocket motors, micro nozzles associated with attitude control, and gas turbine blade cooling. Dr. Shine has an active interest in the area of bio-fluid mechanics and bio-heat transfer. Current works include the development of computational models to study the effect of plaque geometry on the coronary artery wall, development of human thermoregulation model, studies related to the arteries of the circle of Willis (CoW) to identify possible cerebral aneurysm initiation locations, development of hydraulic impedance actuation system for humanoid robots, etc. He has published more than 20 papers in leading journals in fluid mechanics and heat transfer and 40 papers in International conferences in the last five years. He is the principal investigator in the advanced research and development of thermal management systems associated with space Telescopes, IR Spectrometer, General Purpose Humanoid Robot with Human-like Degrees of Freedom. He has secured Rs. 75 Lakhs in research funding through various projects.

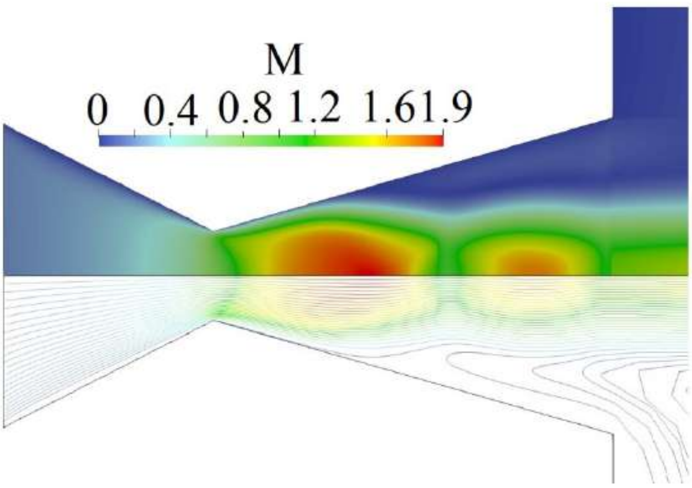



*Figure: Streamlines and Mach number contours for micronozzles of 20 micometer throat width operating at 70kPa presuure difference obtained through DSMC simulations*

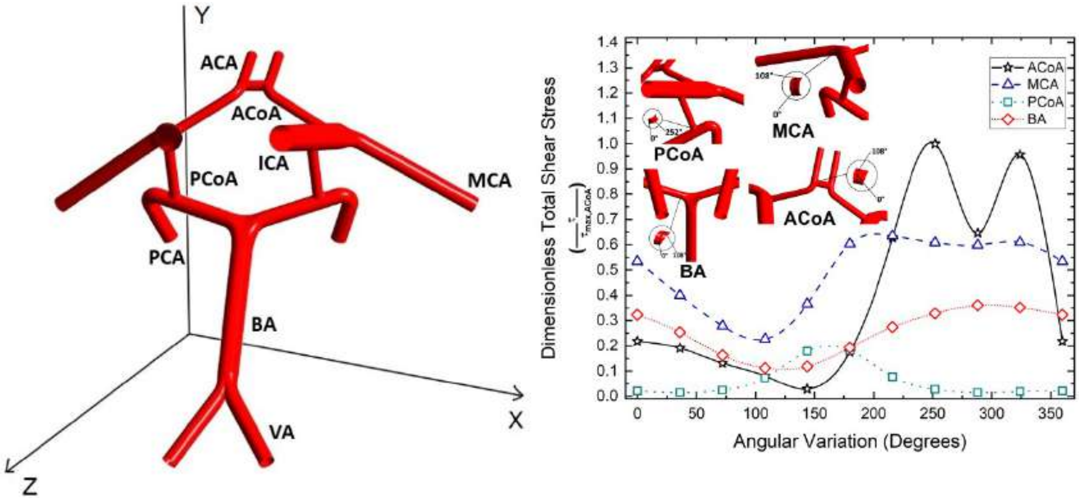
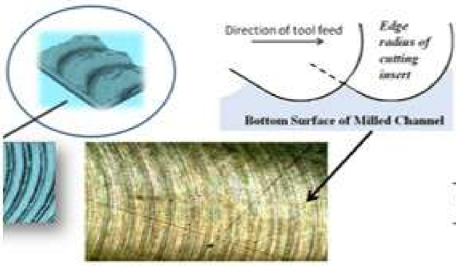


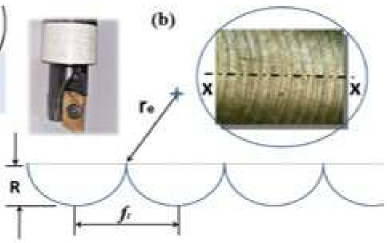

*Figure: Probable aneurysms locations at the arteries of the circle of Willis (CoW) obtained from FSI simulations*

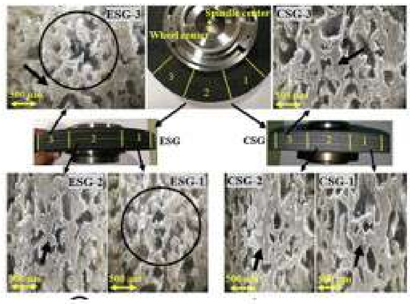
## Dr. Sooraj V. S.

### Machining and precision manufacturing studies on Aerospace materials

Key research during 2020-2021 was to develop and investigate a progressive, intermittent grinding strategy for minimum damage abrasive processing of fiber-reinforced polymer matrix composites. Even though high-quality fabrication procedures for near-net fiber reinforced composite structures are reported in the past, their employment in many functional applications demands machining operations to yield controlled geometric tolerances and surface finish. To meet surface integrity without severe damages, machining using abrasive grains may be a potential solution. However, owing to the non-homogeneous and anisotropic nature of FRCs, continuous engagement of abrasive grains may lead to undesirable effects of grinding force such as fibre pull-out, fiber breakage, matrix failure, etc. The intensity of these damages, which are sensitive to the type of fiber and fiber orientations, is observed to be proportional to the depth of cut maintained by the cutting edge. A progressive intermittent grinding strategy named "eccentric sleeve grinding" is proposed to address the above concerns. The journal and conference publications reported in the year 2020-21 provide the details of this research activity.




Another study was focused on the wettability of engineering surfaces and the influence of machining processes and associated variables on the same. Major studies related to the generation and control of wettability in engineering surfaces are focused on coatings and patterning of surfaces. However, investigations on anisotropic wetting induced by roughness texture after traditional surface generation methodologies such as CNC milling may be useful to optimize the selection of machining conditions such as the feed rate of the cutting tool. A detailed study in this aspect was carried out on aerospace grade aluminium alloy surfaces processed via CNC milling.

Some other research areas include:

- Preliminary simulations on Intermittent grinding strategy for hard-to-cut aerospace materials like titanium alloys
- Studies on machining of ablative composites used for space applications
- Stochastic analysis of surface grinding
- Design for manufacturing studies on payload housings
- Studies on human mimic five finger robotic configuration

# Department of Avionics

## Dr. Anindya Dasgupta

### Solid State Transformers (SSTs)/ Power Electronics Transformers

At PEDS (Power Electronics in electrical Distribution Systems) Lab, work is carried out on Solid State Transformers (SSTs)/ Power Electronics Transformers, which are perceived to be a key component in the future grid. Recent focus has been primarily on the development of sensorless control schemes for Dual Active Bridge Converters (DAB), which are the core power conditioning unit of SSTs. DABs contain a High frequency transformer and an inductor that operates in the range of tens of kHz at a power level handled by traditional transformers operating at 50 Hz. Control schemes require measurement of the high frequency link current, particularly during load disturbances or fault conditions. This sensing arrangement calls for a wide band width sensor and high sampling requirements which not only increase the computational overhead but also becomes an impediment to miniaturized power bus design. Our efforts have been to achieve the required performance without the sensor. So far, the analytical and experimental results have been very encouraging for single cell SSTs. The future aim is to develop similar sensorless schemes for modular SSTs.  The Figure below shows the SST prototype that was developed in-house by the Ph.D. student. All analytical results are being validated through this prototype.

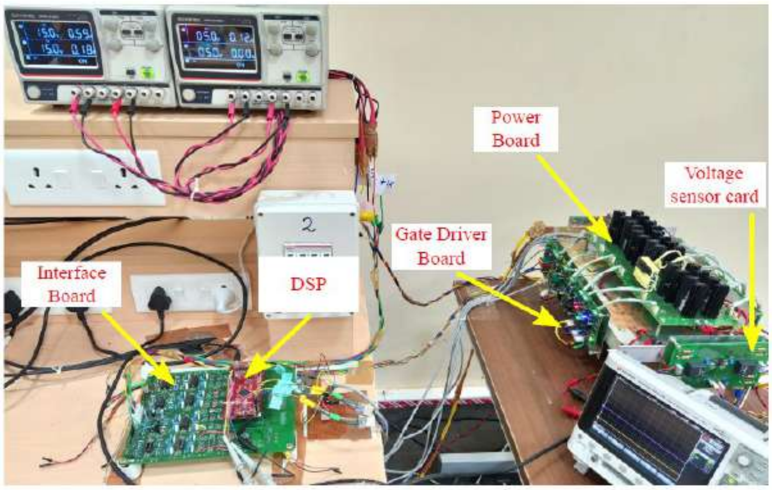



*Figure: A scalable 1.2 kW SST prototype developed in-house by PhD student Mr Gourahari Nayak.*

## Dr. Anoop C. S

### Digitizing interfaces for Industrial Sensors

Digitizing interfaces for a number of industrial sensors has been designed and investigated with simple, but efficient and high-accuracy. One specific research problem taken up is on the field of direct-digitizers for the various types of industrial resistive sensors, with wide-span of operation. Such resistive sensors may need to be in a remote environment, away from the electronics unit. New and efficient digital signal conditioning techniques [1] to interface the above types of resistive sensors were proposed. The first technique employs a simple circuitry that requires a single reference voltage and single operation cycle and provides a direct-digital output proportional to the sensor-resistance. Next, this scheme is further enhanced, using few auxiliary components, to address the case of remote sensors. These novel circuit-designs also ensures features like, short execution time; compatibility to resistive sensors in different configurations; and negligible dependence on many nonideal parameters. Further, a Universal digitizer circuit [2] for Bridge-based Resistive sensors (UDBR) has been proposed and investigated. The UDBR provides a linear transfer characteristic, for all types of resistive bridges. Besides, the digitizer output is independent of the parasitic capacitance of the sensors, connecting wire impedances, and mismatch among the bridge elements. These schemes have also been analysed for errors and validated using extensive experimental studies with various bridge configurations. Linear output characteristic, with all expected meritorious features, is obtained during all these tests. The maximum error is less than 0.06% (UDBR). Tests also establish the capability of the developed resistive-digitizers to realize linearized magnetometers, temperature monitors, and displacement-sensing systems.

*[1] Elangovan K. and **Anoop C. S.**, "Evaluation of New Digital Signal Conditioning Techniques for Resistive Sensors in Some Practically-Relevant Scenarios," IEEE Transactions on Instrumentation and Measurement, vol. 70, pp. 1-9, 2021, Art no. 2004709, doi: 10.1109/TIM.2021.3084316.*

*[2] Elangovan K. and **Anoop C. S.**, "An Efficient Universal Digitizer with Linear Transfer Characteristic for Resistive Sensor Bridges," IEEE Transactions on Instrumentation and Measurement, vol. 70, pp. 1-4, 2021, Art no. 2004904, doi: 10.1109/TIM.2021.3089765.*

## Dr. Basudeb Ghosh

**Metasurface based antenna- Design of reflector and transmit antenna array.**

The metasurface provides an efficient way to manoeuvre the electromagnetic properties on the surface of the structure and it gives an efficient and better antenna performance in comparison to the conventional reflector and transmit array antenna. Recently, the concept of metasurface has been applied to design a Flat top radiation pattern based on phase gradient metasurface is presented for dual-band. Generally, the Flat-top radiation pattern is generated by optimizing the

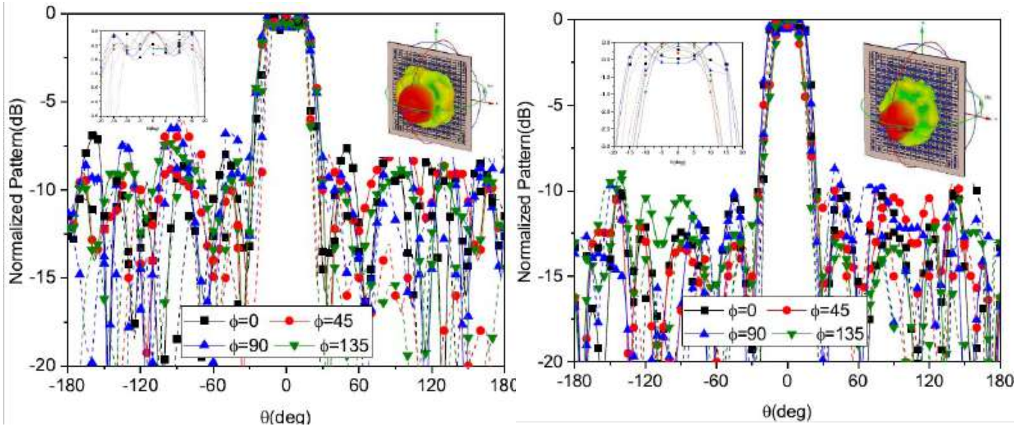
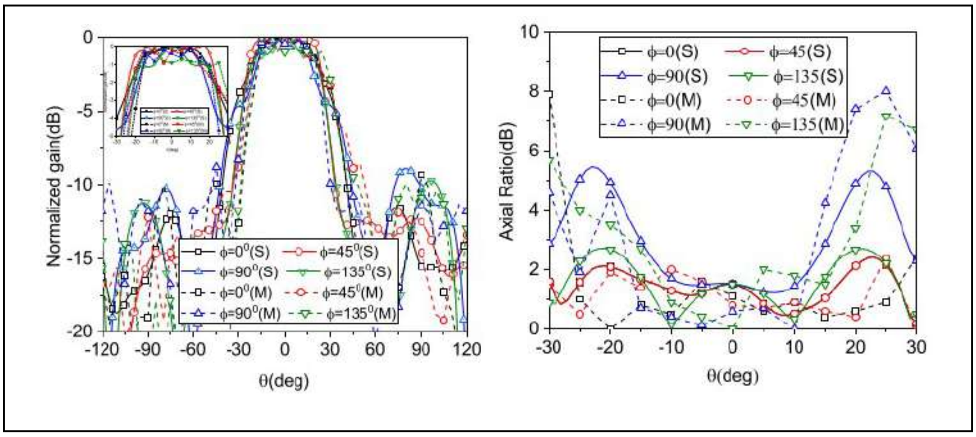



Fig. 1: The flat top radiation pattern of linearly polarized Metasurface antenna at both operating frequency.

local phase characteristics of the metasurface. Here, the basic idea is to divide the entire metasurface (MTS) into four sub-regions, each of which directs the beam in a particular direction to synthesize the flat top radiation pattern. The antenna characteristics are shown in Fig. 1. The similar concept is applied to realize a circularly polarized radiation pattern also. The circularly polarized radiation pattern is generated by dividing the entire metasurface into four sub-regions and the unit cell dimensions are chosen such that the transmission phases for x- and y-polarizations are in quadrature. The polarization of the generated beam can be reconfigured based on the polarization of the incident wave. The performance of the antenna is shown in Fig. 2




List of Publication:

1. Kumar, Pallapati Vinod, and Basudeb Ghosh, ″Synthesis of a Dual-Band Flat-Top Radiation Pattern Using Polarization Dependent Phase Gradient Metasurface". In "Progress in Electromagnetic Research Letters", vol. 100, pp. 81-89, 2021.
2. Kumar, Pallapati Vinod, and Basudeb Ghosh, "Polarization Sensitive Dual-Band Metasurface Lens for X-Band Applications." Progress In Electromagnetics Research M 103 (2021): 141-149

## Dr. Basudev Majumder

### Wireless power transfer with 5G as wireless power grid

The research group is presently working in wireless power transfer with 5G as wireless power grid and designing different phase shifter less beam steering antenna. Brief descriptions about two such proposed work are:

First a rectifier integrated Luneburg lens is designed at K band for wireless power transfer (WPT) applications. The lens consists of two metallic layers with a gap of 0.3 mm between them and has been made by employing the glide symmetry technique. A flare is tailored to match the outer impedance of the lens to the free space impedance. Five microstrip tapers are used at intervals of 180 at the periphery of the lens to collect the energy from it. The rectifying circuits are co-designed and are integrated with these five tapered launchers so as to make the entire structure suitable for capturing the transmitted power from the solar power

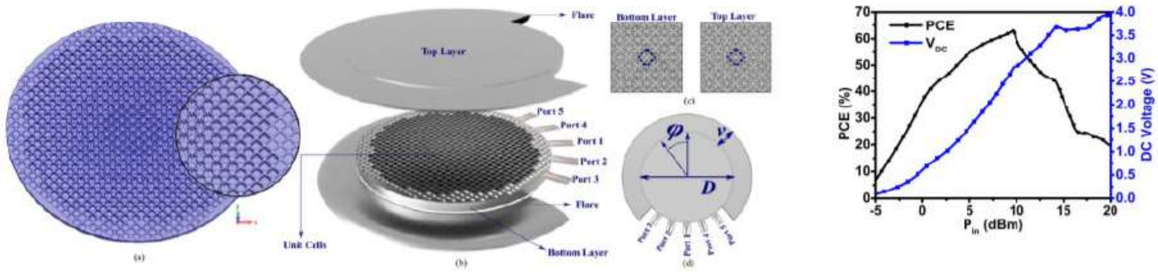



*Figure: 1*

satellite wirelessly, and to convert it to the equivalent voltage. Finally, all the ports are connected with a common load for DC power combining, and the overall performance of the lens integratedrectifier as an energy harvesting system is reported in terms of its power conversion efficiency (PCE) [Figure 1]

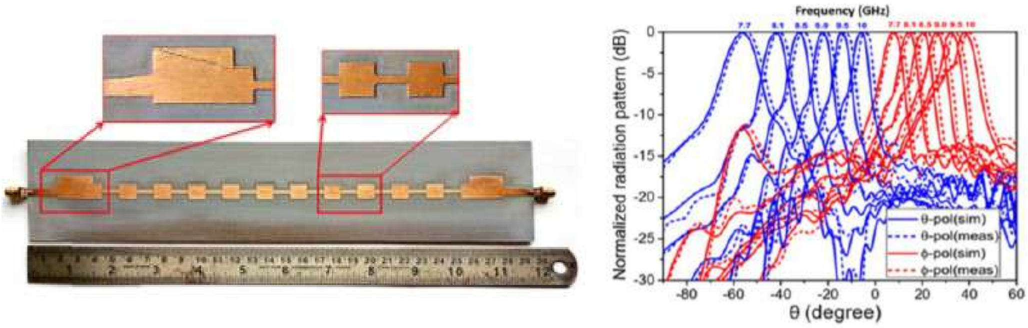



*Figure : 2*

In the second proposed work two configurations of novel dual-band half-mode substrate integrated waveguide (HMSIW) leaky-wave antennas are presented. The first proposed antenna radiates linearly polarized (LP) waves in the lower band and circularly polarized waves in the upper band when the unit cells are cascaded sequentially. The second antenna, where the sidewall via of the HMSIW unit cells is connected alternatingly, provides simultaneous dual beams with different polarization in the upper operational band in addition to the LP beam in the lower operational band. The unit cells of the two antennas are analyzed in terms of their dispersion behaviors. Finally, the performance of both the antennas is experimentally verified. [Figure 2]

*[1]**Basudev Majumder**, Himanshu Meena, Sarath Sankar Vinnakota, Runa Kumari, "Rectifier Integrated Multibeam Lunenburg Lens Employing Artificial Dielectric-as a Wireless Energy Harvesting Medium at mm wave band." in IEEE Photonics Journal, vol. 13, no. 3, June 2021*

*[2]Karthik Rudramuni, **Basudev Majumder**, Puneeth Kumar T R, Krishnamoorthy Kandasamy and Qingfeng Zhang, "Dual Band Asymmetric Leaky Wave Antennas for Circular Polarization and Simultaneous Dual Beam Scanning ", in IEEE Transactions on Antennas and Propagation (TAP),vol. 69, no. 4, pp. 1843- 1852, April 2021*

## Dr. Chinmoy Saha

### Design of Filtenna: Extension to Horn Antenna for Interference/Noise Mitigation using Metamaterial Inspired Concept

The team of advanced microwave research is involved in design and development advanced antennas and circuits at microwave, mm-wave and THz regime which has potential for diversified applications in the area of ground and space applications. One of the key contributions by his research team over last few years is the design and development of frequency notched and multifunctional planar antennas for interference mitigation and cognitive radio applications using metamaterial inspired concept [1]. Recently this concept is extrapolated and applied in the design of horn-filtenna in which a circular split ring resonator array (C-SRR) loaded in the throat of the horn provides excellent out of band interference/noise cancellation [2]. As indicated in Fig., SRR loaded horn-filtenna acting as the feed element in the Cassegrain configuration is placed in the receiver chain for receiving data from satellites [3]. Very strong and wide rejection band (315 MHz) and huge gain suppression in the notch band, 35.42 dB and 24.6 dB for co- and cross-polar radiation, of the proposed horn-antenna can be extremely effective in satellite/wireless communication to eliminate interference from adjacent frequency band without using an additional filter section.

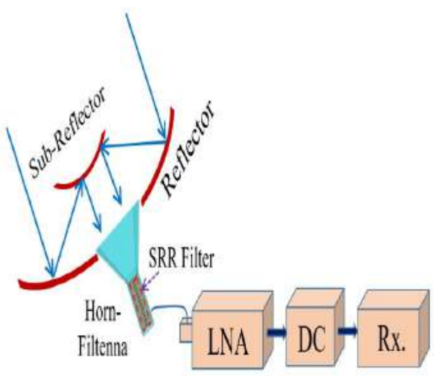



*Figure: Basic block diagram of receiver system with SRR integrated horn-filtenna*

*[1] **L.Ahmed, C. Saha,Y.M.M. Antar and J.Y. Siddiqui**, " An antenna advance for Cognitive Radio: Introducing Multilayered Split Ring Resonator Loaded Printed Ultra-Wideband Antenna with Multi-Functional Characteristics" IEEE Antennas and Propagation Magazine , Vol. 60, issue. 2, pp 20-33, March 2018.*

[2] ***Roy, Sandip Sankar, ChinmoySaha, Naresh Kumar Mallenahalli, and Debdeep Sarkar**. "Circular Split Ring Resonator (C-SRR) Array Integrated Frequency-Notched Horn-Filtenna with Wide and Strong Rejection Band." IEEE Access 9 (2021): 52664-52671.*

[3] ***Sandip Sankar Roy, C. Saha, S.B. Mane, T Nagasekhar, , M Naresh Kumar, C S Padmavathy and G. Umadevi**, "Design of a Compact Multi-Element Monopulse Feed for Ground Station Satellite Tracking Applications" , " IEEE Antennas and Wireless Propag. Lett. Vol. 8,pp. 1721-1725, 2019.*

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## Dr. Chris Prema S.

### Low complexity cyclostationary feature detection using sub-Nyquist samples for wideband spectrum sensing

A low-complexity scheme was implemented to extract cyclic features of wideband signals from sub-Nyquist samples using modulated wideband converter, to identify the modulation of different users in a spectrum as Nyquist rates push contemporary analog-to-digital converters to their performance limits. Due to the sparse spectrum occupancy in wideband, sub-Nyquist sampling is performed and cyclostationary feature extraction is achieved at baseband to identify the modulation scheme with low computational complexity. Currently working on efficient spectrum utilization techniques using spectrum prediction, sensing and localization on widebands.

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## Dr. Deepak Mishra

### DA-SACOT: Domain adaptive-segmentation guided attention for correlation-based object tracking

CVVR lab: computer vision and virtual reality lab are mainly focussing on developing new methods for artificial intelligence. In this lab, we develop new algorithms for various computer vision applications. Deep learning, neural networks, and machine learning research is the prime focus.

Object tracking relies on a recursive search technique around the previous target location, concurrently learning the target appearance in each frame. A failure in any frame causes a drift from its optimal target path. Thus, obtaining highly confident search regions is essential in each frame. In view of generating highly confident search regions for tracking, a generic technique of segmentation guided attention, which can be integrated into any object tracking framework is proposed. Motivated by the strong localization property of segmented object masks, the proposed method introduces instance segmentation as an attention mechanism in the object tracking framework. The core contribution of this paper is threefold: (i) a region proposal module (RPM) based on instance segmentation to focus on search proposals having a high probability of being the target, (ii) a target localization module (TLM) to localize the final target using a correlation filter and (iii) a domain adaptation technique in both RPM and TLM modules to incorporate target specific knowledge and strong discrimination ability. Extensive experimental evaluation on three benchmark datasets demonstrates a significant average gain of 2.47% in precision, 2.55% in AUC score, and 2.15% in overlap score in comparison with recent competing trackers.

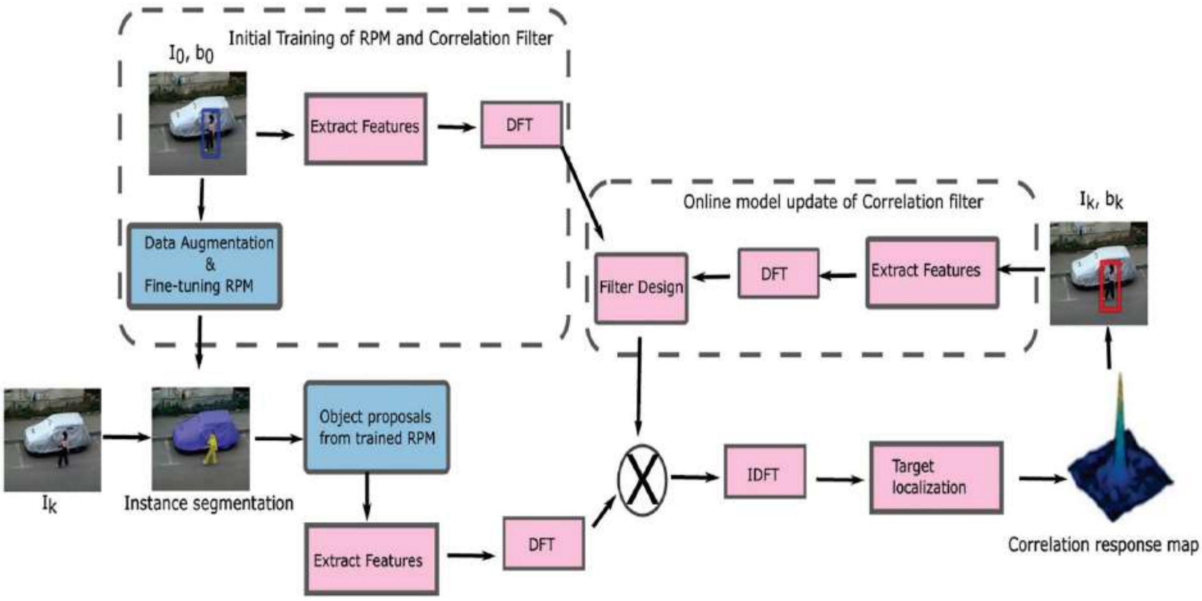


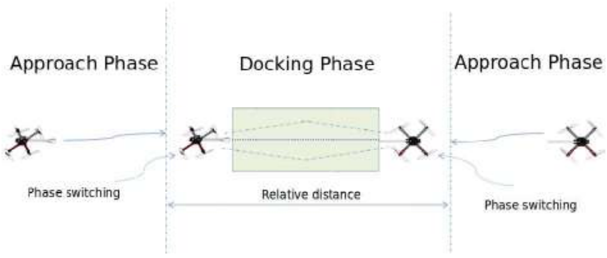

Figure 1 shows the overall framework of the proposed segmentation guided visual object tracking. The initial domain adaptive training of both RPM and CF is done from the first frame I0 where the initial bounding box b0 is known. From k = 2, . . N, each frame Ik is input to the fine-tuned RPM which performs instance segmentation and generates object proposals. The learned Correlation Filter (CF) acts on the object proposals and locates the final target location bk. CF adopts an online model update using features from kth and (k − 1) th frames. The correlation filter performs all operations in the Fourier domain.

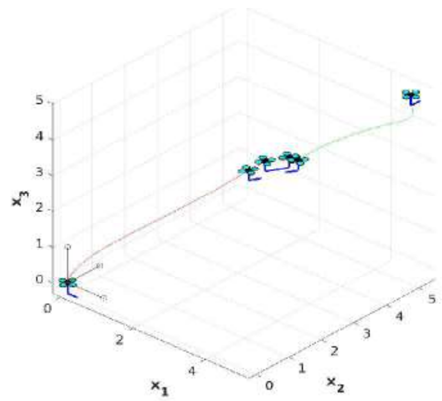
## Dr. Harsha Simha

**Guidance and control scheme for the autonomous docking of quadrotors**

Two quadrotors having rigid docking ports are considered for the purpose of docking. One of the quadrotors has a drogue so that the other can slide through the drogue and finally dock. Docking of quadrotors is achieved in two phases: the approach phase and the docking phase. The approach phase involves two quadrotors that are far apart, approaching each other and hovering at the same height at a set distance with their ports facing each other. Next, in the docking phase, the port positions of the two quadrotors are controlled to achieve the final docking. A guidance and control scheme for the autonomous docking of quadrotors has been developed.

The guidance scheme proposed for the approach phase adopts artificial potential function method to achieve both the translational and rotational requirements simultaneously. A linearized port-to-port dynamics model, which gives a better depiction of the docking requirements and where the linearization has been performed on the state manifold, is employed in the docking phase. Numerical simulation studies illustrate the efficiency of the proposed guidance and control schemes. This study can be extended by including practical constraints on quadrotor flight and docking, such as the influence of disturbances and actuator limitations.



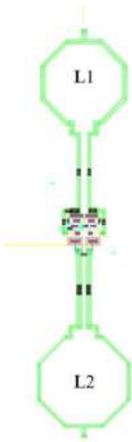



## Dr. Immanuel Raja

### ASIC Design and Characterization Lab

The ASIC Design and Characterization Lab is being setup to work in the field of analog, mixed-signal and RF IC design. In 2020-21, the group focused on 2 major projects:

1. Design of high efficiency power amplifiers for Ka-band 5G communication. With higher modulation schemes, the peak-to-average power ratio increases. This results in poorer operating efficiency of integrated CMOS power amplifiers. The group has been working on techniques to improve the operating efficiency. Doherty technique has been explored for the same and some promising results are obtained. Envelope tracking using low bandwidth supply modulators are being explored.




2. Design of circuits at 100-120 GHz in CMOS: Frequency generation and amplification at sub-THz frequencies are challenging using commercial CMOS. A 106-111 GHz voltage controlled oscillator has been designed. A high gain power amplifier at 110 GHz with an output power of 7.8 dBm and PAE of 4.8% was also designed. On-chip antenna designs were done at 110 GHz, 330 GHz and 550 GHz.

*Figure 1: Layout of 120 GHz Voltage Controlled Oscillator*

## Dr. Lakshmi Narayanan R.

### Sparsity level Estimation for Dynamic Sparse Signals

Work is being carried out in the area of dynamic compressed sensing wherein the aim to acquire data at rates far below the Nyquist rate. This helps to reduce the resources required for subsequent computing. The field of Compressed Sensing, as of today, has evolved beyond acquiring, estimating, reconstructing random vectors and has come a long way up to tracking time varying signals. One important sub-problem which that needs to be addressed is the estimation of the “sparsity level” of the signal, which is essentially the minimum number of components of the signal that need to known for acquiring the signal at sub-Nyquist rates. The sparsity level determines the minimum number of (i) measurements to be obtained of a sparse signal during acquisition and (ii) iterations tobe performed for many of the greedy techniques for the perfect recovery of the sparse signal from the obtained measurements. Multiple solutions for estimating the sparsity level have been developed. These solutions have been applied to multiple real-world problems such as the aircraft vibration signals, the estimation of wireless channels and certain bio-medical signals.

## Dr. Manoj B. S.

### Software Defined Disruption Tolerant Networks and Quantum Big Data Analytics

IIST Systems and Networks Lab (IIST SysNet Lab) focused on two major areas:

In Software-Defined Disruption Tolerant Networks, a Medium-Term Disruption Tolerant Software Defined Network (MDT-SDN) was proposed to handle medium-term disruptions of the order 10 seconds to 6 minutes. Such medium-term disruptions are crucial for the next generation wireless networks that use TCP/IP protocol stack, where the existing disruption tolerant approaches may under-perform due to resource constraints. MDT-SDN enables network control with an additional STORE action which exploits the nodes’ memory for buffering packets within the TCP/IP stack during link disruptions and forwards them as the links become alive. The network with medium-term disruptions using temporal graphs and design the Earliest Arrival Path with Minimal Storage Time (EAPMST) controller algorithm was modeled first to demonstrate the MDT-SDN framework. MDT-SDN along with EAPMST improves the throughput beyond 25% with a random mobility model and is capable of carrying packets and maintaining sessions during medium-term disruptions using the existing TCP/IP stack.

In Quantum Big Data analytics, SysNet lab focused on the following directions: (i) designing a hybrid quantum-classical deep learning model for image scene classification and (ii) a hybrid classical-quantum approach for multi-class classification. We proposed a novel hybrid architecture that uses quantum computation for feature extraction and classical computation for scene classification. In the hybrid architecture, we use quantum measurement-based features to obtain the quantum representations of images. The obtained quantum representations of images are used to train and build a classical deep learning model for image scene classification. The experiments performed on IBM Santiago quantum computer show that the proposed model is suitable for implementation on noisy intermediate scaled quantum computers. Using the proposed architecture, the deep learning model can classify data with an overall accuracy of 95.89%, 86.13%, and 79.32% on UC Merced Land-Use, AID, and NWPU-RESISC45 datasets, respectively, for image scene classification. Further, we proposed the quantum multi-class classifier (QMCC) as a variational circuit with a hybrid classical-quantum approach using quantum mechanical properties such as superposition and entanglement. A unitary operation on a single qubit for the state preparation is designed and also demonstrated using a real quantum computer on the IBMQX platform. The entire variational circuit for the classification task is implemented on a quantum simulator. The quantum simulations were performed on three benchmark datasets: Iris dataset, Banknote Authentication (BNA) dataset, and Wireless Indoor Localization (WIL) dataset for machine learning algorithms. The simulation results show that the proposed QMCC model classified the Iris dataset with an accuracy of 92.10%, BNA dataset with an accuracy of 89.50%, and WIL dataset with an accuracy of 91.73%.

## Dr. Palash Kumar Basu

### Gas Sensor and Bio sensor

Significant research is focussed on the development of nano technology based gas sensors and biosensors. The availability of gas sensors suitable for space applications is very limited. In this context, Palash′s group is trying to investigate low weight, high performance nanostructure gas sensor array on flexible substrate at room temperature where each element of the array will be functionalized by required nano materials (metal Oxide with catalyst) to enhance the performance of the sensor. The group is working actively with IPRC to develop the suitable $H_2$ sensor for leak detection and they have demonstrated superior performance as compared to the available sensor in the market. The validation and signal processing is going on with IPRC. The phase 1 of this project completed successfully. The phase 2 initiated jointly with IPRC. The group is also aimed to develop technology for different applications to monitor the emissions from soil for precession agriculture.This Gas sensor technology will provide new dimensions in the field of precision agriculture, Air pollution monitoring system, Coal mines and man hole gas detection system in low cost. The above development has initiated lot of interest in Space Sector Human Space Flight Centre (HSFC) has agreed to put three modules in the upcoming prestigious Gaganyaan Mission as a part of the Environmental Control and Life Support System (ECLSS). The group is actively working with ISRO to develop first indigenous space qualified gas sensors for Human Space Mission (HSP).

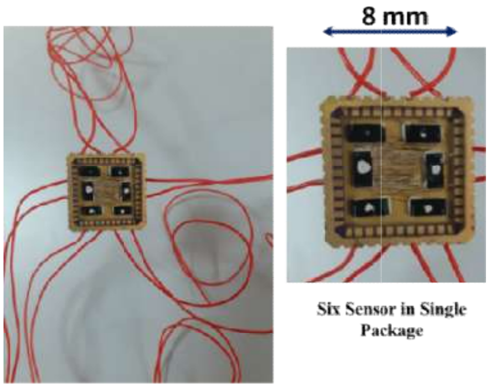



**Figure 1:** Nanomaterials based on CO, $CH_4$, $NH_3$, and $CO_2$ sensors for Environment Control and Life Support System (ECLSS) in the Gaganyyan mission. An initiative has been taken up with SCL, HSFC, SAC to qualify the sensors for the missions. Necessary optimizations are going on to incorporate the activation platform.

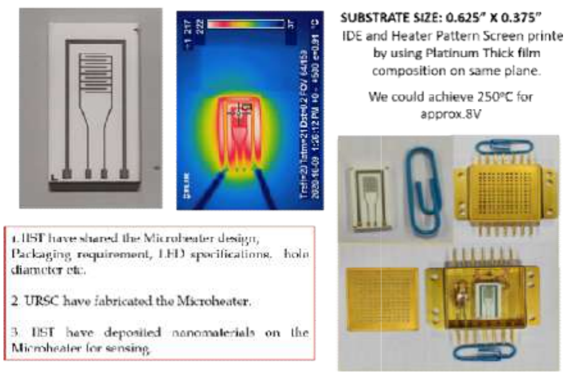



**Figure 2:** Optically Activated CO sensors for Gaganyaan Mission. The same platform has been optimized for $CH_4$ and $NH_3$ sensors. It has been developed in collaboration with URSC.

## Publications:

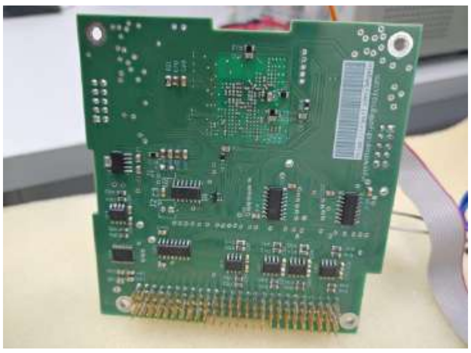
- AkshayaMoulyVijayakumari , Azad Ravi Oraon , SonalieAhirwar , AmalaKannath , Suja K J , Palash Kumar Basu, Defect State reinforced

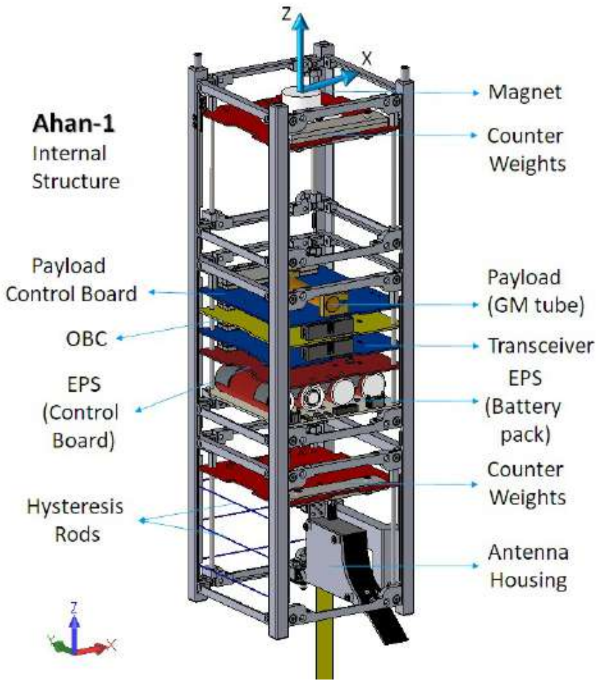
Microwave-Grown Cu x O/NiO Nanostructured Matrix engineered for the development of Selective CO 2 Sensor with Integrated Micro-heater, Sensor and Actuators B: Chemical, 345 (2021) 130391.

- R. K. Kaneriya, GunjanRastogi, **P. K. Basu**, R. B. Upadhyay, A. N. Bhattacharya, *Room temperature photon induced electrical tuning of intersubband transition in GaN HEMT for terahertz applications*, Microelectronic Engineering, 233(2020)111433.

## Dr. Priyadarshnam

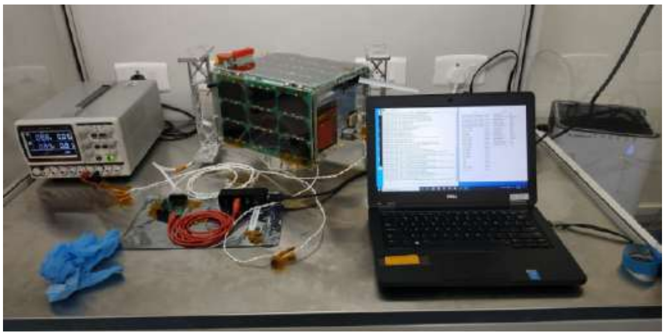
1. Application of Parameterisation of Dynamical Systems to state transfer problem, identification of Bases;
2. **6-D Trajectory Development of Air-breathing phase of Reusable Launch Vehicle** -- 6D-Trajectory development for a hypersonic air breathing vehicle is being developed involving the development of models for aerodynamics, propulsion, guidance and control covering the ascent phase of the flight regime.
3. Orbit optimisation for Venus -- Optimal orbits having longer life and lowest altitude for small satellite on the Venus planet are being developed for the purpose of in situ measurement payloads.
4. Development of IIST Small Satellite and Onboard Computer for IIST small satellite – IIST small satellite is a student 3-U cubesat and is being developed indigenously. The main payload is to measure the radiation at LEO. Except for the communication system, the OBC, EPS and structures are developed by the students of IIST.



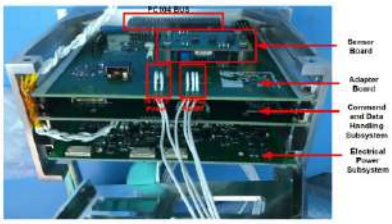




5. Development of PILOT mission for PS-4 stage of PSLV --PiLOT – (Pslv in orbitaL OBC and TTC) is a payload for the 4th stage of PSLV being developed indigenously at IIST by the students. This will carry a RADFET to measure the cumulative radiation dosage at LEO and demonstrate the working of OBC and TTC developed at IIST.

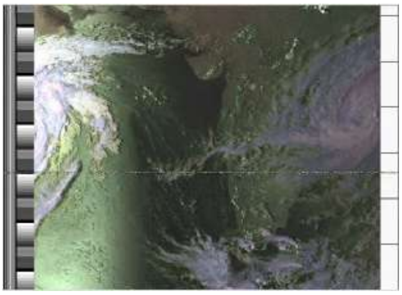
6. Integration and Testing of InspireSat1 -- InspireSat1 is a student satellite jointly developed by IIST and Laboratory of Atmospheric and Space Physics (LASP), University of Colorado, Boulder, USA. During this period the spacecraft was integrated and environment tested at LASP. This spacecraft consists of an IIST designed Onboard Computer (TRL8 level) which is now ready for flight.

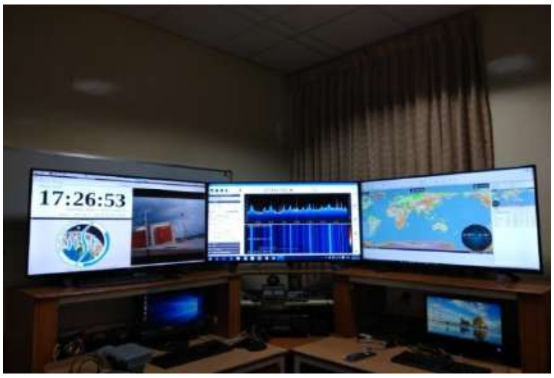



7. Development of IS0 ; IS0 is jointly developed PS-4 payload between NTU, Singapore and IIST. This consists of a low cost solar spectrometer and the InspireSat1 OBC to be demonstrated in the PS-4 platform. This module has been developed at NTU and is now available at IIST for further testing and launch.


8. Satellite Ground Station -- IIST is actively developing a fully operational ground station for tracking the satellites in UHF and VHF. Prototype UHF/VHF antennas have been installed and demonstrated to communicate with the satellites.





## Dr. Rajeevan P. P.

**Power converters, PWM techniques, control of electric drives, and renewable energy**

Works in the areas of power electronics such as power converters, PWM techniques, control of electric drives, and renewable energy is being carried out. One of the main ongoing researches is the development of control schemes for multiphase drives with number of phases more than three, specifically focussing on space applications. Another important area of research is the development of a Load Commutated SCR based Current Source Inverter (CSI) fed Induction Motor drive with open-end Stator Windings for high power applications. The proposed topology has an SCR based CSI at one end of the stator windings and a capacitor fed Voltage Source Inverter (VSI) at the other end as shown in Fig. A. CSI is controlled to feed only the active power whereas VSI controls the reactive power to make the power factor at CSI terminal leading and, thereby, facilitating the natural commutation of the thyristors. This topology does not require any interfacing inductors or separate DC source for VSI and can be used for any three phase induction motor by accessing both ends of the stator windings. The basic concepts developed in this research is then applied to solve the problem of commutation failure at starting and low speeds faced by the conventional load commutated CSI fed synchronous motor drives. This research has led to three publications in IEEE international journals and latest publication is given below.

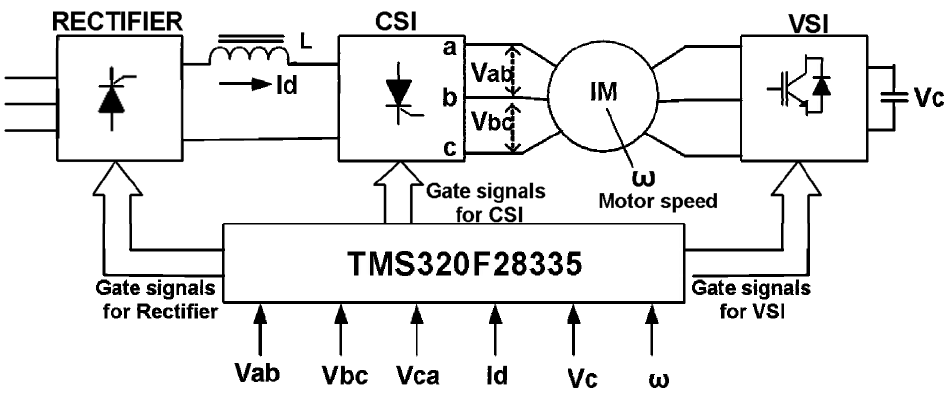



*Figure: A*

*Richu Sebastian C. and **P. P. Rajeevan**, "A Series Voltage Compensated Synchronous Motor Drive With Load Commutation During Starting and Low-Speed Operation," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 9, no. 1, pp. 371-378, Feb. 2021,*

## Dr. Sam K. Zachariah

### Modelling of Multiple sections in General Purpose Humanoid (GPH) and Quadruped Robot

Contributed multiple sections like Kinematics, Dynamics, Actuation systems, Cognitive systems etc. in the Baseline Design Review (BDR) Document on "General Purpose Humanoid (GPH)" having 95 Degrees of Freedom, an advanced R&D initiative by DTDI, ISRO HQ as a part of MyVision-2030

Carried out the dynamic modelling, Preliminary Control design and Simulation of a quadruped robot beiing developed by DRDO for military application.

Developed a novel control scheme for the 3D attitude control of a rigid body using Euler angles avoiding the use of analytical Jacobian, thereby eliminating the issue of representation singularity.

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## Dr. Seena V.

### NEMS Sensor Systems Passive and FET based Active Transduction

Research focuses mainly on the development of ultra-sensitive NEMS Sensor system platforms with novel electromechanical transduction techniques. These miniature microsystems have been demonstrated to have good potential for the development of various applications ranging from cost effective micro sensors in the field of environmental monitoring, homeland security etc. to inertial sensors such as MEMS Accelerometers. These sensor platforms using conventional silicon MEMS as well as novel cost-effective polymer MEMS technologies has been developed.

- **CMOS-MEMS Accelerometer with FET based Active Electromechanical Transduction**

Performances of conventional capacitive MEMS accelerometer sensors are limited by passive detection mechanisms with large area of the electrodes, electromagnetic interference and the need for C-V converters. Transistor based active transduction schemes with suspended gate architectures have the potential to overcome these limitations. While FET based transduction schemes are promising, there are some gaps in the development of MEMS-FET based accelerometers. As per one of our recent research works, we have developed a single axis, high performance silicon CMOS-MEMS accelerometer with novel U-channel SOI SGFET architecture to mitigate the operational limitations of MEMS-FETs due to "pseudo-short channel effect (P-SCE)". Research work is in progress on the investigation of newer device architectures with silicon and 2D semiconductor materials and the process technology development.

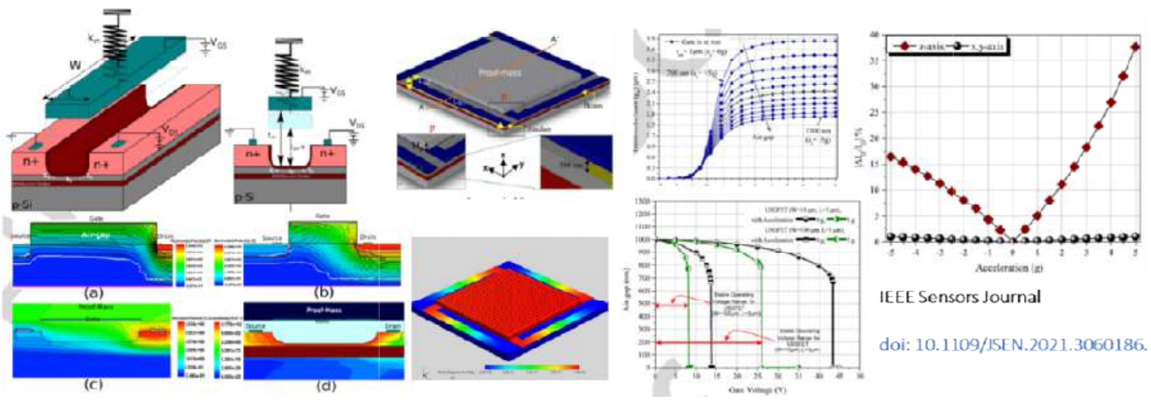



*Figure: CMOS-MEMS Accelerometer With U-Channel Suspended Gate SOI FET: Device design and electromechanical characteristics*

*P. Martha, N. Kadayinti and V. Seena, "A CMOS-MEMS Accelerometer With U-Channel Suspended Gate SOI FET," IEEE Sensors Journal, doi: 10.1109/JSEN.2021.3060186.* •

- **Polymer/Ceramic MEMS: A Nanomechanical Sensor Platform with Low Temperature High Gauge Factor ITO for Electromechanical Transduction**

MEMS biochemical sensors based on nanomechanical cantilevers (NMC) translate bio/chemical interactions into nanomechanical motion that can be detected by various transduction techniques. We have recently reported the development of novel polymer nanomechanical cantilever sensor platform with a high gauge factor Indium tin oxide (ITO) as piezoresistor for electrical transduction. The fabricated SU-8/ITO microcantilevers were experimentally characterized for extracting the mechanical, electrical, and electromechanical properties. A room temperature hydrogen leak detector with sub-ppm sensing capability was developed using these devices and the device has the capability to detect sub-ppm level hydrogen leak with suitable signal conditioning. Part of this work was supported through SERB Extra Mural Project grant.

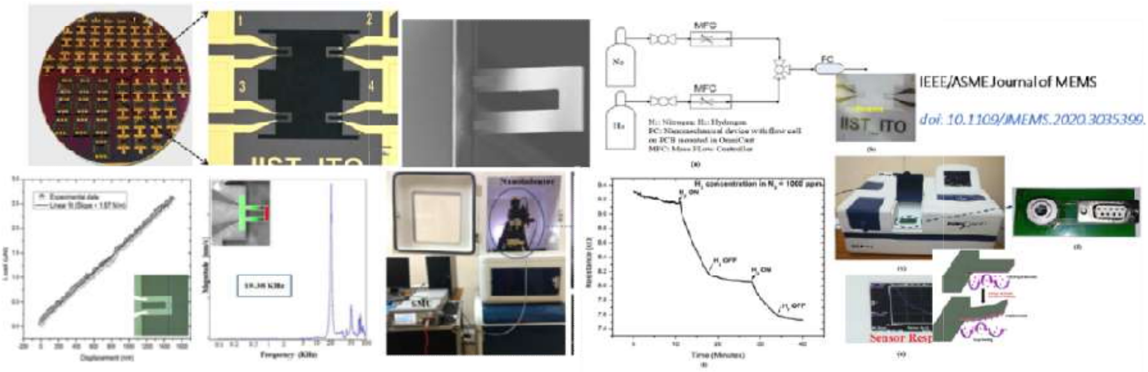



*Figure : Polymer MEMS Nanomechanical Cantilever Sensor: Device development and application in Hydrogen gas leak detection*

*B. S. Tina, C. Anjana, N. Kumar and V. Seena, "Polymer/Ceramic MEMS: A Nanomechanical Sensor Platform With Low Temperature High Gauge Factor ITO for Electromechanical Transduction," IEEE Journal of Microelectromechanical Systems, vol. 30, no. 1, pp. 116-125, Feb. 2021, doi: 10.1109/JMEMS.2020.3035399.*

## Dr. Selvaganesan N.

**Control system design, estimation theory, Biological modelling, fault diagnosis and fractional order control**

**Fractional control design** – Generally, controllers are tuned to meet the desired time and frequency domain specifications for integer/fractional order real coefficient systems whose frequency response is symmetric about the origin of the complex frequency plane. These controllers are tuned through analytical/numerical approaches. On the contrary, the frequency responses of the complex coefficient systems are unsymmetrical and hence tuning of controllers should consider both positive and negative frequencies. In this research, tuning of complex coefficient proportional integral derivative controller is proposed for such systems to meet the different specifications in positive and negative frequencies. Stability of such complex systems are analysed in details.

**Development of Human health care system in Space** - This research work plan to develop a software integrated with few hardware′ s for human healthcare in space. The details modules considers in this work is as follows:

(i) Development of more efficient algorithms for human health monitoring using analytical model and deep learning methods

(ii) Indigenisation and establishment of sensors and wireless communication system

(iii) Monitoring human health care using less no of sensors with adequate accuracy

## Dr. Sheeba Rani J.

**Signal Image processing applications**

The research focus is on developing efficient hardware /hardware-software solutions for signal/image processing applications. Presently the research is focused on the field of Compressed Sensing (CS) by extensively analyzing the greedy recovery algorithms present in the literature and identifying their merits and drawbacks, with a view to develop fast and low-cost hardware to carry out signal reconstructions from massively compressed measurements. To this end, a sparsity independent regularized pursuit (SIRP) algorithm that exhibits sparsity adaptiveness, hardware feasibility, fast convergence and scalability to higher signal dimensions is proposed. Further research has been carried out to introduce algorithmic optimizations in SIRP that aid in the design of hardware architectures targeting fast reconstruction speeds and low hardware complexity respectively. The first architecture targeting fast recovery speed employs hardware sharing and a linear systolic array based parallel column QR update strategy to perform the complex processing steps of the algorithm with increased resource consumption. The second architecture is being designed to trade-off fast reconstruction speeds for low-cost hardware by employing a least mean squares (LMS) strategy instead of complex matrix factorization methods.

*Thomas James Thomas, J. SheebaRani,"Sparsity Independent Regularized Pursuit for Compressed Sensing reconstruction", Signal Processing Elseveir 2020, 172(4):107508*

## Dr. Sooraj R.

### Optical Logic Gates

The implementation of directed logic gates using electroabsorptive (EA) quantum-well (QW) based p-i-n diodes embedded in the waveguiding regions of optical microring resonators (MRR) is proposed. The absorption of the QW incorporated in the MRR configurations varies with respect to the appliedfield due to the quantum confined stark effect and results in optical switching by shifting the resonantwavelength. Various optical logic gate operations are realized by representing the operands as theapplied field on the rings while the operation results of logic gates appears as in the form of lightintensities at the output ports of MRR. The proposed configurations are optimized (in terms ofcoupling coefficient, operating wavelength and applied field) to acheive logic operations such as AND, NAND, XOR, XNOR and Fredkin gates. A new electroabsorptive triple ring resonator configuration isalso proposed which can simultaneously realize optical OR as well as AND gate at the output ports.

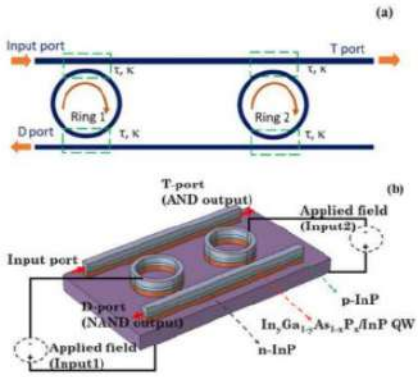


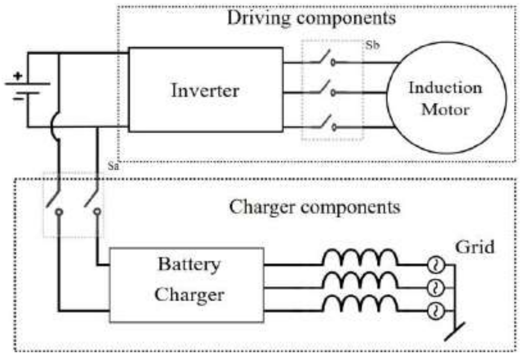

*Figure: (a) Parallel DRR for realizing AND NAND gate. (b) Perspective view of AND, NAND gate based on EA QW embedded on parallel MRR.*

***Fayza K. A, Sooraj Ravindran, Kwangwook Park, Kamal Alameh, Aylin Bengi, Hajara A. V, Yong Tak Lee***Advanced realization and characterization of directed optical logic gates usingelectroabsorptive quantum-well-based micro ring resonator,Optik, Volume221, November 2020, 164426

## Dr. Sudharshan Kaarthik R.

### Integrated EV Battery Charger with Retrofit Capability

A fast on-board integrated battery charger which uses the stator windings of an asymmetrical six-phase machine (rewound from an existing three phase motor) is proposed. The proposed scheme uses the existing three-legged traction inverter for both charging and driving mode. This reduces the total cost of the system compared to the existing battery charging systems for electric vehicles. The leakage inductances of the rewound asymmetrical six-phase machine is used instead of additional inductors as interface between the grid and the inverter, for charging the battery. During driving mode, the windings of the six-phase machine is connected in series, ie. the 30-degree phase belts are connected in series, making it a three-phase machine. During charging, the windings of the six-phase machine is reconfigured to produce zero electro-magnetic torque (a pulsating magnetic-field is produced). In addition, different current control schemes namely, PI, PDF and PR is implemented and compared in this paper.



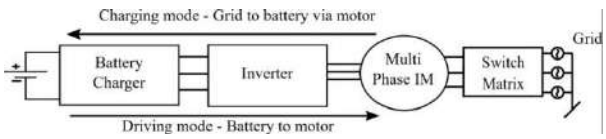
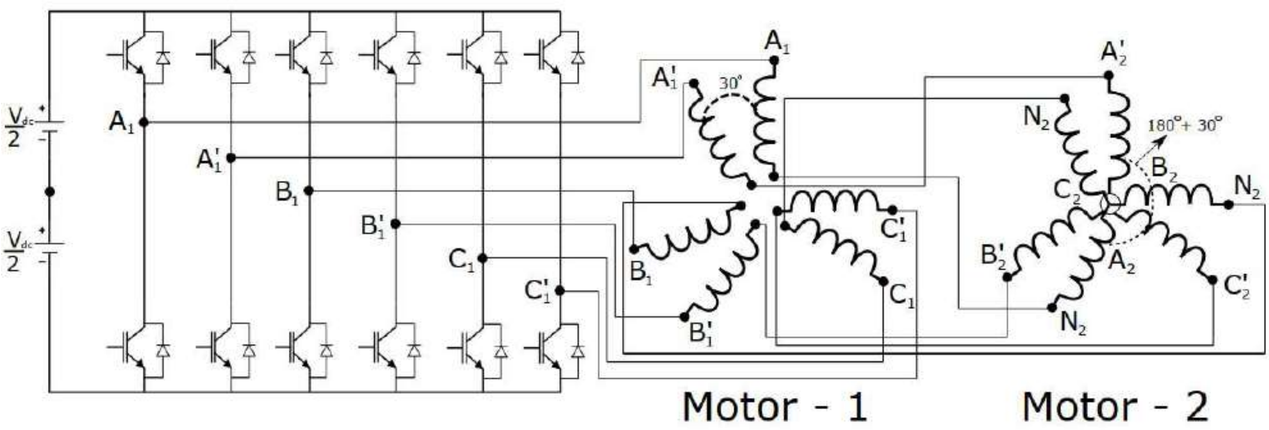



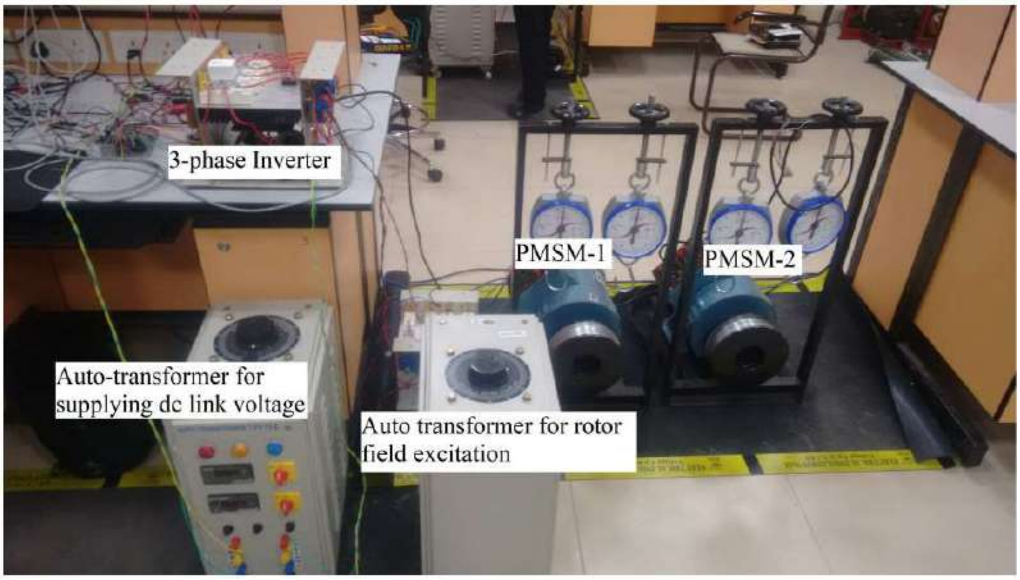

*Figure 2: Existing on-board chargers.* *Figure 2: Proposed integrated charger*

*Published in IEEE Transactions on Transportation Electrification*

**Decoupled Control of Series Connected Split-Phase Synchronous Machines With Open-Circuit Fault**

Split-phase motor drives have advantages such as lower torque ripple, enhanced fault tolerance, higher power-to-weight ratio, and lower DC-link voltage requirement, making it an attractive alternative to the conventional three-phase drives. In the proposed series connected topology, both the motors are connected in different phase sequences, allowing the fundamental component of the winding current to produce torque in the first machine, and sixth-order harmonic currents to produce torque in the other machine. Both the motors used are synchronous machines which have advantages such as higher power density, and easier control. The proposed method can be easily extended to other synchronous machines such as permanent magnet machines and reluctance machines. In this paper, a mathematical model for series-connected split-phase synchronous motors is developed and validated experimentally for decoupled field-oriented control of dual split-phase synchronous machines. Furthermore, the developed model (series connected system) is extended for open-circuit fault operation, and experimental results are presented for the first time. Simulation results as well experimental results for steady state, transient conditions for normal and fault operation are presented to validate the proposed scheme.

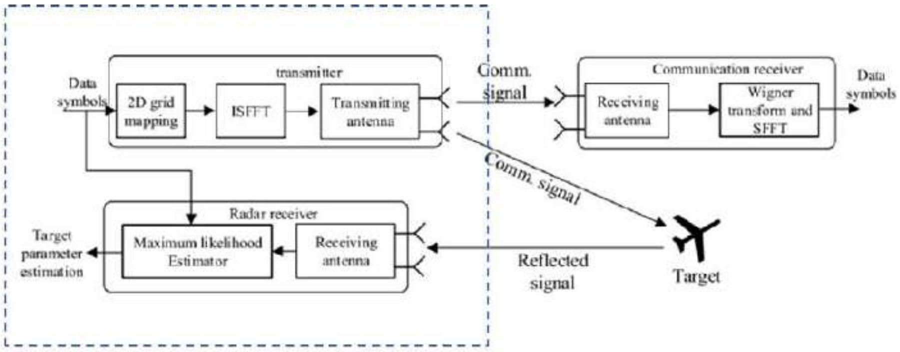



*Published in IEEE Transactions on Industry Applications*

## Dr. Vanidevi M.

### Development of baseband signal processing algorithm in 5G communication and radar system




Base Station /Radar Station

The current research workis carried out in the area of development of joint radar and communication system in one hardware module which finds its application in many scenarios, especially in the military and defence context like military Unmanned Aerial Vehicles (UAVs) that can be used in surveillance, search and rescue operations etc. The research work is also carried out in the development of signal processing algorithm for 5G Massive MIMO communication system in millimetre range such as hybrid beamforming, channel estimation, signal decoding as well developing a deep learning algorithm for SCMA decoder. Recently, our research group started working in the area of Interference analysis and co-existence studies between GSO and NGSO satellite systems.

## Dr. Vineeth B. S.

### Age of Information in Communication Networks

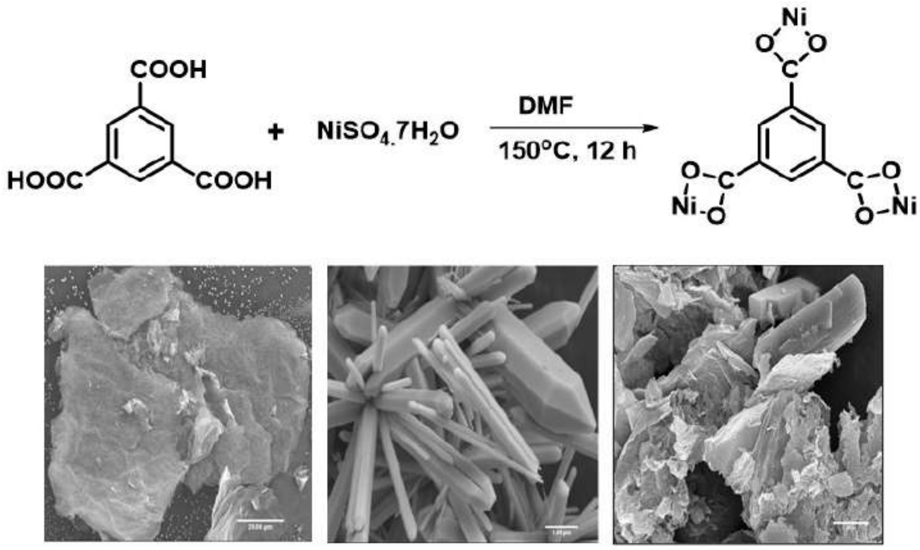
During the period 2020-2021, the group investigated age of information, a new information freshness metric for communication networks. One particular resultis highlighted. Grant-free irregular repetition slotted ALOHA is an approach for massive machine-type communications (mMTC). An optimal design of IRSA schemes for minimizing the average age of information is proposed. The age as a function of the number of UEs, the frame duration, and the repetition distribution of IRSA was characterized. A novel early packet recovery method that further reduces the average age of information was alos proposed. The problem of minimizing AAoI by optimizing over the normalized channel traffic and repetition distribution for all the proposed sampling and recovery schemes was considered. The optimization problem is challenging since the objective function is semi-analytical and can only be characterized using simulations. In an asymptotic regime where the number of UEs, as well as the frame size, is large, we characterize the AAoI using upper and lower bounds. A locally optimal normalized channel traffic and repetition distribution using differential evolution was also obtained. Based on the asymptotic analysis's insights, we propose a pragmatic approach to obtain a normalized channel traffic and repetition distribution for AAoI reduction in the non-asymptotic case. Finally, it was empirically shown that AAoI minimizing schemes outperform conventional throughput optimal schemes.

## Department of Chemistry

### Dr. Gomathi N.

#### Metal Organic Framework for Electrochemical Sensing

2D layered metal-organic framework nanosheets have received extensive research attention owing to its intriguing chemistry and remarkable properties like ultrathin thickness, tunable structure, large specific surface area, high aspect ratio, accessible active sites, large pore volume etc. which leads to diverse applications. To generate 2D MOF nanosheets, the challenge of growth of MOF crystals lies in suppressing its growth along the vertical direction without affecting the other two lateral directions. The confinement of electrons in the 2D nanosheet promotes MOF for the fabrication of highly flexible and transparent electronic devices. The high surface area of 2D nanosheet results in the presence of a large number of exposed active sites on its surface compared to bulk MOF, which contain active sites mostly inside the pores and channels and improves the interaction between substrate species and active sites. This results in the enhancement of the reaction, resulting in improved performance for applications like sensing, catalysis, and separation. Currently we are focussing on the facile one step room temperature synthesis to obtain 2D MOF and are employed as electrode modifier for the determination of antibiotics.




**Ni-MOF/RGO hybrid material for electrochemical sensing**

## Dr. Jobin Cyriac

**Organic-inorganic hybrid perovskites of polysilsesquioxanes and methylammonium tin bromide**

Hybrid metal halide perovskites showed exceptional electronic and optical properties, which make them potential candidates for renewable energy storage applications. Polymeric encapsulants are proven to be defect-passivating agents which render robust perovskite films. A new synthesis of tin halide perovskite encapsulated by a transparent conducting oligomer, namely polysilsesquioxane (PSQ), has been realised. The stability of the tin halide perovskite was improved using the modifier. PSQ possesses good electrical conductivity and HOMO-LUMO energy levels to promote the hole conductivity of the perovskite materials. The photovoltaic conversion efficiencies (PCEs) of ~2.2% were obtained with a short-circuit current density ($J_{SC}$) of ~5.4 mA/cm$^2$, open circuit potential ($V_{OC}$) of ~1.0 V and a fill factor (FF) of ~40% under 1 sun (100 mW/ cm$^2$) illumination. This work opens a new class of chemical modifiers for improving environmental stability.

*Balachandran, N.; Sukumaran, S.; Robert, T. M.; Cyriac, J.; Mathew, D.: Multi-functionalized polysilsesquioxanes assisted synthesis of methylammonium tin bromide perovskite: A novel approach. Materials Science and Engineering: B 2020, 261, 114761.*

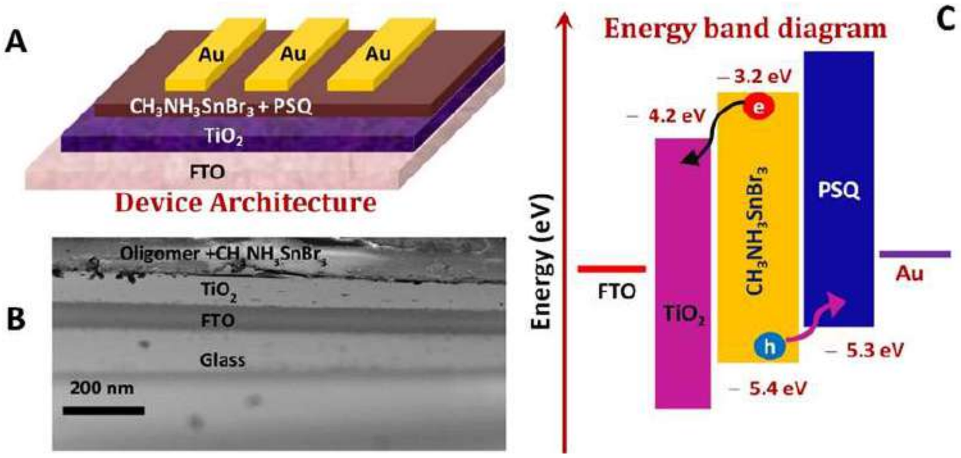



*Figure: (A) The schematic of the device configuration and (B) is the scanning electron microscopy image of a cross-section of the cell showing various layers of the photovoltaic cell. (C) Energy bands diagram of the materials employed for the preparation of the cell.*

## Dr. Kuruvilla Joseph

### Novel polymer composites for advanced space applications

- **Super toughening of epoxy hybrid nanocomposites**

  In this area the main focus is on developing novel nanofiller combinations for simultaneously enhancing the mechanical and toughness of epoxy composites. The group came up with various polymer grafted nanofiller combinations, electrospun fibers, nano wire system for this purpose. All these results are published in international peer reviewed journals

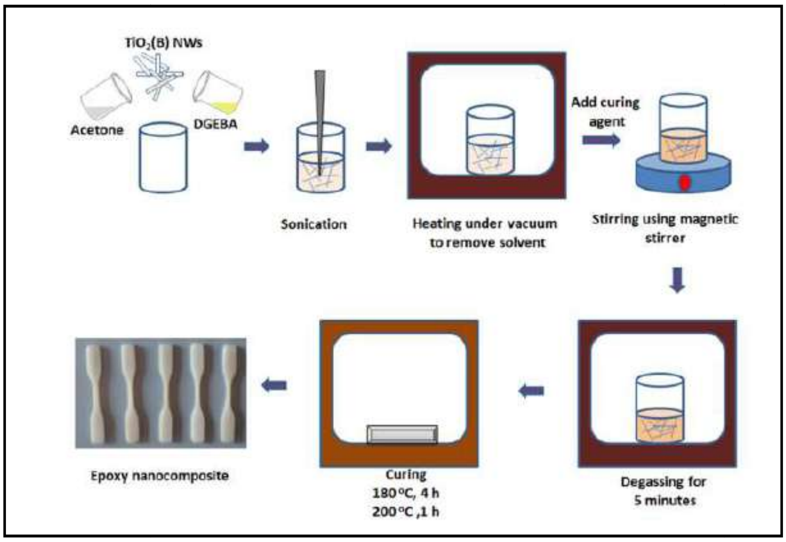



*Figure 1: Schematic of the preparation of $TiO_2$/epoxy nanocomposite (DOI: 10.1002/pc.25058)*

- **Intrinsically conducting polyimide composites with CNT/graphene without compromising optical properties(IIST-ISRO)**
  Transparent and electrically conducting polyimide composites having electrostatic charge mitigation characteristics have been reported to address the concern related to the surface charging of satellites. With our membrane films, we have achieved a surface resistivity of $10^7$ Ohm/square (not published, ISRO confidential project). The qualification test of the material is underway.
- **Biosensors**
  Significant contribution towards disease diagnosis has been made through biosensors for the detection of fructose in semen for infertility test, E *coli* in UTI patients, choline in Alzheimer' s screening, to mention a few these sensors have very high societal importance. Currently, we are involved in developing polymer nanocomposite-based stress sensors for biomedical applications.
- **Microfibrillar composites**
  Another noted area of the group is development of high performance *in situ* microfibrillar composites. The group came up with CNT loaded PET/PP and nylon/PP composites, which have high mechanical strength and conductivity.
- **Lightweight EMI shielding materials**
  At presnt the main focus area of the group is preparation of lightweight materials for EMI shielding application. Currently the group came up with metal oxide/ metal carbide loaded electrospun carbon fiber mat/epoxy to address this issue. These results are interesting in commercial point of view.
- **Low cost carbon fibers**
  This group recently started working on preparing low cost carbon fibers from cheap sources like lignin and PVDF. The results are very important in developing economical carbon fibers as a replacement of high cost PAN carbon fibers
- **Biocomposites**
  Green composites were one my early carrier interests and continuing activity. Our team has developed industrially important biocomposites from natural fibres. I have significantly contributed to this area and published ~100 papers

- **Novel gold nanomaterial based optical sensors for diagnosis of clinically relevant marker molecules.**
- **Development of $N_2O_4$ scrubber system (IIST-ISRO project)**

As of date, this group contributed over 185 international peer reviewed research publications and 3 patents, and many more are underway.

*Jayan JS, Appukuttan S, **Joseph K**. MoS2: Advanced Nanofiller for Reinforcing Polymer Matrix. **Physica E: Low-dimensional Systems and Nanostructures. 2021** Mar 16:114716.*

*Jayan JS, Saritha A, Deeraj BD, **Joseph K.** Synthesis of self‐assembled and porous nano titania‐graphene oxide hybrids for toughening the epoxy. **Polymer Composites. 2020** Oct;41(10):4093-103.*

*Jayan JS, Deeraj BD, Saritha A, **Joseph K.** Theoretical modelling of kinetics of glass transition temperature of PEG toughened epoxy. **Plastics, Rubber and Composites. 2020** Jul 2;49(6):237-44.*

## Dr. Mary J Gladis

**Porous carbon electrode for high performance super capacitor**

With the rising demand for clean and sustainable alternative energy to avoid environment pollution and to mitigate the energy crisis, supercapacitors are considered as one of the most promising electrochemical energy storage systems. Carbon materials with favourable porous architecture and heteroatom functionalities are potential candidates for energy storage applications due to its excellent structural and electrochemical properties. solid-state symmetric supercapacitor (SC) using heteroatom (nitrogen and oxygen) inherently co-doped microporous carbon (HMC) was developed. HMC was prepared by simple carbonization method from 4, 4′-diamino-diphenyl sulphone in a single step with surface area of 1766 $m^2 g^{-1}$ and a total pore volume of 0.87 $cm^3 g^{-1}$. The symmetrical SC was fabricated with polyvinyl alcohol (PVA) supported 6 M KOH and 1 M $Na_2SO_4$ as gel electrolytes. The performance of solid-state SC showed good cycling stability and high energy density. The device exhibited a maximum energy density of 35 W h $kg^{-1}$ with a maximum power density of 3180 W $kg^{-1}$ remained stable (91% capacity retention) after 5000 cycles. Also, the device using porous carbon electrode material with PVA+1 M $Na_2SO_4$ able to light a LED after charging for about 5sec.

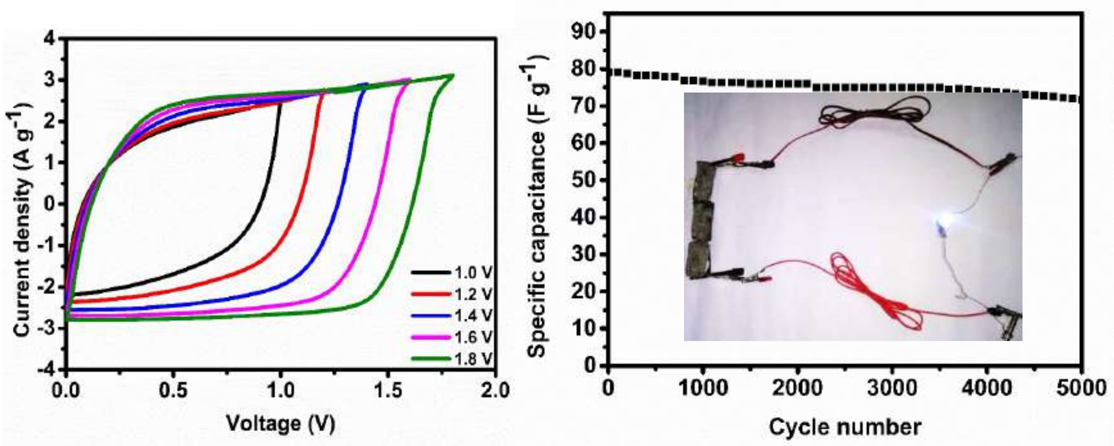



*Figure: Electrochemical characteristics of an HMC electrode as symmetri cal capacitor using PVA+ $Na_2SO_4$ gel electrolytes (a) CV curves at scan rate of 50 mV $s^{-1}$ within different voltage (b) Cycling stability at a current density of 0.6 A $g^{-1}$ (inset shows a white LED powered by three symmetrical devices in series).*

***Reshma C., Haritha H., Mary Gladis J.*** *(2020) Template free one pot synthesis of heteroatom doped porous Carbon Electrodes for High performance symmetric supercapacitor Electrochimica Acta 337, 135698*

## Dr. Nirmala Rachel James

### Stretchable and flexible electrospun polymer fiber composite for electromagnetic interference shielding and oxygen evolution reaction

Everyday life is surrounded by man-made electromagnetic radiations such as microwave radiations for satellite communication, radar wave guidance for aeroplanes, electromagnetic waves received by TV sets and transmitted by broadcasting stations, visible light used for fibre optics communication etc. These wireless technologies cause electromagnetic (EM) pollution, and the widespread use of digital devices is harmful to human health, causes malfunction of electronic devices used in civil or military applications. As a result, the development of high-efficiency electromagnetic interference (EMI) shielding materials with low thickness, wide bandwidth, and lightweight properties is urgently needed. My group is involoved in fabrication of an electrospunfiber composites comprising of copper nanowires, carbon black, strontium doped lanthanum cobalt oxide (LSCO) polyvinylpyrrolidone, and polyurethane/ polyacrylonotrile for EMI shielding. Mechanism of EMI shielding by electrospunfiber composites is represented below. We are successful in developing electrospunfiber composites with high EMI shielding efficiency. Our group also investigates the possibilitiy of using these electrospun polymer fiber composites as freestanding electrodes for oxygen evolution reaction.

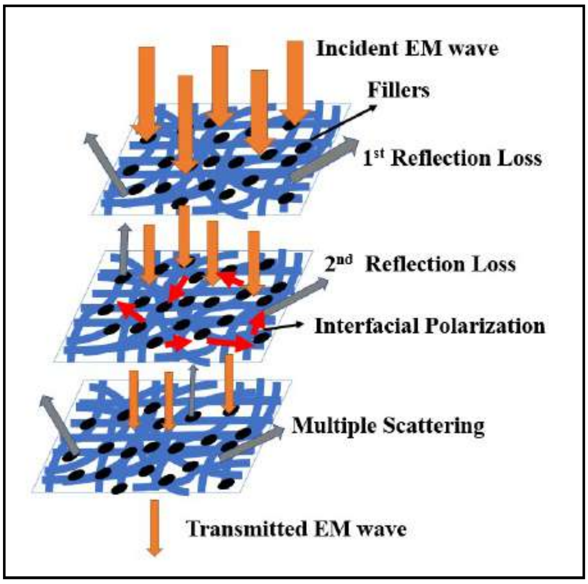



*Figure: Illustrates the mechanism of EMI shielding of electrospun fibrous materials*

## Dr. Prabhakaran K.

### Carbon foams from renewable resources

Carbon foams are new generation lightweight thermo-structural materials. They are prepared from fossil fuel-based precursors like pitches and synthetic polymers. The depletion of fossil fuels necessitates the development of carbon foams from naturally renewable materials. Our research focusses on the development of carbon foams from biomass/bio-waste. A filter-pressing method has been developed for the preparation of carbon composite foams from natural cotton, sawdust, rice husk and newspaper waste. The biomasses dispersed in sucrose solution are consolidated by using a filter-pressing setup fabricated in house. Freeze-drying of the filter-pressed bodies followed by carbonization produces carbon composite foams. Herein, the carbon produced from the biomasses is bonded by the carbon produced from sucrose. The foam density, compressive strength and thermal conductivity of the carbon composite foams are modulated by changing the sucrose solution concentration. The carbon composite foams density in the range of 0.16 to 0.32 g/cm$^3$ exhibited high compressive strength in the range of 0.5 to 2.5 MPa and low thermal conductivity in the range of 0.069 to 0.185 W/mK. The carbon composite foams exhibit excellent fire resistance and high EMI shielding effectiveness.

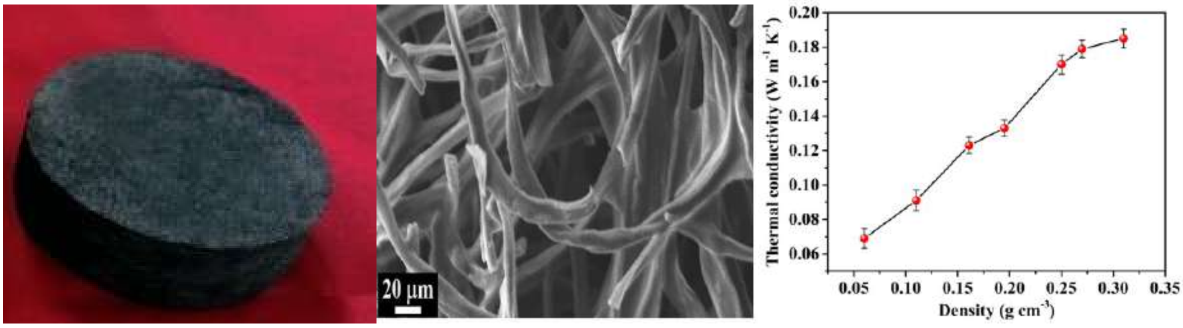



*Figure: Carbon composite foam body, microstructure and thermal conductivity of carbon composite foam prepared from natural cotton*

***Chithra, A; Wilson, P; Vijayan,S; Rajeev,R; Prabhakaran,K** Thermally insulating robust carbon composite foams with high EMI shielding from natural cotton. Journal of Materials Science and Technology 94, 113-122.*

## Dr. Sandhya K. Y.

**Nanomaterials for EC Sensing, Energy Storage and Environmental applications**

Nanomaterials have created a high interest in recent years by virtue of their unusual and unique mechanical, electrical, optical and magnetic properties and various potential uses.Applications based on nanomaterials, rely on their properties such as: highly active surface, higher conductivityand the higher surface area which enhances the efficiency of the nanomaterials based system. Sensors made of nanomaterials can interact at molecular level due to their small size and leading to improved efficiency and performance. Similarly battery electrode materials made of nanomaterials can enhance the capcity and stability compared to that of its bulk. Our research group focuses on (nano)materials for electrochemical (EC) sensors, energy storage and environmental applications such as removal of toxic metal ions from water and sensing of pollutants in water.

**Electrochemical Sensors:**

Our group focuses on EC sensors for important biomolecules and pollutants. The idea is to synthesize nanomaterials of suitable structure and shape for higher efficiency. Materials that can interact with the analyte are chosen for developing

EC sensor electrodes as this will lead to selectivity and enhanced performance. Some of the nanomaterials based EC sensors developed by our group are given below:

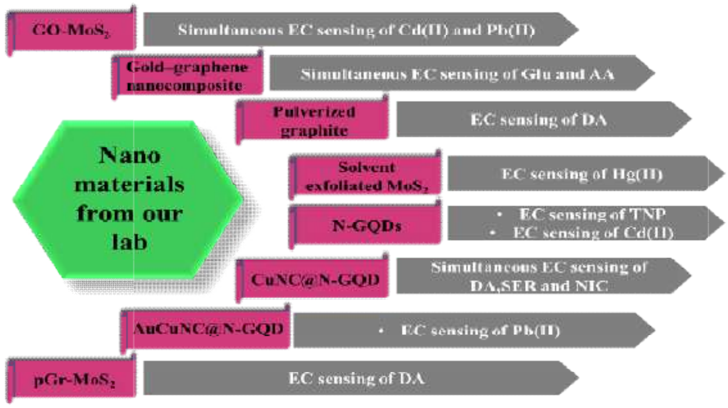
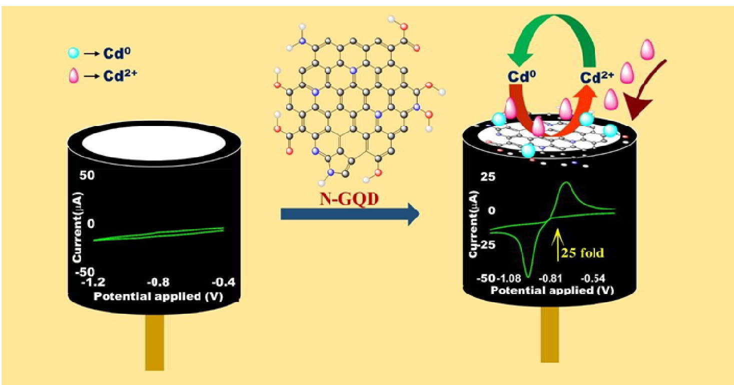



*Figure gives an overview of the EC sensor materials developed in our group*

## Electrochemical sensing of Cd(II) by Nitrogen doped Graphene Quantum Dots

In this work, we have successfully demonstrated for the first time, the ultra-high sensitivity and selective EC sensing of Cd(II) by N-GQDs, which can detect Cd(II) up to 1 × $10^{-5}$ppb which can be drawn-out further to 1 × $10^{-7}$ ppb (ppq) with pre-reduction step. The effectiveN-doping, which is attributed to the synthesis procedure, plays a crucial role in the sensing performance of N-GQDs which spontaneously reduces Cd (II), mostly through the N-sites. The N-doping increases the electron availability of N-GQDs which in turn increases the ability of N-GQDs to reduce Cd (II). This work has established a simple, as well as environmentally friendly material for the sensing of Cd (II) with remarkable selectivity and sensitivity. The N-GQDs/GCE exhibited good reproducibility, reusability and stability and extended the performance to real samples such as groundwater, seawater, and wastewater.



### Environmental Applications-Removal of toxic metal ions from water

Molybdenum disulfideHollow Nano-roses ($MoS_2$HNR) were synthesised through a micelle assisted hydrothermal method and explored for the removal of Hg (II), Pb (II) and Ag (I) from water.The $MoS_2$HNR exhibited simultaneous and efficient removal of Hg (II),Ag (I) and Pb (II) such that a 99.98 % removal from a contaminated water containing 10000 ppb of each metals ion within 30 minutes was achieved with a single treatment.The better removal capacity was attributed to the open hollow cavity and the thin open sheets of the $MoS_2$-HNR.

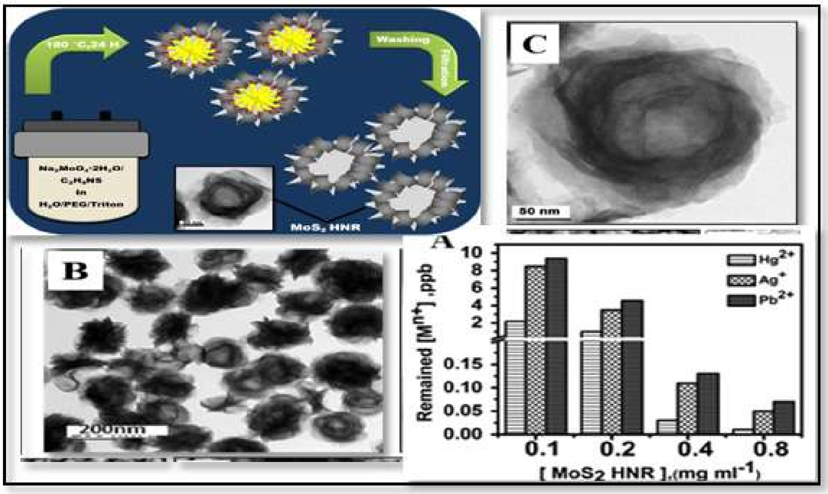



*Figure: Synthesis strategy, Structure and removal efficiency of Hg(II), Ag(I) and Pb(II) by $MoS_2$ HNR*

### Suitability of $MoS_2$ HNR for Supercapacitor electrodes

In this work, we investigated the supercapacitive properties of $MoS_2$ HNR. The synthesized nano $MoS_2$ delivered specific capacitance of 180 F $g^{-1}$ at 1 A $g^{-1}$, whereas it was around 22 F $g^{-1}$ for the bulk $MoS_2$, which was synthesized in the absence of the micelle. The cycling stability was very high and retained 98 % up to 500 cycles, 85 % after 3 500 cycles and 80 % of the initial capacity at 5 000 cycles. The enhanced specific capacitance and cycling stability of the nano $MoS_2$ is probably due to the flower-shaped morphology which consists of thin sheets of $MoS_2$ and with a hollow cavity which increases the accessible surface area and stability, respectively.

## Dr. Sreejalekshmi K. G.

### Design and development of full color emissive all-organic fluororphores

A design strategy to bridge the gap between aggregation-caused quenching (ACQ) and aggregation induced emission (AIE) in fluorophoreswas developed with a novel class of dual state emissive (DSE) full colortunable molecules. Computational chemistry assisted core design predicted stable conformers and the effects of steric and various supramolecular interactions were evaluated. The C4 substituent acted as multifunctional stacking modulator. The designed novel molecules were synthesized and evaluated for photophysical properties to confirm their DSE behaviour with striking quantum yield both in solution and solid states. Importantly, molecules exhibited a very rare full color dual emission in both states (solution: 469-672nm, solid: 466-614nm) thus becoming new entrants in the full color dual state emissive (FCDSE) family, which amplifies their potential use in technological applications.

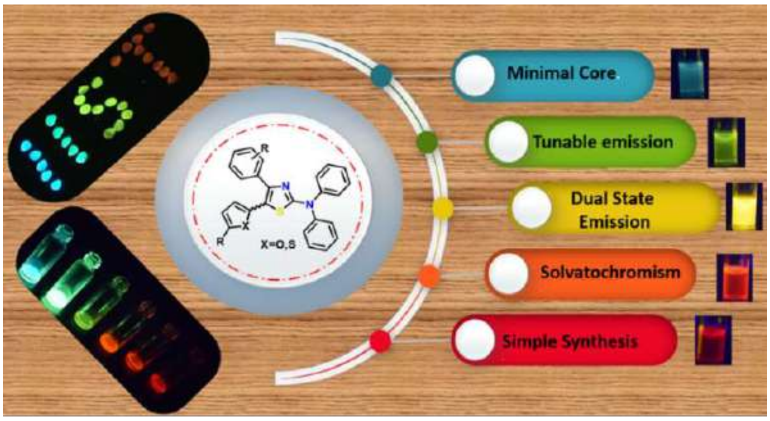



*Figure: Graphical abstract from the publication**

***Rakesh R, Bhavya BS, Vishnu A, K.G. Sreejalekshmi:*** *Discovery of full color emissive thiazole fluorophores in solution and solid states: The core is central and regulating torsional barrier does the trick!, Dyes and Pigments, 181, 2020, 108560. ISSN 0143-7208, https://doi.org/10.1016/j.dyepig.2020.108560**

## Drug Discovery and Theranostics

During these pandemic times, in response to the global call for identifying and characterizing specific and potent SARS-CoV-2 antivirals, we conducted in silico screening of an in-house library to assess its furin inhibition potential. Molecular docking studies indicated zero generation EDA cored PAMAM dendrimer and its guanylthiourea derivatives as potential furin inhibitors. Interestingly, the dendrimer conjugate masks furin′s substrate binding site and hence would prevent the binding of furin to spike protein. Further, molecular dynamics (MD) simulation revealed PAMAM and its conjugates to bind to the catalytic triad of furin. Further biological evaluations are in progress.

***Chithra R Nair and KG Sreejalekshmi:*** *Presented in the Drug Discovery Hackathon 2020, the open source drug discovery Hackathon against Covid-19), a joint initiative of AICTE, CSIR and supported by Office of Principal Scientific Advisor, Govt. of India, NIC and MyGov.*

**Microgravity Research: Development of Microgravity Simulating Platforms and Space Biology Payloads**

In line with the Human in Space Program(HSP),spaceflight hardware design for Drosophila experiment was completed, prototype was built and used for validation. Experimental verification tests using Drosophila kidney stone models are in progress.

For assisting in gravitational biology research, development of microgravity simulators were initiated. As part of an MTech project, a Random Positioning Machine was designed, fabricated, and tested for microgravity science experiments. The platform is now being used for conducting of microgravity science experiments using plants and other biological samples.

*Sathasivam M, Hosamani R, K Swamy B, **Kumaran G Sreejalekshmi**; Life Sciences in Space Research, 2020, 28:74-86: DOI: 10.1016/j.lssr.2020.10.001 PMID: 33612182*

## Department of Earth and Space Sciences

### Dr. Anand Narayanan

**Extragalactic Astronomy**

Sriram Sankar (undergraduate project student) and Anand Narayanan lead a project to study the distribution of metals outsides of galaxies, in the circumgalactic and intergalactic medium. By using absorption line spectroscopy technique on ultraviolet spectra of a quasar obtained using the cosmic origins spectrograph on the Hubble Space Telescope, and visible wavelength spectra obtained using the HIRES instrument on the Keck telescope, Sankar et al. were able to reveal the presence of 100,000 K warm plasma and relatively cooler gas in diffuse gas structures at five different epochs over the 5 billion-to-7.5-billion-year history of the universe. In all cases, the chemical abundance pattern in the diffuse gas was consistent with enrichment from the explosions of massive stars. The study also showed that heavier chemical elements displaced from galaxies remain confined to patchy zones in the circumgalactic and intergalactic space. The study added an essential level of detail in the ongoing efforts to understand the role of feedback on how galaxies and the intergalactic medium co-evolve over cosmic time. The work was published in the Monthly Notices of the Royal Astronomical Society international journal in November 2020. The project student has since then joined the South African Observatory (SAO) for post-graduate studies in astrophysics.

***Sankar, Sriram; Narayanan, Anand;** Savage, Blair D.; Khaire, Vikram; Rosenwasser, Benjamin E.; Charlton, Jane; Wakker, Bart P, Physical Conditions of Five O VI Absorption Systems Towards PG 1522+101, 2020, Monthly Notices of the Royal Astronomical Society, Volume 498, Issue 4, 4864.*

## Dr. Anandmayee Tej

**Protocluster revealed in high-mass star-forming complex, G19.88-0.53**

Detailed continuum and kinematics investigations of G19.88-0.53 unveils for the first time an interesting picture of this complex being a protoclusterharboring multiple components spanning a wide evolutionary spectrum, from hot cores in accretion phase to cores driving multiple outflows to possible UC HII regions. This study led by PhD student, Dr. NamithaIssac, utilizes radio observations taken with the Giant Meterwave Radio Telescope, Pune, India and archival data from the Atacama Large Millimeter Array (ALMA).

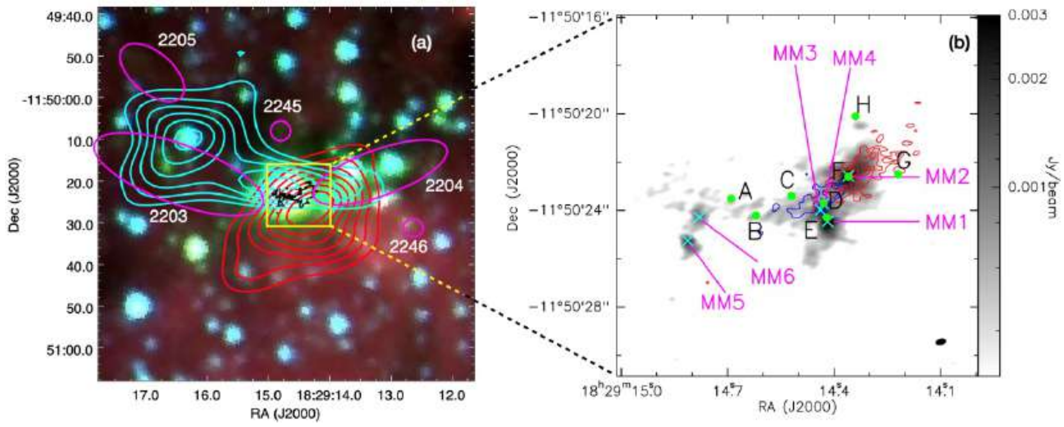



*Fig: (a) Mid-infrared view of the G19.88-0.53 complex with the protocluster at the centre. Large bipolar $C^{18}O$ outflow in the NE-SW direction is shown as contours. (b) A zoomed-in, high-resolution view showing the multiple radio and millimetre components of the proclusters. A new bipolar outflow is seen (contours) in opposite direction and is likely driven by the source MM2.*

***Issac, N., Tej, A.,** Liu, T., Varricatt, W., **Vig, S.,** et al., published in the Monthly Notices of the Royal Astronomical Society in October 2020*

**Stellar cluster formation triggered by cloud-cloud collision in G133.50+9.01**

Compelling observational evidence is presented showing G133.50+9.01 to be a bona fide cloud-cloud collision candidate with signatures of induced filament, core, and cluster formation. The CO molecular line observations reveal that the G133.50+9.01 complex is made of two colliding molecular clouds. A stellar cluster revealed through an over-density of identified young stellar objects is found located along the arc in the intersection region corroborating with a likely collision induced origin. This study led by PhD student, Dr. NamithaIssac, makes use of observations from the Purple Mountain Observatory 13.7-m telescope, China.

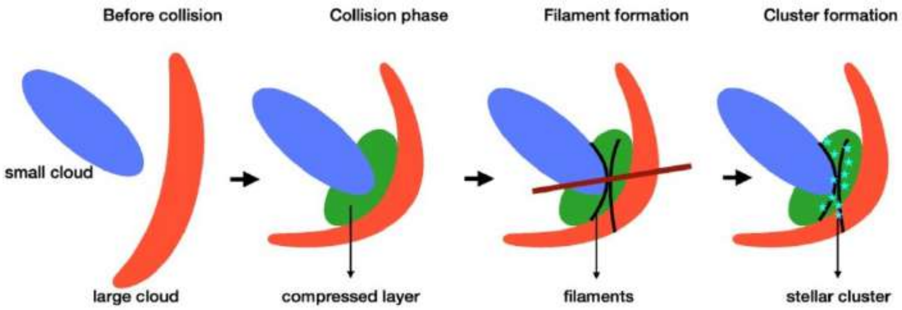



*Fig: Schematic view of cloud-cloud collision triggered filaments and stelllar cluster formation in G133.50+9.01*

***Issac, N., Tej, A.**, Liu, T., Wu, Y., published in the Monthly Notices of the Royal Astronomical Society in December 2020)*

## Dr. Chandrasekar A.

### Land Surface Modelling studies over India

Impacts of Different Rainfall Forcings on Soil Moisture Distribution Over India: Assessment Using the Land Information System

In a recent study, Vibin Jose and Chandrasekar (2021) evaluated the uncertainty in soilmoisture estimates using the five different forcing precipitation data sets from the: Global Data Assimilation System (GDAS), Tropical Rainfall Measurement Mission (TRMM)-Multi-satellite Precipitation Analysis (TMPA), Precipitation Estimation from Remotely Sensed Informat ion using Artificial Neural Networks-Climate Data Record (PERSIANN-CDR), Global Precipitation Mission (GPM), and Indian Meteorological Department (IMD) gridded data over the Indian domain using the Noah land surface model within the NASA Land Information System (LIS) for 3 years from 2012 – 2014. The Table below shows RMSE of soil moisture of all the five simulations with respect to IMD in-situ data at 5 cm depth for different seasons (winter, pre-monsoon, monsoon and post-monsoon) and over differenthomogeneous regions [Northwest India (NW), Central NortheastIndia (CN), West Central India (WC), and Peninsular India (PN)]for the year 2012

| Season | Region | GDAS | IMD | GPM | PERSIANN | TRMM |
|---|---|---|---|---|---|---|
| Winter | NW | 0.10 | 0.07 | 0.12 | 0.10 | 0.10 |
| | CN | 0.09 | 0.05 | 0.11 | 0.08 | 0.09 |
| | WC | 0.06 | 0.05 | 0.08 | 0.08 | 0.07 |
| | PN | 0.12 | 0.08 | 0.11 | 0.10 | 0.11 |
| Pre-monsoon | NW | 0.09 | 0.06 | 0.12 | 0.11 | 0.09 |
| | CN | 0.05 | 0.04 | 0.07 | 0.06 | 0.06 |
| | WC | 0.07 | 0.06 | 0.11 | 0.10 | 0.08 |
| | PN | 0.12 | 0.08 | 0.13 | 0.12 | 0.13 |
| Monsoon | NW | 0.12 | 0.10 | 0.15 | 0.14 | 0.13 |
| | CN | 0.13 | 0.11 | 0.14 | 0.15 | 0.14 |
| | WC | 0.11 | 0.08 | 0.11 | 0.11 | 0.13 |
| | PN | 0.17 | 0.14 | 0.17 | 0.16 | 0.18 |
| Post-monsoon | NW | 0.09 | 0.07 | 0.13 | 0.11 | 0.11 |
| | CN | 0.09 | 0.09 | 0.12 | 0.11 | 0.12 |
| | WC | 0.08 | 0.06 | 0.09 | 0.09 | 0.09 |
| | PN | 0.20 | 0.13 | 0.19 | 0.19 | 0.21 |

The simulation results are compared with the weekly soil moisture station data available from the IMDfor different depths. Results indicate that the LIS-Noah soil moistureestimates forced with IMD rainfall agreed better among thefive simulations with IMD in situ data. The simulated output soilmoisture using IMD as precipitation data has the lowest soilmoisture RMSE for all 3 years as compared to other simulations, while the GPM forced simulation has a higher RMSE value for all3 years. The correlation coefficients of simulated soil moistureoutputs with respect to different in situ stations show that, amongthe five simulations, IMD forced simulation has a higher correlationcoefficient for the majority of stations for the years 2012 and2013. IMD gridded rainfall forced simulationis superior to the other four precipitation forced simulations in allstudy areas and could be used in the future for hydrological andmeteorological models.

***Vibin Jose and Anantharaman Chandrasekar, 2021***, *Impacts of Different Rainfall Forcings on Soil Moisture Distribution Over India: Assessment Using the Land Information System, (accepted for publication in Pure and Applied Geophysics journal)*

## Dr. Gnanappazham L.

### Geoinformatics for vulnerability assessment

Socio-economic vulnerability of Coastal belt of Tamil Nadu was estimated using exposure and capacity related indicators to natural hazards namely cyclone, tsunami, flood etc and man-made hazards like industrial accidents, drought, settlement collapse etc. The analysis was carried out at micro-administrative scale using the census data of 2011 pertaining to 5,235 villages/wards and household data using GIS based hot-spot analysis.The hot spot analysis ofsocio-economic vulnerability and spatial overlay of multi-hazard risk surveys hasidentified three major coastal regions for immediate policy intervention 1) Thestretch between Puducherry and Nagapattinam covering the major parts of Cuddaloredistrict 2) Northern part of Thiruvallur district (North of Chennai) and 3)Surrounding villages of Thoothukudi industrial belt (Figure 1). Prompt disaster mitigation measures(structural and non-structural measures) and effective disaster preparednessplans should be implemented in these regions to reduce disaster risks and achievesustainable socio-economic development.The information generated in this study can be used as a baseline data to identifythe micro administrative units, to be prepared locally to prevent the devastating disasterimpacts, and to increase the resilience of the community.

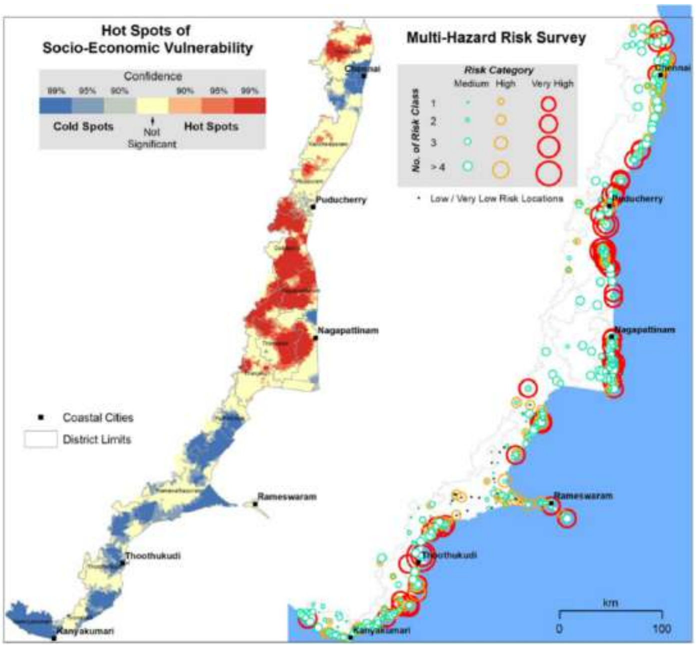



*Figure 1. Hot spots of socio-economic vulnerability (left) and spatial distribution of multi-hazard risks (right) in coastal plains of Tamil Nadu.*

*Balasubramani K, Sekar LG, Kanagarajan A, Ravichandran V, Thilagaraj P, **Gnanappazham L**, Kumaraswamy K, Balasundareshwaran A H & Nina PB (2021) Revealing the socio-economic vulnerability and multi-hazard risks at micro-administrative units in the coastal plains of Tamil Nadu, India, Geomatics, Natural Hazards and Risk, 12:1, 605-630, DOI:10.1080/19475705.2021.1886183.*

## Remote Sensing Techniques for Mineral Exploration

Texture and mineralogy of beach sediments are investigated using samples collected from Thiruvananathapuram coast, Kerala. The results indicate the dominance of medium tofine-grained sands with a high content of ilmenite mineral. The spectral indices generated using the bands of ASTER and Landsat 8 OLI satellite data clearly detect the abundance of medium to finesand area (Figure 2). The potential targets of mineral occurrence can be classified using hyperspectral analysis of above two data. Ilmenite and light minerals spectra derived from satellite data are comparable with field spectra with the score of 2.5 out of 3 using Landsat 8OLI data while its between 1.5 and 2.5 out of 3 using ASTER data. Spectral library developed from Laboratory based data provides highly accurate information of heavy minerals, which significantly increased the accuracy of image classification. The results clearly illustrate the advancedimage processing techniques and multispectral remote sensing datasets are very useful forthe eco-friendly and sustainable exploration of strategic mineral resources. Moreover, theresults will be helpful in identifying optimal wavelengths in hyperspectral remote sensingdatasets for mineral exploration, using advanced mapping techniques and machine learning methods.

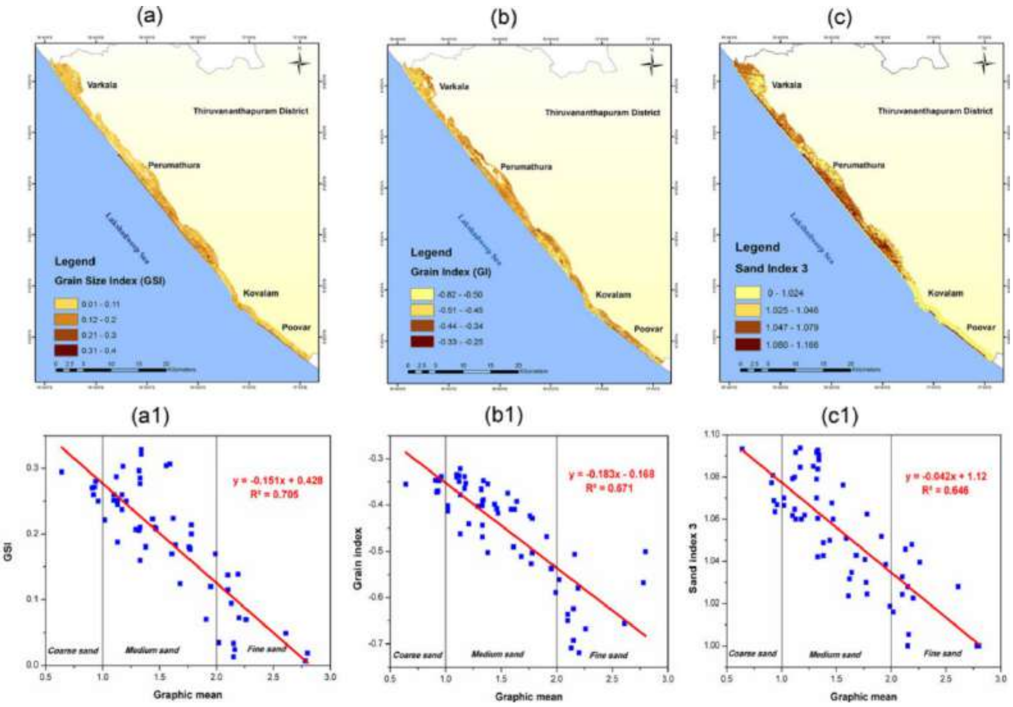



*Figure 2. Satellite derived maps showing texture of beach minerals. (a) Grain size index (GSI) map; (b) Grain index map; (c) Sand index 3 map; (a1) Scatter plot corresponds to Grain size index (GSI); (b1) Scatter plot corresponds to Grain index map; (c1) Scatter plot corresponds to Sand index 3 map.*

*RG Rejith, M Sundararajan, **L Gnanappazham**, VJ Loveson (2020) Satellite-based spectral mapping (ASTER and landsat data) of mineralogical signatures of beach sediments: a precursor insight, Geocarto International, 1-24.*

## Dr. Govindankutty M.

**Data Assimilation and Predictability of Weather**

Forecast Sensitivity of extreme rainfall events are investigated through Ensemble-based Sensitivity Analysis (ESA). ESA enables the assessment of forecast errors and its relation to the flow fields through linear regression approach. The study has far reaching consequences especially in the domain of targeted data assimilation.

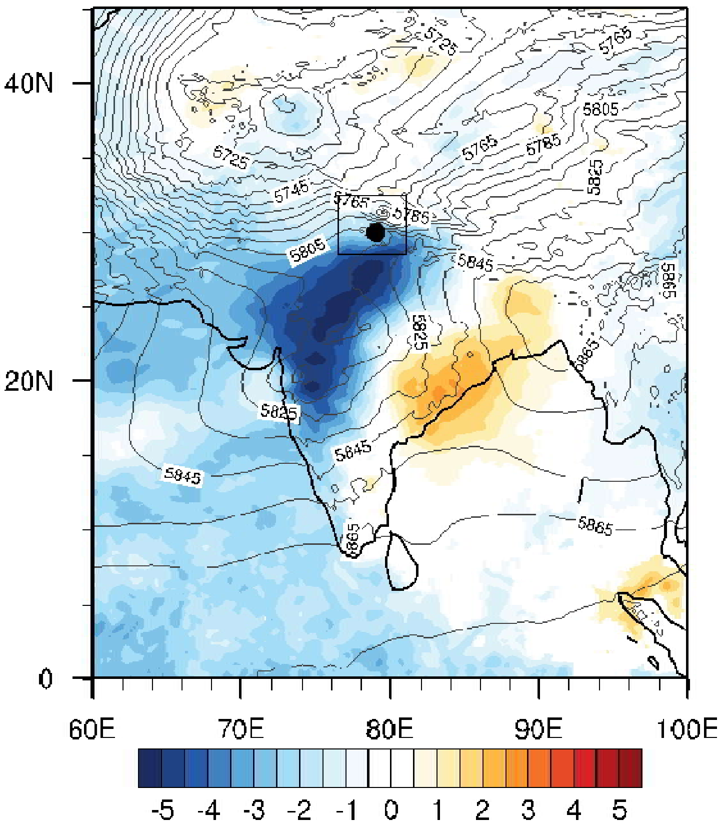



***Figure:** Ensemble sensitivity (shading) of 24-h accumulated precipitation averaged over the square box to the geopotential height at 500 hPa. The black box depicts the region of response function used in the computations*

***George, B., & Kutty, G.** (2021). Ensemble sensitivity analysis of an extreme rainfall event over the Himalayas in June 2013. Dynamics of Atmospheres and Oceans, 93, 101202.*

## Dr. Jagadheep D.

### The GLOSTAR Survey

The Global View of the Star formation in the Milky Way (GLOSTAR) Project provides the most sensitive maps of the radio emission of large parts of the Northern Galactic plane so far, taken withthe Karl G. Jansky Very Large Array (VLA) in New Mexico in two different configurations and the100-m Effelsberg radio telescope. While an interferometer like the VLA can produce very sharpimages of the sky, the large-scale emission is often lost. However, the diffuse radio emission can berecovered by adding data from the 100-m Effelsberg telescope, as shown in the figure below.

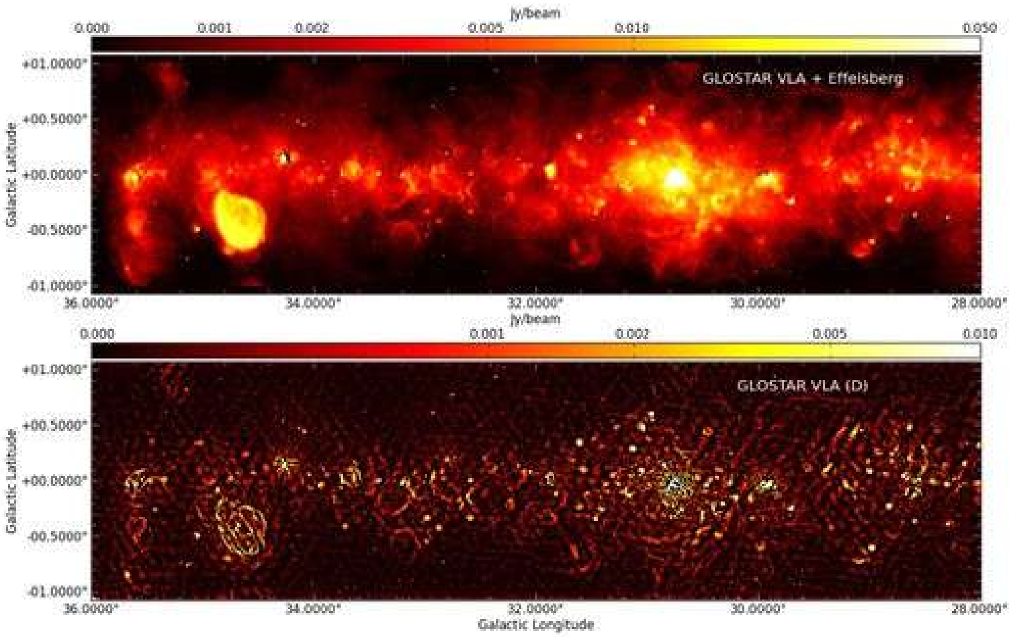



*Figure: Top panel - Continuum radio image of the pilot region in the range 28° < l <36° from the combination of the VLA D-configuration and the Effelsberg single dish images.*

*Bottom- D-configuration VLA image of the full continuum of the same longitude range which was already presented in Medina et al. (2019).*

The initial results are described in three papers and include the survey description, detection of new6.7 GHz methanol masers in the Cygnus X complex and a study of young stellar objects in theGalactic Center region.

*Brunthaler, A. et al. (including J. D. Pandian), A Global View on Star Formation: The GLOSTAR Galactic Plane Survey. I. Overview and first results for the Galactic*

*longitude range 28° < l < 36°, 2021, Astronomy & Astrophysics (in press)* *https://www.aanda.org/10.1051/0004- 6361/202039856*

***Ortiz-León, G.N. et al. (including J. D. Pandian)**, A Global View on Star Formation: The GLOSTAR Galactic Plane Survey. III. 6.7 GHz Methanol maser survey in Cygnus X, , 2021,*

*Astronomy & Astrophysics (in press) https://www.aanda.org/10.1051/0004-6361/202140817*

***Nguyen, H. et al. (including J. D. Pandian)**, Global View on Star Formation: The GLOSTAR Galactic Plane Survey. IV. Radio continuum detections of young stellar objects in the Galactic*

*Centre Region, 2021, Astronomy & Astrophysics (in press). https://www.aanda.org/10.1051/0004-6361/202140802*

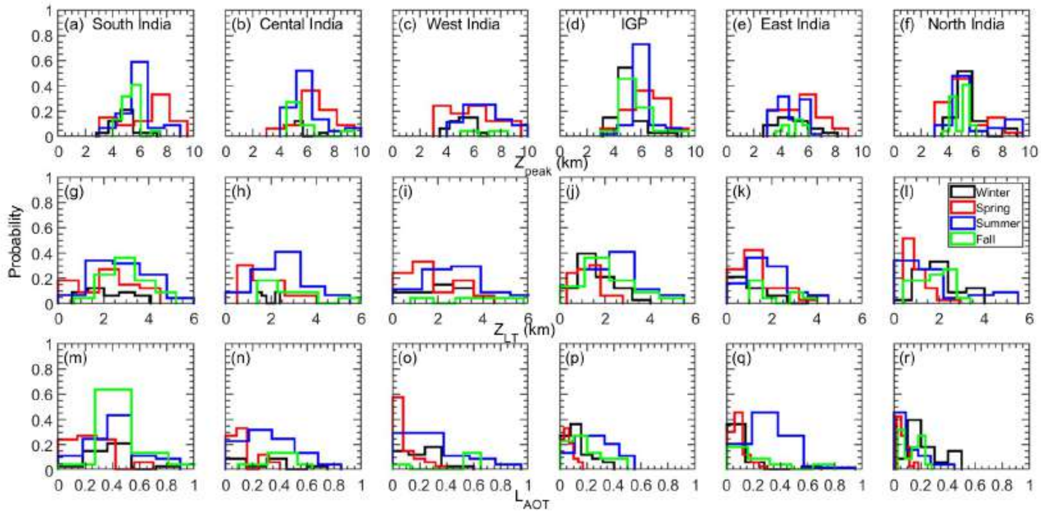
## Dr. Puna Ram Sinha

**CALIPSO observations of ubiquity of aerosol layers in the free troposphere over South Asia: sources and formation mechanisms**

The vertical distribution of aerosols and their composition in the lower troposphere is critically important for assessing their impact on earth's radiation budget, and modulation of cloud microphysics. We analyzed cloud-free aerosol extinction coefficient ($\beta_{ext}$) and particulate depolarization ratios obtained from a space-borne lidar observations, Cloud-Aerosol Lidar with with Orthogonal Polarization (CALIOP) on-board CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) for the period of 2008-2018. We investigated unprecedented climatology of the physical and optical characteristics of elevated aerosol particle layers (EAPL) along with their source and formation mechanism throughout its life cycle in the free troposphere. The EAPL over the Indian region were persistent between 4-6 km during all seasons on annual basis, occasionally reached above 6 km, and exhibited spatio-temporal variations over the Indian region.

The probability of finding a layer thickness ($Z_{LT}$) of 2-3 km is 80-90%, while it is only 10-20% for layer thickness >3.5 – 4 km, suggesting the occurrence of secondary layer is occasional, particularly during monsoon and fall. Dust, polluted dust (dust mixed with smoke) accounted up to 50-80% of the EAPL between near surface to 6 km (up to ~80-90% of the observed EAPL between 4-6 km) for all the seasons and regions. The maximum vertical extent ($Z_{max}$) and a peak height of aerosol layer

($Z_{peak}$) mainly occurred between the altitudes of 6-7 km and 4-6 km, respectively. Locally confined anticyclonic circulation coupled with stratified stable layer within turbulent layers over the Indian region during winter, spring, fall; while vertical transport of pollutants from the PBL to mid-troposphere due to enhanced deep convection in summer could be possible mechanisms of formation of the stratified EAPL at 4-6 km.




## Dr. Rajesh V. J.

### Volcanism on the Moon

The mineralogy and chemical variations of the mare basaltic units in the Mare Humorum on the Moon′s nearside using orbital remote sensing data from recent lunar exploration missions were investigated. Hyperspectral data from Moon Mineralogy Mapper onboardChandrayaan-1 mission showed pigeonites and augites as the major compositions in these basaltic units. Thecompositional trend between pigeonites and augites point towards the differentiation of the basaltic magma whilecooling. The older units crystallized from a Fe-enriched fractionated magma, while the younger unit formed froman Mg and Ca-rich magma. The distinct chemical trends in the pyroxene quadrilateral and the shift in Band I and Band II centres revealed that multiplevolcanic eruptions have occurred in the Mare Humorum. The results also suggest that basaltic magmas that erupted in the Mare Humorum during Imbrian and Eratosthenian periods werederived from heterogeneous source regions.

*Thesniya P. M. and Rajesh V. J. 2020. Pyroxene chemistry and crystallization history of basaltic units in the Mare Humorum on the nearside Moon: Implications* *for the volcanic history of the region. Planetary and Space Science 193:105093. 10.1016/j.pss.2020.105093.*

Spectral and chemical characteristics and ages of the nearside mare basaltic units from the Grimaldi basin, namely Mare Grimaldi and Mare Riccioli, were detected using orbital remote sensing data. Distinct and younger basaltic units of higher FeO, TiO2 and olivine abundances are characteristics of the Mare Grimaldi and Mare Riccioli. The crater size-frequency distribution technique revealed that at least two phases of basaltic magmatism spanning ~3.5 to 1.5 Ga (Late Imbrian – Eratosthenian) have occurred in the Grimaldi basin. The main phase of low to intermediate-Ti basaltic volcanism occurred at ~3.5 Ga ago in both the units, was followed by the eruption of low to intermediate-Ti basalts in the Mare Riccioli at ~3.2 Ga ago. The younger Late-phase event of high to intermediate-Ti basaltic volcanism occurred at ~2.05 Ga and ~1.5 Ga ago in the Mare Grimaldi and Mare Riccioli, respectively. The origin and emplacement of these basalts are proposed to be related to the global thermal evolution of the Moon.

***Thesniya P. M., Rajesh V. J., and Flahaut J.,** 2020. Ages and chemistry of mare basaltic units in the Grimaldi basin on the nearside of the Moon: Implications for the volcanic history of the basin. Meteoritics & Planetary Science 55, Nr 11, 2375 – 2403. 13579.*

## Dr. Rama Rao Nidamanuri

### Advanced Hyperspectral Remote Sensing Research

A commercial level atmospheric correction system for multispectral and hyperspectral remote sensing imagery and a remote sensing system framework for strategic target detection were developed.

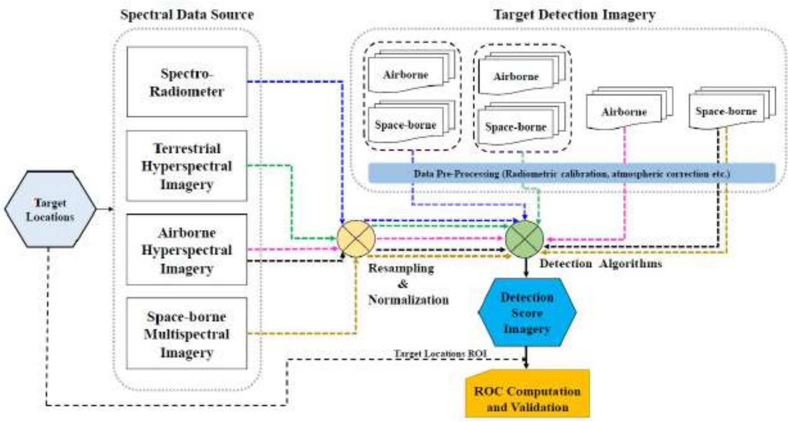



*Figure: Framework adopted for the target detection in multi-platform remote sensing imagery.*

Indo-German collaboration project: Integrating air and spaceborne spectroscopy and laser scanning to assess structural and functional characteristics of crops and field margin vegetation. Performed benchmark studies on high-density LIDAR point cloud applications for 3D modelling of crops for potential application in precision agriculture.

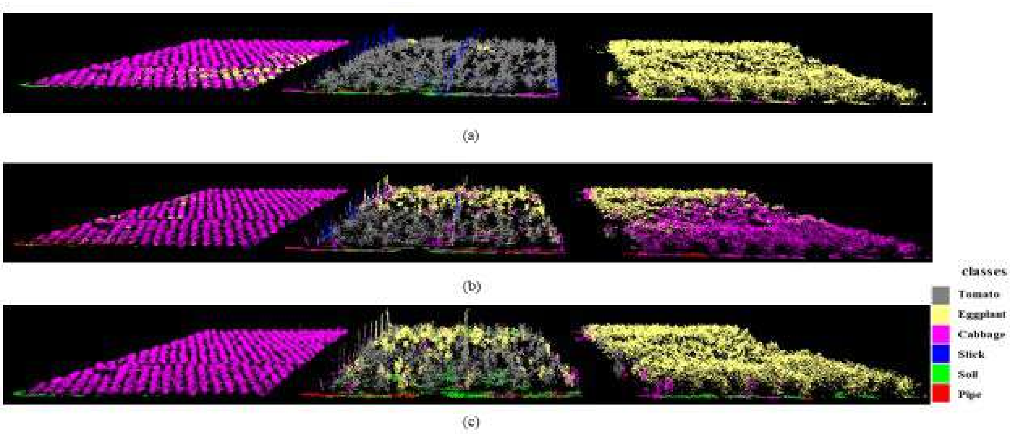



*Figure: 3D modelling of different vegetable crops using LiDAR point cloud*

Spectral Biochemical Analysis of Forest Species using Hyperspectral Remote Sensing – A Case Study from Eastern Ghats Forest Ecosystems.

For the first time, the species level classification of Araku Forest of Eastern Ghats of India has been completed using hyperspectral remote sensing. Developed a hardware based real-time remote sensing imagery classification framework initiated research on development of compact hyperspectral imaging systems and the development of advanced real-time algorithms for hyperspectral image analysis.

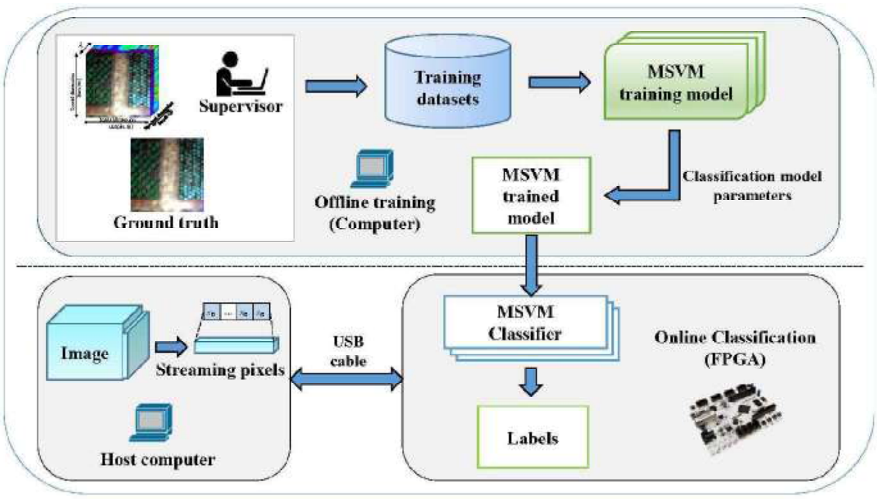



*Figure: Block diagram of the real-time classification framework*

## Dr. Ramiya A. M.

### LiDAR Remote Sensing

India is embracing the concept of smart cities, alongside the developed and developing nations globally, with its recent initiatives on "Smart city mission" by the Government. High precision three-dimensional virtual city models are in demand for managing and monitoring the smart city information infrastructure.LiDAR (Light Detection and Ranging) is one of the most unprecedented geospatial technologies for direct and accurate measurement of elevation of the earth surface. The geo-coded LiDAR data (X,Y,Z) enable extraction of various 3D urban objects true to geometrical measurements which can be directly used for creating 3D city models.

In this research project funded by DST under urban spatial governance, we are focusing on developing an methodological approach to create a spatio-semantic 3D city model of Thiruvananthapuram city from LiDAR dataset captured using airborne platforms.The output of project (3D city models) will be useful for various city planning, architectural design, tourist and leisure activities, environmental simulation, mobile telecommunication, disaster management, homeland security, real estate management, vehicle and pedestrian navigation, and training simulators. As part of the project, the applicability of 3D models for flood simulation and modelling will be demonstrated. Initial results using open datasets are shown in the figure below

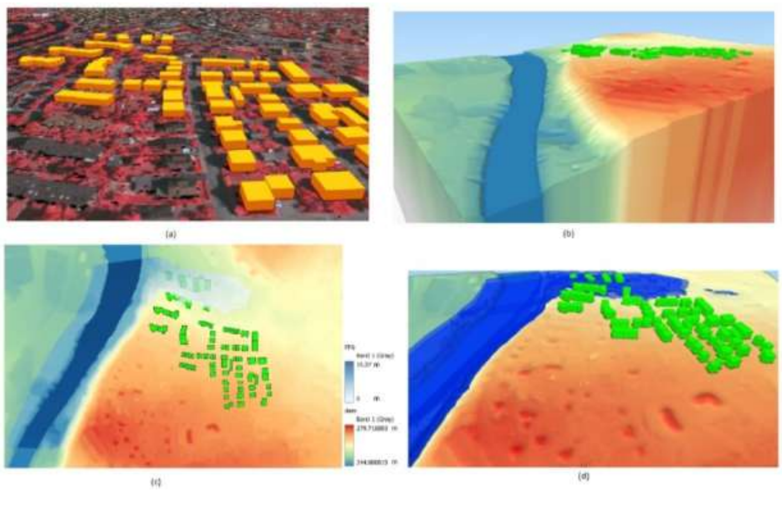


*Figure: (a) LoD1 3D building models (b) DEM of the surface with 3D buildings (c) 2D view of river discharge (d) 3D flood modelling simulation using open LiDAR dataset*

## Dr. Resmi L.

### High-energy astrophysics on explosive transients

Research in this area was focused on three problems. In the first one, in collaboration with Prof. Jacco Vink of Univ. of Amsterdam and Prof. C H Ishwara-Chandra of NCRA, GMRT observations of the persistent source associated with FRB121102 was looked at. Useful constraints on the nature of the central engine powering the FRB and the persistent source was obtained. This result is published in A&A in 2021. The next problem, done in collaboration with Mr. Asif M, DD/MS, IIST, was on the signature of galactic dust seen in late-time X-ray afterglows of Gamma-Ray Bursts (GRBs). Being the first one to consider the dust scattered emission and the original afterglow emission, we will be able to obtain properties of dust in GRB host galaxies which may, in turn, bring light to the origin of GRBs. The last problem is in the emerging field of multi-messenger astronomy. With Mr. Bharath Saiguhan DD/MS, IIST, Prof. K G Arun, CMI, Chennai, and Dr. M Saleem, Univ of Montana, we studied the progenitors of Neutron Star - Black-Hole (NS-BH) mergers observed by LIGO.

## Dr. Samir Mandal

### High Energy Astrophysics

The accretion process around compact objects is very important to understand physics under extreme gravity. My research focus includes the study of accretion physics around stellar as well as supermassive black holes. We use both theoretical and observational tools to probe the physics around compact objects. I was working on the following research objectives:

1. Galactic blackhole sources can be transient or persistent in nature. Transient (or the outbursting) sources provide opportunities to study the temporal and spectral evolution of the source. We study the outbursting sources MAXI J1820+070, 4U 1630-472, H1743-322, MAXI J1535-571 etc using various X-ray instruments data (including AstroSat) across the globe. We model the data to extract the spectral and accretion parameters. Finally, we connect the spectral and accretion parameters to address the accretion dynamics of the sources.Also, we have performed spectro-temporal studies of galactic (GRS 1915+105) and extra-galactic (LMC X-1 and LMC X-3 ) persistent black hole sources.

2.Tidal disruption events (TDEs) of stars by the supermassive black hole at the centre of the galaxy is the most promising model to understand the central activities of inactive galaxies. TDEs are far distant events and very challenging to observe. But with the advent of state-of-the-art ground and space-based observatories, TDEs are observed in multi-wavelength. We model the broadband TDE light curve. Also, we have studied the spectroscopic signature in TDEs and model the spectral line to understand the physical conditions.

3. Theoretical calculation of radiation spectrum from realistic accretion disc is required to model the observed data. We calculate the two temperature hydrodynamic transonic flow solution in presence of cooling around a rotating black hole. We calculate the radiation spectrum using the transonic flow solutions.

## Dr. Sarita Vig

**Investigating early phases in massive star formation**

Massive stars (stars with mass 8 times greater than mass of Sun) are born deeply embedded in molecular clouds, and their formation mechanisms are not very clear. This is in contrast to the scenario of low mass star-formation where the broad evolutionary phases are known and have been observed. However, the details of various phases of pre-main sequence evolution are under active investigation. The following research work has been carried out during the said period.

- Jets of material are expelled from protostars in the early stages of formation. A numerical model has been proposed for which we carry out simulations to explain the observed radio spectral indices of protostellar jets. This model includes the effect of thermal free-free emission as well as non-thermal synchrotron emission.

- Observations of the star-forming region associated with RCW42 was analysed to understand the nature of the HII region and the associated star-formation activity. The feedback effects of the star formation process on the natal molecular cloud are also probed.

In addition, the following research areas were investigated.

- Globular clusters are the oldest objects in the Milky Way galaxy and represent the quintessential test-bed for stellar evolution theories.

Ultraviolet observations of the globular cluster NGC5053 were carried out by the Ultraviolet Imaging Telescope on Astrosat. The data was reduced and analysed to segregate and understand the hot stellar populations in the late stages of stellar evolution.

- Star-forming galaxies are rich reservoirs of dust, both warm and cold. But the cold dust emission is faint alongside the relatively bright warm dust emission. The cold dust content in 4 near-by galaxies areanalysed to probe the nature of the dust emission. For this, we used observations from Giant-Metrewave Radio Telescope (GMRT), Pune and Ultraviolet Imaging Telescope on Astrosat.

# Department of Humanities

## Dr. Babitha Justin

### Gender in History and Culture Studies

Dr. Babitha Justin is the co-Investigator of the Book Project in The Muziris Heritage Project which is one of the major conservation projects in India, where the State and the Central Governments have come together to conserve a millennia-old culture. The aim of the publishing division of the Muziris Heritage Project is to print and publish books that deal with everything unique about the sites under the Muziris Projects Ltd. It may also document and study, preserve and restore historic relics significant to the culture or heritage of Muziris; with an external funding from the state and the central governments.

Babitha Marina Justin is working on the book, *Women in Kodungallur*, which highlights 2000 years of the participation of women in preserving, nurturing a culture and civilisation in absolute anonymity and silence.

## Dr. Gigy J Alex

### Food and Culture Studies and Science Fiction

The evolving patterns of modernity as reflected in the cookbooks and recipe sharing in the Kerala context is an area of investigation. She is interested in identifying and critiquing the culinary representations and understanding the act of cooking as an agency.

## Dr. Lekshmi V Nair

### Science, Technology and Society

An ICSSR sponsored major research project on the Impact of tele- medicine units in India has been undertaken along with DrShaijumon CS, Associate Professor, Department of Humanities, IIST. The project looks into the changes that has happened in telemedicine technology in India before and after the pandemic. A collaborative project with Jagellonian University, Poland on the perception and awareness of different sections of the society towards space programs has also been proposed to ISRO. Studies as part of PhD research include assessing the diffusion of mass media and change in the life of Adivasi communities in Kerala and the disaster management patterns in Kerala.

## Dr. Ravi V.

### Digital Supply Chain and Sustainable Supply Chain Management

Research is focused on topics related to reverse logistics, supply chain digitalization (SCD), and sustainable supply chain management. In reverse logistics, issues related to product recovery management have been modeled as reuse, remanufacturing, recycling, etc., have been carried out. In the area of SCD, identification and prioritization of key customer requirements and design requirements in the context of the electronics industry have been carried out. Also, a framework to analyze the influences and interactions among enablers of SCD has been done. The cause-effect relationships of the enablers of SCD have also been carried out. Similar analysis has also been done for the barriers of SCD. In the case of sustainable supply chain management, major factors affecting the process of eco-efficiency in the electronics industry have been carried out.

## Dr. Shaijumon C. S.

### Technology diffusion and Economic Development

Research collaboration has been established with the Centre for Development Studies and started working on developing a methodology and measuring the Space Economy of India. Economic Analysis of Public Investments in the Indian Space Program has been initiated. Along with Dr. Lekshmi V Nair, a major research project under the category of ‘Novel and Path breaking Major Research Award’ has been awarded by Indian Council of Social Science Research′ for the study on the impact of tele-medicine in rural India. Along with Ph D scholar, a study on the climate variability and extremes has been conducted about rice production and livelihood security in Tamil Nadu. A research study on the economic impact of Covid 19 in Kerala economy has been conducted and submitted to the Govt. of Kerala. Four research papers have been published during the year in the international peer reviewed journals.

## Department of Mathematics

### Dr. Anilkumar C. V.

#### Dynamics and Rheology of Dilute Suspension

Dynamics of micro particles in fluids and the change in rheological parameters due to particle dynamics occur across many industries including many processes relevant to space programs. The problem under our study has physical relevance and represents a limiting case for suspension flows. We developed solutions for some of the problems. A set of ordinary differential equations governing the migration of an arbitrary forced spheroid in a quiescent flow at low Reynolds number is formulated and discussed, assuming a sufficiently diluted suspension to neglect the particle-particle interactions. It is demonstrated that the size of the attractor increases as aspect ratio or/and force increases, whereas it decreases as Reynolds number increases. A delay with the velocity at maximum position is observed and the reason could be the fact that in the absence of inertia, the time at which the velocity reaches its maximum, the position is at its minimum and when the particle experiences its maximum deviation, the velocity is at its minimum. The net migration at zero Reynolds number will be negligible and should increase with the number increases. Inertia should change this to a larger extent at higher values of Reynolds number. A similar problem as a perturbed solution is also solved. The dependencies of oscillations on the parameters can be utilized for better separation of particles or for characterizing the suspension. The results of our analysis can be used to validate complex software developed for suspension flow problems. Development of such a system would be of considerable technical and economic significance.

## Dr. Deepak T. G.

### Multivariate Finite Support Phase Type Distributions

Phase type (PH) distributions, which are defined on the non-negative real line, became quite popular in the last decades as they have been used in a wide range of applications of stochastic models. It forms a dense subset in the space of all distributions defined on the non-negative real numbers and at the same time it is numerically tractable because of its underlying Markovian structure. We could find a multivariate distribution, defined on any k-orthotope in$[0,\infty)^k$, having the analogous properties of the PH class. The new class is named as Multivariate Finite Support Phase Type Distributions (MFSPH). We could study its properties and obtain an Expectation-Maximization algorithm to estimate the parameters of the distribution in the bivariate case. Also, we could demonstrate how this class could be used as approximations for bivariate finite support distributions by using simulated samples.

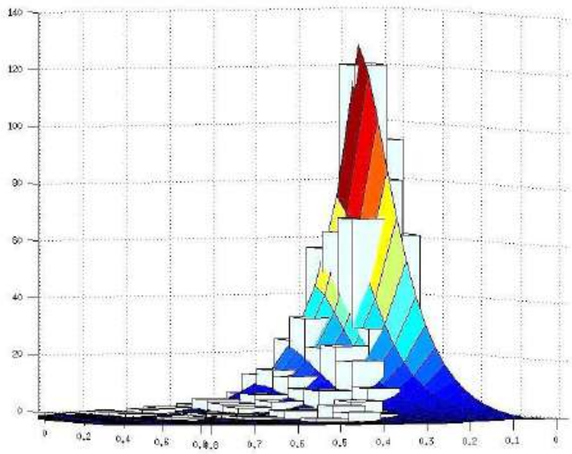


*Figure 1: Bivariate finite support vector(X, Y), X a normalisedG (2, 2) variate over[0, 1],Y = 0.5X +* $\epsilon$*,* $\epsilon \sim$ *115exp(1.5),fitted with BFSPH distribution of order 6 .*

***Pavithra Celeste R.** and **Deepak T. G.**, 2020, Multivariate finite-support phase-type distributions, Journal of Applied Probability-57(4), 1260 − 1275.*

## Dr. Kaushik Mukherjee

### Numerics of singularly perturbed PDEs

Singularly perturbed partial differential equations (SPPDEs) have numerous applications in the various fields of engineering and applied sciences; and these are described mainly by PDEs in which the highest-order spatial derivative is multiplied by an arbitrarily small parameter, known as "singular perturbation parameter". Solutions of these types PDEs are of multiscale in nature; and possess the occurrence of boundary (or interior) layers, which are basically thin regions in the neighbourhood of the boundary (or interior) of the domain, where the gradients of the solutions steepen as the perturbation parameter tends to zero. Due to this layer phenomenon, the classical numerical methods designed on the uniform mesh, usually fail to decrease the maximum point-wise error as the mesh is refined, until the mesh parameter and the perturbation parameter have the same order of magnitude. Therefore, finding cost - effective as well as parameter-uniform numerical solutions of such PDEs and carrying out the associated convergence analysis are considered a challenging task from both the computational and the theoretical perspectives. In this context, the primary objective of our research work is to develop and analyse robust computational methods for various classes of linear and nonlinear parabolic SPPDEs with smooth and non-smooth data, having potential applications in mathematical biology and medical sciences.

## Dr. Subrahamanian Moosath K. S.

### Information Geometry

Information geometry is a branch of Mathematics that applies the techniques of differential geometry to the field of probability theory. Family of probability distributions which constitutes a statistical model has a rich geometric structure as a manifold with Riemannian metric and dual connections. We were looking at the geometry of immersions and submersions in the context of statistical manifolds. In the case of immersions into statistical manifolds a necessary and sufficient condition for the inherited statistical manifold structures to be dual to each other is obtained. A necessary and sufficient condition for a statistical immersion into a dually flat statistical manifold of codimension one to be minimal is given. A necessary and sufficient condition for the inherited statistical manifold structures to be dual to each other is proved for a centro-affine immersion of codimension two into a dually flat statistical manifold. Then proved that the in herited statistical manifold structure is conformally-projectively flat in this case. We introduced the concept of a conformal submersion with horizontal distribution for Riemannian manifolds, which is a generalization of the affine submersion with horizontal distribution. A necessary condition for the existence of such a map is proved.

**Integrable Hamiltonian Systems**

Topological investigation of an Integrable Hamiltonian system means the study of the topology of the corresponding Liouville foliation. our study is on the topological invariants of the foliations which are important in the classification of integrable systems. For non-degenerate integrable Hamiltonian system (M, $\omega$, v = sgrad H) certain results regarding the structure of critical points that do not lie on the isoenergy surface are given. Global symplectic classification of integrable Hamiltonian systems with one degree of freedom in the case of simplest singularities is discussed. Using simple molecules detailed description of global classification of non-degenerate integrable Hamiltonian systems with one degree of freedom is given. We have obtained a necessary and sufficient condition for rough Liouville equivalence of non-degenerate integrable Hamiltonian systems with two degrees of freedom using geometric skeleton. Then proved that the rough Liouville equivalence using molecule and using geometric skeleton are equivalent to each other. A necessary and sufficient condition for Liouville equivalence of non-degenerate integrable Hamiltonian systems with two degrees of freedom using framed geometric skeleton is proved. Then we proved the Liouville equivalence using marked molecule and using framed geometric skeleton are equivalent to each other.

***Mahesh T V and K S SubrahamanianMoosath** , Harmonicity of Conformally-Projectively Equivalent Statistical Manifolds and Conformal Statistical Submersions, Lecture Notes in Computer Science, Springer, vol 12829, 397-404, 2021.*

## Dr. Natarajan E.

**Numerical discretization of nonlinear PDEs over polygonal meshes**

Numerical solutions to Partial differential equations have interesting applications in many areas of Science and Engineering. Eventhough the existence of solutions is guaranteed from the mathematical theory there are no way of finding exact solutions to the problems due to its intrinsic nature like nonlinearity etc., Numerical tehniques comes as a savage to engineers and scientist wherein an approximate solution can be computed beforehand. But the challenge lies with the Numerical analyst to devise an efficient numerical technique having higher order of accuracy and better convergence properties. More recently numerical solutions over general polygonal/polyhedral meshes has attracted many researchers due to its flexibility in meshing, ease of computation of higher order elements etc., My work focusses on devising computable numerical schemes over these meshes with better order of accuracy and rate of convergence. Specific problems of my interest lie in nonlinear convection-diffusion problems, coupled reaction-diffusion problems etc.

## Dr. Prosenjit Das

**Revelation of the structure of $A^2$-fibrations having fixed point free locally nilpotent derivations**

In [Fre09], Freudenburg raised a question ([Fre09, Question 2, pg. 3084]) asking whether any

$A^2$-fibration A over a polynomial ring R over a field containing Q is trivial if A possesses a fixed point free R-LND. Though the question got settled by an affirmative answer in [EKO12] (also see [EKO16]), the mentioned problem by Freudenburg essentially brought attention towards the following question.

Problem 0.1. Let R be a ring containing Q, A a non-trivial $A^2$-fibration over R and D : A $\longrightarrow$ A a fixed point free R-LND. Does D have a slice?

No answer to Problem 0.1 was known. In [BDv5], Babu-Das gives a complete answer to Prob-

lem 0.1 under the assumption that the ring R is Noetherian. The result of Babu-Das describes the complete structure of $A^2$-fibration over Noetherian rings containing Q having fixed point free locally nilpotent derivations. The main results of the article are the following.

Theorem A: Let R be a Noetherian ring containing Q and A an $A^2$-fibration over R with a fixed point free R-LND D : A $\longrightarrow$ A. Then, Ker(D) is an $A^1$-fibration over R and D has a slice, i.e.,

A = Ker(D)[1]. In particular, if R is a normal domain, then A = SymR(I)[1] for some invertible ideal I of R.

Theorem B: Let R be a Noetherian domain containing Q and A an $A^2$-fibration over R having a fixed point free R-LND. Then, A has another irreducible R-LND $D : A \dashrightarrow A$ such that Ker(D) =R[1] and A is an A1-fibration over Ker(D). Further, the following are equivalent.

(I) D is fixed point free.
(II) A is stably polynomial over R.
(III) A = R[2]

References

*[BDv5] **Janaki Raman Babu and Prosenjit Das**. Structure of A2-fibrations having fixed point free locally nilpotent derivations. J. Pure Appl. Algebra, to appear, https://arxiv.org/abs/2001.07632v5.*

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[EKO16] M′ hammed El Kahoui and Mustapha Ouali. A triviality criterion for A2-fibrations over a ring containing Q. J. Algebra, 459:272 − 279, 2016.

[Fre09] Gene Freudenburg. Derivations of R[X, Y, Z] with a slice. J. Algebra, 322(9):3078 − 3087, 2009.

## Dr. Raju K George

### Mathematical Theory of Control, Orbital dynamics and Soft Computing techniques

The problems of fundamental interest in Control theory are the one like Controllability Problems, Observability Problems, Stability Problems and Optimal Control Problems etc. We deal with control systems, described by non-linear differential equations both ordinary adifferential equations and partial differential equations. These problems can be investigated by using the tools of functional analysis, namely, the Theory of linear and non-linear operators. In the analysis we invoke the tools from monotone operator theory and Lipschitz continuous operator theory. In controllability problem, we characterize conditions for controllability of nonlinear and linearized systems. The Steering controllers are obtained by algorithms established through Banach Contraction Principle and other iterative schemes. The theory can be applied for finding steering controllers for artificial satellites and launching satellites. We also employ tools from Artificial

Neural Networks and Fuzzy Logic to obtain Steering Controller for special systems having Fuzzy components.

## Dr. Sabu N.

### Dimension reduction in thin elastic structures

Elastic bodies like plates, shells, rods etc are three-dimensional bodies. However, often, one or more of their dimensions say, the “thickness” is “small” compared to others. In such cases, lower dimensional theories have been proposed as approximations of usual three-dimensional theory. One reason for preferring lower-dimensional theories is their simpler mathematical structure which permits one to obtain a richer variety of results. The other is that these theories are more amenable to numerical computations.

Most of the lower dimensional theories proposed by Koiter, Nagdhi and others rely on a priori assumtions of a mechanical or geometrical nature. Further, it is not evident which is the model most suited to a particular case in mind. The answer to this question is of great importance, for it makes no sense to devise accurate methods of computation for the solution of an inappropriate model. Consequently, before approximating the exact solution of a given lower dimensional model, we should first know whether it is “close enough” to the exact solution of the three-dimensional modelit is intended to approximate. Thus one is lead to the question of mathematically justifying lower-dimensional models starting from the three-dimensional model.

In this direction, the justification for boundary value problem for liner elastic plates and shells with uniform has been studied and we would like to study the corresponding problems for variable thickness.

Piezoelectricity is an electromechanical phenomenon which couples the elastic and electric fields. In general, a piezoelectric material responds to mechanical forces and generates an electric charge. Conversely, an electric charge applied to the material induces mechanical stress or strains. Piezoelectric materials are used as sensors and actuators in some structures. For instance, a distributed system of sensors and actuators displayed upon the surface of a material can detect its deformations and control its vibrations. They are also used in shape controlling for plane propellers, plane wings as well as in manufacturing artificial organs in biomechanics.

The standard methods of numerical approximation of three-dimensional bodies fail for bodies which are thin in some direction, unless the behaviour is resolved in that direction. Thus, the need for two-dimensional models. In this direction, we are working on the two dimensional approximation of boundary value problem for piezoelectric plates and shells.

## Dr. Sakthivel K.

### Inverse Problem for the Generalized Korteweg- de Vries Equation

Wave motion is one of the broadest scientific subjects, and it can be studied at a different technical level depending upon the medium of presence in nature. A special kind of wave motion is the one-dimensional propagation of long water waves in channels of relative shallow depth and flat bottom that have been modelled by Korteweg and de Vries in 1895. This classical model is mainly governed by linear third-order dispersive term, and the wave steepening is modeled by a nonlinear term. A generalized seventh-order K-dV equation has been introduced in the literature to study the steeper waves with a shorter wavelength which describes the physical behavior better than the other K-dV type equations of the third and fifth-order. The higher-order nonlinear and dispersive effects are more important in the physical applications, for example, plasma physics, optical fibers, elasticity, fluid flow through porous media, hydrodynamic, medical imaging, and economics. Our main objective in this project is to determine the source term, which accounts for the topography of the channel, from the measurements of the surface elevation given at some fixed time and spatial domain. We obtained the Lipschitz type stability estimate to determine the source term estimated in terms of certain Sobolev norms of the measurements. The main result follows from the regularity of solutions for the direction problem and certain Carleman type estimates for the seventh order operator.

*A. Arivazhagan, K. Sakthivel and N. Barani Balan, Inverse problem for the generalized K-dV equation, Journal of Inverse and Ill-posed Problems, 26 pages, https://doi.org/10.1515/jiip-2020-0008.*

## Dr. Sarvesh Kumar

### Numerical approximation of fluid flow problems

Research focus is on the development of novel virtual element discretizations techniques for the approximation of coupled fluid flow problems with an emphasis on both computational and theoretical aspects. Primary research interest lies in the domain of computational partial differential equations (PDEs). In particular, works is focused on the development of numerical techniques such as Finite volume element methods, finite element methods, discontinuous Galerkin methods, which are used for obtaining an accurate and robust numerical solution of PDEs occurring in science and engineering with proper initial and boundary conditions. Some of my recent work includes discontinuous finite volume approximation of coupled flow-transport problems, immiscible displacement problems, Stokes equations, nonlinear hyperbolic conservation laws, and optimal control problems. Recently in collaboration with Ricardo Oyarzua ( University of Bio-Bio, Chile) and Dr. Ricardo Ruiz-Baier (Mathematical Institute, University of Oxford, UK, and now at Monash University, Australia), we have introduced new finite volume discretizations to approximate linear poroelasticity equations, representing the interaction between the non-viscous filtration flow of a fluid and the linear mechanical response of a porous medium. This work has been published in the reputed journal **ESAIM: Math. Model. Numer. Anal. 54 (2020) 273-299.** With the same research group, the first time we have developed locking free virtual element approximation for the poroelasticity. This work appeared in **Advances in Computational Mathematics, 47, 2021.** Considering the computational advantages over other existing schemes in the context of fluid flow problems, I have a MATRICS project titled " Discontinuous virtual element approximation for non-stationary fluid flow problems". The duration of this project is 3 years, and it is funded by SERB-DST.

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## Dr. Sumitra S.

### Design of Multi-View Graph Embedding using Multiple Kernel Learning

The graph embedding is the process of representing the graph in a vector space using properties of the graphs and this technique has now being widely used for analyzing the graph data using machine learning algorithms. The existing graph embeddings rely mostly on a single property of graphs for data representation which is found to be inappropriate to capture all the characteristics of the data. Hence we designed graph embedding using multi-view approach, where each view is an embedding of the graph using a graph property. The input space of multi-view learning is then taken as the direct sum of the subspaces in which the graph embedding lie. We did analysis on real world data by incorporating the proposed model on support vector machines (SVM). The reproducing kernel used in SVM is represented as the linear combination of the kernels defined on the individual embeddings. The optimization technique used in simple multiple kernel learning (simpleMKL) is used to find the parameters of the optimal kernel. To analyze the individual representation capability of the embeddings, an R-convolution graph kernel is designed over each of the views. In our experimental analysis, the multi-view graph embedding showed a superior performance in comparison with that of the state-of-the-art graph embeddings as well as graph kernels.

## Department of Physics

### Dr. Apoorva Nagar

**Effect of interparticle interaction in a variation of the symmetric exclusion process.**

The Totally Asymmetric Simple Exclusion Process (TASEP) is a paradigmatic model in nonequilibrium statistical mechanics. In this model, particles move on a lattice undirectionally, and in the presence of an open boundary, one sees various different phases in the system depending on the input and output rates of the particles. In the usual model, the particles have a hard-core interaction amongst themselves, i.e. not more than one particle can be present at a lattice site. We are studying a model in which the inter-particle interactions can be made less rigid by tuning a parameter. Less rigid interactions open up the possibility of having more than one particles at a site. One then expects a different phase diagram in this system. Exploring this phase diagram with a variation in the input, output rates and with the parameter governing inter-particle interactions is the purpose of this work.

**Effect of local resetting on a nonequilibrium multi-particle model**

The effect of resetting on dynamical systems is a topic of much current interest. Here we study the effect of sudden, large and stochastic changes on the behaviour of the system of. In our case, the systems of interest are the various related models of interacting particles on a lattice. We have already looked at the TASEP with open boundaries and explored the effect of resetting on the various phases. We are also looking at a model of exclusion processes with periodic boundaries and a reservoir site.

**To develop models on the pattern formation and evolution of arctic melt ponds**

We are working to develop Statistical Mechanics based models inspired by percolation theory, spin models etc. to study the patterns formed by Arctic melt ponds. These models will be grounded in field observations and satellite data and would help provide accurate description of melt pond behaviour at different stages of evolution. Correspondingly, we are also looking at real data for the melt ponds and trying to characterize them in novel ways, in addition to trying to understand the patterns using our models.

## Dr. Ashok Kumar

**Quantum Science and Technology with Bright Entangled Light**

Quantum entanglement is one of the most exciting phenomena proposed and observed in the 20th century. From a theoretical concept of quantum theory to applications towards quantum computing, quantum communication, and quantum sensing, quantum entanglement is critical. To date, quantum entanglement has been observed in various systems like photonic, atomic and superconducting; among all, the generation and applications of entanglement in photon's different degrees of freedom is most popular and efficient. We are developing a source of bright entangled twin beams of light generated with the interaction of laser beams with hot rubidium vapour cell via a four-wave mixing process. We are planning to use the generated entangled twin beams for quantum communication and quantum sensing applications.

*__Ashok Kumar, Gaurav Nirala__ and Alberto Marino, Einstein-Podolsky-Rosen paradox with position-mementum entangled macroscopic twin beams, Quantum Science and technology, 6, 045016 (2021).*

*Timothy Woodworth, Mohammad Javad Dowran, __Ashok Kumar__ and Alberto Marino, Fundamental sensitivity bounds for quantum enhanced optical resonance*

*sensors based on transmission and phase estimation, Quantum Science and technology (2021).*

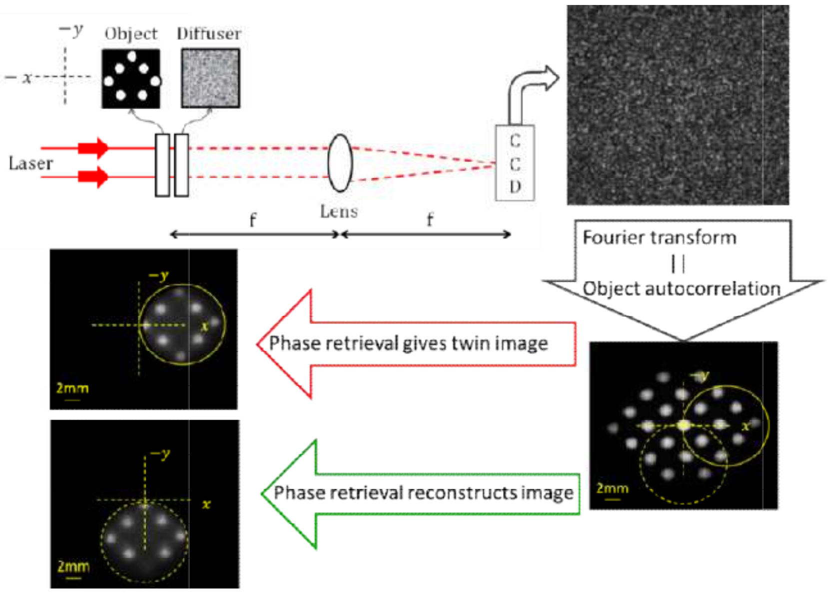
## Dr. Dinesh N Naik

**Single-shot and twin-image free unique phase retrieval**

In astronomy, x-ray crystallography, wavefront sensing, electron microscopy and biomedical imaging; phase part of the object contains valuable information. Camera and photographic plates that are employed for recording, could record only the intensity or the diffraction pattern of the object. To reconstruct the phase of an object from the intensity image of the diffraction pattern recorded at the Fourier plane or equivalently, from the object autocorrelation, generally, digital holography or phase retrieval algorithm (PRA) is used. In holography, an interference pattern or hologram is created, by introducing a separate reference beam. PRA, on the other hand, is a simple iterative computational technique that does not require separate reference beam and complicated setup as that in the holographic techniques. However, PRA being an iterative method requires constraints in the object as well in the Fourier domain as a priori information for successful phase retrieval. We proposed and successfully demonstrated a novel scheme for PRA. A single-shot and twin-image free unique phase retrieval using an aspect of autocorrelation that considers the object asymmetry is achieved. An object is chosen such that it is having mirror symmetry with respect to  axis and asymmetry with respect to  axis. As can be seen from the object autocorrelation image obtained using Fourier transform of the recorded intensity pattern, the portion encircled by dotted line has the features similar to the object, while the portion enclosed by solid line has features of object as well the twin. Therefore, it is clear from this example that due to the object asymmetry, object information is encoded into the object autocorrelation along the asymmetric direction. Hence, for the initial guess which is filtered for  using the solid circle as mentioned in figure, the twin-image gets reconstructed. While for the portion filtered from for, using the dotted circle, shows a twin-image free reconstruction.

*1. Surya Kumar Gautam, Rakesh Kumar Singh, C. S. Narayanamurthy, and Dinesh N. Naik "Reconstruction of complex-object using edge point referencing," Journal of Optics, 22, 055601 (2020).*

*2. **Surya Kumar Gautam**, Rakesh Kumar Singh, C. S. Narayanamurthy, and Dinesh N. Naik "Single-shot and twin-image free unique phase retrieval using an aspect of autocorrelation that considers the object asymmetry" JOSA A , 37, 1826-1831 (2020).*




## Dr. Jayanthi S.

### Solid and Liquid State Nuclear Magnetic Resonance Spectroscopy (NMR)

Research is being carried out in developing analytical and numerical approach to solve time dependent Hamiltonians especially focused on $^{1}H$-$^{14}N$ cross-polarization and double cross polarization under magic angle spinning (MAS). In this framework the focus is on half integer and integer spin quadrupolar nuclei dipolar coupled to spin ½. Work is also progressing in the development of sensitivity enhancement NMR techniques in both solid and solution state applied to peptides under MAS and SARS CoV2 RNA fragments in solution. Solid state deuterium MAS NMR studies are applied to study molecules adsorbed on the inner pore surface of mesoporous silicate materials and the results derived are correlated through supporting molecular dynamic simulations to derive a molecular level picture of structure and dynamics

## Dr. Jinesh K. B.

### Electronic Neurons for future Artificial Intelligence

Research is mainly focusing on developing electronic synapses for emulating biological neurons in human brain, for the future Artificial Intelligence applications. We have developed a series of materials that can function similar to the ion channels called synaptic cleft, and developed capacitor-like structures that function very similar to that of biological neurons. These materials include two-dimensional materials like $MoS_2$, graphene oxide and their multi-layers, multi-ferroic materials like $BiFeO_3$, interfacial engineered $Al_2O_3$ and organic materials such as phthalocyanines. Using Atomic Layer Deposition (ALD), which was developed in the lab itself, we constructed $Al_2O_3$ tunnel junctions that show excellent synaptic behavior. The devices fabricated in our laboratory exhibit the Hebbian learning pattern, the associative learning pattern of biological neurons, which will be beneficial for the unsupervised learning in artificial intelligent systems.

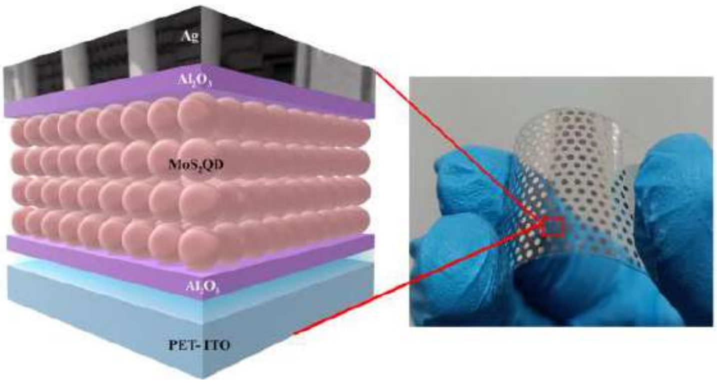



*Figure: the flexible Electronic synapses we developed using $MoS_2$ Quantum dots.*

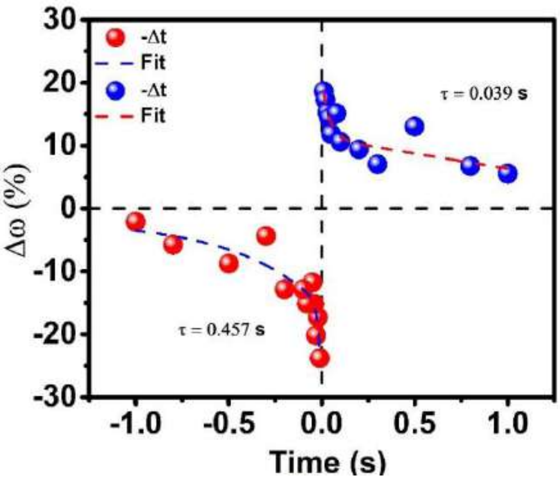


*Figure: (Left) The Associative learning behavior of a biological neuron (from the book "The synaptic organization of the brain by Shepherd, Oxford University Press) and (right) the characteristics of a Quantum Dot-based electronic synapse developed in IIST lab.*


1. *Synthesis of nanodiamonds using liquid-phase laser ablation of graphene and its application in resistive random access memory,* ***A Thomas, MS Parvathy, KB Jinesh****, Carbon Trends 3, 100023*
2. *Influence of intensity on copper phthalocyanine based organic phototransistors,****L. Vijayan, K.S. Kumar, K.B. Jinesh****, Materials Today: Proceedings 47, 1099-1103 (2021)*
3. *Resistive switching in formamidinium lead iodide perovskite nanocrystals: a contradiction to the bulk form,* ***C. Muthu, A. N. Resmi,J. K. Pious, G. Dayal, N Krishna , K. B. Jinesh and C. Vijayakumar****, J. Mater. Chem. C, 9, 288-293, 2021*
4. *The effect of the top electrode on the switching behavior of bipolar $Al_2O_3$/ZnO RRAM,* ***J. Arya,Lekshmi, N., Kumar T., K.B. Jinesh****, Microelectronic Engineering, 250, 111637,2021*


## Dr. Kuntala Bhattacharjee

(currently in Institute of Physics Bhuvaneswar under DST Mobility Fellowship)

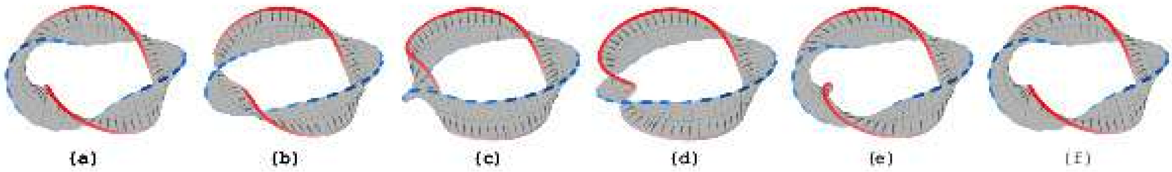
### Low Dimensional Quantum Materials

Research interest is based on low dimensional quantum materials which have potential applications in the areas of electronic, optoelectronics and space sciences. Band engineering, investigations of the optical, electronic and electrical properties of the carbon based thin film coatings comprised of different one dimensional (1D) structures; synthesis, reliability and stability of these thin films for space related stray light control applications are the foremost research interest of my group presently. The group also works on room temperature growth of stanene like 2D films under ultrahigh vacuum conditions on hexagonal surfaces of transition metal dichalcogenides (TMDs) like $WS_2$, fabrication of hybridized metal-semiconductor junction of different polymorphs of same TMD materials and their structural stability under high energy electron beam which are considered as few of the central research interests in the materials science world wide. Under this DST Mobility Scheme, work is also ongoing in the study of adsorption of atoms on the TMD surfaces to modify the local electronic structures. Cutting edge research related to experimental and theoretical investigations of the quantum materials is being carried out actively.

## Dr. Murugesh S.

### Rogue breather modes: Topological sectors, and the ‘belt-trick’, in a one-dimensional ferromagnetic spin chain

Explicit solutions arer presented for breather soliton modes of excitation in the one-dimensional Heisenberg ferromagnetic spin chain. A characteristic




geometrical feature of these breather modes is identified wherein a helicoidal configuration of spins is continuously transformed to one which differs from the initial helicoid by a total twist of ‘2’. This is a curious manoeuvre popularly known as the ‘belt trick’, an illustration of the simple connectedness of the SU(2) group manifold, and its rotation period 4 $\pi$. We show that this effectively splits the configuration space of the ferromagnetic chain in one-dimension into two topological sectors, distinguished by their total twist — either ‘0’, or ‘1’. Further, the energy lower bound of the two sectors is separated by a finite gap varying inversely with the size of the lattice.

### Exact and non-exact Fermi – Pasta – Ulam – Tsingou recurrences in a Heisenberg ferromagnet

We visualize the Fermi – Pasta – Ulam – Tsingou (FPUT) recurrence in a classical Heisenberg ferromagnetic (HF) spin chain by exploiting its gauge equivalence to the nonlinear Schrödinger equation (NLSE). We discuss two types of spatially periodic breather excitations in the spin chain, that are associated with: (I) Akhmediev breather (AB), and (II) Galilean transformed AB. The recurrence in the former is exact in the sense that the initial and final states are identical. In the later, the spin chain undergoes an additional global rotation during the recurrence process, which makes the initial and final states distinguishable. Both the complex solutions (I) and (II) nevertheless show a definite phase shift during the recurrence process. A one-to-one correspondence between HF spin chain and the NLSE seems missing by virtue of the closeness of the FPUT recurrence.

## Dr. Narayanamurthy C. S.

*Applied Optics*

**Optical metrology using digital holography, (Collaboration with VSSC, Trivandrum)**

In collaboration with ISRO centers, applied time average digital holographic technique for Non-Destructive Testing of aerospace structures since 2010. In continuation of that, recently developed a method to evaluate NDT of de-bond structures. The results appeared in the paper entitled "*Computed time average digital holographic fringe pattern under random excitation,* Binu P Thomas, S Annamala Pillai and C S Narayanamurthy, Applied Optics 60 (4), A188- A194, 2021(Optical Society of America journal)

**Shearography for metrology (Collaboration with VSSC, Trivandrum)**

Developing shearographic method for measurements of displacements, defect detection of complex structures.

**Digital holography for metrology (IISU, Vattiyurkavu)**

In collaboration with IISU, working on a problem for testing prism element using digital holography and thin film coating. Detailed experiments are being carried out simultaneously at IISU and IIST.

*Adaptive Optics*

**Wavefront sensing of turbulent impacted beams (IIST, Trivandrum)**

Wavefront detection and sensing of turbulent impacted beams is being carried out using variance matrix approach and conventional wave propagation method. The wave propagation analysis through atmospheric turbulence is carried out for measuring scintillation, beam wandering and beam spreading using conventional methods using Fried parameters or Zernike polynomials. But, we have for the first time used variance matrix approach using measurements from a Shack-Hartmann wavefront sensor of turbulent impacted beam. In this method, the slope data of displaced spots on the sensor due to turbulence and position parameters of non-turbulent impacted beam is used directly and measured their respective first and second moments.

### *Freeform optics (LEOS, Bangalore)*

Conventional two-mirror optical telescope designs are well-known, but to improve the performance of two mirror telescopic system, developed new design using freeform surface. Four variants of the optical design that make use of symmetrical and off-axis freeform surfaces for achieving superior performances in the spectral range from 400nm to 900nm, as compared to regular RC telescope design are proposed. The optical design with freeform surfaces show marked improvements compared to its counter-part comprising of conics and higher order aspherics.

### *Atmospheric optics (NARL, Gadanki)*

The vertical and spatial distribution of elevated aerosol layers obtained using long-term ground-based and space-borne LIDAR observations are developed and using thisthe atmospheric structural changes are being observed over various regions of India.

### Publications

i) Single-shot and twin-image free unique phase retrieval using a part of autocorrelation about the object asymmetry, Suryakumar Gautam, Rakeshkumar Sing, C S Narayanamurthy and Dinesh N Naik, Jl. Opt. Soc. Am A, 37 (11), 1826-1831, 2020

ii) Computed time average digital holographic fringe pattern under random excitation, Binu P Thomas, S Annamala Pillai and C S Narayanamurthy, Applied Optics 60 (4), A188-A194, 2021

iii) Design of two-mirror telescope systems with freeform surfaces: modified configurations and analysis, BV Rao, KV Sriram, CS Narayanamurthy, Journal of Astronomical Telescopes, Instruments, and Systems 7 (1), 014002, 2021

iv) Insensitivity of higher order topologically charged Laguerre Gaussian beams to dynamic turbulence impact, Pramod Panchal, Dinesh Naik and C S Narayanamurthy, (Published online Optics Communications, Elsevier, 2021)

v) Vertical and spatial distribution of elevated aerosol layers obtained using long-term ground-based and space-borne lidar observations, G Gupta, MV Ratnam, BL Madhavan, P Prasad, CS Narayanamurthy, Atmospheric Environment 246, 118172, (2021)

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## Dr. Solomon Ivan

**Experimental demonstration and investigation of entanglement at IIST**

The superposition principle applies to several physical problems. When the problem involves two or more degrees of freedom, the notion of entanglement emerges, as elucidated by Erwin Schroedinger in 1935. Quantum information processing, quantum communication, and quantum computation, have their basis on entanglement, a consequence of the superposition principle. An even more elementary consequence of the superposition principle, as seen in optics experiments, is the formation of fringes that are readily observed on a screen. An instance being, Newton′s rings of Sir Isaac Newton′s fame, observed since 1664. Both entanglement and fringe formation are consequences of the superposition principle. Is there a connection? A table top experiment recently carried out at the Applied and Adaptive Optics lab, Department of Physics IIST, demonstrated this link, that is : fringe movement under some considerations, implies **Polarisation-spatial entanglement.** The experiment also reported **maximal two qubit entanglement.** The work was published as Ref. [1].

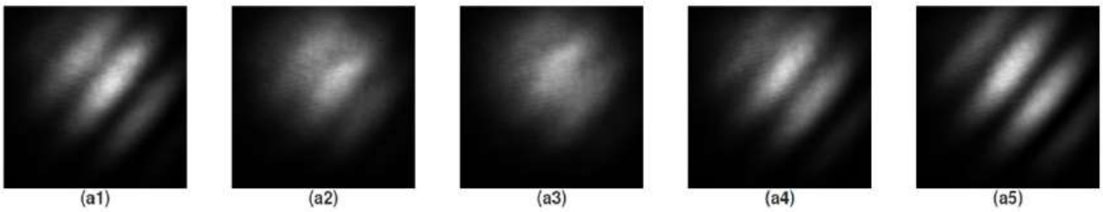



*Figure: (a1)-(a5) Fringe movement showing the presence of entanglement*

The ideas generated in Ref. [1] was extended analytically to more general settings, where the notion of partial coherence was taken in to account. A generalized uncertainty principle suited for the polarization-spatial degrees of freedom was introduced. Partial transpose was implemented through the obtained generalized uncertainty principle. Partial transpose was shown to be necessary and sufficient in detecting entanglement for a class of partially coherent vector light fields which have a spatial part to be Gaussian. An experimental realization of the studied entangled states using classical optical interferometry was outlined. This work was published as Ref. [2]. This work was chosen as an **Editor's pick** by the journal. The experiment relating to this work is now being attempted at IIST. The experiment concerning Ref. [1] was carried out in the Applied and Adaptive Optics Lab of IIST.Apart from this work, two other works are under review. They are listed as Ref. [3*] and [4*].

*[1] **Soumya Asokan and J S Ivan**, Gaussian spatial-polarization entanglement in a folded Mach-Zehnder interferometer, Journal of Optical Society of America A, Vol.37, No.5, 825-832, April (2020).*

*[2] **Soumya Asokan and J S Ivan**, Polarization-spatial Gaussian entanglement in partially coherent light fields, Journal of Optical Society of America A, Vol.38 , No.9, 1304-1311, September (2021). **Editor's pick.***

*[3*] Ameliorated phase sensitivity through intensity measurements in a Mach-Zehnder interferometer, **Jayanth R and J S Ivan**, under review.*

*[4*] A quantum genetic algorithm for optimization problems on the Bloch sphere, **Amal RS and J S Ivan**, under review.*

## Dr. Sourin Mukhopadhyay

### Spectroscopic Imaging Scanning Tunneling Microscopy (SI-STM) and Artificial quantum materials (AQM):

AQMs with their exotic properties promise a new frontier of research in Condensed Matter Physics (CMP). In these AQMs,different atoms coalesce and bind together, their emergent behaviors give rise to new states of matter. On the quantum scale, strong electromagnetic interactions of electrons and associated quasiparticles around the Fermi Surface (FS) produce some of the most complex phases of CMP portraying high $T_c$ superconductivity, nematic/smectic electronic liquids, magnetism, superfluids, fractional charges, topological quantum states etc. Therefore, visualizing evolving dynamics of these electronic interactions(and of elementary excitations), close to the FS, is of fundamental interest to understand complex electronic properties in AQM. Using Spectroscopic Imaging Scanning Tunneling Microscopy (SI-STM) and other transport spectroscopic measurements we explore the quantum realm of these AQM, identify the underlying interactions leading to their unique phases at the atomic scale and their emergent behavior[1].

In CMP, two different paradigms are typically applied to visualize quantum matter.The first is alocal picture, in which one visualizes the quantum states of electrons in atomic orbitals or atimpurity atoms in real space (*r*-space). The second is the momentum or reciprocal space (*k*-space) picture, where electrons are viewed as de Broglie wavesdelocalized throughout the material. Understanding these two separate paradigms is essential for a complete knowledge of the CMP[2]. SI-STM′s unique capability (using quasiparticle scattering) allows it to image directly, the energy resolved electronic local density of states (LDOS) in complex quantum matters in both "*r*-space" and "*k*-space" simultaneously. Since $LDOS\ (E,\vec{r}) \propto \sum|\psi_i(\vec{r})|^2\delta\left(E-\varepsilon_i(\vec{k})\right)$, one essentially images the modulus of the electronic wavefunctions, which is a function of both location **r** and electron energy *E*. Visualizing the energy-resolved density-of-electronic-states (essentially the *quantum wavefunctions of the electrons*) with atomic-resolution is a key tool to understand the emerging behavior of these AQM and developadvanced technologies.In this field, we have a strong collaboration with *Prof. J. C. Séamus Davis*, Oxford Univ., UK, Cornell Univ., USA. At present we are in the process of establishing the SI-STM facility at IIST.

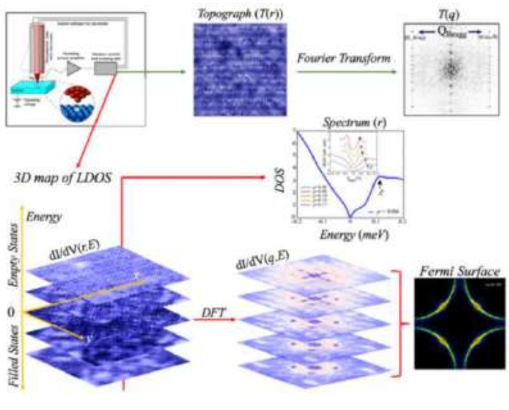



*Fig.1: Visualisation of r-space and k-space electronic structure by SI-STM.*

[1] Sourin Mukhopadhyay et al., Evidence for a Vestigial Nematic State in the CupratePseudogap Phase, Proc. Nat'l Acad. Sci. (PNAS) 116.13249 - Jul 2019.
[2] Kyle M.Shen and J. C. Davis, Materials Today, 11, 14-21 (2008).

***Development of Superconductor based quantum detectors:***

i) *Superconducting Quantum Interference Devices (SQUID):* SQUIDmagnetometers operating at cryogenic temperatures (~4K)with quantum-limited sensitivity, has demonstrated field resolution at the $10^{-15}$ T level. These magnetic sensors (flux to voltage converter) are superior to all other magnetic sensors in sensitivity, frequency response, range, and linearity[3]. We are working with TIFR, Mumbai to develop SQUID basedgradiometer for magnetic anomaly detections.

ii) *Superconductor* based AQM using 2D material growth techniques: These AQM based sensors/devices[4] have immense applications in space and ground based explorations including stealth navigation.We are actively working on Single Photon detectors [5], Transition Edge Sensor (far-infrared sensors) using SQUIDbased superconductingtechnology(extreme signal amplifiers ~$10^{-15}$V/s). The far-IR is a powerful but relatively unexplored spectral band that can enable study of the universe hidden outside the visible/x-ray/UV bands.

[1] Sourin Mukhopadhyay et al., Evidence for a Vestigial Nematic State in the CupratePseudogap Phase, Proc. Nat'l Acad. Sci. (PNAS) 116.13249 - Jul 2019.

[1] Kyle M.Shen and J. C. Davis, Materials Today, 11, 14-21 (2008).

[1] J. Clarke and A. I. Braginski, *Fundamentals and Technology of SQUIDs and SQUID Systems*, The SQUID Handbook Vol. 1,Wiley, New York, 2004.

[1] https://science.nasa.gov/technology/technology-highlights/far-infrared-detectors-superconductivity-enables-new-astrophysical-discoveries

[1] Gol' tsman, G. N. et al. Picosecond superconducting single-photon optical detector. *Appl. Phys. Lett.* 79, 705 – 707 (2001).

## Dr. Sudheesh Chethil

### Quantum Dynamics and Nonclassicality

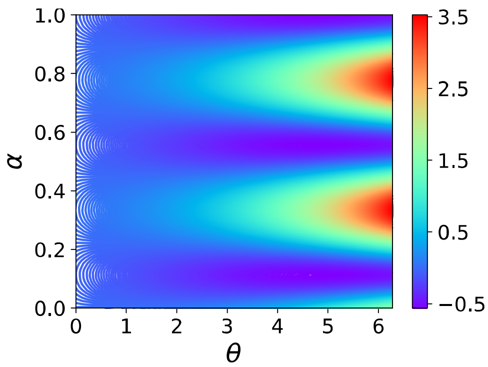
The dynamics of quantum systems play an essential role in quantum information processing and quantum computing. We have studied the dynamics of superposition of wavepackets evolving under different nonlinear Hamiltonians corresponding to Kerr medium, Morse oscillator, and bosonic Josephson junction.

[3] J. Clarke and A. I. Braginski, *Fundamentals and Technology of SQUIDs and SQUID Systems*, The SQUID Handbook Vol. 1,Wiley, New York, 2004.

[4] https://science.nasa.gov/technology/technology-highlights/far-infrared-detectors-superconductivity-enables-new-astrophysical-discoveries

[5] Gol'tsman, G. N. et al. Picosecond superconducting single-photon optical detector. *Appl. Phys. Lett.* **79**, 705–707 (2001).

We have shown that quantum systems' periodic, quasi-periodic, ergodic, and chaotic dynamics can change drastically if we change just the initial state to its superposition by keeping all other system parameters the same. Our initial analysis shows some relation between the interference of the initial state and its dynamics, but a detailed analysis is required to establish a definite connection between them. We have also studied the squeezing properties of arbitrary numbers of superpositions of various squeezed states such as squeezed vacuum state, photon-added coherent states, and two modes squeezed vacuum state. We have considered two kinds of superpositions: the first kind and the second kind. In the case of the first kind, the superpositions of squeezed states do not show both squeezing and higher-order squeezing of all orders. This is found to be true for any state which has quadrature squeezing and multi-mode squeezed states. However, in the case of the superpositions of the second kind (also called generalized




superpositions), it has been shown that the superposition states show significant amounts of quadrature and higher-order squeezing. This is achieved by choosing the proper weight factors in the superpositions; this method also enables us to control the amount of squeezing produced. The vanishing and appearance of squeezing in a superposition state are explained based on expectation values of energy density or stress-energy tensor. States with squeezing are shown to have a negative expected value for the stress-energy tensor for some values of spacetime-dependent phase. In the case of states with no squeezing, the expectation values of energy density are always positive.

*Figure: Energy density plot, which shows negativity where there is squeezing*


1. *Nonlinear dynamics of superposition of wavepackets, **S. Kannan, M. Rohith, C. Sudheesh**, arXiv preprint arXiv:2008.02771 (2020).*
2. *Positive energy density leads to no squeezing,**S. Kannan, C. Sudhesh**, arXiv preprint arXiv:2102.03841 (2021).*

## Dr. Umesh R Kadhane

### Atomic and Molecular Physics

The highlights of the AMP lab has been:

i. Installation and commissioning of 100 eV to 10 k eV electron gun system with fast pulsing option. Procured under DST-SERB funded project, the system is in regular use tot provide very high resolution electron impact mass spectra of PAHs and PANHs. A preliminary Monte Carlo model for dimer formation was built.

ii. A detailed monte Carlo model was designed and tested to recreate the upper atmospheric conditions in the Titan atmosphere and obtained preliminary results.

iii. A plasma reactor and perform mass spectrometric measurements on the complex species formed during the discharge was built. PAHs and PANHs in trace quantities to see if they influence the dynamics will be added.

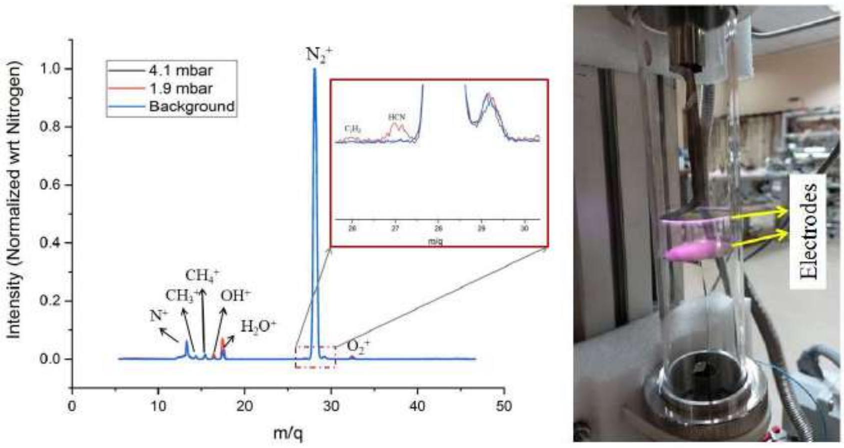
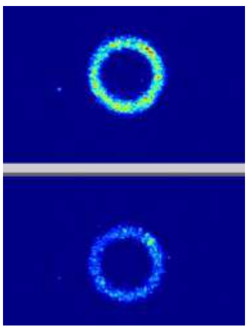



Fig. cation: Right side images shows the plasma glow in Nitrogen + Methane atmosphere simulating the upper atmospheric conditions on Saturn′s moon, Titan.



Electric Propulsion Diagnostics

EPDL lab completed the development, testing and demonstration of seven plasma and beam diagnostics probes and the probes were handed over LPSC to integrate in the upcoming large high vacuum test facility for electric propulsion research. The probes were tested in IIST as well as a IVTF Bangalore with Hall effect thruster.

EPDL also initiated the work on the design, fabrication and supply of Integrated Diagnostics Probe for the upcoming Technology Demonstration Satellite mission (TDS-01).

Fig. caption: 250nm filter, exposure time 200 ns and frame separation of 18 micro second.

## 4.2 Research Projects

IIST support the research of its faculty members through various schemes such as Fast Track projects for newly joined faculty, IIST Projects and IIST-ISRO Projects, coordinated by IIST Research Council headed by Dean (R&D) and Advanced Space Technology Development Cell (ASTDC). The faculty members are also working on projects funded by other external funding agencies such as DST, CSIR and UGC. Currently, 68 research projects are in progress in IIST.

### IIST Projects

| Sl.No. | Name of the Project | Investigators |
|---|---|---|
| 1. | IIST Small- satellite. | Priyadarshnam |
| 2. | Subsystems for INSPIRE sat 1 | Priyadarshanam<br>Harsha Simha M. S |
| 3. | Mechatronic design of Adult sized Humanoid Robot. | Sam K. Zachariah |
| 4. | Geophysical Parameter from Earth Observations Data | V. K. Dadhwal /<br>Rama Rao |
| 5. | Integrated Diagnostics Module (IDM) for TDS-01 Satellite. | Umesh R. Kadhane |
| 6. | Research and development of a low complexity modulated wideband converter for sub-Nyquist wideband spectrum sensing. | S. Chris Prema |
| 7. | Design of On-Chip Passives for Millimeter wave SG (Ka-band) Circuits. | Immanuel Raja |
| 8. | Structuring laser beams for rotational speed sensing and engineered spatial quantum correlations | Ashok Kumar |
| 9. | Development of An Airborne Multi Wavelength Sunphotometer | P. R. Sinha |

## IIST-ISRO Projects

| Sl.No. | Name of the Project | Investigators |
|---|---|---|
| 1. | Optimisation of regenerative cooling channels of liquid rockets engines. | **Shine S R**<br>J. C. Pisharady |
| 2. | Simulation of non equilibrium hypersonic flow in a shock tunnel nozzle. | **Satheesh K.**<br>**Devendra Ghate**<br>K. Srinivasan |
| 3. | Development of an in-house CFD code for the performance prediction of cryogenic and semi-cryogenic engines. | **Deepu**<br>K. N. Dileep |
| 4. | Studies on crack propagation in composites by micro Raman spectroscopy | **Anup S** |
| 5. | Experimental Investigation of Thermoacoustic Instability in Confined Swirl Coaxial Jet Flames | **Mahesh S.** |
| 6. | Laser Sheet Droplet Sizing for Spray Studies | **Aravind V.** |
| 7. | Modeling and Development of N2O4 (oxidant used in rocket engines) Scrubber System | **A. Salih** |
| 8. | Experimental and numerical study of stationary flat flames | **Prathap C.**<br>Assiz M P |
| 9. | Experimental investigation of laminar burning veloc of premixed Isrosene/air/oxygen mixtures using fre expanding spherical flames | **Prathap C.**<br>Assiz M P |
| 10. | Development of Laser Ignition Systems | **Jinesh**<br>C. Prathap |
| 11. | Experimental and Numerical investigation of cavitati venturi | **Pradeep Kumar P.** |
| 12. | Spaceflight-induced changes in kidney stone formation in Drosophila Melanogaster- Microgravity science payload for Gaganyaan - first development flight | **K. G. Sreejalekshmi** |
| 13. | Study of Silicon -Polymer Nanofibers as Anode Material for Lithium Batteries | **K.Y.Sandhya**<br>Nirmala Rachel James |
| 14. | Development of novel N2O4 scrubber system | **Kuruvilla Joseph**<br>S.A. Sali<br>K. Prabhakaran |
| 15. | Superionic conductor as electrolytes for all solid-state- lithium sulfur batteries | **Mary Gladis** |

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| 16. | N-doped mesoporous carbon-sulphur composite bas cathode materials for advanced lithium-sulfur batteri | Mary Gladis |
| 17. | Plasma Functionalized CNT-polymer nanocomposites for Satellite | N. Gomathi,<br>Kuruvilla Joseph,<br>C. Gouri |
| 18. | Design and Development of Brushless DC Motor | N. Selvaganesan |
| 19. | Development of MEMS Accelerometer with Ultra-Sensitive Transductions for Space Applications | Seena V. |
| 20. | Retarding Potential Analyser for Electron and Ion concentration measurement in Martian Atmosphere, Retarding Potential Analyser for Ionospheric Studies (ARIS 101F) - A scientific payload on PS4 orbital platform onboard PSLV C45 | Sudharshan Kaarthik R |

## ISRO Consultancy/Funded Projects

| | | |
|---|---|---|
| 1. | Spectral Characterization and morphology of Olivine-pyroxene spinel bearing lithologies on Moon: implications for lunar endogenic process. | V. J. Rajesh<br>SSPO/Chandrayaan-I AO |
| 2. | A comprehensive study on crustal dichotomy and extensional tectonics in and around valles marineris, mars | V. J. Rajesh<br>SSPO/MOM-I -AO |
| 3. | Algebraic Multigrid method for solving sparse system | E. Natarajan<br>Sarvesh Kumar<br>VSSC |
| 4. | Advanced Retarding Potential Analyzer for Martian Ionospheric Studies (ARIS) | SSPO/MOM |
| 5. | Diagnostic system for testing 300MN SPT | Umesh R Kadhane LPSC |
| 6. | Surface engineering techniques for improving the life performance of ball bearings in ISRO spacecraft mechanisms. | Jinesh K. B.<br>IISU |
| 7. | A Study on the effects of Ionospheric variabilities on the usability of NavIC/GAGAN using observations and models | Priyadarshanam<br>SAC |
| 8. | Development of Surface Discharge Sparkplugs | Jinesh K. B.<br>LPSC |
| 9. | Development of Laser Ignition Systems | Jinesh K. B.<br>LPSC |
| 10. | Development and Implementation of Diagnostic tools | Umesh R Kadhane LPSC |

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|---|---|---|
| | for High Thrust Electric Propulsion System | |
| 11. | Design and development of High Performance Hydrogen Sensor | **Palash Kumar Basu** IPRC |
| 12. | Above ground volume/biomass estimation and validation using airborne S- and L-band NISAR data and radiative transfer modelling | **Rama Rao** (Co-PI) SAC-Ahmedabad |

## Other External Funded Projects

| Sl. No. | Title | Investigators/ Funding Agency |
|---|---|---|
| 1 | To investigate the growth and the local electronic properties of two dimensional stanene on transition metal dichalcogenide (TMDC) and on topological insulator (TI) surface by LEED, STM and STS | **Kuntala Bhattacharjee** UGC-DAE-CSR |
| 2 | Development of a standalone atmospheric correction module for hyper spectral data for indian context | **N. Rama Rao** DST |
| 3 | Spectral biochemical analysis of forest species using hyperspectral remote sensing – a case study from Eastern Ghats forest ecosystems | **N. Rama Rao** DST |
| 4 | Development of PZT ceramic foams | **K. Prabhakaran** DST-SERB |
| 5 | Monitoring the health of mangroves of Maharashtra state using near real time satelite remote sensing data. | **L. Gnanapazham** Department of Forests, Government of Maharashtra |
| 6 | NAVIC Receiver | **Priyadarshnam** **Sheeba Rani** Ministry of Electronics and Information Technology |
| 7 | Investigation of Transition Metal Dicalcogenides based Thin film transistors for ultra sensitive nanomechanical bio/chemical sensor. | **Seena V** DST-SERB |
| 8 | Deep crustal processes during the evolution of archaeanNilgiri block, southern India | **Rajesh V J** MoES |
| 9 | Arc accretion in the past and present and its | **Rajesh V. J.** |

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| | bearing on metallogeny | DST-JSPS India Japan Bilateral Project |
| 10 | Understanding the physical conditions of Baryons outside of galaxies in the low redshift universe. | **Anand Narayanan**<br>DST-SERB |
| 11 | Electron impact secondary electron-ion coincidence sepctrometer for investigation of dissociation dynamics of PAHS. | **Umesh Kadhane**<br>DST-SERB |
| 12 | Max Planck Partner Group for Galactic Star Formation | **Jagadheep D.**<br>Max Planck Society for Radio Astronomy |
| 13 | Investigating the Nanomaterial based Exosome Sensor for Cancer Prognostic: An Approach towards Liquid Biopsy for Cancer | **Palash Kumar Basu**<br>IFCPAR, CEFIPRA (DST) |
| 14 | Study of Gamma Ray Bursts with a focus on their radio afterglows. | **Resmi L**<br>DST-SERB |
| 15 | Wireless-Relod- Wireless Reliable , Low Latency Networks for IIoT and Fieldbus replacent | **Vineeth B. S.**<br>DST-SERB |
| 16 | LOC approaches for Separation and Analysis of Exosome Derived Biomarker for Cancer Prognostic | **Plash Kumar Basu** |
| 17 | Computational and Experimental Investigations on a combined nonlinear vibration absorber energy harvester system. | **Praveen Krishna**<br>DST-SERB |
| 18 | Investigation, Design and Implementation of Multifunctional 5G Antenna Systems for Cognitive Radio and mm-Wave Applications. | **ChinmoySaha**<br>DST-SERB |
| 19 | Development a source of bright entangled light for quantum communication and quantum sensing. | **Ashok Kumar**<br>DST-SERB |
| 20 | Understanding the influence of young massive stars on surrounding interstellar medium | **Sarita Vig**<br>DST-SERB |
| 21 | Life Line for Remorte India : A study of Tele medicine Units of India | **Shaijumon C. S.**<br>**Leshmi V Nair**<br>ICSSR |
| 22 | Discontinuous virtual element approximation for non-stationary fluid flow problems. | **Sarvesh Kumar**<br>DST-SERB |
| 23 | City GML based 3D models for smart cities in India | **Ramiya A. M.** |

| | | |
|---|---|---|
| | using LiDAR point cloud | DST-SERB |
| 24 | Development of Low cost , Low power, High Performance Sensor Array with Suitable Optical Source to Measure the Emission of Green House Gases : Broad Applications Towards Agriculture and Environment Monitoring Including Harsh Condition | **Palash Kumar Basu**<br>DBT |
| 25 | Design of a Transmitter with Integrated Power Amplifier (PA) for Millimeter-Wave 5G Bands in 65nm CMOS | **Immanuel Raja**<br>DST-SERB |
| 26 | Improving the prediction of Thunderstorms using Dual-Resolution Hybrid Ensemble – Variational Data Assimilation System using WRF model | **Govindankutty M**<br>MoES |
| 27 | Development of an Atomic Layer Deposition System | **K. B. Jinesh**<br>DST |

## 4.3 Centres of Excellences

### Advanced Propulsion and Laser Diagnostics Lab

*(Department of Aerospace Engineering)*

The setting up the Advanced Propulsion and Laser Diagnostics (APLD) is aimed at the establishment of a centre of excellence that will serve as (i) centre for conducting academic research in IIST which would assist ISRO activities, (ii) national facility for performing advanced research and (iii) national technological development centre for aerospace organizations. The current objective is to perform propulsion research studies that are of academic interest and also complement ISRO′s ongoing technological development activities.

### Computer Vision and Virtual Reality Lab (CVVR lab)

(*Department of Avionics)*

**Vision:** To transcend in the area of virtual reality and intelligent computer vision for cutting edge space science, societal and technological applications.

**Mission:** To design and develop state of the art technological solution, algorithms for both space and non-space applications.

**Brief Description**: Founded in 2010, the primary research focus of CVVR CoE lies mainly in the development of effective virtual reality, computer vision, and deep learning-based algorithms that help in both space and non-space applications. The lab is currently housed in Room No. L-204, D4-building, under the Department of Avionics, Indian Institute of Space science and Technology. The lab is well equipped with highly efficient GPUs that help in accelerating the pace of research. Image processing and Computer Vision lab sessions for the UG and PG students are also conducted in the CVVR lab. Current research in the lab focuses on Virtual reality tools for Disaster simulation, Object tracking, landslide detection in satellite images, image fusion, etc. The current working members of the lab include research scholars, project fellows, and PG and UG students working on their academic projects. The members actively publish their works in reputed national and international conferences and journals.

The entire development of the proposed CoE was planned in three phases. The first phase consists of a desktop VR lab that consists of the high-end workstation with the latest graphics capabilities, 3D monitors, 3D vision-pro glasses, and application software such as Vizard, Blender, Google Sketch, Adobe Master Suite collection, 3ds Max and Maya. The facility will be upscale by creating an immersive studio type Virtual reality center in phases 2 and 3 which is planned in 2020-21. The proposed facility will be supported by advanced haptic devices, sensors, and force feedback systems for various real-life applications such as navigation, fly through etc.

Some important goals of proposed CoE are to develop simulations and solutions for:

Space Science and Space Technology oriented Research areas in

- Planetary exploration
- Indigenous software development
- Design of VR testbed prototype
- Virtual prototyping of space shuttle
- Remote sensing lidar data visualization in the virtual world
- Virtual walk/fly through etc.

Societal application-oriented research areas in

- Disaster modeling and simulation
- 3-d VR visualization of compounds and chemical
- For theoretical and nonlinear dynamical studies.

- Developing VR teaching simulations for a better understanding of the concepts in different key subjects of Avionics, aerospace, Physical science, and humanities etc.

**Current Infrastructure:**

**Location:** The proposed center will be housed in the Avionics Department in room R304. A research space of 120sqmt is allocated in the Avionics department for the proposed center.

**Computing Resources:** HP Z800 workstation 5 no., Nvidia Quadro 6000 Graphics card 5 nos. Nvidia Titan XP, Nvidia 1080, Nvidia 1060, Fujitsu workstation 10 nos.

Imaging devices: GigE Vision cameras, DSLR camera, Thermal Camera, etc.

**VR/visualization Devices:** Data Gloves, HTC Vive HMD, Nvidia Active stereo goggles, 3 D display monitors 5 nos., Big display Unit

Software and Tools: Visual Studio, Adobe Master Suite, Python, Unity, Blender, etc.

**Featured Work:** Flood flow simulation using augmented reality, computer vision tracking (Single object and multi-object), satellite Image fusion, deep learning techniques for computer vision, and image processing.

**new additions:** Recently HTC Vive device for virtual reality immersive experience has been added to the existing facility.


*Fig. 1. The Desktop VR interface*

**ISRO-IIST Project:** Development of Virtual Reality Model for Disaster Simulation (Phase-1 of Project completed by 31 July 2020)

Key results from the above project:

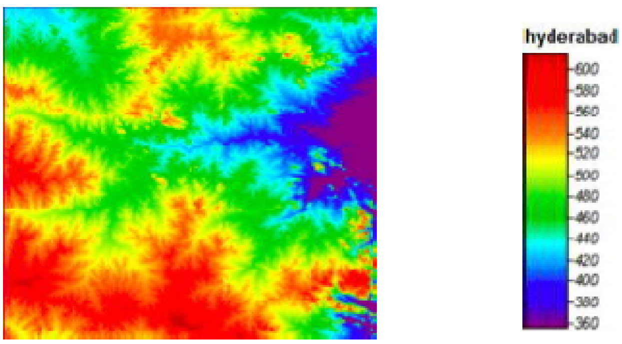


*Fig 2. Hyderabad Test Location A real-world test case of Hyderabad city has been simulated. The test area is about 5721.67 sq.km. The total simulation time is set for ten hours. In the first hour rainfall has been set as 30mm/hr, second-hour rainfall has been set as 40mm/hr, the third hour it is 50 mm/hr, the fourth hour it is 20mm/hr and fifth hour it is 25mm/hr. After five hours there is no rainfall. The slope tolerance has been set as 1.65.*

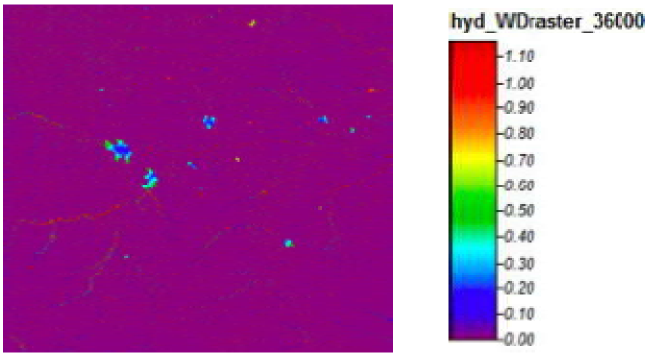



*Fig 3. shows the water depth after 36000s of simulation*

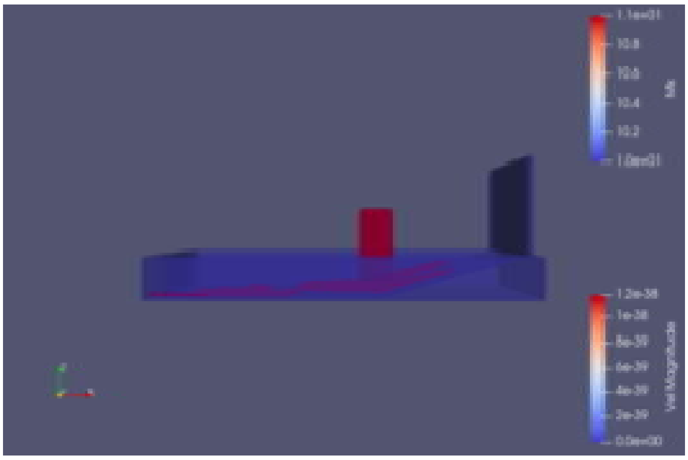


*Fig. 4. A snippet of Dam Break Analysis*

CVVR in news: One student who did his B.tech thesis in the lab won INAE best UG project award in the year 2019. Subsequently, two UG second-year students were mentored (in collaboration with Prof. N Selvaganesan and Dr. Deepak Mishra) to develop an Augmented reality app for the prestigious COVID-AR-2020 challenge. The team of two students was in the top 15 finalists among 300+ teams. Similarly, two students were mentored to participate in the Innocentive ideation challenge and their idea won the first prize. The proposed idea was based on Gamification that has been long recognized as a powerful approach in changing social behavior, including health-related behavior. The objective of the Challenge was to apply gamification in changing people's social behaviorso as to prevent the spread of Coronavirus and other infections. Innocentive, an open innovation, and crowdsourcing company posted such an ideation challenge where teams were to come up with novel ideas for this problem statement.

**Usage**: The established center is used by all the students of the institute for their UG/PG/Ph.D. research work and along with carrying out research and development activities related to various funded projects.

**Funding Agencies**: the CVVR-CoE thankful to Indian Space Research Organization (ISRO), Department of Space (DoS), Indian Institute of Space Science and Technology (IIST) for their funding and encouragement.

## Centre of Advance Research in Nanoscience and Technology

*(Department of Chemistry)*

Center for Nanoscience and Energy Materials was established in Department of Chemistry to carryout focused research in the area of nanoscience and energy storage materials. The center undertakes research for development of silicon based anode and sulphur based cathode for the realization of high capacity lithium ion batteries. The center also do cutting edge research on the development of nanomaterials based chemical/ electrochemical sensors, organic light emitting diode and nanocomposites for structural and functional applications. The center is equipped with state of the art facilities such as atomic force microscope, particle size analyzer, Glove box, electro-spinning machine, Contact angle Goniometer, HPLC, Planetary ball mill and surface area analyzer.

## Small-spacecraft Systems and Pay load CEntre (SSPACE )

*(Interdisciplinary)*

Small-spacecraft Systems and PAyloadCEntre (SSPACE) is an interdisciplinary centre involved in the development of satellite systems and mainly driven by students and faculty of IIST. The SSPACE center is involved in realisation of payloads, related electronics, small satellites, assembly, integration, testing and ground station to carryout mission operations. SSPACE at the moment is involved in the following missions

- ARIS-2 (Advanced Retarding potential analyser for Ionosphere Studies): This is a PS4 payload for LEO ionosphere studies. After the successful launch of ARIS-1 in April 2019, the data collected was analysed and promising results were found. The ARIS-2 version is getting ready for launch.

- AHAN: This is the first satellite designed and developed by the students of IIST. The mission is expected to be flown on PSLV for carrying out measurements of radiation in LEO. The prototypes of all the subsystems were completed during this period. The satellite is waiting to be integrated and tested.

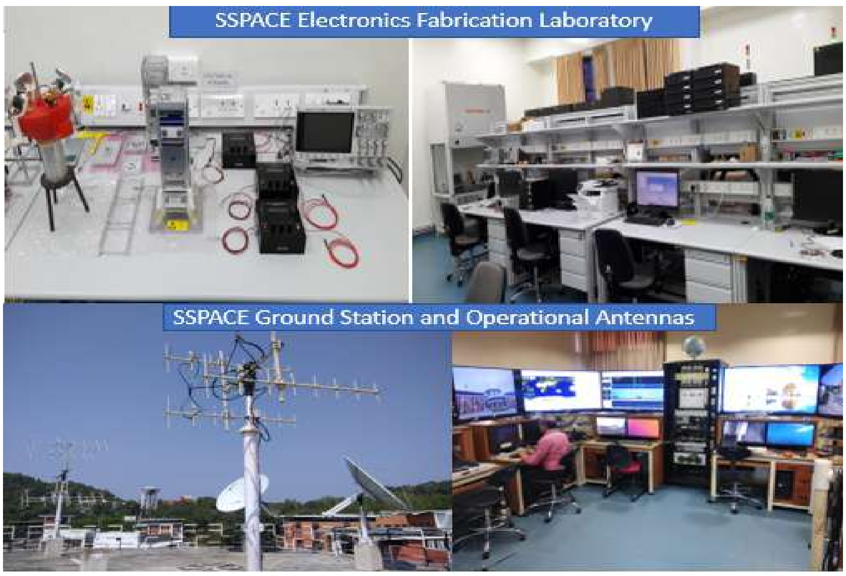
- PILOT (Pslv In-orbitaLObc and Ttc): This is an offshoot of AHAN where the subsystems developed for AHAN mission will be tested in the PS4 stage prior to the flight. The subsystem designs were completed during this period and are awaiting integration and testing.

- InspireSat1: This is a student satellite developed as part of international collaboration with Laboratory of Atmosphere and Space Physics (LASP), University of Colorado, Boulder. During this period, the satellite was integrated and is awaiting testing at LASP.

- AAReST (Autonomous Assembly of Reconfigurable Space Telescope): This is a collaborative mission with Caltech, USA and University of Surrey, UK. The MirrorSat mass dummy version 2 was delivered to Caltech and successfully completed the integrated vibration test. Furthermore, SSPACE delivered the MirrorSat structure for University of Surrey, UK.

- RPA for MoM-2 : For understanding the ionosphere of the planet Mars the payload RPA is being developed by SSPACE, IIST. The design of the high sensitive electronics is being developed.

- RPA for Venus: The ionosphere of Venus will be studied by an RPA being developed for the Venus mission.



*Leftmost Image is the mass dummy developed for Ahan satellite and the rest of 3-images are the structure, and mass dummies developed for AAReST mission*

- IIST successfully installed two experimental 2.4 m antennas. These antennas will be tested for S-band receptions at 2.4Ghz.
- IIST successfully installed an experimental HF loop antenna for ground based ionosonde studies with frequencies 3-30Mhz.

The outcomes of the studies made on these experimental antennas will be used for constructing the operational versions.

## NEMS and Opto – Nanoelectronics (NEMO)

*(Department of Avionics)*

Department of Avionics took the initiative towards development of an R&D ecosystem in the area of VLSI, Micro Electro Mechanical Systems (MEMS)/ Micro/Nanoelectronics/optoelectronics and sensors at IIST for academia, ISRO and other research organizations. Department has established laboratories and research facilities in the area of Micro-Electro Mechanical Systems (MEMS) and Micro/Nanoelectronics. These laboratories support the post graduate programme VLSI and Microsystems and research activities in the areas of micro/nano electronics, micro electromechanical systems (MEMS/NEMS), devices and technologies across all departments in IIST. Close collaborations have been established with many ISRO centres like IISU, VSSC, SCL and IPRC. These are either through formal collaborative projects for development of Micro/Nanosensors or service.

**Centres of Excellence recommended** (multidisciplinary)

- Advanced Combustion Research Lab
- ASIC Design and Characterization Lab
- Advanced Space Robotics & Control Lab.

They will be an integration of several labs of IIST and has been welcomed by several ISRO centres

# 4.4 New Research Facilities / Programmes

## ARIS

IIST had launched its first space mission on PS 4 stage of PSLV C45 on 1st April 2019. An advanced retarding potential analyser for ionospheric studies (ARIS) was designed and built by IIST faculty, project fellows and students with support from IISU and VSSC. ARIS was realized in a shorttimeof just 49 days from the first clearance. The probe functioned during the life of the mission and provided valuable data on electron and ion temperatures, density and mass distribution. A follow sensor for one of the upcoming PSLV missions is under testing and its advanced versions have been shortlisted by ISRO to fly in forthcoming missions to Mars and Venus.The second hardware of ARIS -2 payload is ready and awaiting a launch opportunity. Activities for RPA-V payload for Venus mission are in progress and project funds are awaited. IIST is part of ISRO's TDS-01 satellite mission

## Human Space Flight Program

A proposal by Dr. K Sreejalekshmi jointly with Dr. R Hosnani of University of Agricultural Science, Dharwad, on "Spaceflight induced changes in kidney stone formation in Drosophila melanogaster" has been selected to be flown in the first development flight of Gaganyaan scheduled for the final quarter of 2020. An MoU between HSFC and IIST for an amount of 72 lakhs has been agreed upon and will be signed summarily.The spaceflight hardware design is completed, and experimental verification tests are progressing well in the space life science research unit established at IIST. Along with that, gravitational biology research was also initiated, and a Random Positioning Machine was designed, fabricated, and tested for microgravity science experiments. An MoU is established between IIST and TIFR Mumbai for providing the spaceflight hardware being developed by IIST for TIFRs experiment.

As part of the activities in ChemiSens lab (Department of Avionics), the following facilities were augmented for sensor development for Human Spaceflight Program

Pico-Liter Dispensing Unit: To dispense minimum 500pL solution on selected position. It can cover 100 mm State of the art Gas calibration facility: Upgrading the Calibration facility for static and dynamic gas mixing to generate desire concentration of gases in ppt level at different pressure, moisture, and temperature. It can calibrate gas sensors in mixed gas condition to study the cross sensitivity of the gases. This system will come with SMU and data logger system continuously for 20 days. High Definition Microscope and surface profilometer and Optical spectrometer for Gasochromic measurement.

Gas sensor development lab

Drosophila culture facility and Stereo microscope

Research is in the advanced level for developing Indigenized gas sensors for crew cabin monitoring led by Dr Palash Basuwith SAC and SCL. Other explored areas include development of handheld sensor platform for point-of-care purpose, wireless communication systems for human health monitoring, prognosis, and diagnosis by Dr.Selvaganesan, Dr.Vanidevi and Dr. T G Deepak. An Internet of Things (IoT) Lab for developing Ambient Assisted Living (AAL) technology was set up as part of the Systems and Networking Lab (SysNet Lab) in the Avionics department. New technologies for assisted living for ground and human space missions are being developed in this lab for experiments. Another project dealing with the human thermal management by Dr Shine in collaboration with SCTIMST, Thiruvananthapuram is under consideration for induction in the HSP.

## ExoWorlds: A proposed ISRO Exoplanet Mission

The last decade has seen the Indian Space Research Organization (ISRO) make major inroads in the field of planetary explorations. Envisaging a giant leap forward, a pioneering ISRO mission, ExoWorlds, is proposed which holds the promise to be the world-leading facility in the next decade for studies of planets beyond the Solar System – the exoplanets. A few thousand planets have now been discovered displaying extreme diversities in their macroscopic properties. The central goal of this mission is to conduct, for the first time, a comprehensive survey of chemical composition and atmospheric processes of a large population of exoplanets. This would lead to a paradigm shift in our understanding and classification of planetary systems and shed crucial light on their formation and evolution. This breakthrough science goal will be realized through high-precision transit spectroscopy which offers a unique opportunity to probe the exoplanetary atmospheres without the need for direct imaging. To achieve this, ExoWorlds is proposed as a dedicated mission for exoplanet spectroscopy housing a focused payload that comprises of a 2-m class telescope, two medium resolution (R ~ 500) spectrometers that will span the entire NUV-Visible-IR spectral range between 0.25 - 5 $\mu$m at very high photometric precision. A fine guidance sensor (FGS) along with a fast-steering mirror will ensure precise pointing and stability in an L2 orbit. The unprecedented broad and simultaneous spectral coverage with high precision will enable the detection of a rich variety of chemical species; retrieve the pressure-temperature profiles; probe the outer atmospheres for clouds and hazes; and delve into the realms of habitable planets and biomarkers. With a proposed mission timeline of 5 years, ExoWorlds would place the Indian astronomy community at the forefront in the emerging field of exoplanetary science.

Led by Indian Institute of Space Science and Technology (IIST), ExoWorlds is a collaborative project of IIST, ISRO, IoA-University of Cambridge, TIFR, IUCAA, IIA, PRL, ARIES, SNBNCBS, IISERKolkata, Christ University, Bangalore, and St Joseph College-Bangalore.

## Multi-Disciplinary Computing Center

IIST has developed an infrastructure in the interdisciplinary block for the Multi-disciplinary Computing Centre to host parallel computing clusters, servers, and workstations. The aim of the center is to become a centre of excellence in computational techniques and computer simulations for science and engineering and provide expertise in big Data Analysis, Climate Modelling, Computational Fluid Dynamics, Computational Structural Mechanics, Computation-Assisted Materials Science, Computer Vision and Virtual Reality, Machine Learning, Network Science and Engineering, Nonlinear Dynamics, Optimisation, Geoinformatics, Monte Carlo Simulations.

The facility contains a server room and a workstation room. Redundant UPS power supply and Network Raceways for both UTP and fibre cables are installed in the centre. Currently, the centre has one parallel computing cluster named *Virgo* with 22 Teraflops capacity, 31 workstations, and a GPU server. There are about 150 users using this facility.

## Facility for fabrication and testing of batteries

Facility for fabrication and testing of batteries including glove box is established in Department of Chemistry. OLED fabrication lab was set up with the facilities for fabrication and characterization of organic light emitting diodes. The facilities include Glove box, spin coater, UV-ozone cleaner and evacuator, spectrometer with CCD based detector, I-V measurement system for OLED and OLED life time measurement system and four point probe system for measuring sheet resistance.

## Machine Learning Lab

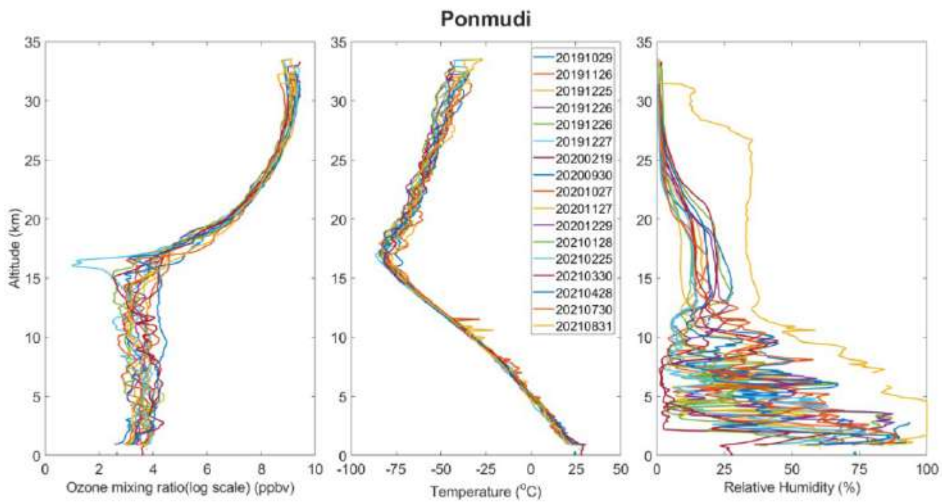
Department of Mathematics has setup a Lab for "Machine Learning" especially to enhance the research facilities to M. Tech and PhD students

## Climate Observatory at Ponmudi

IIST has established a Climate Observatory at its Ponmudi Campus (8.76°N, 77.12°E, 1.1 km, AMSL. Over the years, many observational campaigns converinggreen house gases (GHG), meteorology, boundary layer, aerosols-cloud interactions, and radiation balance studies have been carried out by the faculty of IIST.

*Ozonesonde Balloon Experiment from IIST Ponmudi*

A collaborative program on the measurement of the verticle profile of ozone along with meteorological parameters at multiple sites (Ponmudi, Hyderabad, Nagpur, Jodhpur) has been initiated under coordination and support of the Earth & Climate Area (ECSA) of the National Remote Sensing Centre (NRSC/ISRO). As part of this study, coordinated monthly launches from the IIST campus Ponmudi has been conducting since October 2019. A preliminary profile of $O_3$ partial pressure and concurrent radiosonde measured temperature and Relative Humidity over IIST Ponmudi, Trivandrum is presented in the figure below.



# 4.5 Advanced Space Research Group (ASRG)

ASRG with its vision to facilitate the seamless integration of ideas, expertise and know-how between IIST and ISRO centers, thereby leveraging collective wisdom to forge the puzzle pieces for futuristic space programs, has an empowerment committee headed by Registrar, IIST, an ASRG cell headed by Chief Technology Officer, IIST and has members from all the academic departments as well as from the Capacity Building Program Office (CBPO), ISRO. A total of 20 projects are approved with VSSC, LPSC, IISU, and HSFC as participating Centres from ISRO. A total budget of 971 lakhs has been earmarked to various projects.

| Sl No. | Title of the Project | IIST Principal Investigator | Collaborating ISRO Centre |
|---|---|---|---|
| 1. | Development of Control design strategy for coupled MIMO (multi input multi Output) systems | Dr Rajesh Joseph Abraham | VSSC |
| 2. | Control design strategy for systems with structured uncertainty. | Dr Rajesh Joseph Abraham | VSSC |
| 3. | Nano structured high performance anode materials for high power, higher safety and fast charging Li-ion battery. | Dr Mary Gladis J. | VSSC |
| 4. | High-Q dielectric thinfilms with tunablity in Microwave frequencies for Space applications. | Dr. K.B.Jinesh | VSSC |
| 5. | Development of Yttrium Iron Garnet (YIG) thin films for space applications and Dielectric Test setup for ceramics at high Electric field andtemperatures. | Dr. K.B.Jinesh | VSSC |
| 6. | Development of Magneto Dielectric Substrate/ Metamaterial based L-band Antenna | Dr. Basudeb Ghosh | VSSC |
| 7. | Implicit large EddySimulation of Jets. | Dr. Manoj T Nair | VSSC |

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|---|---|---|---|
| 8. | Supersonic combustion of isrosene behind two strut configuration | Dr. V. Aravind | VSSC |
| 9. | Development of Graphene based anticorrosion coating for stainless steel bipolar plates of PEM fuel cells | Dr. K. Y. Sandhya | VSSC |
| 10 | Improved Silicon-graphene based composite as anode materials for lithium battery cells and exploring the possibility of other battery technologies | Dr. K. Y. Sandhya | VSSC |
| 11 | Graphene nano platelets incorporated zinc rich epoxy coating for corrosion protection of steel hardware | Dr.Mary Gladis J. Dr. Kuruvilla Joseph | VSSC |
| 12 | High Performance SAR ADC with auto calibration and self-correction for sensor closed loop application | Dr. Immanuel Raja | IISU |
| 13 | Near and field diagnostics NET | Dr. Umesh R Kadhane | LPSC |
| 14 | Development and implementation of LIF inversion algorithm for NET diagnostics at SEP facility in LPSC | Dr. Umesh R Kadhane | LPSC |
| 15 | Life time predication of HET liner using simulations | Dr. Umesh R Kadhane | LPSC |
| 16 | Experimental and Numerical Investigation of Direct Contact Condensation of GCO2/ steam in LN2 | Dr. Dr. Prathap C & Dr. Manu K V | LPSC |
| 17 | Performance and Instability Analysis of Methane- Oxygen Combustion using shear coaxial injectoron | Dr. Aravind V | LPSC |
| 18 | Three-dimensional DSMC (Direct simulation monte- carlo)simulation for satellite thrusters | Dr. Shine S R | LPSC |

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| 19 | Development of Real Time Gas Sensor Array to Monitor Critical Gases in Crew Module for Human Space Mission | Dr. Palash Kumar Basu | HSFC |
| 20 | Spaceflight Induced changes in Kidney Stone formation in Drosophila melanogaster experimentation. Biology payload for GAGANYAN. | Dr. K G. Sreejalekshmi | HSFC |

## 4.6 Memorandum of Understanding (MOU)

IIST has signed various MOU in three categories, namely (i) with various universities and research organisations to cooperate in the field of education, undertake joint research, exchange faculty and students, (ii) with specific agencies and industries and ISRO to undertake a research project and deliver specific design or product, and (iii) framework MOU, to participate in national and international multi-institutional research programs.

IIST is actively considering extending this cooperation by facilitating student and faculty exchange programs across universities, joint doctoral programme etc., in the future.

MoUs are existing with the following Institutions / Organisations :

- University of Cambridge
- Technion- Israel Institute of Technology
- Nanyang Technical University, Singapore
- University of Colorado, Boulder, USA
- Niigata University, Japan
- Cnrs, Femto-St, Besançon, France
- Isae Supaero, France
- IIT Guwahati

New initiatives include:

- IIST is part of an **international consortium** (**GLOSTAR**) that is carrying out an extensive new survey of our galaxy, the Milky Way, to get a global view on the star formation activity.

- **Public Health Foundation of India** has entered into a MoU with **AHPI, IISc and IIST** to develop and implement a Certificate Program in Healthcare Technology, which will combine both theoretical and practical aspects.
- IIST has signed MoU with **TIFR, Mumbai** for the hardware required for space life science experiments and for work on the advanced technological applications using the Superconducting Quantum Interference Device.
- Discussions and approval process are underway with **Centre for Development Studies** (CDS) for research and academic activities in areas of Economics and Sociology and with **National Central University (NCU), Taiwan.**
- A draft proposal is being made for the technology development of Microwave Rocket Propulsion at IIST which will be submitted to **DTDI (Directorate of Technology Development and Innovation).**
- Discussions are also ongoing with **Augsense Lab Pvt. Ltd., Rajasthan Central University and TCS** for a joint satellite mission.

## 4.7 Patents & IPR

Institute's policy is to protect its intellectual property, and contribute to the country's industrial growth by facilitating commercial exploitation of such property through transferring technology and licensing its patents. Such activities were initiated in IIST in 2014, and are being coordinated by Dean IPR & Continuing Education.

| Sl. No. | Title | Patent No. | Inventors |
|---|---|---|---|
| 1 | Gluten protected gold quantum cluster as a creatinine sensor(Approved title : Novel Bio-Sensor for Detection of creatinine) | 201741000489 | Meegle S. Mathew<br>Kuruvilla Joseph |
| 2 | A new self referencing digital lensless holography arrangement using Sagnac interferometer and decollimated beam | 201741010417 | Rakesh Kumar Singh<br>Annie Varghese |

| | | | |
|---|---|---|---|
| 3 | Reliable room temperature Gas sensor with negligible baseline drift suitable at different air flow condition | 201741027050 | L. Karthikeyan<br>Akshaya M. V.<br>Palash Kumar Basu |
| 4 | A System and Method For Acquisition of IRNSS Signal having efficient architectures | 201741041848 | Jiljo K. Moncy<br>Sheeba Rani J. |
| 5 | A method for processing a low OH value Hydroxyl Terminated Poly Butadine based solid propellant for space boosters | | KN Ninan<br>CP Regunandan Nair<br>CH Devi Vara Prasad |
| 6 | Eco friendly hypergolic earth storable liquid propellant with hydrogen peroxide oxidiser and liquid hydrocarbon for space applications | | KN Ninan<br>Mary Gladis<br>S Reshmi<br>B Siva Kumar |
| 7 | A method for developing fuels with improved efficiency using laser-produced nanoparticle suspensions | | Vinilkumar R. R.<br>Resmi A. N.<br>Jinesh K. B.<br>Aravind Vaidyanathan |
| 8 | Flapping Wing Mechanism and the wing design of the bionic Micro Aerial Vehicle. | 201941026796 | K. G. Sreejalekshmi<br>Mrudul C<br>Sam Noble |
| 9 | Closed loop in-plane movable suspended gate FET(CLIP-SGFET) based accelerometer and the fabrication method thereof. | 202041048333 (IIST/IPR/02/2019) | Seena V.<br>Anju Sebastian<br>Naveen Kadayinti |
| 10 | Quad Cross and Symmetrical Non-planar Beam Piezoresistive MEMS | IIST/IPR/04/2019 | Seena V.<br>Hari K.<br>Rohith S |

| | | | |
|---|---|---|---|
| | accelerometers for low cross axis sensitivity and fabrications methods thereof | | |
| 11 | Multipurpose resilient elasto-magnetic abrasive spheres for fine finishing of surfaces | 3340/CHE/2013 | V S Sooraj<br>V Radhakrishnan<br>Nirmala J |

# 4.8 Awards & Recognition

**Dr. Y.V.N. Krishnamurthy,** Sr. Professor & Registrar, IIST received the prestigious ISRO Outstanding achievement award on 24th March 2021 as part of the ISRO awards 2018.

**Dr. Kuruvilla Joseph,** Outstanding Professor, Department of Chemistry and Dean (Student Activities, Student Welfare and Outreach is listed among the top 2 percent scientists (rising stars), by Stanford University, across the world in all subject fields. The University has cited Prof. Kuruvilla Joseph in the Single Year list under the category of citation impact during the single calendar year 2019. This was announced in November 2020.

## Department of Aerospace Engineering

| Sl. | Name | Designation | Award / Recognition |
|---|---|---|---|
| 1 | Varshith Reddy | B.Tech student | INAE Project award Topic: 'Iterative Patched Conic Technique for Lunar Transfer Trajectories', guided by Dr. R.V. Ramanan, Adjunct Professor |
| 2 | Aswathy | PhD Scholar<br><br>Department of Aerospace | Best Paper award for the paper titled "An Improved response function based stochastic meshless method for Reliability |

| | | | |
|---|---|---|---|
| | Arun C.O | Engineering<br><br>Associate Professor | analysis of Euler-Bernoulli Beams" in International Conference on Systems, Energy & Environment |

## Department of Avionics

| | | | |
|---|---|---|---|
| 1 | B S Manoj | Professor | IEEE Outstanding Researcher 2020 Award by IEEE Kerala Section |


| | | | |
|---|---|---|---|
| 2 | Sudharshan Karthik | Associate Professor | Kerala State Young Scientist Award and Chief Ministers Gold Medal |

| | | | |
|---|---|---|---|
| 3 | Anoop C.S | Associate Professor | "Outstanding Reviewer" Recognition, from IEEE Transactions |
| 4 | Gayathri | B.Tech student | INAE Best UG project award for ' A variational inference algorithm for Node Classification, using a convolutional energy architecture' , 2020 under the guidance of Dr K S S Moosath, Professor, Department of Mathematics and Dr Deepak Mishra, Associate Professor and Head, Department of Avionics |

## Department of Chemistry

| | | | |
|---|---|---|---|
| 1 | Pravin Kumar | M.Tech | INAE Project award: jointly supervised by Dr. Chakravarthy, Associate professor, Department of Aerospace Engineering and Dr. Narayana Murthy from VSSC |

| | | | |
|---|---|---|---|
| 2 | Neema PM and Jobin Cyriac | PhD Scholar<br>Associate Professor | Best Poster presentation - 'Rapid detection of basic amino acids using the luminescence switching of WS2 nanosheets-Ag nanoparticles composite' in National Conference on Recent Trends in Materials Science and Technology; |
| 3 | Sreekala K | PhD Scholar | **Best paper award** for the paper - Graphene-Lithium Cobalt Vanadate as Synergistic Immobilizer of Polysulfides for Advanced Lithium-Sulfur Batteries, Sreekala K, Haritha H, Mary Gladis J, in International Symposium on Advanced Materials (**ISAM-2021**) organized by Materials Research Society of India (**MRSI**) -Trivandrum Chapter and Sree Chitra Tirunal Institute of Medical Science and Technology (**SCTIMST**). |
| 4 | Shaiju S Nazeer | DBT-Ramalingaswami Faculty | Best oral presentation award - "Autofluorescence spectroscopy and multivariate analysis for predicting the induced damages to other organs due to liver fibrosis" - New era sensing technologies: healthcare, environmental and rural application" organized by IIT Dharwad |

## Department of Earth and Space Sciences

| | | | |
|---|---|---|---|
| 1 | Sudhanshu Shekhar Jha and Reji J | PhD Scholars | Best Oral Presentation award in the IEEE GRSS Young Researcher Event - 2020 |
| 2 | Jayati Vijayawargiya | PhD scholar | M Tech Thesis Award in the IEEE GRSS Young Researcher event 2020 |

## Department of Mathematics

| | | | |
|---|---|---|---|
| 1 | K.S.S. Moosath<br>Mahesh T V | Professor | Best paper award in 2$^{nd}$ National Conference on Recent Advancements in Physical Sciences, NIT Uttarakhand 2020 |

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# PUBLICATIONS


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# 5. PUBLICATIONS

IIST faculty and research scholars conduct high quality original research work leading to publications in top rated journals and conferences. This knowledge dissemination to the academic community and society at large is achieved through publications in journals (236), conference papers (50) and 7 book chapters.

## 5.1 Journal Publications (236)

In the reporting year IIST had 236 journal publications, 50 conference papers and 7 book chapters.

### Department of Aerospace Engineering

- Danish Handa, Shankar Kumar, Sarath Babu Thekkoot Surendran, V S Sooraj. (2021). Simulation of Intermittent Grinding for Ti-6Al-4V with segmented wheel. Materials Today Proceedings (Elsevier) 44, 2537-2542.
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- Pradeep, A., Anupama, S., &Sudheesh, C. (2020). Dynamics of observables in a q-deformed harmonic oscillator. The European Physical Journal D, 74(1), 1-8.

## 5.2 Book Chapters (7)

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- P. Neelima, S.V.S. Narayana Murthy, P. Chakravarthy, T.S. Srivatsan (2020), High Entropy Alloy: Challenges in Commercialization and the Road Ahead, High Entropy Alloys: Innovations, Advances, and Applications, edited by T.S. Srivatsan and Manoj Gupta, CRC press
- Unnikrishnan K.R., Praveen Krishna I.R., Arun C.O. (2020) Free Vibration Analysis of Pre-stressed Membrane Using Element Free Galerkin Method. In: Satapathy S., Raju K., Molugaram K., Krishnaiah A., Tsihrintzis G. (eds) International Conference on Emerging Trends in Engineering (ICETE). Learning and Analytics in Intelligent Systems, vol 2. Springer, Cham.
- Gigy J Alex (2020) Posthuman in the PostAnthropocene Universe published in Literature, Theory and the History of Ideas: An Updated Compendium
- Shaijumon C.S. (2020). Indian Economy: Current Crisis and the Way Out, Mathrubhumi Yearbook Plus 2021, Mathrubhumi Publishers, pp 148-161
- Priya V, Lekshmi V. Nair. (2020). Ageing and the Aged A Medical Perspective in Antony Palackal & Nisha (eds), Ageing, Care and Well Being: Reinventing Social Gerontology, Vol- 2,Rawat Publications: New Delhi
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# 5.3 Conference Proceedings (50)

## Department of Aerospace Engineering

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- Ananthkumar et.al., Suhail, Priyadarshnam, et.al.., V S Sooraj, Raveendranath P., Bijudas C.R, Chakravarthy P.. (December 2020.). Design and development of a 3U Cubesat for In-situ Radiation Measurements. 2nd National Conference on Small Satellite Technology and Applications (NCSSTA), India.
- Ananthkumar et.al.,Suhail, Priyadrshnam et.al., V. S. Sooraj, Raveendranath P.. (December 2020.). Development of a PS4-OP Payload for Technology Demonstration of Small Satellite Subsystems. 2nd National Conference on Small Satellite Technology and Applications (NCSSTA), India.
- Danish Handa, V.S.Sooraj. (December 2020.). Minimal damage abrasive machining of fibre reinforced polymer composites via cost-effective modification of conventional grinding system. National Conference on Materials Science and Technology (NCMST), India.
- Badal, P.K., Chakraborty, M., Vaidyanathan, A.,. (December 2020.). Design and computational analysis of scramjet inlet operating between Mach 5 and 10. 3rd National Aerospace Propulsion Conference (NAPC 2020), India.
- Jain, P., Chakraborty, M., Chavan, T.N., and Vaidyanathan, A.,. (December 2020.). Computational Study of Aero-Acoustic Feedback in Supersonic Cavity Flow. 3rd National Aerospace Propulsion Conference (NAPC 2020), India.
- Sekar, A., Chakraborty, M., and Vaidyanathan, A.. (December 2020.). Numerical Investigation of Blockage of Scramjet Strut Injector Model in a Supersonic Wind Tunnel. 3rd National Aerospace Propulsion Conference (NAPC 2020), India.
- Samridhi Sharma and C. Prathap. (December 2020.). Modelling & Optimisation of non-contact type Liquid Desiccant Dehumidifier. 8th International and 47th National Conference on Fluid Mechanics and Fluid Power, IIT Guwahati, India.

- Kesava Vishnu G, Midhun R, AssizMp, Jinesh K.B and C. Prathap. (December 2020.). Investigation of Laser Ignition System (LIS) using Hydrogen, Methane and Propane Combustible mixtures. 8th International and 47th National Conference on Fluid Mechanics and Fluid Power, IIT Guwahati, India.
- V. Viswanath, J. Peter, D. K. Agarwal, M. K. Vasudevan, C. Prathap, T.J. Tharakan, S.Sunil Kumar. (December 2020.). Direct Contact Condensation of sub – sonic, inversely buoyant steam jet in a stagnant pool of water. 8th International and 47th National Conference on Fluid Mechanics and Fluid Power, IIT Guwahati, India.

## Department of Avionics

- Nibin Raj, D.V.V. SaiTeja, Vineeth B. S.. (December, 2020). Pano2RSSI: Generation of RSSI maps for a room environment from a single panoramic image. ANTS 2020, IIIT Delhi, Online.
- Govind A.M, Vineeth B. S.. (December, 2020). On the average and peak age-of-information for Berkeley-MAC protocol. ANTS 2020, IIIT Delhi, Online.
- Harshavardhana T. G., Pragya Shah, Vineeth. B. S.. (January, 2021). Design of Joint Relay Placement and Scheduling Algorithms for Time-Slotted Networks with Half-Duplex Constraints. COMSNETS 2021, Online.
- Sneha Gem Mathew, and S. Chris Prema. (October 2020). Reduction of Misdetection in Sub-Nyquist Spectrum Sensing. IEEE International Conference on Computing, Communication and Security ICCCS 20202, IIT Patna, Online.
- Ajin Ghosh K K, Pradeep Kumar P, Bijudas C R, V. Seena. (April, 2020). PERFORMANCE STUDY OF VALVELESS TRAVELINGWAVE PIEZOELECTRIC PUMP IN MICROCHANNELS. 5th Thermal and Fluids Engineering Conference (TFEC), 2020 New Orleans, LA, USA
- Joel Zacharias, Harsha Nikhita, V.Seena. (November, 2020). Novel Polymer MEMS Capacitive Hydrogen sensor with Palladium Ring on Membrane-Mass Architecture. 5th IEEE International Conference on Emerging Electronics(IEEE-ICEE 2020), IIT Delhi.
- Reann Jesma, Shalini Singh, V.Seena. (November, 2020). Three-axis Piezoresistive MEMS Accelerometer with Extended Twin Mass Structure. , IIT Delhi.

- Pramod Martha, Anju Sebastian, Seena V, and N. Kadayinti. (March, 2021). A technique for modelling and simulating transistor based MEMS sensors. IEEE INERTIAL 2021, International virtual symposium.
- Noble Sebastian, Chavva Subba Reddy and Immanuel Raja. (February, 2021). A 3.55 dB NF Ultra-Compact Noise-Optimized LNA for 5G mm-Wave Bands in 65nm CMOS. 2021 34th International Conference on VLSI Design and 2021 20th International Conference on Embedded Systems (VLSID), .
- S. Roahith and P. P. Rajeevan. (2020). Four Level Current Hysteresis Switching Based Control of STATCOM for Reactive Power Compensation. 2020 IEEE International Conference on Power Electronics &IoT Applications in Renewable Energy and its Control (PARC), Mathura, India.

## Department of Chemistry

- Yogesh S Choudhary and Gomathi N. (January, 2020). Facile fluorescence detection of Hg2+ and Cu2+ in aqueous media employing CdTe quantum dots capped with different branched ligands. International Conference on Functional Materials- ICFM 2020, IIT Kharagpur, West Bengal.
- Yogesh S Choudhary and Gomathi N. (December, 2020). Stabilizing CdTe quantum dots using a branched chain ligand for heavy metal ion sensing. National Conference of Recent Trends in Materials Science and Technology, Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram.
- Varsha M V and Gomathi N. (December, 2020). Voltammetric detection of caffeine using nickel based metal-organic framework/reduced graphene oxide composite. National Conference of Recent Trends in Materials Science and Technology, Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram.
- Chithra R Nair and KG Sreejalekshmi. (December, 2020). Virtual Screening of 1,3-Thiazole Containing Small Molecule Drugs Against SARS-CoV-2. National Conference of Recent Trends in Materials Science and Technology, Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram.
- K. Y. Sandhya. (August, 2020). Novel Electrochemical Energy Devices for Storage. NEEDS-2020, Webinar by IITM, Chennai.

- Saisree S, K Y Sandhya. (2020). Electrochemical sensing (Best Oral Presentation Award). International Conference on "Advances in Material Science and Chemistry (ICAMSC-2020), Amrita VishwaVidyapetam.
- Saisree S, K Y Sandhya. (January, 2020). International Conference on Functional Materials, 2020" (ICFM-2020), IIT, Kharagpur.
- Saisree S, K Y Sandhya. (2020). Materials Research Society of India Trivandrum chapter annual technical meeting, SCTIMST, Thiruvanathapuram.
- Arya Nair, J. S., K. Y. Sandhya. (January, 2020). International Conference on Functional Materials, 2020" (ICFM-2020), IIT, Kharagpur.
- Arya Nair, J. S., K. Y. Sandhya. (2020). Current challenges in experimental physical chemistry, IIT Dhanbad, in association with RSC.
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- Arya Nair, J. S., K. Y. Sandhya. (2020). Materials Research Society of India Trivandrum chapter annual technical meeting, SCTIMST, Thiruvanathapuram.
- Saisree S, K Y Sandhya. (March, 2020). Best Poster Award, Chemistry in managing Corona Virus and Chemistry Against COVID-19. National Online Quiz and Poster competition :' Chemistry in managing Corona Virus and Chemistry Against COVID-19, Madhav Science PG college UJJAIN and IPS academy Indore catalyzed by Association of Chemistry Teachers (ACT) C/o HomiBhabha Centre for Science Education (TIFR).

## Department of Earth and Space Sciences

- Vibin Jose, A Chandrasekar. (December, 2020). Impacts of various rainfall forcings on soil moisture distribution over India for a three year period using Land Information System. TROPMET 2020, NESAC, Shillong.
- Kutty G and Noel Chwang. (February, 2021). International Ocean Vector Winds Science Team Meeting, Banglore, India.
- Thesniya P. M., Rajesh, V. J., and Saranya R. (2021, February). Spectral and compositional analyses of chromium spinels from the Sittampundi Anorthosite Complex, southern India, Indian Planetary Science Conference 2021, PRL, Ahmedabad.

- Asif Iqbal Kakkassery, Haritha A., and Rajesh, V.J. (2021, February). Olivine-serpentine-magnesite association in Salem ultramafic complex, southern India: A potential terrestrial analogue site for comparable occurrences on Mars, Indian Planetary Science Conference 2021, PRL, Ahmedabad.
- Deepchand, V., Haritha, A., Thesniya, P.M., Rajesh, V.J., Binoj Kumar, B.R. (2021, February). Comparative chemical and spectral characterization of chromites in Nuggihalli schist belt, western Dharwar craton, Indian Planetary Science Conference 2021, PRL, Ahmedabad.
- Thesniya, P. M., Rajesh, V.J., and J. Flahaut. (2020, November). Evidence for Late-Imbrian and Eratosthenian Mare Volcanism from the Grimaldi basin on the Nearside of the Moon: Implications for the Lunar Mantle Heterogeneity and Thermal Evolution, 6th Shear Zones and Crustal Blocks of southern India, University of Kerala, Thiruvananthapuram.
- Haritha, A., Rajesh, V.J., Sanjeev Kumar, and Asif Iqbal Kakkassery. (2020, November). Spectrochemical characterization and genesis of magnesite at Attappadi region, Northern Kerala, 6th Shear Zones and Crustal Blocks of southern India, University of Kerala, Thiruvananthapuram.
- Uthup, S., Tsunogae, T., Rajesh, V.J., Takamura, Y., Santosh, M., Tsutsumi, Y. (2020, November). Neoarchean arc magmatism and Paleoproterozoic granulite facies metamorphism in the Bhavani suture zone, southern India. Northern Kerala, 6th Shear Zones and Crustal Blocks of southern India, University of Kerala, Thiruvananthapuram.
- Uthup, S., Tsunogae, T., Rajesh, V.J., Tsutsumi, Y. (2020, July). Tectonics and crustal evolution of Shevaroy Block, Southern India: Insights from petrology, geochemistry, and U-Pb zircon geochronology, Japan Geoscience Union (JpGU 2020) meeting.

## Department of Humanities

- Shaijumon C S. (January, 2020). Economic Slowdown of India: A Theoratical Explanation. National Conference on India’s Economic Slowdown: Cyclical or Structural, Govt. Arts College, Thiruvananthapuram.
- Shaijumon C S. (March, 2020). Writing Fundable Research Projects and Getting Avenues for Project Funding in Social Sciences. International Seminar on Gateway to Research and UGC Care list Publications, University of Calicut.

- Shaijumon C S. (May, 2020). India's Economic Policy Responses of the Macroeconomic Impact of Covid-19. International Webinar on Economic Impact of Covid-19, Department of Economics, St. Theresa's College.
- Shaijumon C S. (June, 2020). Socio-Economic Impact of Covid-19. National Webinar on Resurgence of Society in the Post Covid-19 Scenario, Sree Ayyappa College for Women, Chunkankadai, Nagercoil.
- Shaijumon C S. (August, 2020). Analysing Macroeconomic Impact of Covid-19 in India. National Webinar on "Socio-Economic Perspectives of Covid-19, MES Kalladi College, Mannarkkad.

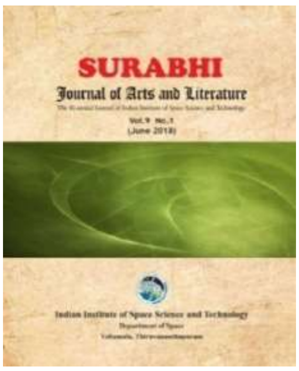
## Department of Mathematics

- Mahesh T V and K S Subrahamanian Moosath. (December, 2020). Geodesics and Statistical Submersions. 2nd National conference on Recent Advances in Physical Sciences, NIT Uttarakhand.

## Department of Physics

- Single-Shot Jones Matrix MicroscopySKGautam, P Panchal, P Mishra, DN Naik, CS Narayanamurthy, R.K. Singh, ICOL-2019: Proceedings of the International Conference on Optics and Electro-Optics,
  Design of Photorefractive Waveplates Using Stokes Parameters, SR Lekshmi, CS Narayanamurthy, ICOL-2019, 809-812

# 5.4 Institute Publications




**Surabhi:** Journal of Arts and Literature is a bi-annual art and creative journal published by Indian Institute of Space Science and Technology. It publishes creative and literary articles written by students, staff and faculty of IIST as well as employees from various centres of Department of Space. It also publishes interviews of interesting and talented personalities from DOS.

## 5.5 In-house Publications


The Sounding Rocket (TSR) is the biannual student newsletter composed and designed by students at IIST chronicling life and times at the institute.

## 5.6 IIST News Letter


The IIST news letter brings out the latest developments in the institute. It covers the whole spectrum of activities in the institute.

## 5.7 Literary Publications

- Nikhil Eyeroor, " The Mystery of Intuition " Surabhi magazine, IIST Journal of Arts and Literature. Vol.13, No.1, June 2020, pp 11-12.

- Nikhil Eyeroor, " Born in a haunted house " Surabhi magazine, IIST Journal of Arts and Literature. Vol.14, No.2, December 2020, pp 14-15.

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# INFRASTRUCTURE, FACILITIES & OTHER UNITS

# 6. INFRASTRUCTURE, FACILITIES & OTHER UNITS

## 6. 1 Infrastructure

The major works completed by CMD, IIST during the period were:

- Vehicular Underpass
- Play courts (Badminton court & Squash court)
- Rain water harvesting phase-2
- NEM Sensor Lab_in Avionics Block
- Cylinder storage shed for Gas Sensor Lab

Inauguration


Gate

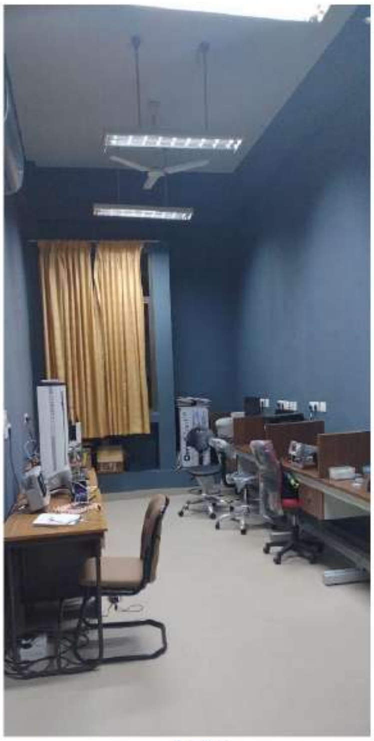
Under Passage

Shed

Under LPSC

Badminton Court

Squash court



NEM

Rain Water Harvesting

# 6.2 Facilities

## Library & Information Services

Library has continued to play the pivotal role of developing print and digital collection and providing various information services to the academic, research and administrative community of IIST.

Status of library collection during the reporting period is given below:

| Sl No | Resources | New Addition During 2020-2021 | Total No. as on 31st March 2021 |
|---|---|---|---|
| 1 | Books<br>( Book, Hindi, BB, Heritage) | 262 | 33419 |
| 2 | E-Books | 2535 | 6380 |
| 3 | Print Journals | 0 | 72 |
| 4 | Online Journals | 0 | 5 |
| 5 | Online Databases | 2 | 16 |

| | | | |
|---|---|---|---|
| | | | (Total No. of Online Journals 5700+) |
| 6 | Research Writing Tool | 1 | 1 |
| 6 | Similarity Detecting Tool | 0 | 1 |
| 7 | Online Tools | 0 | 2 |
| 8 | Bound Volumes | 237 | 1178 |
| 9 | CD / DVD | 4 | 1043 |
| 10 | Maps | 0 | 122 |
| 11 | Reports | 187 | 1192 |

Because of pandemic situation, the focus was shifted more to the digital / web based services. All the electronic resources subscribed by the library were connected to the user community through the IIST Virtual Library (IVL). Library made continuous efforts to ensure use of these resources efficiently and effectively.

Library continued to provide services such as Similarity Checking Service, IIST Lectures through YouTube Channel, Content Scanning, Portal Management, Management of Institute Social Media Pages, Shodhganga Co-ordination, Classification and Linking of Free / Open Source Resources etc. A software - Book Bank Management System (BBMS) was developed in-house and made operational at the beginning of the semester.

Library continued to acts as the publishing centre of the institute by bringing out newsletter, magazine, annual report, workshop / conference materials etc.

Orientation programmes were arranged for new students to familiarise library resources, procedures and practices. Webinars were organised to help users to make best use of subscribed resources and web based tools.

After the lock down period, the library started working by following the Covid 19 protocol. Sanitisation and social distancing were followed. All library forms converted to digital version. Users were advised to use 'Books on Call Service' to get required books issued.

## Computer Systems Group

CSG operates and maintains computer systems, networking and communication infrastructure in IIST in order to ensure 24x7 availability of all IT and non-IT systems and services that are essential for routine functioning of academic and administrative departments of IIST.

a. server infrastructure
b. network infrastructure
c. web servers, mail servers, database servers and domain servers
d. computer and network security systems
e. physical-security systems
f. video-conferencing systems
g. software licenses.
h. public-address and conference audio systems
i. audio-visual and multi-media display systems
j. desktop, laptop and workstation computers
k. computer-peripherals
l. telephones
m. ePayment and SMS
n. VSAT
o. spares, cables, toner-cartridges & batteries.

IT and non-IT services have been facilitated to students, faculty and staff, in 4 academic blocks, 5 administrative facilities and 11 residential hostel buildings located across the campus.

## RESPONSE TO COVID PANDEMIC SITUATION.

After onset of COVID19 in 2020, few of IT infrastructure and services were extended to home of staff, faculty and studentsfor all work/learn activitiesin order to enable continuation of academic and administrative activities of IIST.

Interactive virtual classroom/meeting infrastructure, manpower and resources were setup for conduct of virtual interactive classes and exams, meetings, webinars.

IIST′s own MOODLE online learning platform at https://moodle.iist.ac.in was setup for preparation of content and conduct of courses and exams online.

“Learn-at-home” access of COURSERA global learning platform obtained were made available to students under COVID19-free-for-university scheme offered to IIST. This facilitated completion of 1007 courses having an estimated elearning value of USD 2 million for students.

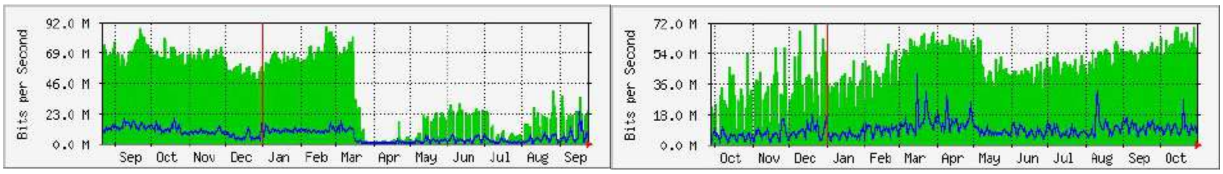
Remote access to in-campus computing facilities, labs and software resources were facilitated to members of faculty and students learning and teaching from home.

All members of faculty, staff and students were guided and supported in operation and use of online facilities.

The other additions include:

- Microsoft Campus Licensing Agreement renewed to make all its software available for students and faculty.
- Free-for-university license of AUTODESK subscribed from Autodesk for use by staff, students and in academic labs.
- Upgrade of Systems & Services planned for web services in operation.
- New stand-alone Servers proposed for hosting in SPACENET.
- EGPS/EPROC serversinstalled at IIST. Commissioning of EPROC operations pending.
- Work in progress for security audit and migration of purchase networks to SPACENET for link with VSSC in order to operationalise EPROC.
- 46 Scientific and Engineering software used by academics departments are hosted in licensing servers maintained atCSG.
- OFC network extended to the newly constructed Student Activity Centre and New Gate in the year 2020-21.Extension of CAMPUS NETWORK to Ponmudi & Magudagiri campuses proposed.

- Wireless Infrastructure to be upgraded as OEM support expires 2022. Proposal for technology-based to be obtained from OEMs in 2022.
- CAMPUSNET - HOSTELS LANS: Consistent complaints about connectivity due to inadequate WiFi signals now available in 11 Hostels. Wired networks to be setup in hostels.
- 10 year period of NKN service has ended in Mar-2021. Awaiting confirmation from NIC/MHRD for extension of NKN services.
- Daily internet usage peaked upto 164 Mbps till the sudden suspension of academic classes and closure of the institution on account of lockdown from 23 Mar 2020.




Consumption of internet bandwidth in campus varied with the pandemic situation in 2020-21 as in graphs above.

- 10Mbps Internet Bandwidth from BSNL linkis being upgraded to 100Mbps with 64 IPv4 addresses for redundancy and increased bandwidth requirements.
- DoS/ISROs directives on improving cyber-security of information systems and networks are being implemented in IIST as part of the IT &ITeS Implementation Programme (IIIP) of DoS/ISRO.
- Antivirus subscription existing for 450 users; to be increased to 2600 nos. to comprehensively cover all users of computers/smart phones in CAMPUSNET.
- VAPT Web Security Audit of IIST being conducted by ISRO DISM.VAPT of IIST SPACENET also proposed to be conducted by ISRO HQ DISM.
- Application Security Audit of all Internet & Intranet Web Applications proposed to be conducted by CERT-IN empanelled3rd party agencies.
- CCTV – 200 out of 216 cameras installed. 126 operational. CCTV Monitoring by CSIF, Hostel, Canteen, HoDs and CCTV Operations Centre in Admin Block being setup.
- Newly constructed New Under-Pass, New Gate and Student Amenities Centre are included for surveillance.

- Surveillance of entrances, stairs, elevators, corridors and outdoors of all buildings in the campus functional.

- CCTVs are also being installed in research laboratories to enable 24x7 day-night surveillance. Classrooms have also been fixed with cameras.
- Biometric Access & Attendance Systems – 70 devices for secure access to 24hr.Labs and attendance in office.
- XRAY Baggage Scanner newly installed for New Entry/Exit Gate – now available for both entry gates.

- Web-conferencing & Webinar facilities setup for :
  - Conduct of Interactive Classes & Online Exams
  - Viva Voce and Doctoral Committees
  - On-line UG Admission 2020
  - Virtual Convocation 2020
  - On-line PG (MTech/MS) Admissions 2020
  - ISRO Placement Counselling 2020
  - APJ Abdul Kalam Lecture 2020

- Public-Address systems for campus events and activities & Audio-Visual and Multi-Media Display systems for classrooms and conference-rooms.
- Commissioned audio-visual and multimedia services in Multi-Purpose Hall in Student Amenities Centre.

| Consolidated Report of Services rendered to End-Users/Devices by CSG. ~ | | |
|---|---|---|
| Wired LAN Services for Official Desktop PCs | 900 | devices |
| Wired LAN Services for Network Printers | 20 | devices |
| Wireless LAN Services for Official Laptop PCs | 200 | devices |
| Wireless LAN Services for Offical Desktop PCs | 20 | devices |
| Wireless LAN Services for BYOD Laptop PCs of Students | 660 | devices |
| Wireless LAN Services for BYOD Smarphones | 300 | devices |
| eLearning MOODLE Platform User Management Services | 900 | users |
| Official eMAIL ID Login User Login Services | 200 | users |
| Student eMAIL ID User Login Services | 900 | users |
| Web-Conferencing ZOOM User Login & Conference Scheduling Services (discontinued) | 40 | IDs |
| Web-Conferencing BLUEJEANS Conference Scheduling Services | 5 | IDs |
| Web-Conferencing WEBEX Conference Scheduling Services | 1 | IDs |
| Microsoft O365 TEAMS Web-Conferencing Login & Conference Scheduling Services | 1200 | users |
| Web-Conferencing ZOOM Webinar Scheduling Services (discontinued) | 1 | IDs |
| MiFare Proximity ID Card Authentication Services | 1400 | cards |
| Biometric ACS Enrollment Services | 1400 | templates |
| Inventory & Help-Desk System Login & Update Services | 140 | users |
| End-Point Security ANTIVIRUS Client Services | 450 | clients |
| Remote-NETWORK INGRESS-Access Services | 30 | users |
| Remote-NETWORK EGRESS-Access Services | 20 | users |

| Consolidated Report of Inventory of IT & Non-IT Systems, Devices and Accessories operated / maintained/technically-supported/stored by CSG | |
|---|---|
| Computers | 1441 |
| Computer Operating Systems | 1323 |
| Servers & Storage Systems | 86 |
| Network - Switches, Routers & Firewalls | 183 |
| Network - Wireless Devices | 267 |
| Network - SFPs, Modems & PoE Devices | 165 |
| Physical Security & Surveillance Systems & Devices | 332 |
| Audio-Video Conference Systems & Devices | 44 |
| Multimedia Systems & Devices | 162 |
| Public-Address & Conference Audio Systems & Devices | 294 |
| Telephone Connections & Instruments | 364 |
| Printers & Scanners | 316 |
| UPS | 38 |
| Tools & Testing Equipment | 2 |
| | **5017** |

## Software Support Group

Software Support Group (SSG), lead by a team of IT professionals provides various software services and technical assistance in Indian Institute of Space Science and Technology.

SSG implement software support and services to the various departments such as Academics, Administration, Transport, Canteen, Purchase, Stores, Accounts and Placement in the Institute. SSG has designed, implemented, customized, tailored and updated many web applications within short time span without compromising accuracy. SSG plays an important role in providing software solutions based on Institute demand.

**SSG Activities – A quick walk through**

During the reporting year, the major accomplishments of SSG include the release of software namely, Book Grant Management System, IIST Research Activities Evaluation Portal and Official Messaging System; that offered key benefits to the students and staff of IIST.

Book Grant Management System – To assist the library staff in verifying and issuing book grant to undergraduate students. This eased the approval process and manual intervention of granting amount to students based on the eligibility and claimed amount.

IIST Research Activities Evaluation Portal – To compile the progress of research projects in IIST.

Official Messaging System – To send emails and/or SMS to individuals or groups.

a. **Software tools developed for various activities in the Institute:**
   Analysis, Design, Coding, Implementation, Maintenance and Enhancement
   1. Thesis Submission and Evaluation Portal – To submit thesis files for review and evaluation.
   2. Canteen Booking System – Allows online booking and cancelation of breakfast/lunch/dinner services with online payment mechanism.
   3. Medical Record Management System – Record keeping of consultation summary and medicine stock management.

4. Online Examination Software – To conduct online examination and generated score sheet.
5. IIST Admission Software – For registration to U.G., P.G. and Ph.D. Programmes.
6. Online Counselling Software – For U.G. and P.G. admissions.
7. iCampus – Manages academic functions in IIST campus.
8. Academic Portal – Student view for academic activities in IIST.
9. Online Student Feedback System – To record course feedback from student.
10. Placement Software – For placement assistance.
11. ISRO Absorption Counselling Software – For ISRO absorption.
12. Convocation Portal – For registration and posting convocation related information.
13. Material Management System – For Stores, Construction and Maintenance Division.
14. Online Application Submission for Recruitment – For Appointment on Short-term Contract Basis and Technical Assistant.
15. CHSS Card Printing System – For generating CHSS cards.
16. Student Activity Board – Event Management System.
17. Card Generation System – For printing identity cards to students and employees.
18. Access Control System – For tracking BACS - IN-OUT status of students.
19. Payment Information System – For tracking budget details.
20. Student/Staff Directory – Manages student and staff details.

b. **Customized Applications:**

Implementation, Maintenance and Enhancement

1. COWAA IIST MIS
2. Canteen Management System
3. TOMD for Transport
4. Personal Information System

c. **Software Support:**

Technical and User support

1. IIST Website
2. COINS Software
3. COWAA Database support, backup and trouble shooting

**d. Other Activities:**

1. Website design for seminars/workshops on request
2. Analyze and provide various reports and charts based on requirement.
3. Application deployment.

**e. Current Software Development:**

1. PG and PhD Online Application Portal - Revamp
2. Online Transcript Submission System – Design and Implementation

# Medical Facilities

a. Permanent staffare covered under Contributory Health Service Scheme (CHSS) of DOS.

b. Students: Two Medical Officers and four nurses extend Medical Facilities to the students round the clock. The students are also covered under Group Medi Claim Insurance Policy and Accident Insurance Policy.
For specialized treatment, lab examinations etc., students are referred to outside hospitals recognized under the Insurance agency. A fully equipped Ambulance is available to meet emergency situations.

c. Manpower engaged on contract: Employees State Insurance Scheme covers the health insurance of contract staff. Rest of the staff under direct contract are advised to take medical insurance coverage, the premium of which is paid by IIST.

## Sports Facilities

The Sports Committee of IIST is responsible for the promotion and pursuance of all physical sporting activities in IIST. The resolute commitment and enthusiasm of the student community combined with the unfailing encouragement and guidance from the committee has created tremendous opportunities for students to hone their sports talents.

Well maintained Indoor and outdoor Sports facilities are available for the faculty, staff and students of IIST. The sporting facilities in the campus include two basketball courts, a cricket net pitch area, table tennis facilities in hostels as well as in the academic block, and an athletics stadium and football ground in the adjacent plot of Magudagiri. Facilities for indoor games such as chess, caroms and table tennis are available in all the Hostels and also in the Student Activity Centre.

The Student Activity Centre of IIST houses a Recreational Hall for Chess, Caroms, Billiards and table tennis, a well-equipped Gymnasium, badminton courts (wood-floored) and a Squash Court. The gymnasium is furnished with the latest gadgetry and workout equipments. Qualified instructors are available exclusively to train students in various equipments.

Football Ground in Magudagiri (Plot 2)

Outdoor fitness facility near the Adhithi canteen

Long Jump Pit

Basketball court

Short Put Area

Cricket Net Pitch Area

Billiards

Carom

Table Tennis

Badminton Court

Squash Court


Adjustable Bunch


Cable Crossover or Functional Trainer


Preacher Curl bench


Lat Pulling Down


Treadmill


Elliptical trainer


Leg Curl Extension


Gym bike


Flat bench press

Due to the pandemic the annual sports meet, inter-house tournaments within IIST and other games, swimming training classes which used to be organised in the Pirappancode international swimming pool and the extra-mural comeptitions did not happen this year.

## Canteen Services

Canteen Services of IIST caters to the need of more than 800 students in the residential campus. In addition, more than 300 users comprising of faculty members, officers, staffs and research scholars respectively also avail canteen facility. The dining Hall has a capacity of 420. Latest kitchen equipments such as Cook wok, Self cooking centre, automatic chappathy machine, etc. are available to simplify the food production. Canteen Advisory Committee which has student and faculty members decide the menu. In addition to this, Canteen Management Committee, Canteen Procurement Committee and Canteen Accounting Committee are constituted to facilitate smooth functioning of Canteen Services. In this year of the pandemic also, canteen services were extended to all concerned following strictly the COVID protocols.

## Bank / Financial Services

An exclusive branch of Union Bank of India along with its ATM, caters to the banking needs of students and staff.

## Security Services

Campus security is entrusted to CISF personnel. Janitorial staff are provided in all buildings.

## Hindi Section and Official Language Implementation

IIST has a full fledged Hindi Section which not only caters to the Constitutional and Statutory requirements regarding the Official Language, Hindi, but also creates a conducive environment for the officials of the Institute to learn Hindi and work in Hindi. During the year, efforts were made for implementing the provisions of Official Languages Act, Rules made there under and orders/ instructions issued by the Department of Official Language from time to time regarding progressive use of Hindi.

### *MAJOR ACTIVITIES RELATED TO POLICY IMPLEMENTATION*

❖ Four Hindi Workshops were conducted on **29th June, 2020** for the Executives, on **September 25th, 2020** for the faculty members, on **23rd December, 2020** for the Employees of Administrative areas and on **18th February, 2020** for the Employees and officers of Technical areas.

❖ Four Quarterly meetings of the OLIC were conducted on (29.06.2020, 24.09.2020, 24.12.2020, 23.12.2020) in order to review the progress in the implementation of OL Policy and four Quarterly Progress Reports regarding progressive use of Hindi in the Institute were sent to the Department of Official Language.

❖ **Hindi Fortnight Celebrations** were conducted in the institute during the second half of September. During this fortnight, various competitions like ***Hindi Essay Writing, What does the picture say competitions*** were conducted for staff members and for the students of IIST. Merit certificates and cash prizes were awarded to the winners of Hindi Competitions.

❖ The third issue of Hindi House Journal of IIST named '**Antarish Dhaaraayen**' was digitally displayed during the Hindi Fortnight. The E-magazine contains articles, poems, reports of major functions and creative works of students and personnels of IIST as well as the technical articles in Hindi sent by the employees of various centre/ units of DOS/ ISRO

❖ The facility of working in Hindi named 'COINS' were launched on December 18, 2020 in the IT systems of the Institute. Now purchase orders and other documents which comes under Section 3 (3) of Official Language Act 1963 can be prepared in bilingual form.

❖ As the percentage of employees possessing working knowledge in Hindi in the institute is above 80, the institute was notified as an office possessing working knowledge in Hindi as per Rule 10(4) of the OL Act 1976. Individual letter will be send to those employees who possess proficiency in Hindi to use Hindi in their official works when official gazette notification is received.

❖ Record of Degrees conferred, Provisional Certificates, Degree Certificates and all other certificates such as certificate of participation/ certificate of merit etc., were prepared and issued in bilingual format (both Hindi and English). Institute Brochure, Annual Report 2019-2020 were prepared in Hindi.

❖ Standard forms used in various Administrative Departments and Academics were bilingualised, visiting cards, name boards and rubber stamps were prepared in bilingual format.

❖ Fifty name plates containing local name, Hindi, English and Botanical names of major trees were prepared and displayed in IIST campus.

❖ In order to ensure the compliance of Official Languages Act, 1963, Official Languages Rules, 1976 and relevant orders issued by the Dept. of Official Language time to time, check Points were re- established.

❖ In order to encourage the progressive use of Hindi **the incentive scheme for doing official work in Hindi** was continued.

❖ Sr. Hindi Officer, IIST provided faculty assistance for the conduct of OL workshops in viz. VSSC, IISU, and IPRC and also for the online workshops conducted by TOLIC, Thiruvananthapuram.

***PARTICIPATION IN VARIOUS PROGRAMMES:-***

❖ ***Joint Rajbhasha Utsav organized by Town Official Language Implementation Committee***

IIST, Valiamala is a member ofTown Official Language Implementation Committee (Office-2), Thiruvananthapuram and actively participated in its activities. The employees of the institute participated in **Joint Rajbhasha Utsav** organized under the auspices of the TOLIC. **Smt. Mini Kumari R. G, Sr. Project Assistant** won the **first prize in Translation** and **Smt. Bindya K.R, Deputy Registrar (Grade – I), Administration** won **consolation prize** in **'What does the picture speak'** competition.

❖ Shri. R. Jayapal, Sr. Hindi Officer and Smt. Cimy Asaf attended the **State Level Inter TOLIC Technical Seminar** organized under the auspices of Thiruvananthapuram Town Official Language Implementation Committee (U) on 15th January, 2021 through online. The aim of this programme was to familiarize with the various E - Tools such as Kantasth, Pravachak, Pravaah, Manthra etc.

## Gender Sensitization Committee and ICC

Gender Sensitization Committee and Internal Complaints Committee are available in IIST which not only addresses gender related issues but also provides training programs.

## SC/ST Cell

The Scheduled caste / Scheduled Tribe cell protects the interest of the employees and students in this category.

## Public Information Office

The institute has a Public Information Office which dissiminates information in a time bound manner.

# 6.3 Administration and Other Units

## Academics

| | |
|---|---|
| Dr. Vinay Kumar Dadhwal | Director |

## Deans

| | |
|---|---|
| Dr. A Chandrasekar | Academics, Continuing Education |
| Dr. Raju K George | Research and Development & IPR |
| Dr. Kuruvilla Joseph | Students Activities, Student Welfare & Outreach |

## Officers

| | |
|---|---|
| Dr. Y.V.N. Krishna Murthy | Registrar |
| Dr. Sennaraj V | Deputy Registrar, Grade II (Academics) |
| Shri. R Hari Prasad | Deputy Registrar Grade II (Finance) |
| Shri. Mohan Sukumar | Scientist/Engineer 'SF' (Computer System Group) |
| Smt. Bindya K R | Deputy Registrar, Grade I (Administration) |
| Shri. Ramanathan S | Deputy Registrar, Grade I (Administration) |
| Shri. Subash Chandran M B | Deputy Registrar, Grade I (Purchase) |
| Shri. Rakesh R Menon | Deputy Registrar, Grade I (Stores) |
| Shri. Abdunnasar A | Library Officer-D |
| Shri. Vinod Kaimal K P | Head- Canteen Services |
| Smt. Rajeena Beegam S<br>Smt. Reny Thomas | Deputy Registrar, Grade I (Finance) |
| Shri. Jayapal R | Senior Hindi Officer |
| Shri. Pradeep Kumar K R | Senior Administrative Officer (In Charge of Hostel ) |

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# FACILITIES AND POLICIES FOR PERSONS WITH DISABILITY


KABHI KABHI LAGTA HA
APUN HI
BHAGWA
HA

# 7. FACILITIES AND POLICIES FOR PERSONS WITH DISABILITY

## Facilities

Buildings have disabled access ramp, lifts, accessible toilets etc., for the convenience of persons with reduced mobility. All the academic blocks, Administrative building and Library are provided with ramp and lifts and toilet for Divyangjan. Student Activity Centre, Hostels and mess building are also provided with accessible toilets and ramps.

## Budget allocation

Separate budget is not earmarked but activities for implementation of Rights of Persons with Disability Act, 2016 is accorded top priority and expenditure incurred in the general budget.

## Affirmative action

Indian Institute of Space Science and Technology admits PwD students to UG & PG programmes as per Government of India guidelines with 5% reservation on horizontal level. 2020 UG Admission: 1 seat was filled. (7 seats were reserved out of Total 140 seats)

2020 PG Admission 1 seat was filled. (5 seats were reserved out of total 90 seats)

The details of the policies and actions for implementation of the Rights of Persons with Disability Act, 2016 are described as a separate chapter from the annual report of 2019-20.

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# EVENTS & ACTIVITIES


AASTIK
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# 8. EVENTS & ACTIVITIES

The pandemic disrupted not just the academic activities but also the host of events and extracurricular activities of the Institute. The students, faculty and staff of the institute continued to remain connected through online platforms and several online events and activities were conducted. These online competitions and events along with the events hosted by the Institute in the campus provided a platform for all concerned to remain connected and tide over the difficulties of these times.

## Online Musical Program

IIST Music Club organised DHUN - an online competition where students were free to perform anything musically sound with attractive prizes on 31st May 2020. This provided a welcome release for students who were deprived of the extra curricular activities they would have been involved in they were in the campus. Rather than a competition, it was a musical treat and much needed extravaganza.


## World Environment Day Celebrations

IIST celebrated World Environment Day on 14th June 2020 by planting saplings observing all Covid 19 protocols.


## International Day of Yoga (IDY) Celebrations

Ministry of Ayurveda, Yoga and Naturopathy and Department of Space had communicated plans to observe International Day of Yoga in a non congregative manner on 21.6.2020. Students, faculty, staff and family members joined thousands of others from their respective homes by doing the 45 minute long Common Yoga Protocol (CYP) drill on 21.6.2020, by observing Covid-19 protocols.

Links to IDY Videos (Hindi, English and Regional Languages), website and social media pages of Ministry of AYUSH were also shared in IIST website.

## IIST @ Schools -2020

IIST has organized a new edition of IIST@Shcools program named "Beyond the Horizon" from 3rd to 7th August 2020 in association with Sargakshetra Academy & Charitable Centre. The program was aimed to create awareness about space science & technology and to instill scientific temper among the school children. The programe was organized in the webinar mode for the school students of 10th to 12th standard from all over the country. IIST Director Dr. V K Dadhwal inaugurated the program and delivered the keynote address on 3rd August 2020. Dr. YVN Krishnamurthy, Registrar IIST delivered the special lecture and Dr. Kuruvilla Joseph, Dean Students Activities presented the theme lecture. Dr. Dhayalan from Dept of Aerospace, Dr. Sreejalekshmi of Dept of Chemistry, Dr. Rajesh VJ, Dr. Govindan Kutty, Dr. Jagadeep and Dr. Anand Narayanan from Dept of Earth and Space Science, Dr. Shaijumon C S from Dept of Humanities, Dr. Subramanian Moosath from Dept of Mathematics, Dr. Umesh Kadhane, Dr. Jinesh KB and

Dr. Dinesh N Naik from Dept of Physics, delivered lectures in different dimensions of Space sciences, Science and Technology and its applications.

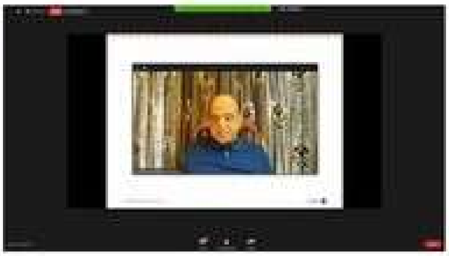

## Independence Day and Republic day Celebrations @ IIST

IIST celebrated Independence day 2020 and Republic day 2021 in a contained manner due to the pandemic situation but with all the respect and fervour demanded for the occasion.

# IIST Foundation Day

IIST celebrated its 14th Foundation Day from 12th to 14th September 2020. It included a webinar on **"Passage to IIST"**, on 12th September 2020 and **Ankesh Mishra Memorial Quiz competition** organised by IIST Alumni Association on 13th September 2020.

**The Sixth Dr APJ Abdul Kalam Lecture** was delivered on the occation by Padma Vibhushan Dr K Kasturirangan, Former Chairman, ISRO and Space Commission who also inaugurated the 14th IIST Foundation Day celebrations.

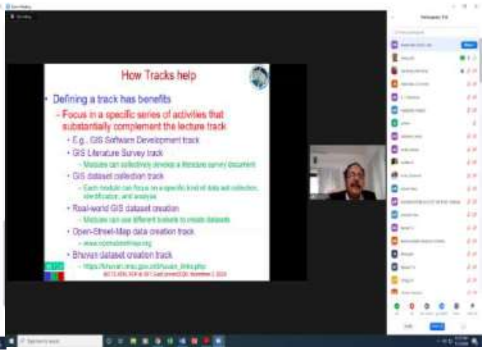



**IIST Industry Meet II** was also organized where stalwarts from ISRO and experets from industries interacted. Dr B N Suresh, Chancellor, IIST, Dr V Narayanan, Director, LPSC, Dr G Narayanan, Chairman & Managing Director, NSIL, Dr P Subba Rao, CEO, Ananth Technologies; Dr V K Dadhwal, Director, IIST, Dr YVN Krishna Murthy, Registrar, IIST participated in the IIST Industry Meet.

# GeoConnect 2020

## AICTE Faculty Development Programme on Advanced Geo-computational Techniques (AI & Computing for Remote Sensing & GIS)

Advanced Geo-computational Techniques was a 5-days AICTE ATAL sponsored faculty development programme conducted during 2-6 November, 2020. The FDP was inaugurated at two levels: at national level in a centralized way organized by the AICTE, and at the institute level by Dr V K Dadhwal, Director, IIST. The FDP had active presence and support of 14 external experts from different areas of research and from IITs, IIIT and IIST.




## Virtual Conference Pair on Geo- Spatial Start Ups- Academia : Opportunities and Challenges

IEEE GRSS Bangalore Chapter, Indian Society of Remote Sensing, Kerala Chapter, Indian Institute of Space Science and Technology jointly organized 2 conferences in online mode. The *(i) Geospatial Industry - Academia Harmony: Bridging Skills Gap in India* on 11 Sept. 2020 and (ii) *Geospatial Start-ups - Academia: Seeding, Nurturing and Growing* on 25 Sept. 2020 were organized aimed at comprehending the status and suggesting a workable way forward for all the stakeholders (Industry, academic faculty and students). A total of 153 participants attended the program.


## Constitution Day Celebration @ IIST

Constitution Day was celebrated on 26th November 2020 in IIST to commemorate the adoption of the Indian Constitution. Dr V K Dadhwal, Director, unveiled the 'Preamble Wall' that has been set up in the Library. Director led the Institute by reading the Preamble. Celebrations were organised following all the Covid protocol.

- **Talk by Dr Gopa Kumar on Constitution and Constitutionalism,** As part of the 70th year of Constitution celebrations, IIST also organised a talk on "Constitution and Constitutionalism : The Essence and Spirit of Indian Constitution" by Dr Gopa Kumar on 28.10.2020 (Wednesday)

## 9th IIST Astronomy and Astrophysics School (IAAS-2020)

The Department of Earth and Space Sciences organised its 9th Astronomy and Astrophysics School online called IAAS from 18 – 28 Dec 2020. The objective of the school is to acquaint students with broad areas in astrophysics. 80 students from various Universities, IITs, IISERs and colleges across India participated in the programme. The faculty members of the Department gave 30 lectures across a range of topics during the school and covered the following topics:

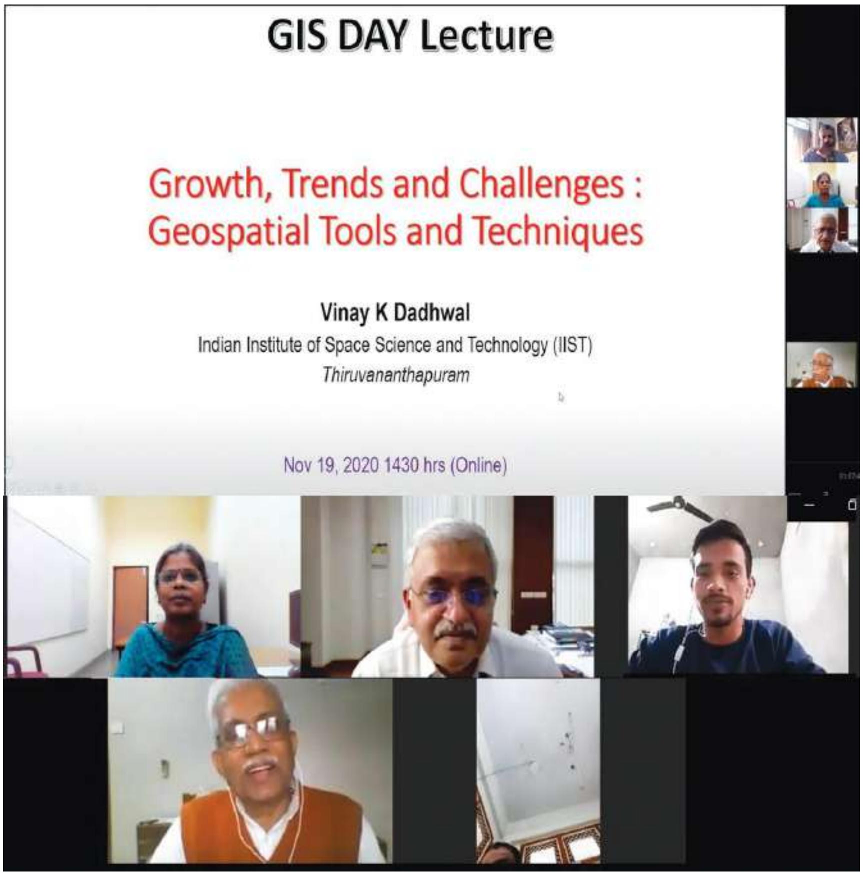
- *Introduction to Astronomy and Astrophysics* by Dr. Anand Narayanan
- *Star formation and Interstellar medium* by Dr. Sarita Vig
- *Detection Techniques: Extrasolar Planets* by Dr. Anandmayee Tej
- *Stellar evolution and compact objects* by Dr. Samir Mandal
- *Galaxies and Cosmology* by Dr. Vikram Khaire

## Ask an Astronomer

A series of interactive sessions with the public was initiated in 2020 called Ask an Astronomer. IIST co-hosted the event alongwith Astronomical Society of India – Public Outreach and Education Committee (ASI-POEC) and IISER-Mohali. The objective of the series is engagement and communication of recent research results in Astronomy to the public, in-line with the mandate of social scientific responsibility. The monthly event has been organised as an online event and is live-streamed on the YouTube Channel of ASI-POEC. It is typically held on the second weekend of every month. Dr. Sarita Vig, is the host and a moderator of the event. Five events were held between Nov 2020 and March 2020.

## GIS Day 2020 @ IIST

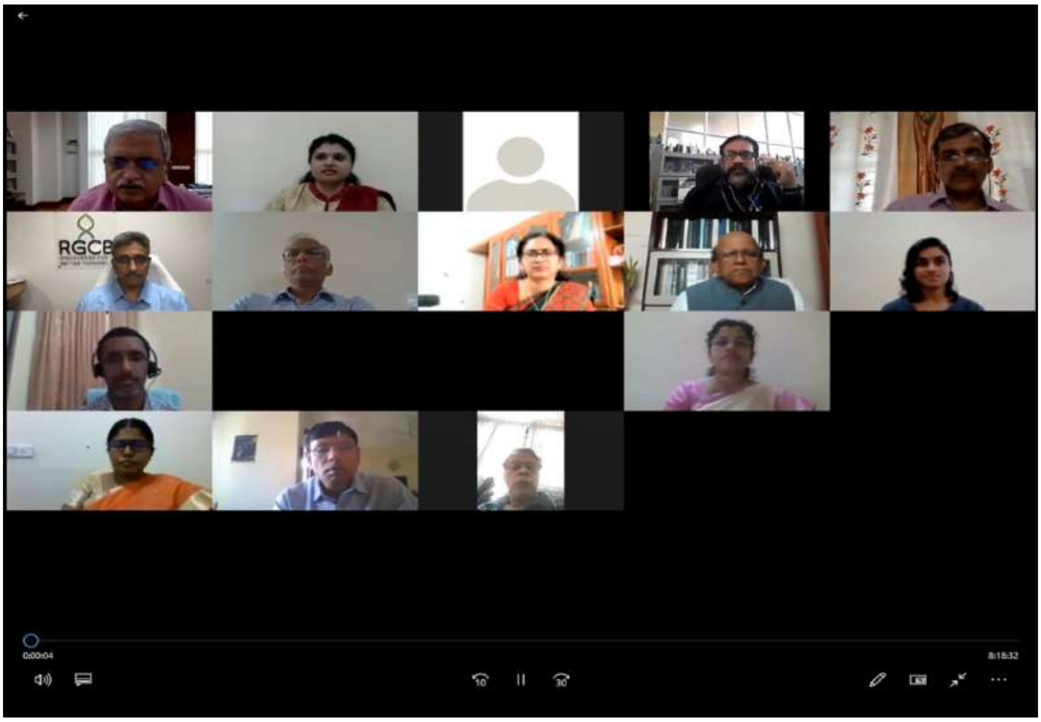
Every year International GIS Day is celebrated in 3rd week of November. At IIST, this year GIS Day 2020 was celebrated with a Special Lecture by Dr V K Dadhwal, Director, IIST on 'Growth, Trend and Challenges of Geospatial Tools and Techniques. As an outreach activity, two competitions were conducted for school students of Thiruvanathapuram (i) Online mapping competition using open GIS platforms like Google Earth and Bhuvan and (ii) Essay competition on identifying the local environmental or societal problem and find solution using the above GIS platforms to rectify or improve the situation.




## National Conference on Recent Trends in Materials Science and Technology (NCMST-2020)

Department of Chemistry, IIST in association with the Society for Polymer Science India (SPSI), Thiruvananthapuram Chapter,organised the National Conference on Recent Trends in Materials Science and Technology (NCMST-2020) during December 7-9, 2020 to discuss the latest advancements in different aspects of

Materials science and Technology. Due to the Covid-19 pandemic situation, the conference was conducted in online mode. The year 2020 was celebrated as the centenary year of the existence of Polymer Science and IIST joined the global scientific community by organising this conference. Prof. Sabu Thomas, Vice-Chancellor MG University, Kottayam and a well known researcher and academician in areas related to Polymer Science and Technology, inaugurated the conference and delivered the keynote lecture on ‘100 years of Macromolecular Science’. The inaugural programme was presided over by Dr. VK Dadhwal, Director IIST and Dr. Chnadrabhas Narayana (Director, RGCB, Tvpm) released the conference proceedings. Dr. YVN Krishna Murthy, Registrar IIST and Dr. Benny K George (Chairman, SPSI Tvpm Chapter) offered felicitations.During Technical sessions, seventeen distinguished researchers from all over India shared their experiences on topics such as energy materials, polymers, blends and composites, ceramics, metals and alloys, nanomaterials, smart and functional materials etc. Bright young scholars were provided the opportunity to showcase their work through live poster presentations before the peers and were enlightened by the insights and suggestions provided by the experts. Fifty six posters were presented and three posters were selected for awards. The intense deliberations during the conference motivated the youngsters to take up challenging tasks in the potential research areas. Three hundred participants from various universities and research/academic institutes from all over India participated in the conference.

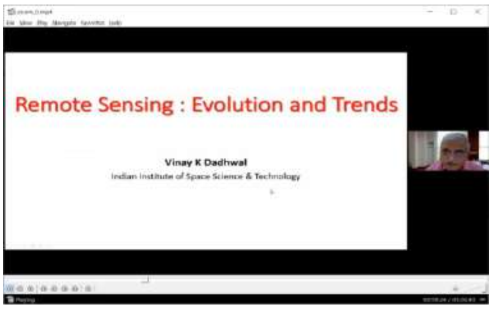


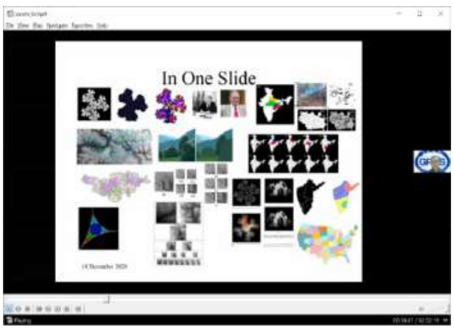
## Faculty Development Programme on Control and Automation

An online Faculty Development Programme on Control and Automation was organised by the Department of Avionics during 15th to 18th December 2020 for the benefit of faculty members, scientists/engineers from industries as well as research scholars. 45 participants from all over the country attended the programme in online mode. Resource persons were drawn from industry as well as academia like ISRO, DRDO, Air India, IISc Bengaluru, IIT Kanpur, IIT Mandi etc. Lectures on various topics in Missile Control, Launch Vehicle Control, Wind Turbine Control, Biomedical Modelling and Control etc were well appreciated by the participants.

## IEEE India Geoscience and Remote Sensing Young Researchers Conclave 2020

The conclave was held online from December 18 -20, 2020 with an aim to be a platform for enhancing network, peer research.



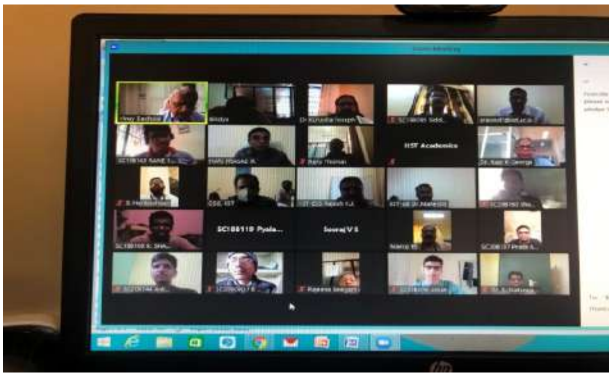
## Webinar series on Atmospheric Science

Department of Earth and Space Sciences conducted a series of webinar during November 2020-March 2021. Speakers of the webinar included the experts from the various national and international institutions.

1. Webinar on Monsoonal Clouds by Shri G S Bhat, Center for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bengaluru
2. A review of aerosol-cloud interactions: measurement challenges (Droplet Measurement Technique (DMT) USA) by Dr. Duncan Axisa
3. Talk on Atmospheric Aerosols by Prof. S. Ramachandran, Space and Atmospheric Sciences Division, Physical Research Laboratory, Ahmedabad

## Swachhta Pakhwada 2021

Swachhta Pakhwada 2021 in IIST was organized from 1st to 15th February 2021. On 1st February 2021, Director, IIST administered the mass pledge online which was repeated by all.

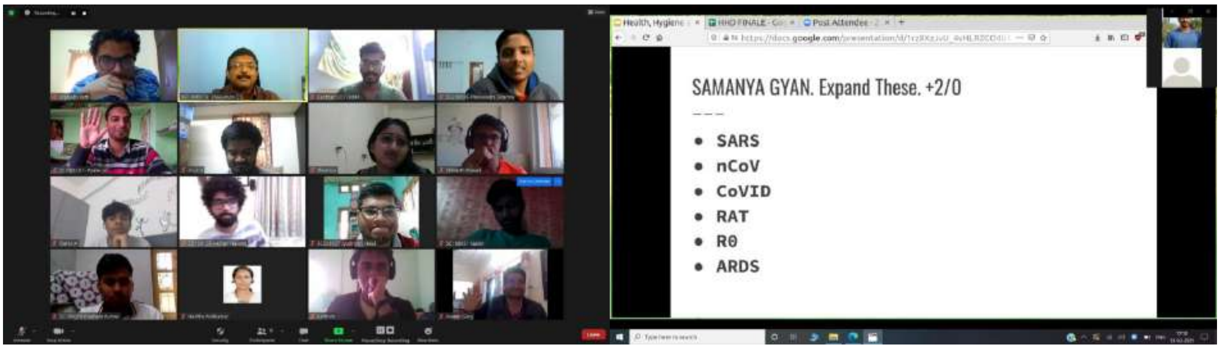


Widespread publicity about Swachhta Pakhwada 2021 activities was given through posters, banners display on intranet and internet website, Mygov portal, etc.


Two Live sessions on Personal Health and Hygiene by IIST Medical Officer was organized for the cleaning staff in IIST. The talk was quite informative in the current pandemic situation and the participants could clear their doubts on the sanitization measures to be adopted by them.

IIST also organised a webinar on 24th February 2021 for all the employees including faculty members, students and staff on 'Green Protocol – A way forward to Zero Waste Campuses' by Shri Vishnu J Menon, Green Protocol Consultant

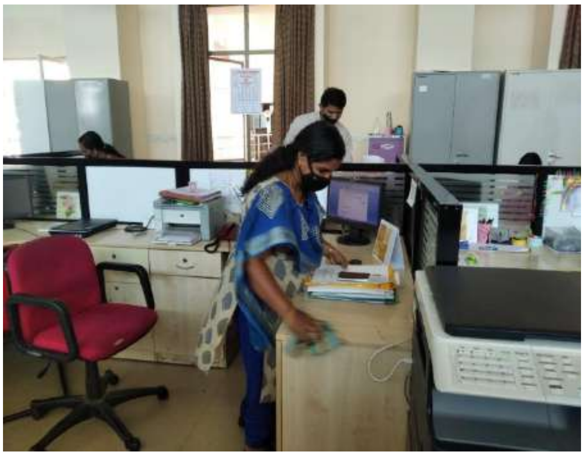

As part of the IIST Swatch Bharath related awareness Programs 2021, an online Quiz Competition on Health, Hygiene and Covid was conducted on 13th February, 2021 (Saturday) from 09.30 am to 4.00 pm. IIST alumnus Mr. Prabodh Shreedhar Katti (2011 B Tech Avionics Batch), Scientist Engineer of SAC Ahmadabad was the quiz master. The quiz program was conducted for IIST Students and 12 teams participated for the Preliminary round and six teams in the final round.




Hygiene kits were prepared in cloth bags with IIST logo and name for distribution to orphanages. Mask and sanitary napkins were included in the kits were girls and masks for boys. Wall mountable Pedal Sanitary dispenser which was fabricated in IIST along with dispenser bottle were also supplied to each orphanage. 10 litres each of sanitizer prepared by Department of Chemistry, IIST was also supplied to the orphanages.

Medical Checkup of contractual staff has been planned in IIST. The contractors have been asked to collect basic medical data from each of the staff under their contract. It is proposed to conduct medical checkup for the staff in phased manner in view of the current pandemic situation. The age group from 50-60 years will be provided at the beginning.

In view of the current pandemic situation, individual departments took up the cleaning drives in their own departments.



# Inauguration of Main Entrance Access Road and Student Activities Centre (SAC)

Main Entrance Access Road and Student Activities Centre (SAC) of IIST were inaugurated by Dr. K. Sivan, Chairperson, IIST Governing Council, Secretary, DOS and Chairman, ISRO on 8th February 2021. Dr. V. K. Dadhwal, Director, IIST, Shri. S. Somanath, Director, VSSC, Dr V Narayanan, Director, LPSC. Shri D Sam Dayala Dev, Director, IISU and Shri S. K. Kanungo. Director, STPO graced the occasion.


Student Activities Centre comprising a Gymnasium, Multipurpose Hall, Amphitheatre, Indoor Badminton Courts, Open Gathering Area, Billiards Court, Squash Court, Facilities for Table Tennis, Carroms, Chess and other facilities caters to various hobbies of the students and also to promote sports and fitness.

Keeping in view the COVID-19 pandemic, the programme was arranged observing all necessary protocols.

# Womens Day Celebration 2021

Womens day Celebration at IIST was celebrated in online mode on 31st March 2021. Chief Guest for the function was Smt Mangala Mani, Scientist / Engineer at NRSC and a member of the 36th Indian Expedition Team to Antarctica. Her talk titled "Choose to Challenge" kept the audience enthralled and made not only the women community but whole of the viewers proud.

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# ALUMNI ACTIVITIES

# 9. ALUMNI ACTIVITIES

## Support for UNICEF Campaign

IISTAA took initiative to support UNICEF India in conducting an awareness drive of its #EVERYCHILDALIVE Campaign for alumni, students and faculty of IIST. UNICEF India relies on the support and donations from businesses and individuals to sustain and expand health, nutrition, water and sanitation, education and child protection programs for all girls and boys in India.

## Public Event: Space Biology Webinar

IISTAA, in association with IIST and Amity Centre for Astrobiology, organised a Panel discussion on Space Biology which was open to general public on Aug, 9 2020. The theme for the discussion was "Learnings in space biology over the last 3 decades, opportunities and challenges in the 2020s". Expert panellists were invited from the following institutions:

- IIST
- Centre of Excellence in Astrobiology, Amity University, Mumbai
- Blue Marble Space Institute of Science
- BioServe Space Technologies, University of Colorado
- Saha Institute of Nuclear Physics, Kolkata
- University of Agricultural Sciences, Dharwad

Due to a wonderful response during theevent registration, it became necessary to purchase a paid Video conferencing licence exclusive for IISTAA Outreach. The panel discussion was well appreciated and saw a participation from varied institutions across the country.

## Website Launch

A new website for IISTAA with the address https://alumni.iist.org.in/ was created by Vaave. It was officially launched by Director, IIST Dr. VK Dadhwal on Aug 29th, 2020.The website has information about:

- Vision & Mission of IISTAA
- Chapters of IISTAA based on location
- Database of members of various batches

- Events planned
- Provision for registration of new members
- Various ways in which Alumni can assist the other alumni or students of IIST

The newly designed website has more robust interactive features and efforts are underway to get the alumni from all batches registered.

## Alumni Leadership Program (ALP)

Being a customer of Vaave, IISTAA was provided with two free enrolments for the Alumni Leadership Programme (ALP) from July 4, 2020. It was a unique certification course with 6 Learning Tracks on Alumni Management and developing and fostering strong alumni network. The following programs were attended by Ms Surbhi Baghotia & Mohd Ahmad:

- Track 1: Alumni Relations Overview
- Track 2: Building an Alumni Program
- Track 3: Engagement Activities
- Track 4: Student Development and Mentoring Programs
- Track 5: Fundraising and Giveback Programs
- Track 6: Institutional Development

The 6-week Training Program helped in learning about building thriving alumni communities. The learnings were shared with other members of the Executive Body by conducting summary sessions for each track.

## Creative Engagements by IISTAA Outreach Team

IISTAA Outreach Team has been involved in bringing awareness and actively engaging the alumni community in various activities organised by IISTAA using various social media platforms and organising signature events. Some of the efforts are highlighted below:

- ARTIIST: An initiative to celebrate the creative escapades of everyday lives of IIST community at large. Sharing stories, including experience, techniques and other things involved in creation of work of art. The underlying idea is to promote the creators/artists among alumni and connect like-minded people through sharing and highlighting their creative side.
- Community Art Series: To bring attention to community artwork at IIST. A 5-part series which covers the story of how the murals now present on the

walls of IIST came to be. Painters directly involved in the project share their stories about struggles and learnings and highlight how great things happen when community comes together.

- Newsletter 'IISTIAN' : A new mouthpiece for IISTAA, this first official newsletter was released during the foundation day function held on Sep 14th, 2020.
- 'Zeroing In- the Science Podcast' : It is a collaborative initiative between TSR (The Sounding Rocket) team and IISTAA. This audio program was launched in Sep, 2020is currently in its first season. It is aimed at bringing across short conversations with scientific researchers closer home, from across the country, and around the globe to the IIST community & beyond. It chronicles the science and the people behind it - to bring it all to a wider general public.

The establishment of independent Outreach team within IISTAA was fruitful in better engagement with alumni & student community and general public.

## Major internal Meetings

Executive committee regularly meets to review and plan the activities of IISTAA. The following meetings have been conducted by the IISTAA Executive Body:

| S. No. | Meeting details | Date |
|---|---|---|
| 1. | Meeting with Vaave team for website | Jul 4, 2020 |
| 2. | 5thExecutive Body Meeting | Aug 8, 2020 |
| 3. | Meeting with Director IIST, Dean SA, Vaave team for website launch | Aug 29, 2020 |
| 4. | 1st Annual General Body Meeting (AGM) | Sep 6, 2020 |

## Foundation Day

IISTAA was actively involved in the celebration of IIST Foundation Day on Sept 14th, 2020. The following events were organised by IISTAA leading up to the Foundation Day:

- Webinar: Academia in Space System development (Sep 12th, 2020): IISTAA, in association with IIST, organised a Panel discussion on Academia in Space System development. The following panellists shared their experience & on-going projects, followed by a moderated Qn A session:

- Prof. Guglielmo Aglietti, Space Institute Director, University of Auckland
- Dr. Amal Chandran, Director, Satellite Research Centre, NTU, Singapore
- Dr. Umesh R. Kadhane, Associate Prof. & Head, Dept. of Physics, IIST

The webinar was open for general public and was well appreciated.

- Ankesh Mishra Memorial Quiz (Sep 13th, 2020): A quiz was organized for IIST students, faculty& alumniin fond memory of Ankesh Mishra, founder of Quiz Club, IIST.
- Foundation Day: A short interaction between IIST and the members of Alumni community was organised on the IIST Foundation Day. The following events took place:
  - Briefing of IIST Activities
  - Release of Newsletter 'IISTIAN'
  - Address by Dr. BN Suresh, Chancellor IIST & Dr YVN Krishnamurthy, Registrar IIST.

The Foundation Day celebration marked completion of one year since the formal inauguration of the IISTAA.

## Interaction of IIST graduates 2020 Batch with Alumni

IISTAA organised an interaction session on October 10, 2020 with IIST Students who graduated in 2020 with a moderated Q&A session. The focus was on providing students with a well-rounded perspective on centre selection including but not limited to work carried out in different centres, life in different cities, etc.

## Student Alumni Relations Cell (SARC) Internship Program

IISTAA is coordinating with Vaave and the IIST Students to form a Student Alumni Relationship Cell (SARC). It is a student-led team which assists both Alumni Association and Institution in building and strengthening alumni networks. 20 students from 3rd and 2nd year have been selected to take part in the 6 months internship program for the same. The objectives of the Program are:

- Database building
- Strengthening relationships
- Managing engagement activities
- Branding alumni

The internship program commenced on Oct 17th, 2020and a detailed introduction to the program was given by Vaave followed by the journey mapping for the next 6 months.

## Two- part event on ‘Quantum Technology: Towards the second quantum revolution’

IIST Alumni Association, in collaboration with IIST and qBraid, organised a two part event with the following sessions:

**a. Introductory Session on Quantum Computing (Jan 9th, 2021)**
An introductory session on Quantum Computing was taken by Aritra Sarkar (B.Tech. 2013 Batch ECE (Avionics)) as a necessary step before moderating the panel discussion on the same topic. Aritra is a Ph.D. candidate in the department of Quantum and Computer Engineering, Delft University of Technology.
**b. Moderated Panel Discussion on Towards the Second Quantum Revolution (Jan 16th, 2021)**

Panel discussion on Quantum Computing was open to the general public and had experts from industry and academia. The details of panellists are as follows:

Dr. Kanav Setia (B.Tech. 2011 Batch Aero) is the CEO of qBraid, a quantum computing start-up that he co-founded. Dr. Setia received his B.Tech in Aerospace Engineering from IIST and a Ph.D. in Physics from Dartmouth College. His research focuses on developing efficient quantum algorithms for solving quantum chemistry problems. He was one of the earliest contributors to Open Fermion, Google’s quantum computing repository. He has worked with IBM where he developed a new quantum algorithm which is among the most efficient quantum algorithms. He also holds a joint patent with the IBM team for his work on a different quantum algorithm.

Dr. Urbasi Sinha is a Professor at the Light and Matter Physics group at the Raman Research Institute in Bangalore, India. She joined RRI in 2012 and is now heading the Quantum Information and Computing (QuIC) laboratory at RRI (http://www.rri.res.in/quic/). She is also an associate faculty member at the Institute for Quantum Computing (IQC), University of Waterloo, Canada, and the Centre for Quantum Information and Quantum Control, University of Toronto, Canada. She is heading Indias′ first project on satellite-based secure quantum communications (Quantum Experiments using Satellite Technology).

Dr. J Solomon Ivan is a Physicist and Associate Professor at the Department of Physics, Indian Institute of Space Science and Technology, Trivandrum. At IIST, he teaches a variety of courses on Optics, Quantum Mechanics, Quantum Information Theory, and more. A remarkable teacher with an innate ability to explain complex ideas with simplicity, he is also a well-renowned researcher. Dr. Solomon completed his Masters in Physics from IIT Madras before embarking on his Ph.D. in Theoretical Physics from IMSc Chennai. His current research delves into problems in Classical & Quantum Optics and Quantum Information Theory and follows both a theoretical and experimental approach. The panel discussion was well appreciated and garnered good response.

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# AUDIT REPORT

## 2020-2021

BALAMURALI & ASSOCIATES

CHARTERED ACCOUNTANTS

"Thiruvathira" , T.C.50/100(2) , Kalady , Karamana.P.O- 695002
Ph- 91-9387496230 , ca.balamurali.tvm@gmail.com

## INDEPENDENT AUDITOR'S REPORT

We have audited the accompanying financial statements of **INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY, Valiamala P.O., Thiruvananthapuram – 695547 which comprise the Balance Sheet as at 31 March 2021**and the Income and Expenditure Statement for the year then ended, and a summary of significant accounting policies and other explanatory information.

### Management's Responsibility for the Financial Statements

Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position & financial performance of the Institute in accordance with the Accounting Standards issued by the Institute of Chartered A accountant of India. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

### Auditor Responsibility

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

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 judgement,

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 Institute's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Basis of Qualified Opinion.

1. Reconciliation of Fixed Assets with regard to quantity, location, cost is pending.
2. The balances in Sundry Creditors, Loans and advances and other personal accounts are subject to confirmation by respective parties.

Qualified Opinion

In our opinion and to the best of our information and according to the explanations given to us, subject to the above mentioned opinion, the financial statements give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India.

i. In the case of the balance sheet, of the state of affairs of the Institute as at 31st March 2021
ii. In the case of the Income and Expenditure statement, of the deficit for the year ended on that date.

Place: Thiruvananthapuram
Date: 24-11-2021

For BALAMURALI & ASSOCIATES
Chartered Accountants
ICAI FRN - 0123745
BALAMURALI, M.Com,FC
Proprietor
ICAI.M.No-223319

BALAMURALI & ASSOCIATES TRIVANDRUM Chartered Accountants

UDIN-21223319AAAABV9699

## INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
## THIRUVANANTHAPURAM

### BALANCE SHEET AS AT 31ST MARCH, 2021

(Amount in Rs.)

| | Schedule | As at 31.03.2021 | As at 31.03.2020 |
|---|---|---|---|
| **CORPUS/CAPITAL FUND AND LIABILITIES** | | | |
| Corpus / Capital Fund | 1 | 1,98,69,75,536 | 2,09,97,63,396 |
| Reserves and Surplus | | 2 | 2 |
| Earmarked Funds / Endowment Funds | 2 | 4,56,02,357 | 4,20,11,176 |
| Long Term Liabilities and Provisions | 3 | 28,73,29,857 | 33,00,78,837 |
| Current Liabilities and Provisions | 4 | 6,54,34,309 | 13,50,01,903 |
| TOTAL | | **2,38,53,42,061** | **2,60,68,55,314** |
| **ASSETS** | | | |
| Fixed Assets | 5 | 1,88,95,21,884 | 2,00,79,91,394 |
| Long Term Assets, Loans, Advances etc | 6 | 13,68,22,837 | 13,59,00,519 |
| Current Assets, Loans, Advances etc | 7 | 35,89,97,340 | 46,29,63,401 |
| TOTAL | | **2,38,53,42,061** | **2,60,68,55,314** |

**Significant Accounting Policies & Notes on Accounts** 18

As per our report of even date attached.

For Balamurali & Associates
Chartered Accountants
FRN : 012374S

C.A. Balamurali C. V.
(Proprietor, Mem No. 223319)

Place : Thiruvananthapuram
Date : 23rd November, 2021

For and on behalf of
Indian Institute of Space Science and Technology (IIST)

S. Somanath
Director

R. Hari Prasad
Finance Officer

For BALAMURALI & ASSOCIATES
Chartered Accountants
ICAI FRN - 012374S
BALAMURALI, M.Com,FC
Proprietor
ICAI M.No-223319

# INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
## THIRUVANANTHAPURAM

## INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH, 2021

(Amount in Rs.)

| | Schedule | 2020-21 | 2019-20 |
|---|---|---|---|
| **INCOME** | | | |
| Grants / Subsidies | 8 | 58,25,00,000 | 64,25,00,000 |
| Fees / Subscriptions | 9 | 4,29,38,851 | 3,82,87,905 |
| Interest Income of IIST | 10 | 63,09,814 | 79,95,906 |
| Interest Earned on Grant & Retirement Funds | 11 | 1,24,40,767 | 1,83,43,118 |
| Other Income | 12 | 34,78,138 | 42,82,554 |
| Gross Surplus of Canteen Accounting Committee | | 0 | 20,29,185 |
| **TOTAL (A)** | | **64,76,67,570** | **71,34,38,668** |
| **EXPENDITURE** | | | |
| Establishment Expenses - Regular | 13 | 32,85,15,430 | 32,88,68,491 |
| Establishment Expenses - Support Services | 14 | 13,67,93,154 | 16,93,80,803 |
| Academic & Other Student Expenses | 15 | 10,38,29,047 | 13,10,00,787 |
| Other Administrative Expenses | 16 | 6,61,22,517 | 13,75,80,831 |
| Interest Refundable by IIST | 17 | 1,24,40,767 | 1,83,43,118 |
| Gross Deficit of Canteen Accounting Committee | | 21,09,667 | 0 |
| Gross Deficit of Student Activities Account | | 163 | 0 |
| Depreciation | 5 | 23,08,67,886 | 22,91,16,189 |
| **TOTAL (B)** | | **88,06,78,631** | **1,01,42,90,219** |
| Excess of Income over Expenditure (A-B) | | (23,30,11,061) | (30,08,51,551) |
| Less : Prior Period Items | | **(1,02,23,201)** | **7,19,816** |
| **Balance being Surplus/(Deficit) carried over to Corpus/Capital Fund** | | **(22,27,87,860)** | **(30,15,71,367)** |
| **Significant Accounting Policies & Notes on Accounts** | 18 | | |

As per our report of even date attached.

For Balamurali & Associates
Chartered Accountants
FRN : 012374S

C.A. Balamurali C. V.
(Proprietor, Mem No. 223319)

Place : Thiruvananthapuram
Date : 23rd November, 2021

For and on behalf of
Indian Institute of Space Science and Technology (IIST)

S. Somanath
Director

R. Hari Prasad
Finance Officer

## INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
## THIRUVANANTHAPURAM

## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

(Amount in Rs.)

| | As at 31.03.2021 | As at 31.03.2020 |
|---|---|---|
| **Schedule 1 :: CORPUS / CAPITAL FUND** | | |
| **Total Grant Received - Capital and Revenue (A)** | | |
| Opening Balance of Total Grant Received | 9,25,38,09,987 | 8,35,13,09,987 |
| Add : Grant received during the year | 69,25,00,000 | 90,25,00,000 |
| | 9,94,63,09,987 | 9,25,38,09,987 |
| **Total transfer to Revenue Grant (B)** | | |
| Opening Balance of amount transferred to Revenue Grant | 4,53,75,37,442 | 3,89,50,37,442 |
| Add : Transfer to Revenue Grant of 2020-21 | 58,25,00,000 | - |
| Add : Transfer to Revenue Grant of 2019-20 | - | 64,25,00,000 |
| | 5,12,00,37,442 | 4,53,75,37,442 |
| **Surplus / Deficit transferred from Income & Expenditure Account (C )** | | |
| Opening Balance of net income / (expenditure) | (2,61,65,09,149) | (2,31,49,37,782) |
| Add/Deduct : - Current Year Surplus / (Deficit) | (22,27,87,860) | (30,15,71,367) |
| | (2,83,92,97,009) | (2,61,65,09,149) |
| **Balance at the year end (A - B + C)** | **1,98,69,75,536** | **2,09,97,63,396** |

INDIAN INSTITUTE OF SPACE SCIENCE & TECHNOLOGY * THIRUVANANTHAPURAM * Govt. of India Dept. of Space

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM

## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | DOS - Dr. Palash - HSP - Real Time Gas Sensor | DOS - MOM2 - RPA - Dr. Ambili KM | DOS-SAC- Dr. Rajesh V J | DOS - Dr. Umesh - Planetary Exploration | DOS - Dr. Rajesh V J (Spectral) | VSSC - Dr. Natarajan E | IISU - Dr. Umesh Kadhane - Proj Assistant |
| a) Opening balance of the funds | -10,34,025 | -4,94,624 | 2,39,168 | 0 | 2,01,385 | 2,33,116 | 95,038 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 0 | 0 | 0 | 10,00,000 | 0 | 0 | 3,00,000 |
| ii) Income from Investment made on account of Funds | 0 | 0 | 0 | 4,027 | 0 | 0 | 0 |
| iii) Other additions | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | -10,34,025 | -4,94,624 | 2,39,168 | 10,04,027 | 2,01,385 | 2,33,116 | 3,95,038 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 86,153 | 0 | 0 | 0 | 0 | 1,28,440 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 86,153 | 0 | 0 | 0 | 0 | 1,28,440 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 2,90,573 | 12,32,526 | 0 | 0 | 0 | 0 | 2,37,333 |
| - Rent/Consumables | 55,091 | 0 | 0 | 0 | 10,857 | 0 | 4,341 |
| - Other Administrative Expenses | 1,247 | 12,309 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 3,46,911 | 12,44,835 | 0 | 0 | 10,857 | 0 | 2,41,674 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 4,33,064 | 12,44,835 | 0 | 0 | 10,857 | 1,28,440 | 2,41,674 |
| **Net Balance payable as at the year-end (a+b-c)** | **0** | **0** | **2,39,168** | **10,04,027** | **1,90,528** | **1,04,676** | **1,53,364** |
| **Net Balance receivable as at the year-end (c-a-b)** | **14,67,089** | **17,39,459** | **0** | **0** | **0** | **0** | **0** |

*Note : Classified under Current Assets under Sch 8*

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021**

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| | IISU - Perf. of Ball Bearings - Dr. Jinesh KB | IPRC - Dr. Palash - 2018 - Hydrogen Sensor | ISRO-GBP - ABLN & C Project | ISRO -Dr. K G Sreejalekshmi - Gaganyaan | ISRO - MOM - Dr. Rajesh VJ | LPSC - Dr Dinesh N Naik | LPSC - Dr.Jinesh K B - Laser Ignition System |
| a) Opening balance of the funds | 2,27,382 | 65,533 | 7,23,170 | -50,364 | 5,81,882 | 14,26,200 | 26,41,942 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 0 | 0 | 0 | 28,80,000 | 0 | 0 | -50,000 |
| ii) Income from Investment made on account of Funds | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 2,27,382 | 65,533 | 7,23,170 | 28,29,636 | 5,81,882 | 14,26,200 | 25,91,942 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 86,153 | 0 | 0 | 0 | 13,89,120 | 19,88,067 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 86,153 | 0 | 0 | 0 | 13,89,120 | 19,88,067 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 72,751 | 24,200 | 0 | 6,99,327 | -45,652 | 97,856 | 1,08,423 |
| - Rent/Consumables | 0 | 0 | 0 | 1,76,810 | 15,119 | 0 | 0 |
| - Other Administrative Expenses | 0 | 0 | 0 | 8,177 | -3,908 | 4,558 | 0 |
| Sub Total | 72,751 | 24,200 | 0 | 8,84,314 | -34,441 | 1,02,414 | 1,08,423 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 72,751 | 1,10,353 | 0 | 8,84,314 | -34,441 | 14,91,534 | 20,96,490 |
| **Net Balance payable as at the year-end (a+b-c)** | **1,54,631** | **0** | **7,23,170** | **19,45,322** | **6,16,323** | **0** | **4,95,452** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **44,820** | **0** | **0** | **0** | **65,334** | **0** |

*Note : Classified under Current Assets under Sch 7*

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 15<br>LPSC - Dr. Jinesh K B - SDS | 16<br>LPSC - Dr. Umesh K - Monte Carlo Model | 17<br>LPSC - Dr. Umesh Kadhane | 18<br>LPSC Dr. Umesh K - Plasma Thruster | 19<br>LPSC - High Thrust EPS - Dr. Umesh K | 20<br>SAC - NavIC (IRNSS) Gagan | 21<br>DBT - Dr. Palash - 2017- Liquid Biopsy for Cancer |
|---|---|---|---|---|---|---|---|
| a) Opening balance of the funds | 5,15,258 | -6,329 | 2,92,830 | -1,13,754 | 56,34,283 | 3,38,848 | 46,150 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 1,16,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| ii) Income from Investment made on account of Funds | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 6,31,258 | -6,329 | 2,92,830 | -1,13,754 | 56,34,283 | 3,38,848 | 46,150 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 0 | 0 | 0 | 45,99,413 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 0 | 0 | 0 | 45,99,413 | 0 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 0 | 0 | 0 | 0 | 6,53,829 | 1,15,167 | 3,14,833 |
| - Rent/Consumables | 0 | 0 | 0 | 0 | 1,58,717 | 0 | 0 |
| - Other Administrative Expenses | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 0 | 0 | 0 | 8,12,546 | 1,15,167 | 3,14,833 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 0 | 0 | 0 | 1,28,715 |
| Total (c) | 0 | 0 | 0 | 0 | 54,11,959 | 1,15,167 | 4,43,548 |
| **Net Balance payable as at the year-end (a+b-c)** | **6,31,258** | **0** | **2,92,830** | **0** | **2,22,324** | **2,23,681** | **0** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **6,329** | **0** | **1,13,754** | **0** | **0** | **3,97,398** |

*Note : Classified under Current Assets under Sch 7*

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 22<br>DBT - Dr. Palash - Green House Gases | 23<br>DBT - Dr. Shaiju - Ramalingaswami Fellowship | 24<br>DBT- RamaRao (Rural Urban Interface) | 25<br>DBT - Dr. Rama Rao N | 26<br>DRDO - ARMREB - Dr. K. Prabhakaran | 27<br>DRDO - SASE - Dr. Govindankutty M | 28<br>DST - Dr. Rama Rao N |
|---|---|---|---|---|---|---|---|
| a) Opening balance of the funds | 0 | 22,35,000 | 0 | 37,49,586 | 3,48,697 | 1,60,490 | 9,94,697 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 22,13,040 | 0 | 20,00,000 | 0 | 0 | 0 | 0 |
| ii) Income from Investment made on account of Funds | 23,632 | 77,662 | 0 | 51,541 | 3,06,048 | 0 | 0 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 22,36,672 | 23,12,662 | 20,00,000 | 38,01,127 | 6,54,745 | 1,60,490 | 9,94,697 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 0 | 0 | 0 | 1,26,525 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 0 | 0 | 0 | 1,26,525 | 0 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 2,53,580 | 12,65,000 | 0 | 3,58,200 | 2,03,000 | 0 | 7,79,540 |
| - Rent/Consumables | 12,94,667 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Other Administrative Expenses | 2,44,358 | 54,598 | 0 | 2,35,294 | 58,623 | 0 | 0 |
| Sub Total | 17,92,605 | 13,19,598 | 0 | 5,93,494 | 2,61,623 | 0 | 7,79,540 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 32,07,633 | 2,90,406 | 0 | 0 |
| Total (c) | 17,92,605 | 13,19,598 | 0 | 38,01,127 | 6,78,554 | 0 | 7,79,540 |
| **Net Balance payable as at the year-end (a+b-c)** | **4,44,067** | **9,93,064** | **20,00,000** | **0** | **0** | **1,60,490** | **2,15,157** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **0** | **0** | **0** | **23,809** | **0** | **0** |

*Note : Classified under Current Assets under Sch 7*

## INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
## THIRUVANANTHAPURAM

## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| | DST - CNRS - Dr. Palash Basu - 2020 - Biomarker | DST-Dr Jinesh KB- Atomic Layer Deposition | DST - KIRAN - WOS(A) - Pushpa K - Quantum | DST - NGP - A.M Ramiya - Smart Cities 3D | ICSSR - Dr. Shaijumon - 2020 - Tele Medicine Units | Mangrove Cell - Dr. Gnanappazham - 2018 | Max-Planck - Dr. Jagadheep - 2017 |
| a) Opening balance of the funds | 8,42,015 | 0 | 0 | 0 | 5,20,000 | 13,93,517 | 33,50,167 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 8,73,812 | 87,85,760 | 11,63,280 | 27,17,841 | 0 | 6,63,000 | 0 |
| ii) Income from Investment made on account of Funds | 26,131 | 0 | 0 | 43,385 | 1,110 | 0 | 0 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 17,41,958 | 87,85,760 | 11,63,280 | 27,61,226 | 5,21,110 | 20,56,517 | 33,50,167 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 0 | 22,050 | 2,59,247 | 95,800 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 4,99,701 | 0 |
| Sub Total | 0 | 0 | 22,050 | 2,59,247 | 95,800 | 4,99,701 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 2,32,581 | 0 | 1,62,587 | 1,00,920 | 2,05,672 | 4,28,420 | 7,30,414 |
| - Rent/Consumables | 0 | 0 | 0 | 11,930 | 0 | 0 | 5,200 |
| - Other Administrative Expenses | 85,842 | 0 | 86,925 | 2,32,804 | 4,378 | 63,780 | 0 |
| Sub Total | 3,18,423 | 0 | 2,49,512 | 3,45,654 | 2,10,050 | 4,92,200 | 7,35,614 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 3,18,423 | 0 | 2,71,562 | 6,04,901 | 3,05,850 | 9,91,901 | 7,35,614 |
| **Net Balance payable as at the year-end (a+b-c)** | **14,23,535** | **87,85,760** | **8,91,718** | **21,56,325** | **2,15,260** | **10,64,616** | **26,14,553** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

*Note : Classified under Current Assets under Sch 7*

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM

SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 36 MeitY SAMEER - Dr. Priyadarshnam | 37 SERB - 2018 - Dr. Anand N. - Baryons | 38 SERB - Dr. Ashok - Quantum Communicatio | 39 SERB - Dr. C S Narayanamurthy - Wavefront | 40 SERB - Dr. Immanuel R - 5G Bands | 41 SERB - Dr. Chinmoy Saha - 2020 - 5G Antenna | 42 SERB - Dr. Resmi L - 2017 - Gamma Rays |
|---|---|---|---|---|---|---|---|
| a) Opening balance of the funds | 14,73,137 | 5,84,815 | 20,93,437 | 0 | 0 | 27,30,000 | 6,50,618 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 6,81,530 | 1,50,000 | 0 | 33,00,000 | 24,73,630 | 0 | 0 |
| ii) Income from Investment made on account of Funds | 36,136 | 22,270 | 1,05,678 | 0 | 0 | 90,088 | 11,386 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 21,90,803 | 7,57,085 | 21,99,115 | 33,00,000 | 24,73,630 | 28,20,088 | 6,62,004 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 11,37,840 | 3,17,333 | 0 | 0 | 0 | 0 | 0 |
| - Rent/Consumables | 49,830 | 11,965 | 2,78,484 | 0 | 0 | 0 | 0 |
| - Other Administrative Expenses | 0 | 86,059 | 1,11,592 | 0 | 0 | 1,60,000 | 51,504 |
| Sub Total | 11,87,670 | 4,15,357 | 3,90,076 | 0 | 0 | 1,60,000 | 51,504 |
| iii) Fund Returned to the Funding Agency | 2,23,079 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 14,10,749 | 4,15,357 | 3,90,076 | 0 | 0 | 1,60,000 | 51,504 |
| **Net Balance payable as at the year-end (a+b-c)** | **7,80,054** | **3,41,728** | **18,09,039** | **33,00,000** | **24,73,630** | **26,60,088** | **6,10,500** |
| **Net Balance receivable as at the year-end (c-a-b)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Note : Classified under Current Assets under Sch 7*

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**SCHEDULES TO BALANCE SHEET AS AT 31$^{ST}$ MARCH, 2021**

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| | SERB - Dr. Sarita Vig - 2019 - Young Massive Stars | SERB - Dr. Sarvesh - 2020 - Virtual Element | SERB - Dr. Seena V - Nanomechanical Sensor | SERB - Dr. Jayanthi S | SERB - 2018 - Dr. Umesh K. - PAH | SERB - Dr. Roymon Joseph | SERB - Dr. Seena V |
| a) Opening balance of the funds | 10,10,000 | 2,20,000 | 6,50,190 | 9,457 | 31,41,932 | 0 | (8,981) |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 0 | 0 | 9,00,000 | 0 | 1,50,000 | 70,139 | 0 |
| ii) Income from Investment made on account of Funds | 40,712 | 6,855 | 0 | 0 | 1,39,181 | 0 | 0 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 10,50,712 | 2,26,855 | 15,50,190 | 9,457 | 34,31,113 | 70,139 | -8,981 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 2,62,563 | 1,12,882 | 1,78,500 | 0 | 26,28,525 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 2,62,563 | 1,12,882 | 1,78,500 | 0 | 26,28,525 | 0 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 1,55,000 | 0 | 3,76,960 | 0 | 3,44,667 | 21,290 | 0 |
| - Rent/Consumables | 27,987 | 18,375 | 4,55,287 | 0 | 22,420 | 0 | 0 |
| - Other Administrative Expenses | 56,000 | 20,000 | 0 | 11,008 | 0 | 48,849 | 0 |
| Sub Total | 2,38,987 | 38,375 | 8,32,247 | 11,008 | 3,67,087 | 70,139 | 0 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 5,01,550 | 1,51,257 | 10,10,747 | 11,008 | 29,95,612 | 70,139 | 0 |
| **Net Balance payable as at the year-end (a+b-c)** | **5,49,162** | **75,598** | **5,39,443** | **0** | **4,35,501** | **0** | **0** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **0** | **0** | **1,551** | **0** | **0** | **8,981** |

*Note : Classified under Current Assets under Sch 7*

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
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## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| | SERB - 2019 - Dr. Vineeth B S - Wireless ReLod | UGC - DAE - Dr. Kuntala B | DST Inspire - Dr. Mahesh S | DST Inspire - Dr. Basudev M | DST - Dr. Vikram Khaire | AICTE - INAE - Aswathy RV - 2017 | AICTE - INAE - 2018 Batch |
| a) Opening balance of the funds | 3,13,417 | 4,69,400 | 27,059 | 7,00,000 | 0 | 64,677 | 1,40,160 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 3,06,060 | 0 | 0 | 0 | 22,00,000 | 70,000 | 5,80,000 |
| ii) Income from Investment made on account of Funds | 11,130 | 0 | 0 | 0 | 0 | 0 | 0 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 6,30,607 | 4,69,400 | 27,059 | 7,00,000 | 22,00,000 | 1,34,677 | 7,20,160 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 2,89,000 | 4,20,000 | 0 | 0 | 7,66,129 | 90,000 | 6,00,000 |
| - Rent/Consumables | 0 | 0 | 0 | 0 | 0 | 0 | 19,332 |
| - Other Administrative Expenses | 44,723 | 0 | 0 | 0 | 36,000 | 0 | 20,000 |
| Sub Total | 3,33,723 | 4,20,000 | 0 | 0 | 8,02,129 | 90,000 | 6,39,332 |
| iii) Fund Returned to the Funding Agency | 16,213 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 3,49,936 | 4,20,000 | 0 | 0 | 8,02,129 | 90,000 | 6,39,332 |
| **Net Balance payable as at the year-end (a+b-c)** | **2,80,671** | **49,400** | **27,059** | **7,00,000** | **13,97,871** | **44,677** | **80,828** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

*Note : Classified under Current Assets under Sch 7*

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
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## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| | AICTE - INAE - 2019 - Nisha | KSCSTE - PDF - Dr. Linsha V - 2019 | KSCSTE - PDF - Dr. Prescilla - 2018 | KSCSTE - PhD - Elizabeth George - 2018 | KSCSTE - PhD - Haritha A - 2018 | SERB - PDF - Dr. Krishnaswamy R - 2017 | SERB - TARE - Dr. Santhosh B |
| a) Opening balance of the funds | 24,194 | 89,967 | 39,984 | 3,661 | 37,281 | 1,86,299 | 3,09,863 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 1,45,000 | 4,17,633 | 0 | 2,94,821 | 2,37,524 | 0 | 0 |
| ii) Income from Investment made on account of Funds | 0 | 0 | 0 | 3,331 | 2,808 | 0 | 13,460 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 1,69,194 | 5,07,600 | 39,984 | 3,01,813 | 2,77,613 | 1,86,299 | 3,23,323 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 1,50,000 | 35,200 | 31,793 | 2,78,690 | 2,57,613 | 0 | 60,000 |
| - Rent/Consumables | 9,450 | 0 | 0 | 0 | 0 | 0 | 2,12,411 |
| - Other Administrative Expenses | 0 | 44,486 | 0 | 20,000 | 0 | 0 | 25,000 |
| Sub Total | 1,59,450 | 79,686 | 31,793 | 2,98,690 | 2,57,613 | 0 | 2,97,411 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 1,59,450 | 79,686 | 31,793 | 2,98,690 | 2,57,613 | 0 | 2,97,411 |
| **Net Balance payable as at the year-end (a+b-c)** | **9,744** | **4,27,914** | **8,191** | **3,123** | **20,000** | **1,86,299** | **25,912** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

*Note : Classified under Current Assets under Sch 7*

# INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
## THIRUVANANTHAPURAM

## SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | 57<br>AICTE - INAE - 2019 - Nisha | 58<br>KSCSTE - PDF - Dr. Linsha V - 2019 | 59<br>KSCSTE - PDF - Dr. Prescilla - 2018 | 60<br>KSCSTE - PhD - Elizabeth George - 2018 | 61<br>KSCSTE - PhD - Haritha A - 2018 | 62<br>SERB - PDF - Dr. Krishnaswamy R - 2017 | 63<br>SERB - TARE - Dr. Santhosh B |
|---|---|---|---|---|---|---|---|
| a) Opening balance of the funds | 24,194 | 89,967 | 39,984 | 3,661 | 37,281 | 1,86,299 | 3,09,863 |
| b) Additions to the Fund | | | | | | | |
| i) Donation/Grants | 1,45,000 | 4,17,633 | 0 | 2,94,821 | 2,37,524 | 0 | 0 |
| ii) Income from Investment made on account of Funds | 0 | 0 | 0 | 3,331 | 2,808 | 0 | 13,460 |
| iii) Other additions (Specify Nature) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (a + b) | 1,69,194 | 5,07,600 | 39,984 | 3,01,813 | 2,77,613 | 1,86,299 | 3,23,323 |
| c) Utilisation/Expenditure towards objective of funds | | | | | | | |
| i) Capital Expenditure | | | | | | | |
| - Fixed Assets | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Others | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ii) Revenue Expenditure | | | | | | | |
| - Salaries, Wages & Allowance | 1,50,000 | 35,200 | 31,793 | 2,78,690 | 2,57,613 | 0 | 60,000 |
| - Rent/Consumables | 9,450 | 0 | 0 | 0 | 0 | 0 | 2,12,411 |
| - Other Administrative Expenses | 0 | 44,486 | 0 | 20,000 | 0 | 0 | 25,000 |
| Sub Total | 1,59,450 | 79,686 | 31,793 | 2,98,690 | 2,57,613 | 0 | 2,97,411 |
| iii) Fund Returned to the Funding Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (c) | 1,59,450 | 79,686 | 31,793 | 2,98,690 | 2,57,613 | 0 | 2,97,411 |
| **Net Balance payable as at the year-end (a+b-c)** | **9,744** | **4,27,914** | **8,191** | **3,123** | **20,000** | **1,86,299** | **25,912** |
| **Net Balance receivable as at the year-end (c-a-b)** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

*Note : Classified under Current Assets under Sch 7*

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021**

| Schedule 2 :: EARMARKED/ENDOWMENT FUNDS (contd.) | TOTAL 2020-21 | TOTAL 2019-20 |
|---|---|---|
| a) Opening balance of the funds | 4,02,88,760 | 4,87,72,613 |
| b) Additions to the Fund | | |
| i) Donation/Grants | 3,56,62,754 | 2,86,93,644 |
| ii) Income from Investment made on account of Funds | 10,16,672 | 27,60,275 |
| iii) Other additions (Specify Nature) | 0 | 0 |
| Total (a + b) | 7,69,68,186 | 8,02,26,532 |
| c) Utilisation/Expenditure towards objective of funds | | |
| i) Capital Expenditure | | |
| - Fixed Assets | 1,19,63,438 | 1,93,94,554 |
| - Others | 4,99,701 | 26,95,537 |
| Sub Total | 1,24,63,139 | 2,20,90,091 |
| ii) Revenue Expenditure | | |
| - Salaries, Wages & Allowance | 1,38,52,595 | 1,10,92,074 |
| - Rent/Consumables | 28,38,273 | 27,00,276 |
| - Other Administrative Expenses | 22,04,957 | 39,15,993 |
| Sub Total | 1,88,95,825 | 1,77,08,343 |
| iii) Fund Returned to the Funding Agency | 38,75,389 | 1,39,338 |
| Total (c) | 3,52,34,353 | 3,99,37,772 |
| **Net Balance payable as at the year-end (a+b-c)** | **4,56,02,357** | **4,20,11,176** |
| **Net Balance receivable as at the year-end (c-a-b)** *Note : Classified under Current Assets under Sch 7* | **38,68,524** | **17,22,416** |

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021**

(Amount in Rs.)

| | As at 31.03.2021 | As at 31.03.2020 |
|---|---|---|
| **Schedule 3 :: LONG TERM LIABILITIES AND PROVISIONS** | | |
| a) Employee Provident Funds and Retirement Benefits | | |
| - General Provident Fund | 5,24,81,292 | 4,63,67,806 |
| - Contributory Provident Fund | 82,40,284 | 73,26,729 |
| - New Pension Scheme | - | 46,876 |
| - Retirement Benefits - Provision | 21,58,81,075 | 21,06,43,767 |
| - Retirement Benefits - Funds Received including Interest | - | 5,71,89,453 |
| **Sub Total (a)** | **27,66,02,651** | **32,15,74,631** |
| b) Caution Deposit | | |
| - Caution Deposit from Students | 1,07,27,206 | 85,04,206 |
| **Sub Total (b)** | **1,07,27,206** | **85,04,206** |
| **TOTAL** | **28,73,29,857** | **33,00,78,837** |

| | As at 31.03.2021 | As at 31.03.2020 |
|---|---|---|
| **Schedule 4 :: CURRENT LIABILITIES AND PROVISIONS** | | |
| a) Current Liabilities | | |
| 1. Sundry Creditors | | |
| - For Goods | | |
| Capital Goods | 75,16,541 | 1,20,92,255 |
| Revenue Expenditure | - | - |
| - For Services | 1,42,79,300 | 1,79,11,418 |
| 2. Statutory Liabilities | | |
| - Overdue | - | - |
| - Others | 10,32,346 | 28,72,734 |
| 3. Other Current Liabilities | | |
| - Interest refundable to DOS (received) | 73,39,210 | 2,89,14,157 |
| - Interest refundable to DOS (accrued) | 1,92,051 | 7,98,962 |
| - B.Tech Fees refundable to DOS | 1,34,73,502 | 5,02,54,928 |
| - Others | 2,16,01,359 | 2,21,57,449 |
| **Sub Total (a)** | **6,54,34,309** | **13,50,01,903** |
| **TOTAL** | **6,54,34,309** | **13,50,01,903** |

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY THIRUVANANTHAPURAM
Govt. of India Dept. of Space

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM

SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021

(Amount in Rs.)

Schedule 5 :: FIXED ASSETS

| Particulars | Gross Block (at cost) as at 01.4.2020 | Additions | | Transfer to Installed from Uninstalled | Deletions | Gross Block (at cost) as at 31.03.2021 | Rate of Depreciation | Depreciation | | | | | Net Block as at 31.3.2021 | Net Block as at 31.3.2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Installed | Under Installation | | | | | As at 01.04.2020 | For the year | Prior Period | Deletions | As at 31.3.2021 | | |
| Land | 3,32,52,002 | 0 | 0 | 0 | 0 | 3,32,52,002 | 0.00% | 0 | 0 | 0 | 0 | 0 | 3,32,52,002 | 3,32,52,002 |
| Building | 1,94,30,47,769 | 30,15,35,164 | 0 | 0 | 2,00,18,712 | 2,22,45,64,221 | 10.00% | 92,84,05,328 | 13,01,34,010 | 2,43,900 | 54,25,072 | 1,05,33,58,166 | 1,17,12,06,055 | 1,01,46,42,441 |
| Plant & Machinery | 1,12,10,93,750 | 2,91,35,587 | 0 | 0 | 1,59,35,634 | 1,13,42,93,703 | 15.00% | 65,80,40,033 | 7,22,65,729 | 6,42,159 | 61,60,012 | 72,47,87,909 | 40,95,05,794 | 46,30,53,717 |
| Furniture & Fittings | 18,96,65,821 | 9,77,085 | 0 | 0 | 0 | 19,06,42,906 | 10.00% | 10,26,58,648 | 87,98,425 | 0 | 0 | 11,14,57,073 | 7,91,85,833 | 8,70,07,173 |
| Ambulance | 8,80,644 | 0 | 0 | 0 | 0 | 8,80,644 | 15.00% | 6,40,677 | 35,995 | 0 | 0 | 6,76,672 | 2,03,972 | 2,39,967 |
| Motor Cars & Bikes | 1,67,45,834 | 0 | 0 | 0 | 0 | 1,67,45,834 | 15.00% | 1,12,27,281 | 8,27,783 | 0 | 0 | 1,20,55,064 | 46,90,770 | 55,18,553 |
| Motor Buses & Truck | 1,07,70,031 | 28,34,608 | 0 | 0 | 0 | 1,36,04,639 | 15.00% | 68,19,171 | 10,17,820 | 0 | 0 | 78,36,991 | 57,67,648 | 39,50,860 |
| Computers | 12,36,74,320 | 83,26,735 | 0 | 0 | 0 | 13,20,01,055 | 40.00% | 10,99,03,195 | 88,39,144 | 0 | 0 | 11,87,42,339 | 1,32,58,716 | 1,37,71,125 |
| Software | 9,67,22,626 | 16,53,750 | 0 | 0 | 0 | 9,83,76,376 | 40.00% | 8,60,99,990 | 49,48,522 | 0 | 0 | 9,10,48,512 | 73,27,864 | 1,06,22,636 |
| Library Books | 6,40,83,708 | 4,44,911 | 0 | 0 | 0 | 6,45,28,619 | 60.00% | 6,17,81,816 | 16,48,082 | 0 | 0 | 6,34,29,898 | 10,98,721 | 23,01,892 |
| Campus networking | 4,74,40,346 | 2,09,790 | 0 | 0 | 0 | 4,76,50,136 | 40.00% | 4,44,92,681 | 12,62,982 | 0 | 0 | 4,57,55,663 | 18,94,473 | 29,47,665 |
| Canteen Equipments | 2,13,22,289 | 4,34,647 | 0 | 0 | 0 | 2,17,56,936 | 15.00% | 1,44,94,308 | 10,89,394 | 0 | 0 | 1,55,83,702 | 61,73,234 | 68,27,981 |
| Soft Furnishing | 10,43,023 | 0 | 0 | 0 | 0 | 10,43,023 | 100.00% | 10,43,023 | 0 | 0 | 0 | 10,43,023 | 0 | 0 |
| ***Uninstalled Assets*** | | | | | | | | | | | | | | |
| Plant & Machinery | 23,68,256 | 0 | 0 | 0 | 0 | 23,68,256 | 0.00% | 0 | 0 | 0 | 0 | 0 | 23,68,256 | 23,68,256 |
| Vehicle | 28,30,000 | 0 | 4,608 | 28,34,608 | 0 | 0 | 0.00% | 0 | 0 | 0 | 0 | 0 | 0 | 28,30,000 |
| TOTAL | 3,67,49,40,419 | 34,55,52,277 | 4,608 | 28,34,608 | 3,59,54,346 | 3,98,17,08,350 | | 2,02,56,06,151 | 23,08,67,886 | 8,86,059 | 1,15,85,084 | 2,24,57,75,012 | 1,73,59,33,338 | 1,64,93,34,268 |
| Previous Year | 3,51,06,10,023 | 16,32,35,572 | 45,63,908 | 28,40,985 | 6,28,099 | 3,67,49,40,419 | | 1,79,67,26,157 | 22,91,16,189 | 15,045 | 2,51,240 | 2,02,56,06,151 | 1,64,93,34,268 | 1,71,38,83,866 |
| Capital Work in progress | 35,86,57,126 | 0 | 10,13,36,466 | 30,64,05,046 | 0 | 15,35,88,546 | | 0 | 0 | 0 | 0 | 0 | 15,35,88,546 | 35,86,57,126 |
| TOTAL | | | | | | | | | | | | | 1,88,95,21,884 | 2,00,79,91,394 |

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**SCHEDULES TO BALANCE SHEET AS AT 31ST MARCH, 2021**

(Amount in Rs.)

| | As at 31.03.2021 | As at 31.03.2020 |
|---|---|---|
| **Schedule 6 :: LONG TERM ASSETS, LOANS, ADVANCES ETC** | | |
| a) Loans | | |
| - Staff | 72,29,878 | 63,07,560 |
| b) Advances and other amounts on capital account recoverable in cash or in kind or for value to be received | | |
| - Interim Advance to SPCL | 12,43,00,000 | 12,43,00,000 |
| c) Security Deposits | 52,92,959 | 52,92,959 |
| **TOTAL** | **13,68,22,837** | **13,59,00,519** |
| **Schedule 7 :: CURRENT ASSETS, LOANS, ADVANCES ETC** | | |
| a) Current Assets | | |
| 1. Inventories | | |
| - Canteen inventories | 6,19,720 | 6,52,891 |
| 2. Sundry Debtors | | |
| - Debtors outstanding for a period exceeding six months | | |
| - Others | | |
| 3. Cash Balances in hand (including cheques/drafts and imprest) | 1,12,220 | 1,30,655 |
| 4. Bank Balances | | |
| a) With Scheduled Banks | | |
| - On Current Accounts | (1,55,35,649) | 68,92,166 |
| - On Deposit Accounts | 21,84,38,948 | 24,24,39,005 |
| - On Earmarked & Retirement Benefits Accounts | 12,34,69,581 | 15,98,28,089 |
| **Sub Total (a)** | **32,71,04,820** | **40,99,42,807** |
| b) Loans, Advances and Other Assets | | |
| 1. Advances and other amounts recoverable in cash or in kind or for value to be received | | |
| - On Capital Account | 3,65,769 | 3,59,444 |
| - Prepayments | 1,84,30,363 | 3,90,71,071 |
| - Others | 1,19,54,965 | 97,25,254 |
| 2. Income Accrued | | |
| - On Bank Deposits | 10,11,227 | 36,85,807 |
| - On Other Deposits | 1,30,195 | 1,79,018 |
| **Sub Total (b)** | **3,18,92,520** | **5,30,20,594** |
| **TOTAL (a+b)** | **35,89,97,340** | **46,29,63,401** |

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**SCHEDULES FORMING PART OF INCOME AND EXPENDITURE ACCOUNT**
**FOR THE YEAR ENDED 31ST MARCH, 2021**

(Amount in Rs.)

| | 2020-21 | 2019-20 |
|---|---|---|
| **Schedule 8 :: GRANTS / SUBSIDIES** | | |
| (irrevocable Grants & Subsidies Recovered) | | |
| 1. Central Government | 58,25,00,000 | 64,25,00,000 |
| **TOTAL** | **58,25,00,000** | **64,25,00,000** |
| **Schedule 9 :: FEES / SUBSCRIPTIONS** | | |
| 1. Entrance Fees | 46,07,470 | 41,50,250 |
| 2. Annual Fees/Subscriptions | 3,83,31,381 | 3,41,37,655 |
| **TOTAL** | **4,29,38,851** | **3,82,87,905** |
| **Schedule 10 :: INTEREST INCOME OF IIST** | | |
| 1. On Term Deposit | | |
| a) With Scheduled Banks | 58,80,774 | 78,79,748 |
| b) Others | 0 | 0 |
| 2. On Loans / Advances | | |
| a) Employee/Staff | 2,38,462 | 1,16,158 |
| 3. Others | | |
| a) Interest on IT Refund | 1,90,578 | 0 |
| **TOTAL** | **63,09,814** | **79,95,906** |
| **Schedule 11 :: INTEREST EARNED ON GRANT & RETIREMENT FUNDS** | | |
| 1. On Term Deposit | | |
| a) With Scheduled Banks | 1,22,43,887 | 1,81,11,227 |
| b) Others | 1,96,880 | 2,31,891 |
| **TOTAL** | **1,24,40,767** | **1,83,43,118** |
| **Schedule 12 :: OTHER INCOME** | | |
| 1. Rent Receipts | 18,663 | 5,75,372 |
| 2. Sale of Tender Forms | 13,995 | 7,500 |
| 3. Sale of Scrap / Vehicles / Trees | 3,22,312 | 4,45,200 |
| 4. Student Activities Income (External) | 0 | 3,00,000 |
| 5. Miscellaneous Income | 31,23,168 | 29,54,482 |
| **TOTAL** | **34,78,138** | **42,82,554** |

## INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
## THIRUVANANTHAPURAM

### SCHEDULES FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH, 2021

(Amount in Rs.)

| | 2020-21 | 2019-20 |
|---|---|---|
| **Schedule 13 :: ESTABLISHMENT EXPENSES - REGULAR** | | |
| 1. Salaries & Allowances | 28,86,61,918 | 29,59,99,211 |
| 2. Contribution to NPS | 2,22,77,947 | 2,25,07,395 |
| 3. Contribution to CPF | 2,68,920 | 2,68,920 |
| 4. Medical Expense- Staff | 39,59,376 | 27,12,231 |
| 5. Expense on Employees Retirement & Terminal Benefits | 1,26,59,713 | 67,64,522 |
| 6. Interest on PF Contribution | 6,87,556 | 6,10,902 |
| 7. Staff Training Expense | 0 | 5,310 |
| **TOTAL** | **32,85,15,430** | **32,88,68,491** |

| | 2020-21 | 2019-20 |
|---|---|---|
| **Schedule 14 :: ESTABLISHMENT EXPENSES - SUPPORT SERVICES** | | |
| 1. Consultancy & Manpower Charges | 5,71,97,517 | 8,56,91,363 |
| 2. Remuneration to Contract Employees | 63,92,293 | 68,76,348 |
| 3. CISF Expenses | 7,32,03,344 | 7,68,13,092 |
| **TOTAL** | **13,67,93,154** | **16,93,80,803** |

| | 2020-21 | 2019-20 |
|---|---|---|
| **Schedule 15 :: ACADEMIC & OTHER STUDENT EXPENSES** | | |
| 1. Admission Expense | 44,48,638 | 48,45,251 |
| 2. Assistanceship to Students | 3,35,66,752 | 3,34,86,155 |
| 3. Library Services | 2,15,30,184 | 2,37,02,374 |
| 4. Academic Expense | 3,52,30,867 | 5,21,70,918 |
| 5. Supplies & Materials | 87,84,219 | 1,54,67,567 |
| 6. Student Activities Expense | 2,68,387 | 10,28,523 |
| 7. Student Activities Expense (External) | 0 | 3,00,000 |
| **TOTAL** | **10,38,29,047** | **13,10,00,787** |

| | 2020-21 | 2019-20 |
|---|---|---|
| **Schedule 16 :: OTHER ADMINISTRATIVE EXPENSES** | | |
| **1. Maintenance & Upkeep** | | |
| Repairs & Maintenance - CMD | 1,94,46,336 | 3,76,81,686 |
| Repairs & Maintenance - Labs & Others | 1,20,53,797 | 1,64,33,906 |
| House Keeping Expense | 8,35,730 | 10,12,314 |
| **Sub Total (a)** | **3,23,35,863** | **5,51,27,906** |
| **2. Professional Charges** | | |
| Audit Fees | 1,89,050 | 1,53,400 |
| Legal Expense | 3,00,123 | 6,00,391 |
| **Sub Total (b)** | **4,89,173** | **7,53,791** |
| **3. Administrative Expenses - Others** | | |
| Vehicle Operating Expense | 66,64,463 | 2,01,48,063 |
| Electricity & Water Charges | 1,63,08,901 | 2,75,22,691 |

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM

SCHEDULES FORMING PART OF INCOME AND EXPENDITURE ACCOUNT
FOR THE YEAR ENDED 31ST MARCH, 2021

(Amount in Rs.)

| | 2020-21 | 2019-20 |
|---|---|---|
| Travelling Expense | 75,099 | 63,68,681 |
| Research & Development Expense | 57,37,434 | 1,29,96,394 |
| Printing & Stationery | 17,97,089 | 40,86,710 |
| Advertisement & Publicity | 2,05,897 | 5,47,357 |
| Hospitality Expense | 9,18,133 | 29,27,565 |
| Telephone & Internet Expense | 18,19,957 | 16,55,035 |
| Office and other Miscellaneous Expense | 5,85,120 | 28,58,227 |
| Recruitment & Review Expense | 3,17,070 | 8,49,717 |
| CEP & IPR Expenses | 4,42,419 | 4,28,017 |
| Compensation Paid | 0 | 18,45,146 |
| Bank Charges | 33,009 | 1,35,950 |
| GST - Input Tax Credit Utilized | -16,07,110 | -6,70,418 |
| **Sub Total (c)** | **3,32,97,481** | **8,16,99,134** |
| TOTAL | **6,61,22,517** | **13,75,80,831** |

**Schedule 17 :: INTEREST REFUNDABLE BY IIST**

| | | |
|---|---|---|
| Interest to CPF Fund [Expense] | 3,07,675 | 5,56,001 |
| Interest to DOS [Expense] | 67,32,299 | 1,16,18,146 |
| Interest to GPF Fund [Expense] | 27,99,666 | 26,56,820 |
| Interest to Retirement Fund [Expense] | 26,01,128 | 35,12,151 |
| TOTAL | **1,24,40,767** | **1,83,43,118** |

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**Schedule 18 :: SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2021**

A. **Significant Accounting Policies**

1. Basis of Accounting
The financial statements have been prepared in accordance with the Generally Accepted Accounting Principles in India (Indian GAAP) and are prepared on accrual basis under the historical cost convention. The accounting policies adopted in the preparation of the financial statements are consistent with those followed in the previous year.

2. Use of estimates
The preparation of the financial statements in conformity with Indian GAAP requires the Management to make estimates and assumptions considered in the reported amounts of assets and liabilities (including contingent liabilities) and the reported income and expenses during the year. The Management believes that the estimates used in preparation of the financial statements are prudent and reasonable. Future results could differ due to these estimates and the differences between the actual results and the estimates are recognized in the periods in which the results are known / materialize.

3. Inventories
The inventories represents canteen inventories and is valued at lower of cost or net realizable value as certified by the Canteen Manager.

4. Depreciation
   a. Depreciation has been provided on the written down value method as per the rates prescribed in the Income Tax Act, 1961.
   b. Depreciation on assets acquired in a particular year is provided for the whole year irrespective of date of addition.
   c. Depreciation has not been charged on capital work in progress and on those assets under installation as on 31.03.2021.
   d. Software not having perpetual licenses are written off over the license period.

5. Revenue Recognition
   a. Grant in aid received from the Department of Space, is accounted on accrual basis. Out of the total grant received, the amount received towards revenue expenditure is treated as Revenue Grant / income over the period necessary to match them with the costs for which they are intended to compensate, on a systematic basis. The remaining grant forms part of the Corpus Fund along with other grant received.
   b. Tuition fees, fines and other recoveries from underperforming students (as per the policy of the institute) are accounted on cash basis. As per Department of Space instructions, Fees received from B.Tech students (performing and non-performing students) who have joined the Institute prior to 2018 is not recognized as income and is shown as a liability payable to Department to Space after adjusting related costs. With respect to BTech students joining the Institute from 2018 onwards the Fees received is recognized as Income of the Institute.
   c. Interest income is accounted on accrual basis. Interest on deposits created out of grant received is refundable to Department of Space.

6. Fixed Assets
   a. Land – (i)The present activity of the Institute is in the Valiamala campus which has been handed over by LPSC vide letter no. VSSC/CMG/2010 dated 05.08.2010 and has been measured at 53.43 acres. No value has been separately provided in the books for this land. (ii) 20 acres of Land in Survey No. 4003 in Thennoor Village has been assigned and handed over to ISRO authorities on 31.12.2007 as per letter No. B8-85534/07 dated

Govt. of India
Dept. of Space

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**Schedule 18 :: SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2021 (contd)**

01.01.2008 of District Collector, Trivandrum subject to the condition that facilities stated by ISRO in their letter no. ISST-DIR-2007 dt 06.12.2007 should be set up in the property within 18 months. The said land should be used only for scientific and educational purposes. No value has been mentioned in the Land Assignment Order and hence the value of the property is taken at Re. 1/- for each property.

b. Building –Construction of buildings has been completed in 2020-21. Capitalisation has been done to the extent of bills received from the builder i.e 90%.
c. Plant and Machinery – It mainly constitutes Laboratory Equipment, Office Equipment, Electricals & Electronics and other Machinery.
d. Buildings and other Fixed Assets are carried at cost less accumulated depreciation. Cost comprises the purchase price or acquisition cost, installation charges and any attributable cost of bringing the assets to working condition for its intended use. Exchange differences arising on restatement / settlement of foreign currency payables relating to acquisition of depreciable fixed assets are adjusted to the cost of the respective assets and depreciated over the remaining useful life of such assets.
e. Capital Work-in-Progress pertains to construction in progress at Valiamala.
f. Assets that have been delivered to IIST up to 31.03.2021 have been recognized as assets but depreciation has not been charged on Assets under installation.

7. Foreign currency transactions
Foreign currency monetary items outstanding at the Balance Sheet date are restated at the year-end rates. Non-monetary items are carried at historical cost. The exchange differences arising on restatement / settlement of long-term foreign currency monetary items are capitalised as part of the depreciable fixed assets to which the monetary item relates and depreciated over the remaining useful life of such assets.

8. Earmarked / Endowment Funds
Earmarked / Endowment Funds mainly include external agency funding received for research & development purpose and conduct of seminars & workshops. Value of assets procured out of such funds for the purpose specified have gone to reduce the value of Fund in hand and have not been treated as an asset of the Institute as the ownership of the same vests with the funding agency. Earmarked / Endowment Funds are held in a separate Current Account linked to Term Deposits. The interest received in the account has been taken as the Institutes Income. Interest claims in the future, if any, from the disbursing parties of such Earmarked / Endowment Funds will be met at the time of the claim based on the deposit rates prevailing during the period of holding of the particular Fund.

9. Employee Benefits
Employee benefits include General Provident Fund (GPF), Contributory Provident Fund (CPF), New Pension Scheme (NPS), and Group Insurance Scheme (GIS). The Institute's contribution to CPF and NPS are considered as defined contribution plans and are charged as an expense as they fall due based on the amount of contribution required to be made.
GPF and CPF funds are maintained separately by the Institute in Savings Bank Account and linked Flexi deposits. Annual Interest provision on GPF and CPF balance is made from Interest earned during the year from investment of such funds in flexi deposits. Interest earned over and above the provision made is transferred to an Interest Fluctuation Reserve and in the event of a shortfall in interest earned, the difference is met from such Reserve, and any balance shortfall after adjustment with Reserve is met by IIST.
Retirement Benefits consisting of pension fund, gratuity and leave encashment received from previous employers of employees joining from other Government organizations have been transferred to Department of Space. Funding of yearly requirement of pensionary & retirement benefits will be by Department of Space.

Govt. of India
Dept. of Space

## INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
## THIRUVANANTHAPURAM

**Schedule 18 :: SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2021 (contd)**

10. Taxes on income
    Being a non-profit institution existing solely for education purposes and being wholly financed by the Government of India, the income of the Institute is exempt under section 10[(23C)][iiiab] of the Income Tax Act, 1961.

11. Research and Development Expenses
    Revenue expenditure pertaining to research is charged to the Income and Expenditure Account. Fixed assets utilized for research and development are capitalized and depreciated in accordance with the policies stated for Fixed Assets.

12. Provisions and Contingencies
    A provision is recognised when the Institute has a present obligation as a result of past events and it is probable that an outflow of resources will be required to settle the obligation in respect of which a reliable estimate can be made. Provisions (excluding retirement benefits) are not discounted to their present value and are determined based on the best estimate required to settle the obligation at the Balance Sheet date. These are reviewed at each Balance Sheet date and adjusted to reflect the current best estimates.

**B. Notes to the Accounts**

1. Depreciation
   Assets are depreciated at written down value method as per rates prescribed in the Income Tax Act, 1961 as recommended by the Office of the Principal Director of Audit, Scientific Departments, Bangalore. Software not having perpetual licenses are written off over the license period

2. Revenue
   a. Out of Grant of Rs. 69,25,00,000/-received during 2020-21, Rs. 58,25,00,000/- received specifically towards revenue expenditure has been transferred to Revenue Grant.
   b. Interest earned (actually received) on funds from grant-in-aid maintained in deposits is refundable to DOS. Interest of Rs. 73,39,210/- (excluding the interest received on the Provident Fund Accounts and Earmarked Funds) has been actually received during 2020-21 and the same has been shown as refundable to DOS. Accrued interest for bank balances as on 31.03.2021 held in State Bank of India, Valiamala have not been provided for due to non-receipt of confirmation from the branch.
   c. Fees received from B.Tech students (performing and non-performing students) who have joined the Institute prior to 2018 is not recognized as income and is shown as a liability payable to Department to Space after adjusting related costs. Based on the Department of Space Letter No. B. 12011/7/2015-Sec.2 dated 21.10.2015, "Fees paid back by students on receipt of Assistanceship package and receipts from non-performing students" are to be remitted back to Government Account. During 2020-21, an amount of Rs. 1,34,73,502/- has been shown as refundable to DOS after deducting related costs.
   d. With respect to BTech students joining the Institute from 2018 onwards the Fees received is recognized as Income of the Institute based on the decision of the Twelfth Finance Committee, IIST.
   e. Canteen Accounting Committee accounts is maintained separately and the gross deficit / surplus, which is exclusive of administrative cost, is recognised in the Income and Expenditure Account.

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM

**Schedule 18 :: SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2021 (contd)**

3. Fixed Assets
   a. Land – There is a stay by the Honorable High Court of Kerala on carrying out construction activities on a part of land (approximately 80 acres) purchased at Ponmudi in Trivandrum District for setting up the Institute. Over and above this 80 acres, approximately 20 acres of land at Ponmudi and 44.18928 acres at Valiamala has been transferred by the Government of Kerala free of cost in December 2007 and April 2009 respectively. These two properties have been brought into the books of accounts in 2013-14 by assigning a nominal value of Re. 1/- each. The present activity of the Institute is in the Valiamala campus which has been handed over by LPSC vide letter no. VSSC/CMG/2010 dated 05.08.2010 and has been measured at 53.43 acres. No separate lease agreement / transfer of ownership of land was obtained by IIST. No value has been separately provided in the books for this land.
   b. Capital Work-in-Progress includes a sum of Rs. 5,39,41,977/- towards project management and consultancy charges and service tax of Rs. 7,73,61,215/-, both pending for appropriation to fixed assets on final completion of all buildings.
   c. An amount of Rs. 23,68,256/- pertaining to assets that have been delivered to IIST before 31.03.2021 but under installation as on 31.03.2021 have been accounted as fixed assets & depreciation has not been charged on the same. Office Equipment worth Rs. 6,85,011/- procured from CMS computers has been uninstalled for 7 years.

4. Employee Benefits
   a. Employer and Employee contribution to New Pension Scheme is being transferred to NSDL.
   b. The Institute has entered into a Group Insurance Scheme (GIS) agreement with Life Insurance Corporation of India from 2011-12 onwards.
   c. Provision for interest on PF Contribution, at the rates prescribed, have been made and the corresponding expenditure has been adjusted against Interest earned on GPF and CPF funds parked in Savings Accounts (linked to flexi deposits) and the balance interest earned has been retained as Interest Fluctuation Reserve. Provision for Retirement Benefits [Pension, Gratuity & Leave Encashment] has been incorporated based on the actuarial valuation provided by Life Insurance Corporation during 2018-19. The provision for 2020-21 has been made by assuming a 10% hike in service cost of 2019-20. In addition, the retirement benefits from the previous employers for the members governed under the GPF have not been received in all cases. Funds received has been transferred to Department of Space as advised by them. By way of DOS Letter No. E.28015/1/2016-V dated 11.08.2020, IIST has been advised to continue to project the funds requirements towards Pension & Retirement Benefits through Grant-in-Aid till common guidelines are issued to Autonomous Bodies.

5. Prior Period Item

   Details of prior period items are as given below :-

| Details | Prior period expenses |
|---|---|
| Housekeeping Expenses | 32,710.00 |
| AMC – Lab Equipment | 92,272.00 |
| GST portion of buy back sale | 2,197.00 |
| Internet Charges – 2019-20 | 3,89,400.00 |
| Prior Period Depreciation | 8,86,059.00 |
| **Total (A)** | **14,02,638.00** |

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**Schedule 18 :: SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2021 (contd)**

| Details | Prior period income |
|---|---|
| Transport expenses reimbursed | 38,215.00 |
| Travelling Expense reimbursed | 2,540.00 |
| Depreciation reversal | 1,15,85,084.00 |
| **Total (B)** | **1,16,25,839.00** |

Net prior period income (A-B) = Rs. 1,02,23,201.00

6. Academic Expenses
Academic Expenses mainly include expenses towards Lectures for students, Project & Internship expenses, stipend / fellowship paid to PhD and M.Tech students and expenses incurred on Seminars, Symposia and Conferences.

7. Admission Expenses
Admission expenses include expenses incurred towards B.Tech, M.Tech and PhD admissions

8. Assistanceship to Students
As per the approval of The Chairman, Board of Management-IIST / Secretary, DOS vide Letter No. PP & PM : IIST : 09-10 dated July 17th, 2009, the B. Tech students of the Institute are entitled for an assistanceship of Rs. 49,000/- [increased to Rs. 51,400/- from Even semester 2014-15] for each semester towards Statutory Semester Fee, Student Amenity Fee, Hostel & Dining, Establishment charges and Medical cover. For the students who have joined the Institute prior to 2018, the assistanceship amount of Rs. 48,400/- (exclusive of book grant) for a semester is disbursed to eligible students based on the performance of the previous semester. The assistanceship amount disbursed is then remitted back by the students to the Institute and expenditure corresponding to the assistanceship so received (under Hostel, Dining & Medical cover) is set off against the assistanceship amount.

From 2018 admission onwards fees is collected from all the students at the beginning of the Semester and the eligible Assistanceship is disbursed based on the performance of the student at the end of the semester

During 2020-21, an amount of Rs. 3,35,66,752/- was disbursed as assistanceship.

9. Supplies and Materials
Supplies and Materials mostly consist of lab consumables.

10. Salary
Salary cost for the month of March 2020 has not been taken into the books of accounts for 2020-21 as March salary for a particular year for central government employees is released in April of that year only. Expenditure for March 2020 to February 2021 has been shown in 2020-21.

11. Bank balances
The negative balance in the SBI and UBI Current Account represents the cheques issued on the closing date of the financial year which are not presented for payment. The Institute has sufficient balance to cover these cheques issued in the flexi deposits maintained with UBI. Hence, the negative balance does not represent any Overdraft.

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
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**Schedule 18 :: SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2021 (contd)**

12. Earmarked / Endowment Funds
    a. An amount of Rs. 231.11 lakhs pertaining to expenditure for Externally Funded projects has been met from IIST bank accounts and is to be transferred from the balance in Earmarked Funds bank accounts to IIST's main bank account.
    b. As on 31.03.2021, assets amounting to Rs. 7.55 crores have been purchased from externally funded projects. The same has not been included in the Balance Sheet of the Institute as the ownership of the same vests with the sponsor.

13. Format of accounts
    The accounts of the Institute are prepared as per proforma suggested by the Office of the Principal Director of Audit, Scientific Departments, Bangalore.

14. Insurance
    The Institute being an autonomous body under the Department of Space (DOS), it is governed by the rules and regulations as applicable to DOS. As per the "Book of Financial Powers" prescribed by DOS "No Government property whether movable or immovable shall be insured. No liability shall be incurred in connection with the insurance of such property without the prior approval of the Department of Space in consultation with the Member for Finance." The matter was taken up for consultation with the Department of Space during 2012-13 and it was decided in the Seventh Finance Committee meeting of IIST dated 3rd June, 2014 not to insure the assets of the institute.

15. Inoperative Balances
    An amount of Rs. 16.81 lakhs (credit balances) relates to balances that have been outstanding from 01.04.2020.

16. Balances in personal accounts
    Balances in personal accounts are subject to confirmation from respective parties.

17. Contingent Liabilities
    a. The unexecuted portion of the contracts entered into by the Institute will form part of the current liability of the Institute. However, the same could not be quantified.
    b. Interest earned on Earmarked / Endowment Funds held in a separate Current Account linked to Term Deposits has been taken as the Institutes Income. Interest claims in the future, if any, from the disbursing parties of such Earmarked / Endowment Funds will be met at the time of the claim based on the deposit rates prevailing during the period of holding of the respective Fund
    c. In the case of buildings / structures completed by SPCL, only 90% has been billed by SPCL and subsequently paid by IIST. The balance 10% (approximately Rs. 24.22 crores) has not been billed and the same will be paid only on completion of the project. In case of all other works completed by SPCL and not billed as on 31.03.2021 provision has not been made in the books of accounts since the same is not quantifiable.

18. Building Construction:
    The institute entered into a contract with SPCL, Mumbai on 27.08.2008 for Rs. 278.60 crores with a completion period of 18 months for setting up building and infrastructure at its campus in Valiamala on turnkey basis. The work was completed and the building handed over on 06.02.2021. The Institute reserves the right to impose the levy of compensation for delay. As per clause 2 of the agreement the institute can levy penalty on the works which will have an impact on the accounts. The same could not be quantified due to want of details. As on

Govt. of India
Dept. of Space

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**Schedule 18 :: SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2021 (contd)**

31.03.2021, advance amount paid to SPCL towards interim advance amounts to Rs. 12.43 crores. The Institute currently holds the following instruments as security with respect to the contract with SPCL.

| Nature of security | Amount (in crores) |
|---|---|
| Security Deposit – Bank guarantee | 12.14 |
| Performance Bank guarantee | 12.14 |
| Bank guarantee against Interim Advance | 12.43 |

19. Figures for the previous year
Figures for the previous year have been regrouped and/or reclassified wherever considered necessary.

As per our report of even date attached

For Balamurali & Associates
Chartered Accountants
FRN : 0123748

BALAMURALI, M.Com,FC
Proprietor
ICAI.M.No-223319

C.A. Balamurali C. V.
(Proprietor, Mem No. 223319)

For and on behalf of
Indian Institute of Space Science and Technology (IIST)

S. Somanath
Director

R. Hari Prasad
Finance Officer

Place : Thiruvananthapuram
Date : 23rd November, 2021

**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**
**THIRUVANANTHAPURAM**

**RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31ST MARCH, 2021**

(Amount in Rs.)

| Receipts | 2020-21 | 2019-20 | Payments | 2020-21 | 2019-20 |
|---|---|---|---|---|---|
| **I. Opening Balance** | | | **I. Expenses** | | |
| a.Cash and DD's in hand | 1,30,655 | 55,351 | **a.Establishment Expenses - Regular** | | |
| b.Bank Balances | | | Salaries & Allowances (admin & faculty) | 28,90,27,787 | 29,57,47,968 |
| In current accounts | 68,92,166 | 2,22,72,101 | Contribution to NPS | 2,22,77,947 | 2,25,07,395 |
| In deposit accounts | 24,24,39,005 | 27,22,99,687 | Contribution to CPF | 2,68,920 | 2,68,920 |
| In earmarked/retirement benefits accounts | 15,98,28,089 | 15,12,58,047 | Medical Expense- Staff | 39,79,043 | 29,37,813 |
| | | | Employees Retirement Benefits | 74,22,405 | 27,29,600 |
| **II.Grants Received** | | | Interest on PF Contribution | 6,87,556 | 6,10,902 |
| a.From Government of India | 69,25,00,000 | 90,25,00,000 | Staff Training Expenses | 0 | 5,310 |
| | | | | | |
| **III. Interest Received** | | | **b.Establishment Expenses - Support Services** | | |
| a. On Bank Deposits | 67,20,925 | 84,96,475 | Consultancy & Manpower Charges | 5,75,91,492 | 8,73,21,732 |
| b. On Other Deposits | 0 | 0 | Remuneration to Contract Employees | 63,32,293 | 68,76,348 |
| c. Loans, Advances etc | 2,38,462 | 1,16,158 | CISF Expenses | 7,41,73,027 | 7,67,64,139 |
| d. Others | 1,90,578 | 0 | | | |
| | | | **c. Academic & Other Student Expenses** | | |
| **IV. Other Income** | | | Admission Expense | 44,48,638 | 48,45,251 |
| a. Entrance Fees | 46,07,470 | 41,59,250 | Assistanceship to Students | 3,35,20,522 | 3,35,24,739 |
| b. Annual Fees/Subscriptions | 3,76,08,656 | 3,79,96,270 | Library Services | 1,96,74,068 | 2,34,34,853 |
| c. Other Income | 34,22,178 | 40,51,661 | Academic Expense | 3,48,28,539 | 5,16,53,114 |
| | | | Supplies & Materials | 90,40,196 | 1,49,69,514 |
| **V. Any other receipts** | | | Student Activities Expense | 2,68,387 | 10,83,523 |
| a. MCF Hassan - ISRO | 4,62,984 | 2,00,000 | | | |
| b. Security Deposits received | 18,90,942 | 8,60,097 | **d. Other Administrative Expenses** | | |
| c. Earnest Money Deposits received | 11,52,729 | 43,27,493 | Repairs & Maintenance | 1,10,80,251 | 1,86,87,620 |
| d. Performance Guarantee received | 11,060 | 10,09,681 | Repairs & Maintenance - CMD | 2,04,73,098 | 3,72,34,316 |
| e. Advance for Research & Seminars | 3,66,79,426 | 3,14,53,919 | House Keeping Expense | 10,09,623 | 8,27,132 |
| f. BTech Fees refundable to DOS | 1,34,73,502 | 1,91,33,840 | Audit Fees | 1,89,050 | 1,79,950 |
| g. Caution Deposit from Students | 27,41,000 | 1,98,000 | Legal Expense | 3,00,123 | 6,05,247 |
| h. Bond Amount received [Btech] | 10,00,000 | 0 | Vehicle Operating Expense | 67,86,489 | 2,15,36,853 |
| i. Stale cheques | 95,126 | 35,082 | Electricity & Water Charges | 1,65,36,545 | 2,76,63,344 |
| j. Canteen Accounting Committee | 18,66,899 | 2,25,41,674 | Travelling Expense | 5,75,501 | 66,64,837 |
| k. Miscellaneous receipts | | 0 | Research & Development Expense | 58,78,672 | 1,21,95,754 |
| l. Interest received and payable to DOS | 73,39,210 | 1,28,11,021 | Printing & Stationery | 17,95,928 | 41,20,865 |

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**THIRUVANANTHAPURAM**

**RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31ST MARCH, 2021**

(Amount in Rs.)

| Receipts | 2020-21 | 2019-20 | Payments | 2020-21 | 2019-20 |
|---|---|---|---|---|---|
| m. Net addition to Statutory Liabilities(Staff) | 1,08,32,809 | 1,21,39,768 | Advertisement & Publicity | 1,99,146 | 5,47,357 |
| n. Unexplained credits - Banks | 1,400 | 38,232 | Hospitality Expense | 8,97,669 | 29,88,140 |
| o. Tax Collected at Source | 0 | 0 | Telephone & Internet Expense | 20,02,387 | 17,05,363 |
| p. Recovery of loans to staff | 3,77,682 | 2,88,466 | Office Expense | 6,17,568 | 28,29,624 |
| q. Contingency advance | 0 | 1,26,893 | Recruitment & Review Expense | 2,93,086 | 8,56,658 |
| r. Increase in TDS, GST & Labour Cess | 0 | 5,22,391 | CEP & IPR Expenses | 4,42,419 | 4,28,017 |
| s. TDS refund from IT Department | 29,24,898 | 0 | Compensation Paid | 0 | 18,45,146 |
| t. IPRC - Honorarium received | 1,500 | 0 | Bank Charges | 33,009 | 1,35,950 |
| | | | GST - Input Tax Credit Utilized | (1,93,697) | (4,04,852) |
| | | | **II. Payments made against funds for various projects** | | |
| | | | DOS - Dr. Palash - HSP - Real TIme Gas Sensor | 4,24,859 | 10,34,025 |
| | | | DOS - MOM2 - RPA - Dr. Ambili KM | 12,44,835 | 13,56,229 |
| | | | DOS-SAC- Dr. Rajesh V J | 0 | 0 |
| | | | DOS - Dr. Umesh - Planetary Exploration | 0 | 0 |
| | | | DOS - Dr. Rajesh V J (Spectral) | 10,857 | 4,10,748 |
| | | | VSSC - Dr. Natarajan E | 1,28,440 | 0 |
| | | | IISU - Dr. Umesh Kadhane - Proj Assistant | 2,41,674 | 1,89,846 |
| | | | IISU - Perf. of Ball Bearings - Dr. Jinesh KB | 72,751 | 36,49,045 |
| | | | IPRC - Dr. Palash - 2018 - Hydrogen Sensor | 1,61,402 | 8,72,905 |
| | | | ISRO-GBP - ABLN & C Project | 0 | 0 |
| | | | ISRO -Dr. K G Sreejalekshmi -Gaganyaan | 8,84,314 | 50,364 |
| | | | ISRO - MOM - Dr. Rajesh VJ | -34,441 | 1,75,645 |
| | | | LPSC - Dr Dinesh N Naik | 14,61,204 | 0 |
| | | | LPSC - Dr.Jinesh K B - Laser Ignition System | 19,26,045 | 4,41,971 |
| | | | LPSC - Dr. Jinesh K B - SDS | 5,397 | 15,45,345 |
| | | | LPSC - Dr. Umesh K - Monte Carlo Model | 0 | 1,06,452 |
| | | | LPSC - Dr. Umesh Kadhane | 0 | 0 |
| | | | LPSC Dr. Umesh K - Plasma Thruster | 0 | 1,35,333 |
| | | | LPSC - High Thrust EPS - Dr. Umesh K | 61,69,193 | 71,34,201 |
| | | | SAC - NavIC (IRNSS) Gagan | 57,603 | 4,42,237 |
| | | | DBT - Dr. Palash - 2017- Liquid Biopsy for Cancer | 4,43,548 | 15,65,812 |
| | | | DBT - Dr. Palash - Green House Gases | 17,92,605 | 0 |
| | | | DBT - Dr. Shaiju - Ramalingaswami Fellowship | 13,19,598 | 2,37,000 |

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**RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31ST MARCH, 2021**

(Amount in Rs.)

| Receipts | 2020-21 | 2019-20 | Payments | 2020-21 | 2019-20 |
|---|---|---|---|---|---|
| | | | DBT-RamaRao (Rural Urban Interface) Phase-II | 0 | 0 |
| | | | DBT - Dr. Rama Rao N | 37,42,882 | 4,84,807 |
| | | | DRDO - ARMREB - Dr. K. Prabhakaran | 6,66,504 | 8,55,407 |
| | | | DRDO - SASE - Dr. Govindankutty M | 0 | 7,612 |
| | | | DST - Dr. Rama Rao N | 7,88,438 | 8,77,623 |
| | | | DST - CNRS - Dr. Palash Basu - 2020 - Biomarker | 3,18,423 | 0 |
| | | | DST - KIRAN - Pushpa K - Quantum Mech | 2,71,562 | 0 |
| | | | DST - NGP - A.M Ramiya - Smart Cities 3D | 6,04,901 | 0 |
| | | | ICSSR - Dr. Shaijumon - 2020 - Tele Medicine Units | 3,05,850 | 0 |
| | | | Mangrove Cell - Dr. Gnanappazham - 2018 | 5,31,575 | 16,01,281 |
| | | | Max-Planck - Dr. Jagadheep - 2017 | 7,35,614 | 7,70,562 |
| | | | MeitY SAMEER - Dr. Priyadarshnam | 16,13,896 | 28,27,818 |
| | | | SERB - 2018 - Dr. Anand N. - Baryons | 4,15,357 | 2,74,785 |
| | | | SERB - Dr. Ashok - Quantum Communication | 3,90,076 | 0 |
| | | | SERB - Dr. Chinmoy Saha - 2020 - 5G Antenna | 1,60,000 | 0 |
| | | | SERB - Dr. Resmi L - 2017 - Gamma Rays | 51,504 | 2,83,026 |
| | | | SERB - Dr. Sarita Vig - Young Massive Stars | 5,00,441 | 0 |
| | | | SERB - Dr. Sarvesh - 2020 - Virtual Element | 1,51,257 | 0 |
| | | | SERB - Dr. Seena V - Nanomechanical Sensor | 14,94,932 | 28,58,318 |
| | | | SERB - Dr. Jayanthi S | 11,008 | 1,47,467 |
| | | | SERB - 2018 - Dr. Umesh K. - PAH | 24,83,478 | 3,39,097 |
| | | | SERB - Dr. Roymon Joseph | 70,139 | 2,52,012 |
| | | | SERB - 2019 - Dr. Vineeth B S - Wireless ReLod | 3,49,936 | 6,01,396 |
| | | | UGC - DAE - Dr. Kuntala B | 4,20,000 | 28,000 |
| | | | DST - Dr. Vikram Khaire | 8,02,129 | 0 |
| | | | AICTE - INAE - Aswathy RV - 2017 | 90,000 | 1,45,000 |
| | | | AICTE - INAE - 2018 Batch | 6,19,332 | 7,18,548 |
| | | | AICTE - INAE - 2019 - Nisha | 1,59,450 | 1,10,806 |
| | | | KSCSTE - PDF - Dr. Linsha V - 2019 | 79,686 | 3,82,433 |
| | | | KSCSTE - PDF - Dr. Prescilla - 2018 | 31,793 | 4,31,952 |
| | | | KSCSTE - PhD - Elizabeth George - 2018 | 2,98,690 | 1,29,533 |
| | | | KSCSTE - PhD - Haritha A - 2018 | 2,57,613 | 1,10,000 |
| | | | SERB - PDF - Dr. Krishnaswamy R - 2017 | 0 | 1,74,289 |
| | | | SERB - TARE - Dr. Santhosh B | 3,22,548 | 0 |
| | | | ATAL - AICTE - Dr. Ramarao N. | 93,000 | 0 |

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## RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31ST MARCH, 2021

(Amount in Rs.)

| Receipts | 2020-21 | 2019-20 | Payments | 2020-21 | 2019-20 |
|---|---|---|---|---|---|
| | | | ATAL - AICTE - Dr. Chandrasekar | 93,000 | 0 |
| | | | DST - NRDMS - Dr. Ramarao N. | 60,246 | 1,86,781 |
| | | | TIFR - Dr. Resmi L (Travel) | 1,80,648 | 0 |
| | | | SERB - Dr. Rakesh Kumar Singh | 0 | 85,215 |
| | | | SERB - PDF - Dr. Linsha Vazhayal - 2017 | 0 | 1,95,849 |
| | | | SERB - PDF - Dr. Priyanka B - 2017 | 0 | 1,15,323 |
| | | | DAE - NBHM - CSDEA - Dr. Sakthivel | 0 | 2,00,000 |
| | | | SERB - DST - National Conference - Dr. Sakthivel | 0 | 1,50,000 |
| | | | DAE - ICIAM - Dr. Sakthivel (Travel) | 0 | 1,92,677 |
| | | | SERB - DST - Dr. Deepak TG (Travel) | 0 | 1,13,009 |
| | | | SERB - PhD - Aravind G P (Travel) | 0 | 1,45,560 |
| | | | SERB - PhD - Aryadutt Oamjee (Travel) | 0 | 1,24,461 |
| | | | SERB - Dr. Chinmoy Saha (Travel) | 0 | 1,40,546 |
| | | | SERB - PhD - Shashank V (Travel) | 0 | 65,331 |
| | | | DST - Inspire Faculty - Dr. Sakthivel | 12,612 | 0 |
| | | | **III. Expenditure on Fixed Assets & Capital Work-in-Progress** | | |
| | | | a.Purchase of Fixed Assets | 61,12,37,360 | 11,40,62,535 |
| | | | b.Expenditure on Capital Work-in-progress | (50,57,21,158) | 14,87,68,349 |
| | | | **IV. Other Payments** | | |
| | | | Security Deposits (Asset) paid | - | 2,21,170 |
| | | | Security Deposits repaid to Contractors | 16,89,512 | 9,97,824 |
| | | | Earnest Money Deposits repaid | 18,11,083 | 46,84,370 |
| | | | Performance Guarantee repaid | 4,41,669 | 8,02,207 |
| | | | Contingency Advance to Staff | 84,164 | 0 |
| | | | Loans to staff | 13,00,000 | 37,50,000 |
| | | | Canteen Accounting Committee | 39,18,398 | 2,03,27,834 |
| | | | Charges recoverable from banks | 4,752 | 14,660 |
| | | | Stale Cheques - paid | 12,482 | 7,67,669 |
| | | | Decrease in TDS, GST & Labour Cess | 18,40,388 | 0 |
| | | | Employee recovery - Ex ISRO employees | 2,74,424 | 17,518 |
| | | | Tax deducted at source [from IIST] | 14,61,960 | 29,04,671 |
| | | | Unexplained credits - Banks - transferred | 38,231 | 8,35,381 |

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM

RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31ST MARCH, 2021

(Amount in Rs.)

| Receipts | 2020-21 | 2019-20 | Payments | 2020-21 | 2019-20 |
|---|---|---|---|---|---|
| | | | Btech Fees refunded to DOS | 5,02,54,928 | 0 |
| | | | Interest refunded to DOS | 1,16,42,097 | 0 |
| | | | MCF Hassan - ISRO | 2,84,446 | 45,330 |
| | | | Caution Deposit repaid to Students | 5,18,000 | 0 |
| | | | Student Activities Account payments | 163 | 0 |
| | | | Sundry Debtors | 1,14,681 | 0 |
| | | | Retirement funds paid to DOS | 5,97,90,581 | 0 |
| | | | **V. Closing Balances** | | |
| | | | a.Cash in hand | 1,12,220 | 1,30,655 |
| | | | b.Bank Balances | | |
| | | | In current accounts | (1,55,35,649) | 68,92,166 |
| | | | In deposit accounts | 21,84,38,948 | 24,24,39,005 |
| | | | In earmarked/retirement benefits accounts | 12,34,69,581 | 15,98,28,089 |
| Total | 1,23,54,29,352 | 1,50,88,91,556 | Total | 1,23,54,29,352 | 1,50,88,91,556 |

**Significant Accounting Policies & Notes on Accounts** 18

As per our report of even date attached.

For Balamurali & Associates
Chartered Accountants
FRN : 012374S

C.A. Balamurali C. M.Com,FC
(Proprietor, Mem No. 223319)

Place : Thiruvananthapuram
Date : 23rd November, 2021

For and on behalf of
Indian Institute of Space Science and Technology (IIST)

S. Somanath
Director

R. Hari Prasad
Finance Officer

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**Indian Institute of Space Science and Technology**

Declared as Deemed to be University under Section 3 of the UGC Act, 1956

An autonomous institute under Department of Space, Govt. of India

Valiamala P O, Thiruvananthapuram - 695 547, Kerala

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