RAMAN RESEARCH INSTITUTE
2022 - 2023
ANNUAL REPORT

From the Director

It has been a year full of new learnings, presented through many opportunities for knowing deeper about the ongoing and proposed research activities at the Raman Research Institute (RRI).

With the incoming of a few bright and young faculties during this academic year, my conviction is that the future of the Institute, which has newer heights to soar to, is in safe hands. These faculties have brought-in fresh ideas, greater enthusiasm and renewed energy -- all of these will help RRI take-on bigger challenges and complex scientific problems in future. As they settle in their new roles and responsibilities at the Institute, I wish them a successful academic career.

This report is a synopsis of the research and academic activities at RRI for the period April 1, 2022 to March 31, 2023. While providing an overall view of the Institute's organisation and facilities, the report's primary aim is to place on record the research published in the scientific journals, PhD degrees awarded and other scientific activities such as colloquia, conferences, prestigious named lecture series, seminars, workshops and others, held at the Institute.

2022 – 2023 marks the Institute's Platinum jubilee year, which commenced on November 7, 2022. The occasion was graced by the august presence (virtual) of Dr. Srivari Chandrasekar, Secretary, Department of Science and Technology (DST), Shri S. Somanath, Chairman, Indian Space Research (ISRO), Dr. K. Kasturirangan and Shri AS Kiran Kumar, former chairmen, ISRO and members of the RRI Council and Trust , Dr. Jyotsna Dhawan and Vivek Radhakrishnan, who are members of the RRI Trust. In addition, several noted academicians, scientists, former and present RRI faculty, friends of the institute and students joined-in for the celebration.

The Platinum jubilee logo, depicting the sphere eversion, was unveiled on the day. The theme of the logo is inspired by the eversion of the sphere in differential topology – the process of turning a sphere inside out, in a three-dimensional space. At this milestone, the vision for RRI, in the coming decades, could be to 'evert' and bring out its inner strength built over the first 75 years, even as we plan for the future. Eversion also points to the unity in diversity of research at RRI. To some, it may seem that RRI is peering out to the wondrous vast cosmos while in the everted form. To others, it may appear to peer into the mysterious depths of the quantum frontier.

The milestone year is being celebrated by hosting numerous national and international conferences, a women-centric conference, seminars, scientific talks, lectures and science outreach activities.

The Platinum jubilee opened with the conference 'Showcasing RRI' , wherein the faculty, both the past and the current, presented the Institute's scientific contributions through the 75 years. 'Women in Optics and Photonics in India' conference was a platform to unite and promote women who have excelled in STEM, particularly those in the fields of Optics. 'Frontiers in Cosmology' was an excellent gathering of scientists working on some of the cutting-edge and mega-science astronomy projects and missions in the world. The other major conferences slated to be held as part of the Platinum Jubilee year are the Raman Conference in Light and Matter Physics (August 14-18), Quantum Gravity @RRI(September 4-8), Frontiers in Physics of Soft and Biological Matter (September 25-30) and Frontiers in Statistical Physics (December 4-8) – together covering all of the core research themes at the Institute.

This year witnessed the launch of the prestigious Pancharatnam Lecture Series, named in the honour of Sivaramakrishnan Pancharatnam, a student of Sir CV Raman and a doyen in the field of Optics. This prestigious quarterly academic lecture targets the scientist, faculty and student communities. These lectures are live streamed via the RRI's official YouTube channel for the larger benefit of the scientific community. So far, three such lectures were organised.

A total of 87 students are enrolled in across the Institute's diverse PhD programme. Ten students received their PhD degrees and four students submitted their theses over the past one year. During the same period, 136 research papers were published in referred journals, most of them with high impact factors. Among other publications include papers presented during the conference proceedings, some book chapters and popular science articles. These publications showcase the rich variety of scientific works spanning quantum to cosmos and beyond.

After a two-year hiatus posed due to the Covid-19 pandemic, the year gone-by witnessed the return of physical meetings and scientific events. The Institute hosted talks by various international and national scientists and eminent academicians. These talks opened up newer arenas of studies and research for the Institute's student community.

Equity Diversity and Inclusion (EDI) , a task force to unite the faculty, students and all the staff, was launched on July 11, 2022. It aims at creating an environment of fair, inclusive and mutually-respectful working space. In this regard, a webpage was also launched.

Over 800 visitors participated in the National Science Day celebrations this year. On this day, the Institute, together with the India Post, Department of Posts, Government of India, released a special Postal Cover themed 'National Science Day'. Since 1987, February 28 is celebrated as the National Science Day (NSD) in India to commemorate the discovery of the Raman Effect by Sir CV Raman, for which he was conferred the Nobel Prize in Physics, in 1930. Adding to NSD celebrations was the inauguration of the Institute's Archival Gallery – a dedicated space narrating the story of life and science of Sir Raman. The four walls, carefully designed and curated with the help of archive material maintained by the Institute's Library, narrate the life and science of Sir Raman, the birth and the scientific journey of RRI since 1948.

The Institute kept open its gates to a large number of young school and college students round the year. The RRI's stall depicting the Archival Gallery displayed at the India International Science Festival held in Bhopal bagged the 'Best Conceptual Pavilion' award among 150 stalls.

All these are small steps initiated by the Institute in its numerous endeavours towards taking science to the society.
In its scientific journey through the past 75 years, the Institute has traversed along the path laid down in 1948 by Sir CV Raman, the institute's founder-director and a world-renowned physicist. The rock-solid foundation -- to pursue fundamental research in the frontier and contemporary areas of Physics remains the Institute's motto.

I consider this both my honour and privilege to lead RRI, as it celebrates 75 years of its scientific excellence and glory.

Tarun Souradeep
Director

RRI at a Glance

RRI is an icon that symbolizes and represents the heritage of Indian physicist and Nobel Laureate Sir C V Raman, continuing his legacy and style of qualitatively impactful research that earns the nation a respectable place. The Institute preserves the inspirational spirit of this stalwart of our scientific cultural history.

History

Nobel Laureate, Sir C V Raman, founded the Raman Research Institute in 1948 on land that had been gifted to him by the Government of Mysore. After the Professor's demise in 1970, a public charitable trust was created - the Raman Research Institute Trust – and the lands, buildings, deposits, securities, bank deposits, moneys, laboratories, instruments, and all other movable and immovable properties were transferred to the RRI Trust. The function of the RRI Trust was to maintain, conduct and sustain the Raman Research Institute.

In 1972, RRI was restructured to become an aided autonomous research institute and since then has been receiving funds for its research from the Department of Science and Technology of the Government of India. A set of Regulations and Bye-Laws were framed for its administration and management.

Administration

The Governing Council is the executive body of the Institute and conducts the administration and management of the Institute. The Director is the Chief Executive and Academic Officer and is responsible for the administration of the Institute. He exercises general supervision over the programmes and research projects of the Institute. The Administrative Officer is responsible for the general administration of the Institute and represents it in legal and other related proceedings. The Finance Committee helps the Council with financial matters.

Mission

The mandate of the Institute is primarily research in fundamental sciences that advances the knowledge of mankind by creating new knowledge, secondly communicating this knowledge to the next generation thus empowering them with higher learning and scientific temper, and thirdly maintaining an institution of higher learning where academic culture and scientific temper are promoted. The research conducted at the Institute continually advances knowledge base via an improved understanding of the fundamental laws and behaviour of nature spanning from sub-atomic to cosmological length scales thereby laying the basic foundation for advancement of science and its component benefits to society. More importantly, RRI strives to engender quality research manpower through its vibrant Post-doctoral, Doctoral, Research Assistantship and Visiting Student programmes.

Director

The current Director of the Raman Research Institute is Tarun Souradeep

Location

RRI is located on a 20-acre site in Bengaluru. The verdant campus with a mix of manicured landscapes and patches of wilderness provides a serene environment away from the hustle and bustle of the developing metropolis beyond its walls, perfectly suited for the creative research and higher learning conducted within.

Research Areas

The institute conducts research in fundamental sciences under the follwoing select contemporary research themes - Astronomy and Astrophysics, Light and Matter Physics, Soft Condensed Matter and Theoretical Physics.

Research Laboratories

- X-ray Astronomy Laboratory
- Cosmological Recombination & Reionization Laboratory
- Light-Matter Interactions
- Laser Cooling & Quantum Optics
- Ultrafast and Nonlinear Optics
- Quantum Information & Computing
- Quantum Interactions
- Quantum Mixtures Laboratory
- Phase Transitions & Electro-optics
- Rheology and Light Scattering
- Microscopy and Scattering
- Biophysics
- Chemistry
- Microscopy and Dielectric Spectroscopy
- Nanoscale Physics of Soft and Living Matter
- Soft and Adaptive Materials Laboratory
- Brain Computer Interface

Research Facilities

- **Soft Matter Measurement Laboratories**
  - Analytical Physical Measurement
  - X-ray Diffraction
  - Scanning Electron Microscopy
  - Atomic Force Microscopy
  - Nuclear Magnetic Resonance Imaging
  - Micro-Raman Spectroscopy
  - Magnetic Studies
  - Photophysical Studies
- **Mechanical Engineering Services**
  - Mechanical Workshop
  - Sheet metal, paint and carpentry facility
- **Electronics Engineering Group**
- **Gauribidanur Field Station**
- **Library**
- **IT & Computing**
- **Infrastructure**
  - Guest House
  - Canteen
  - Clinic
  - Sports facilities
  - Crèche

Education

RRI offers the following programmes for advanced learning and knowledge communication in basic sciences, including theoretical and experimental methods and skills.

- PhD Programme
- Postdoctoral Fellowships
- Pancharatnam Fellowships
- Visiting Students Programme
- Research Assistant Programme

Funding

The research of the Institute is nurtured and sustained by grants-in-aid from the Department of Science and Technology, Government of India, and extra-mural grants.

Governing Council

The Governing Council is the executive body of the Institute and conducts the administration and management of the Institute. Its members hold office for five-year term.

Shri A.S. Kiran Kumar (Chair)
Vikram Sarabhai Professor, (Former Chairman, ISRO/Space Commission/ Secretary, Department of Space), Indian Space Research Organisation, Antariksh Bhavan, New BEL Road, Bengaluru - 560 231

Dr. K. Kasturirangan
Honorary Distinguished Advisor, ISRO, Raman Research Institute, Bengaluru - 560 080

Prof. Vijay P Bhatkar
Chancellor of Nalanda, University Chairman of ETH Research Lab, National President of Vijnan Bharati Bavdhan, Off Mumbai-Bengaluru Bypass, Pune - 411 021

Prof. Annapurni Subramaniam
Director, Indian Institute of Astrophysics, 2nd Block,100 Feet Road, Koramangala, Bengaluru - 560 034

Prof. Rupamanjari Ghosh
Former Vice-Chancellor, Shiv Nadar University, Dadri, Gautam Buddha Nagar, Uttar Pradesh - 201 314

Dr. Srivari Chandrasekhar
Secretary, Department of Science & Technology, Ministry of Science & Technology, Technology Bhavan, New Mehrauli Road, New Delhi - 110 016

Shri Vishvajit Sahay
Additional Secretary & Financial Adviser, Department of Science & Technology, Ministry of Science & Technology, Technology Bhavan, New Mehrauli Road, New Delhi - 110 016

Prof. Tarun Souradeep (Ex-Officio Member)
Director, Raman Research Institute, Bengaluru - 560 080

Finance Committee

Shri A.S. Kiran Kumar (Chair)
Vikram Sarabhai Professor, (Former Chairman, ISRO/Space Commission/ Secretary, Department of Space), Indian Space Research Organisation, Antariksh Bhavan, New BEL Road, Bengaluru - 560 231

Prof. Rupamanjari Ghosh
Former Vice-Chancellor, Shiv Nadar University, Dadri, Gautam Buddha Nagar, Uttar Pradesh - 201 314

Shri Vishvajit Sahay
Additional Secretary & Financial Adviser, Department of Science & Technology, Ministry of Science & Technology, Technology Bhavan, New Mehrauli Road, New Delhi - 110 016

Prof. Tarun Souradeep (Ex-Officio Member)
Director, Raman Research Institute, Bengaluru - 560 080

Academic Committee

Till 25 January 2023

Prof. Tarun Souradeep, *Chairperson*
Director, Raman Research Institute, C.V. Raman Avenue, Sadashivanagar, Bengaluru - 560 080

Prof. Sadiqali Rangwala, *Member*
Chairperson, Students Academic Affairs Committee, RRI

Prof. Reji Philip, *Member*
Coordinator, Admissions Committee, RRI

Prof. Arun Mangalam, *Member*
Professor & Chair of Theory Group, Indian Institute of Astrophysics, Sarjapur Road 2nd Block, Koramangala, Bengaluru - 560 034

Prof. Sachindeo Vaidya, *Member*
Professor, Centre for High Energy Physics, Indian Institute of Science, Bengaluru - 560 012

Prof. B.K. Kanaujia, *Member*
School of Biotechnology, Jawaharlal Nehru University New Delhi - 110 067

Prof. Pawan Dhar, *Member*
School of Computational & Integrative Sciences, Jawaharlal Nehru University, New Delhi - 110 067

Rector-II/Controller of Examination (CoE) or his nominee, *Special Invitee*
Jawaharlal Nehru University, New Delhi - 110 067

Mr. Naresh VS, *Secretary*
Administrative Officer (i/c), RRI

From 26 January 2023

Prof. Tarun Souradeep, *Chairperson*
Director, Raman Research Institute, C.V. Raman Avenue, Sadashivanagar, Bengaluru - 560 080

Prof. Ranjini Bandyopadhyay, *Member*
Chair of Admission Committee, RRI

Dr. Sayantan Majumdar, *Member*
Chair of Doctoral Programme Monitoring Committee, RRI

Prof. Ajith Paramaeswaran, *Member*
International Centre for Theoretical Sciences, Bengaluru -560 089

Prof. Anindya Das, *Member*
Department of Physics, Indian Institute of Science, Bengaluru - 560 102

Prof. T.V. Vijay Kumar, *Member*
School of Computer & Systems Sciences, Jawaharlal Nehru University, New Delhi - 11067

Prof. Satyabrata Patnaik, *Member*
School of Physical Sciences, Jawaharlal Nehru University, New Delhi - 110 067

Rector-II/Controller of Examination (CoE) or his nominee, *Special Invitee*
Jawaharlal Nehru University, New Delhi - 110 067

Mr. Naresh VS, *Secretary*
Administrative Officer (i/c), RRI

Organisation

A&A and Library
Biman Nath

LAMP
Reji Philip

SCM
Ranjini Bandyopadhyay

TP
Madhavan Varadarajan

EEG
A. Raghunathan

GBD Field Station
T. Prabu (Officer-in-charge)

Accounts
Suresh Varadrajan

Purchase
C.N. Ramamurthy

Executive Assistant
VG Subramanian

Administration
Naresh V.S.

Stores
B.S. Murthy

Director
Tarun Souradeep

Establishment
Sachin S Belvadi

IT & Computing
Jacob Rajan

MES
Mohamed Ibrahim

Faculty Academic Affairs Coordinator
Biman Nath (Admin Associate - V G Subramanian)

Research Program & Facilities Coordinator
Biswajit Paul (Till 22 August 2022); Reji Philip (From 23rd August 2022 (Admin. Associate - V G Subramanian)

Doctoral and Postdoctoral Program Coordinator
Sadiqali Rangwala (Till 23 November 2022); Director (From 24 November 2022) (Admin Associate – Shailaja V S)

Amenities & Infrastructure Coordinator
Shiv Sethi (Admin Associate - Sachin Belvadi)

Computing Facility and IT Infrastructure Coordinator
Sanjib Sabhapandit (Admin Associate - Jacob Rajan)

RRI Science Forum
Gautam Soni, Andal Narayanan, Nayantara Gupta

Colloquia
Ranjini Bandyopadhyay (Chair), Sanjib Sabhapandit, Urbasi Sinha, Vikram Rana

Hostel Wardens
Shiv Sethi, Arun Roy, Pramod Pullarkat

Admissions Coordinators
Ranjini Bandyopadhyay, Saurabh Singh

Students Academic Affairs Committee
Sadiq Rangwala (Chair), Pramod Pullarkat, Shiv Sethi, Reji Philip, Sanjib Sabhapandit (Till 7 December 2022)

Doctoral Program Monitoring Committee
Sayantan Majumder, Sanjib Sabhapandit, Urbasi Sinha, Vikram Rana (SAAC changed to DPMC from 8 December 2022)

In-House meeting
PhD students - 3rd year

Joint Astronomy Programme Representative of RRI
Vikram Rana

Complaints Committee
Srivani K S (Chair), Naresh V S, Vasudha K N, Mamatha Bai R, Bhanu Ravinder (External member)

Overseas Travel Committee
Biswajit Paul (Chair), Reji Philip, Supurna Sinha

Evaluation Committee
Sumati Surya (Chair), Sadiq Rangwala, Sayantan Majumdar, Vikram Rana

Coordinators of Visiting Students Programme
Naresh V S

RRI Official Language Implementation
Naresh V S, Suresh Varadarajan, C N Ramamurthy, B Srinivasamurthy, Shailaja V S, Gayathri G, Harini Kumari, Mamatha Bai R.

Sports Committee

Sayantan Majumdar (Chair), V G Subramanian, Sachin Belvadi, Saumya Ranjan Behera, Bapan Debnath (till 19 July 2022), Mukesh Singh Bishta and Maitri Mandal (from 20 July 2022)

Anti-ragging Committee

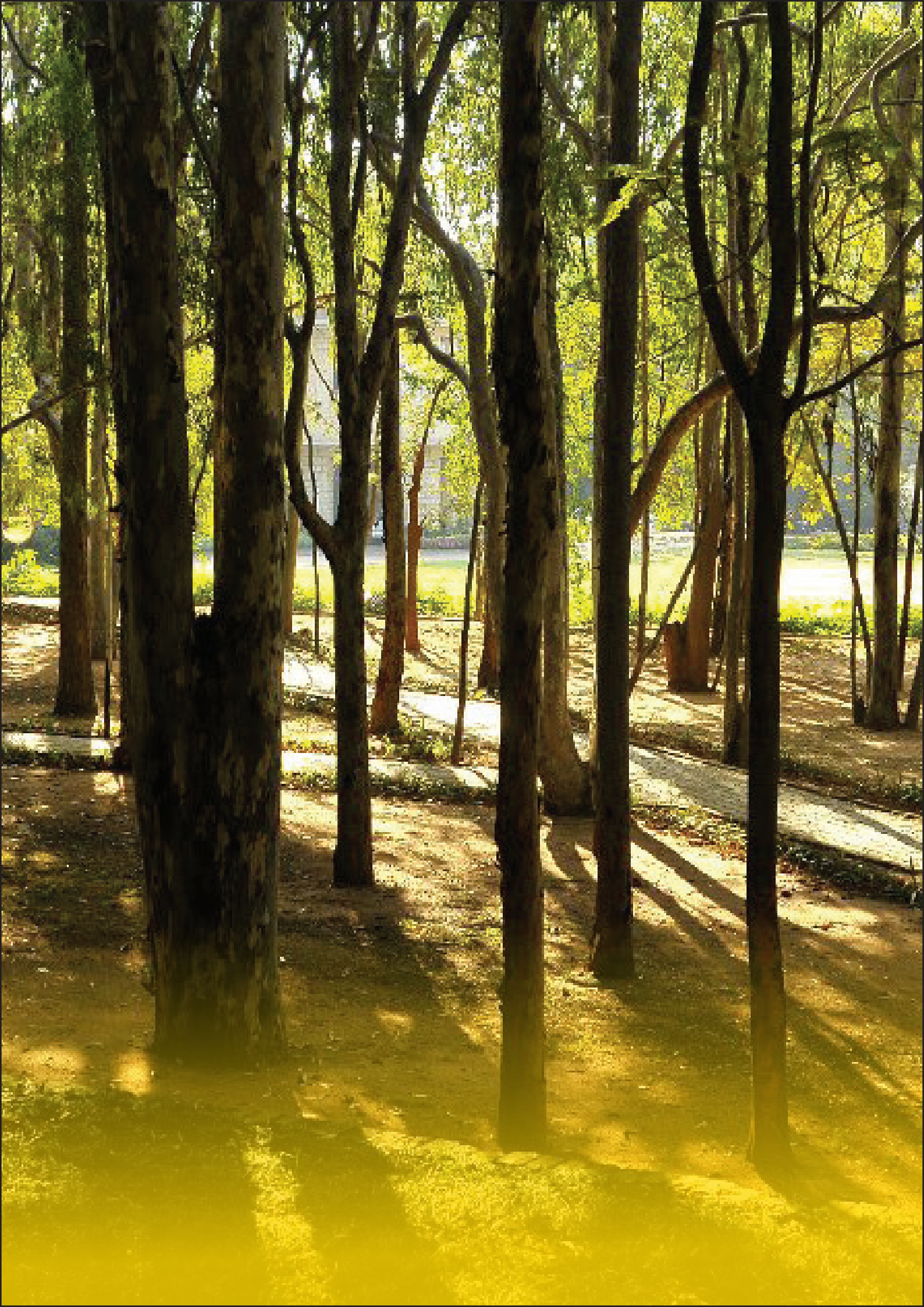
Director (Chair), Chandrashekar M R (External Member), Ranjini Bandyopadhyay, Srivani K S, Saumya Ranjan Behera, Palak

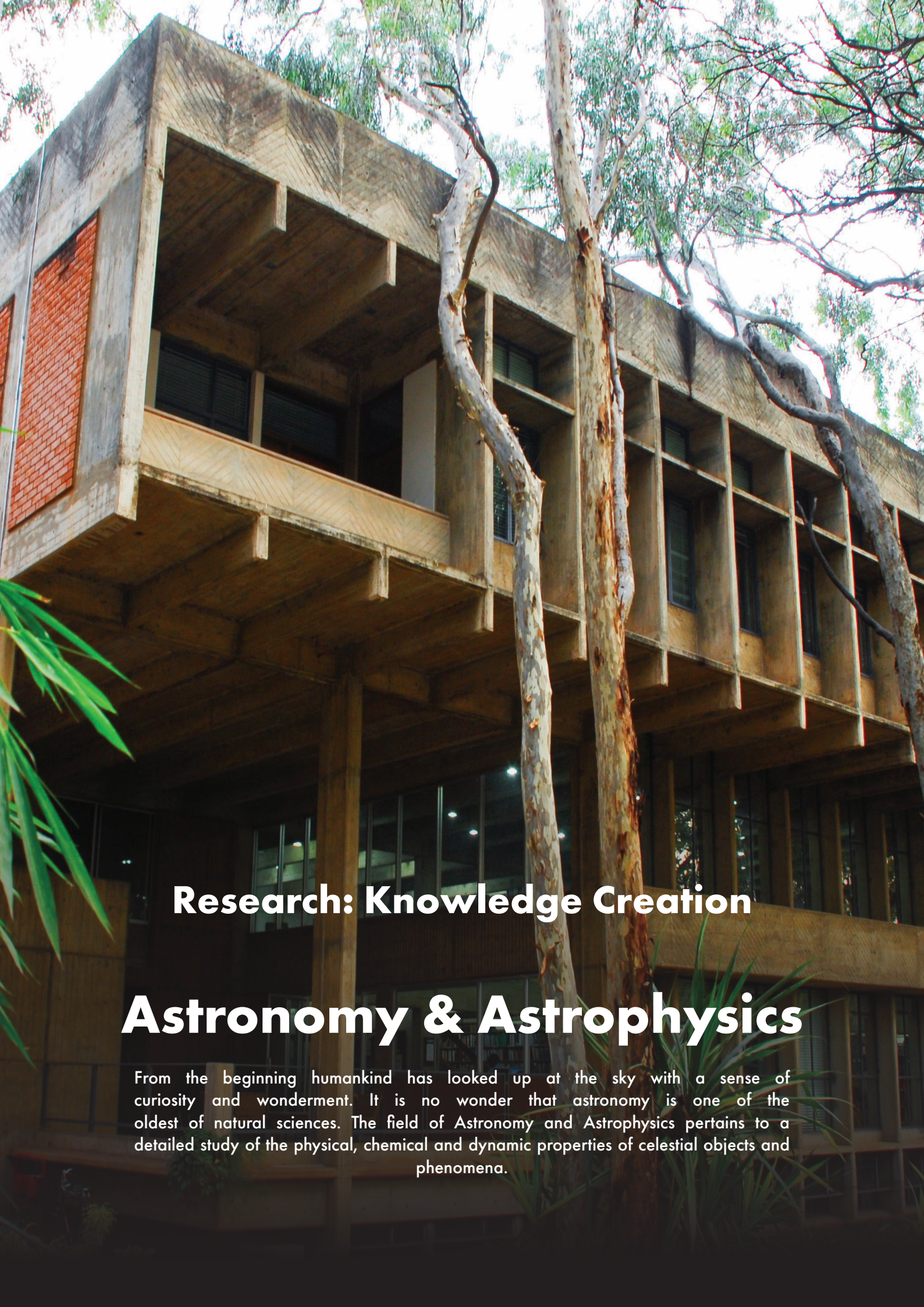
Canteen Committee

Shiv K Sethi (Chair), Ranjini Bandyopadhyay, Sachin Belvadi, V G Subramanian

Equity, Diversity and Inclusion

Ranjini Bandyopadhyay (Chair/Co-ordinator) Mamata Bai (Admin Associate), Prajwal Shastri (Ombudsperson)





Research: Knowledge Creation

Astronomy & Astrophysics

From the beginning humankind has looked up at the sky with a sense of curiosity and wonderment. It is no wonder that astronomy is one of the oldest of natural sciences. The field of Astronomy and Astrophysics pertains to a detailed study of the physical, chemical and dynamic properties of celestial objects and phenomena.

Extreme Astrophysical Processes in X-ray Binaries

An X-ray Polarimeter instrument, POLIX, has been developed at RRI. It will be launched onboard the upcoming ISRO mission XPoSat. X-ray Polarimetry is a new tool in the study of extreme astrophysical processes around compact stars.

Some of the most extreme astrophysical processes take place around compact stars in binary stellar systems. We investigate these objects using spectroscopic and timing data from a variety of space X-ray observatories. In the coming years, X-ray polarimetry will be a new tool in high energy astrophysics. POLIX works on the principle of anisotropic Thomson scattering of polarized X-rays and it will operate in the energy range of 8-30 keV. The POLIX instrument has been developed at RRI and building its flight model is complete and its space qualification tests were conducted successfully.

POLIX will be very useful for measurement of the degree and direction of the X-ray polarisation of bright cosmic X-ray sources, including accretion powered binary X-ray pulsars, galactic black hole candidates, rotation-powered pulsars and magnetars, supernova remnants and pulsar wind nebulae, and active galactic nuclei. For each of these sources, many details are known but some very crucial information is missing that can be learnt only from X-ray polarisation measurements.

The Imaging X-ray Polarimetry Explorer (IXPE) mission of NASA, launched in December 2021, has started exploring this relatively unexplored area of high energy astrophysics and has detected polarized X-rays in the 2-8 keV band in almost all different classes of X-ray sources. The POLIX instrument onboard XPoSat will make complimentary observations in the 8-30 keV band in a few dozen such sources. In many sources, the hard X-rays are expected to have a larger degree of polarization.

With the launch of POLIX, there will be broadband polarization data for many X-ray sources leading to excellent improvement in our understanding of the emission mechanism in these classes of astrophysical X-ray sources.

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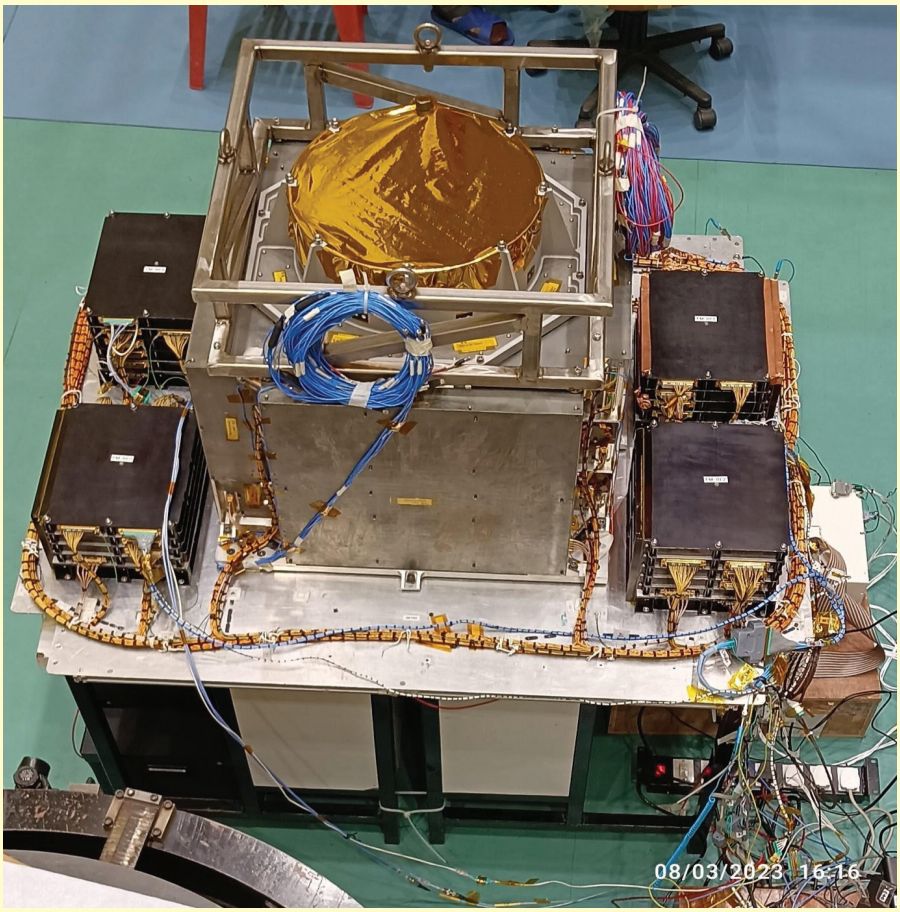

Figure: The Flight Model of POLIX undergoing Integrated Bench Test

Selected Publications:

1. Synchrotron cutoff in Ultraluminous X-ray sources, Tanuman Ghosh, Shiv Sethi, Vikram Rana, 2023, Astrophysical Journal (in press)

2. Changes in the distribution of circum-binary material around the HMXB GX 301-2 during a rapid spin-up episode of the neutron star, Hemanth Manikantan, Biswajit Paul, Kinjal Roy, Vikram Rana, 2023, Monthly Notices of the Royal Astronomical Society, 520, 1411

3. NuSTAR discovery of a cyclotron line in GRO J1750-27, Ashwin Devaraj and Biswajit Paul, 2022, Monthly Notices of the Royal Astronomical Society Letters, 2022, 514, L46

Experimental cosmology

Understanding the formation of first stars and galaxies has been often referred to as the final frontier in observational cosmology.

Referred to as the cosmic dawn, this period has several long-standing questions. These include understanding star formation in pristine environments, their impact at large distances and finally, a timeline for various events that occurred over this period.

21-cm radiation from neutral hydrogen is an extremely promising tool to study the formation of first stars. However, its faint amplitude makes its detection a daunting task. Such a detection requires custom radiometers that can be calibrated and characterized to 1 part in a million.

Raman Research Institute is a world leader in designing and developing precision radiometers. The CMB DISTORTION laboratory at RRI is a front-runner in 21-cm cosmology.

Over 2022-23, we carried out extensive analysis of the data from RRI's indigenously-built SARAS telescope. Astrophysical models, including galaxies that are bright in radio wavelengths, were used to constrain the properties of the very first sources of radiation. We modelled data from SARAS 3 to throw light on the energy output, luminosity and masses of the first generation of galaxies that are bright in radio wavelengths. Using this data, constraints were placed on the masses of the early galaxies, along with limits on their energy outputs across radio, X-ray, and ultraviolet wavelengths. The findings were published in the Nature Astronomy journal [1]. A similar analysis with SARAS 2 datasets disfavoured models with low flux of the stars in UV wavelengths and weak heating of the gas in the intergalactic medium [2].

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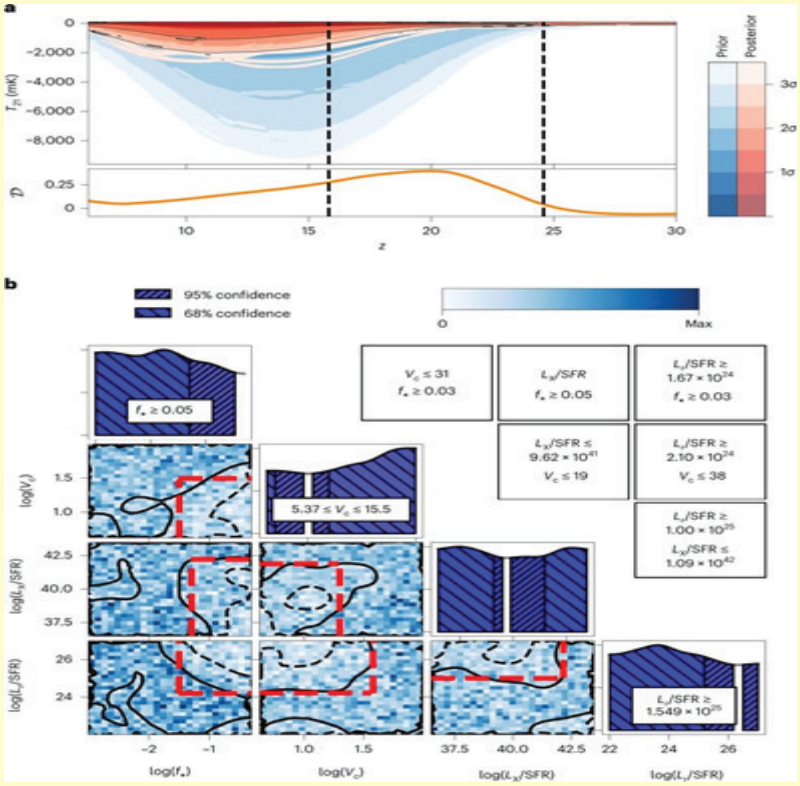

Figure: 1 (a) shows the 21-cm signals as constrained by SARAS. (b) shows astrophysical parameters constrained.

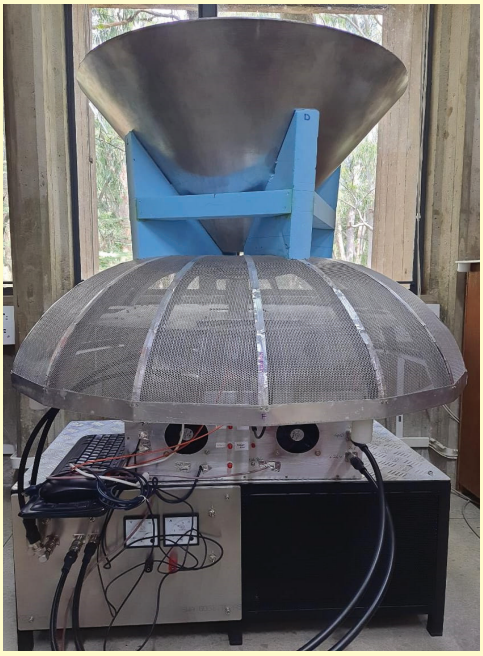

Figure 2: The laboratory model of PRATUSH undergoing testing at RRI

Complementary to SARAS, RRI has proposed PRATUSH, a space-based experiment to detect the global 21-cm signal in the pristine environment offered by the lunar farside. The PRATUSH instrument has been designed, a laboratory model ready and has been undergoing tests. PRATUSH-1 is being proposed as an Earth orbiter which will be succeeded by PRATUSH-2 for a lunar launch. To investigate the effect of RFI primarily resulting from FM radio transmission on PRATUSH-1, we have developed 'STARFIRE' - an algorithm to identify the most suitable orbits around Earth to maximise scientific returns [3].

We have analysed 94 nights of observations from the HERA telescope to yield the most sensitive limit on the amplitude of the 21-cm power spectrum across all the experiments and ruled out a large set of scenarios corresponding to poor X-ray efficiency [4]. We have also investigated a model where the global signal detection experiment can be co-located with the upcoming mega-radio telescope the Square Kilometre Array Low in Western Australia. Co-locating an array of outriggers with the SKA-Low would have several advantages including RFI excision in the global experiment and improving SKA science capabilities with the custom receivers in the outriggers [5].

Selected Publications:

1. Bevins, H. T. J., Fialkov, A., de Lera Acedo, E., et al. Astrophysical constraints from the SARAS 3 non-detection of the cosmic dawn sky-averaged 21-cm signal, 2022b, Nature Astronomy, 6, 1473

2. H. T. J. Bevins, E. de Lera Acedo, A. Fialkov, W. J. Handley, Saurabh Singh, Ravi Subrahmanyan, Rennan Barkana, A Comprehensive Bayesian re-analysis of the SARAS2 data from the Epoch of Reionization, 2022a, Monthly Notices of the Royal Astronomical Society, 513, 4507

3. Ghosh, Sonia, M. Sathyanarayana Rao, and Saurabh Singh, STARFIRE: An algorithm for estimating radio frequency interference in orbits around Earth, 2023 , Astronomy and Computing, 100727

4. HERA collaboration, Improved Constraints on the 21 cm EoR Power Spectrum and the X-Ray Heating of the IGM with HERA Phase I Observations, 2023, The Astrophysical Journal, 945, 124

5. Rao, M. S., Shankar, N. U., Subrahmanyan, R., & Singh, S. 2023, Detecting global signal from cosmic dawn and epoch of reionization with SKA, Journal of Astrophysics and Astronomy, 44, 24

6. CHIME/FRB collaboration, Sub-second periodicity in a fast radio burst, 2022, Nature, 607, 256

Cosmic Accelerators in Space

Study of Blazars using multi-messenger astronomy

The cosmic ray group has studied and worked on unidentified gamma-ray sources in our Galaxy inorder to reveal their characteristics which are helpful in identifying them.

We have also worked on some Blazars located far away from our Galaxy to understand their emission mechanisms using multi-messenger astronomy.

TXS 0506+056 is the well known Blazar from which the IceCube detector located at the South Pole detected astrophysical neutrinos. The group re-evaluated this source as an emitter of astrophysical neutrinos using the latest flare data recorded by the MAGIC experiment in December 2018.

A detailed study of another Blazar, Mrk 180, was speculated earlier to be a source of ultrahigh energy cosmic ray events. It was found that the proton-proton interactions inside this source could be the underlying mechanism of gamma-ray production.

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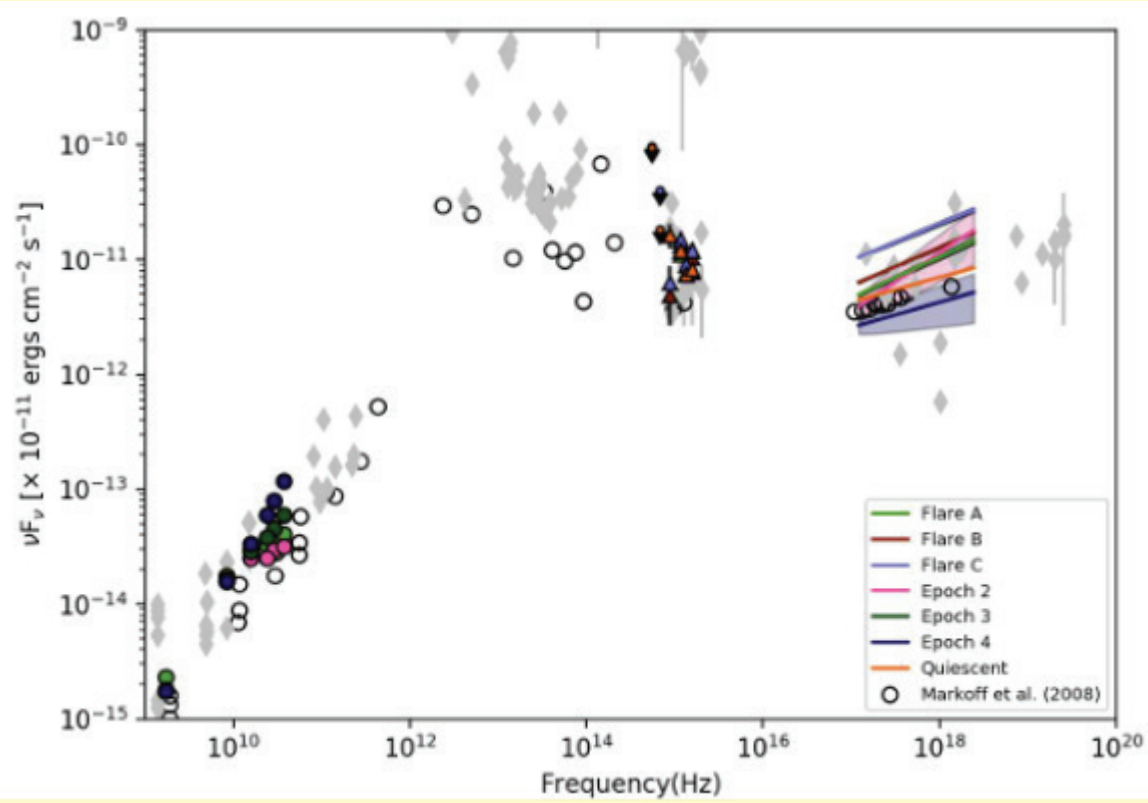


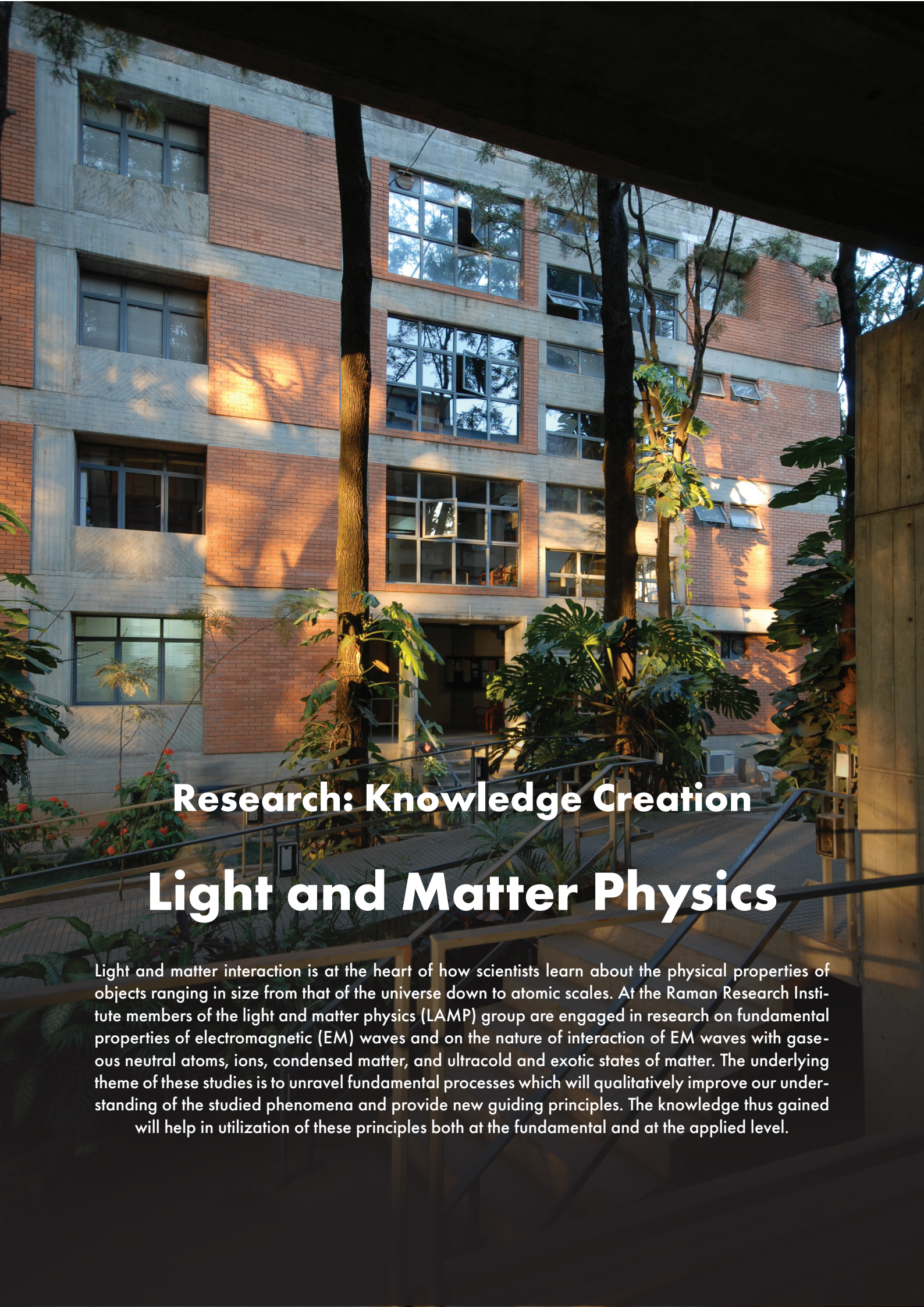
Figure: The multi-wavelength data of M81 at different epochs and flaring periods are shown in color. In the X-ray band, the power law component of the X-ray spectrum obtained in these different states has been shown, with the shaded region representing the errors at 90% confidence level (2.706σ). The simultaneous multi-wavelength data from Markoff et al. (2008) at a quiescent period are also shown by open circles for reference. The gray diamonds are the archival data obtained from NASA/IPAC Extragalactic Database (NED), shown here as a secondary constraint for modeling at the frequencies where the simultaneous/quasi-simultaneous data are not available*

Selected Publications:

1. Gunjan Tomar and Nayantara Gupta, ApJ 2023, " X-ray flares in long-term light curve of low luminosity AGN - M81*"

2. Sandeep Kumar Mondal, Saikat Das and Nayantara Gupta, ApJ 2023,"Exploring the Emission Mechanisms of Mrk 180 with long term X-ray and gamma-ray data"

3. Aditi Agarwal et al., ApJS 2023, "Analysis of the intra-night variability of BL Lacertae during its August 2020 flare"



Research: Knowledge Creation

Light and Matter Physics

Light and matter interaction is at the heart of how scientists learn about the physical properties of objects ranging in size from that of the universe down to atomic scales. At the Raman Research Institute members of the light and matter physics (LAMP) group are engaged in research on fundamental properties of electromagnetic (EM) waves and on the nature of interaction of EM waves with gaseous neutral atoms, ions, condensed matter, and ultracold and exotic states of matter. The underlying theme of these studies is to unravel fundamental processes which will qualitatively improve our understanding of the studied phenomena and provide new guiding principles. The knowledge thus gained will help in utilization of these principles both at the fundamental and at the applied level.

Quantum Technologies with Ultra-cold atoms

Using Laser cooling and trapping techniques, we trap and cool neutral atoms to temperatures in the micro-Kelvin regime to explore the quantum world and demonstrate applications in measuring tiny magnetic, electric and electromagnetic fields reliably.

Our subtheme consists of two main experimental set-ups: (a) Simultaneous laser cooling and trapping of neutral Sodium and Potassium atoms (QuMiX) and (b) Rydberg excitation in thermal and cold Rubidium atoms (Rydberg Lab).

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(a) QuMiX: This is a newly built state-of-the-art experimental facility [1] where we simultaneously cool and trap two separate species of neutral atoms – sodium and potassium – near absolute zero temperature. Interspecies interactions between these two species of cold atoms via photon exchanges have already been experimentally studied. At present, we are trapping these atoms in arbitrary structured optical potential, implementing further cooling techniques to create Bose-Einstein condensate mixtures and investigating the spin correlations for improving upon our previously published results on Quantum sensing and magnetometry.

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(b) Rydberg Lab: This is also a new laboratory where we have demonstrated creation of highly excited Rydberg atoms [2] in thermal vapor, and very recently in the cold cloud of Rubidium atoms. This is the first, and till date the only laboratory in India, where cold Rydberg atoms have been created. Rydberg atoms are futuristic quantum systems where many aspects of Quantum Technologies including Quantum Computing, Quantum Sensing and Quantum Simulations can be developed and RRI is presently in the global race in doing so having developed this experimental facility. Already, in our laboratory high resolution magnetic sensing and quantum interference experiments via Electromagnetically Induced Transparency (EIT) studies have been performed and at present the results are being written up for future publications.

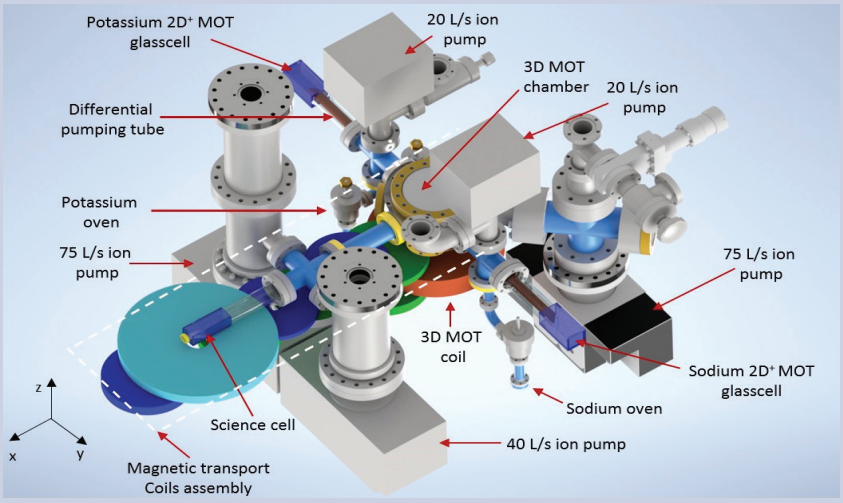

Figure 1: The schematic diagram giving a comprehensive overview of the QuMiX experimental set-up

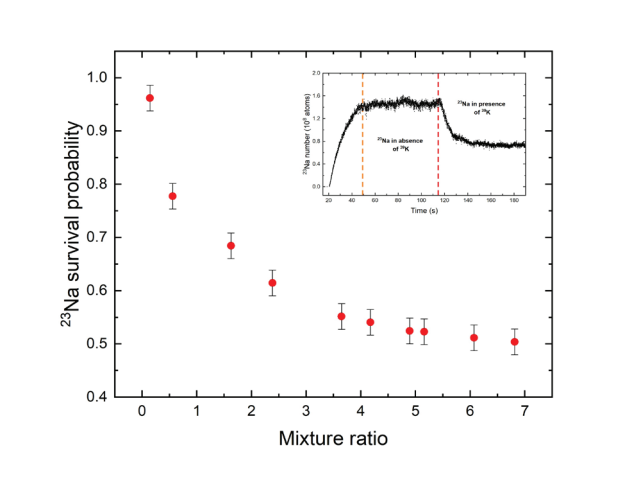

Figure 2: Photon-assisted interspecies interaction between ultra-cold atoms studied as a function of "mixture ratio" (the relative numbers of cold potassium atoms immersed in the bath of cold Sodium atoms). As this ratio increases the survival probability of a Sodium cold atom in trap decreases indicating the role of inter-species off-resonant interactions. (inset) A representative raw data of atom numbers in trap. These interactions are practically impossible to detect in room temperature samples. These experiments demonstrate the advantages of cold atom experiments to detect correlations and interactions which is essential to understand and develop quantum technologies.

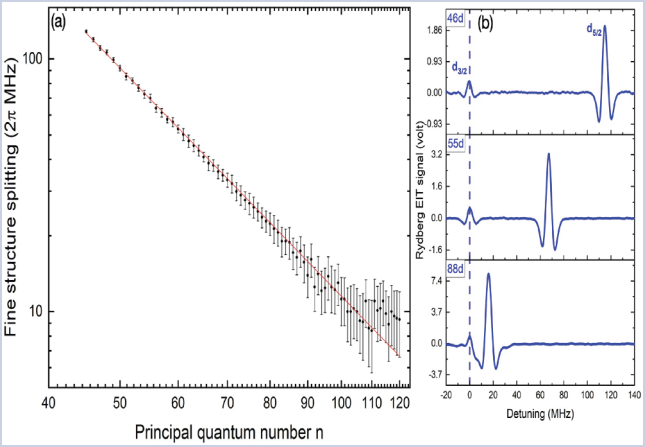

Figure 3: The Electromagnetically Induced Transparency (EIT) signals from Rydberg atoms which allows for precise determination of energy and the corresponding "quantum defect" in highly excited Rydberg atoms. (a) Variation of the fine structure splitting between the $nD_{3/2}$ and $nD_{5/2}$ Rydberg states with the principal quantum number n. The solid line is the fit to the data. (b) Fine structure splitting for three different principal quantum numbers n = 46, n = 55 and n = 88 depicting the decrease in the splitting for higher Rydberg states.

Selected Publications:

1. Fast loading of a cold mixture of Sodium and Potassium atoms from compact and versatile cold atomic beam sources, S Sutradhar, A Misra, G Pal, S Majumder, S Roy, S Chaudhuri, arXiv preprint arXiv:2210.14084 (Accepted for publication in AIP Advances, featured article in journal)

2. Transition frequency measurement of highly excited Rydberg states of 87Rb for a wide range of principal quantum numbers, Silpa B S, Shovan Kanti Barik, Saptarishi Chaudhuri, Sanjukta Roy, Optics Continuum 1(5), 1176-1192 (2022)

Photonic quantum science and technologies

A single photon or a pair of entangled photons is a ubiquitous workhorse in quantum science and technologies, both for fundamental tests of the principles of quantum mechanics as well as varied applications including secure quantum communications, quantum computing, as well as other quantum information processing protocols. The Quantum Information and Computing (QuIC) lab at RRI is the first lab in India to work on single and entangled photons and their applications, and continues to work on breakthrough research in this domain.

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The year 2022 has been special for the lab and for the photonic quantum information community, in general, with the Nobel Prize in Physics 2022 being awarded to stalwarts from this field. The Nobel Prize was awarded jointly to Alain Aspect, John F. Clauser and Anton Zeilinger for "experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science".

Given that QuIC lab has been focusing on this exact field and we have been exploring new frontier avenues in the domain for several years, I was invited to write a review article on the experiments that led to the Nobel Prize in Physics 2022 [1]. We have also authored an encyclopedia chapter on photon sources for quantum technologies [2] and book chapters on the topic in the prestigious Progress in Optics [3].

One of our main research results this year has been in the domain of higher dimensional quantum information processing (QIP). Simply put, we usually hear of a "qubit" or the quantum bit which is essentially a two-dimensional system in coherent superposition of two basis states. With "n" qubits, we can achieve a 2n dimensional state space, that is, for instance, responsible for the exponential power of a quantum computer.

In our lab, we are working on an exciting alternative approach which uses more than two basis states. Thus, instead of a "qubit", we form what is called a "qudit", where the dimension is greater than 2. There are many advantages to this and one can find some details here [4]. Higher dimensional QIP has proven advantages in quantum computing as well as secure quantum communications with promises of higher key rate and lower QBER (Quantum Bit Error Rate) than the qubit-based protocols. Thus experimentally realising higher-dimensional entangled states along with the studies of quantification of the entanglement are of critical importance.

So far, all the relevant investigations towards quantifying entanglement globally have mainly focused on providing bounds (maximum/minimum) on entanglement measures. The existing method of characterising the quantum state is Quantum State Tomography (QST), which can then be used to quantify entanglement. It requires the determination of an increasingly large number of parameters as the dimension of the system grows. A method for empirical estimation of entanglement for any arbitrary dimensional entangled state was not available.

In our recent work [5], we have formulated analytical relations between statistical correlation measures and known entanglement measures for any arbitrary dimension. By using just two sets of measurements, we have experimentally quantified the amount of entanglement in a pair of three-dimensional photonic qutrits using an experimental architecture that we have indigenously developed in a bottom-up approach [6]. Our new method gives a more experimentally friendly and less cumbersome alternative to QST. For the first time, it experimentally demonstrates non-equivalence between different measures of entanglement in a higher dimensional quantum state [5].

The results shed deeper understanding of how entanglement is to be quantified and also, on how to better assess the efficacy of an entangled state for a given technological application, for instance, quantum communication protocols like quantum teleportation (a technique for transferring quantum information from a sender at one location to a receiver some distance away) where the success and accuracy of the process depend on the amount of entanglement.

In another result this year, also related to higher dimensional QIP, we were able to theoretically devise new means of controlling decoherence (interaction of a system with the environment leads to a loss in the coherence of the system) in such entangled systems [7]. As decoherence is one of the fundamental deterrents to several applications in QIP including quantum computing and quantum communications, our new methods are expected to play a significant role in improving the performance of such systems.

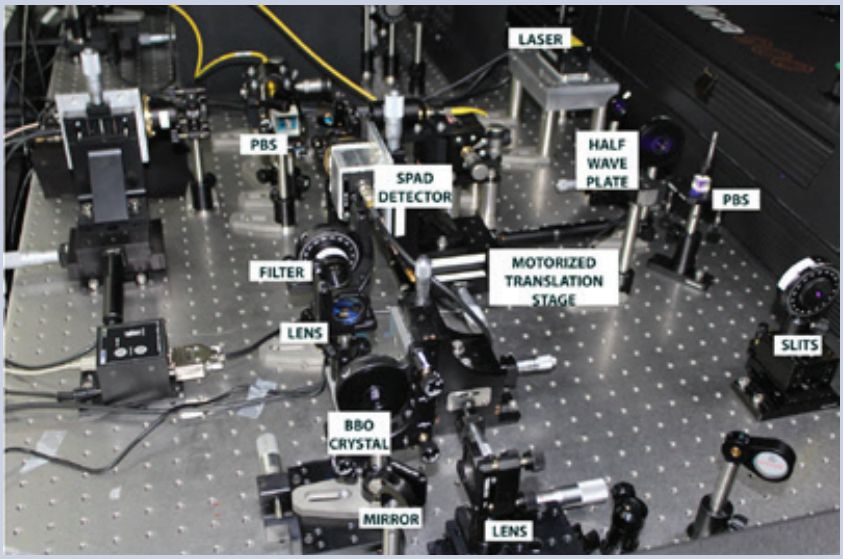

Figure: An actual photograph of the indigenously developed photonic spatial qudit architecture at the Quantum Information and Computing lab, RRI Bangalore.

Selected Publications:

1. The experiments that led to the Nobel prize in Physics 2022, Urbasi Sinha, Resonance, 28 (1), 2023

2. Photon sources for quantum technologies, Urbasi Sinha, Encyclopaedia of Materials: Electronics, ISBN: 9780128197288, 2023

3. Photon sources and their applications in quantum science and technologies, Urbasi Sinha, SR Behera, Mehak Layal, Progress in Optics, Book chapter 2023

4. Quantum Slits open New Doors, Urbasi Sinha, Scientific American (invited article), January 2020 issue

5. Direct determination of entanglement monotones for arbitrary dimensional bipartite states using statistical correlators and one set of complementary measurements, D. Ghosh, T.Jennewein, Urbasi Sinha, Quantum Science and Technology, 7 045037, 2022

6. Correlated photonic qutrit pairs for quantum information and communication, D.Ghosh, T.Jennewein, P.Kolenderski and Urbasi Sinha, OSA Continuum 1 (3), 2018

7. Entanglement protection in higher dimensions, A. Singh and Urbasi Sinha, Physica Scripta, 97, 085104, 2022

Research: Knowledge Creation

Soft Condensed Matter

Soft matter, as the name implies, encompasses materials that are easily deformed by thermal fluctuations and external forces. Some common examples of soft matter that we use in our day-to-day life include lotions, creams, polymer melts or solutions, paint and many biological materials like cells and tissue. The building blocks of these materials are macromolecules with typical size ranging anywhere from few nanometers to few micrometers and are held together by weak inter macromolecular forces and exhibit complex structures and phase behavior. The SCM group at RRI actively studies colloids, complex fluids, liquid crystals, nanocomposites, polyelectrolytes, self-assembled systems, polymers and biological materials. A fundamental understanding of the structure- property correlations, phase behavior of these systems, and response to external stimuli form a major part of the experimental research activities in the SCM group. Theoretical work carried out by the group broadly concerns developing phenomenological theories of elasticity and topological defects in soft matter

Nanoscale Biophysics

Biophysical forces play a vital role in formation of cellular and molecular structures and their synergy with biological function. Research efforts, with novel nano- and micro-scale tools, are ongoing to understand force-sensing and response in biological model systems of protein-DNA assemblies as well as whole cell mechano-sensing.

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This year, we are excited to report our recently completed work on temperature control of the new gene-editing tool, the CRISPR-Cas9 system and the study of electrostatic interactions responsible for breaking down single molecules of nucleosome arrays (DNA-protein complexes).

CRISPR-Cas9 technology has been successfully used for many applications such as the basic studies of gene function and genome editing in agriculture as well as medicine. We presented, to our knowledge, a very first detailed report on the temperature-dependent binding and release of cleaved products by Cas9 enzyme. We showed that Cas9 enzyme can find and bind the target DNA sites at a temperature as low as 4°C. This should expand low-temperature application possibilities in this technology. We also demonstrated that the enzyme, post cleavage of DNA, holds-on very strongly to the cleaved ends. The products can be controllably released in a temperature or denaturant dependent manner. We are excited about this crucial advance of this platform into the forefront of biomedical and analytical biotechnology, in both in-vivo and in-vitro applications.

In another project, we investigated the molecular interactions responsible for the intra- and inter-nucleosomal stability in chromatin structure. In the case of chromatin, the location and structural variations of nucleosomes play a key role in the DNA compaction, its accessibility for protein expression, etc. Using nanopores, we have demonstrated, for the first time, the force spectroscopy of nucleosome array complexes in a substrate-independent manner. We showed that the nucleosomes breakdown into smaller structures in the presence of an extremely high electric field near the nanopore as the oppositely charged DNA (-ve) and histone proteins (+ve) are pulled in opposite directions. The magnitude of pulling force can be controlled by varying the applied voltage. We found that at about 380 mV (19 pN), 50% of the nucleosomes breakdown into smaller structures providing us a quantitative estimate of the molecular stability. These results help us accurately model the genome-scale chromatin folding as well as open technological fronts for developing molecular diagnostic devices to screen for epigenetic biomarkers revealing the onset of certain diseases.

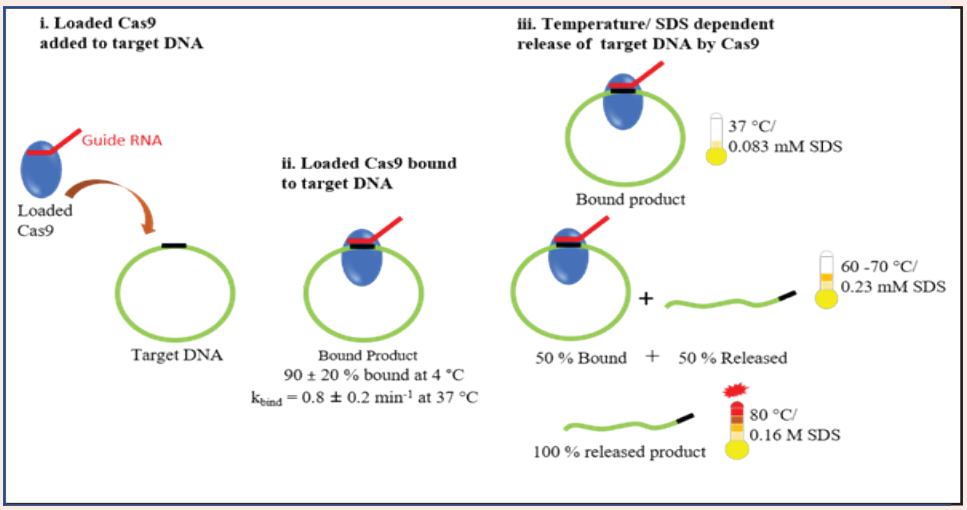

Figure 1: Schematic of the temperature dependent activity of Cas9 enzyme cleaving DNA products [1]

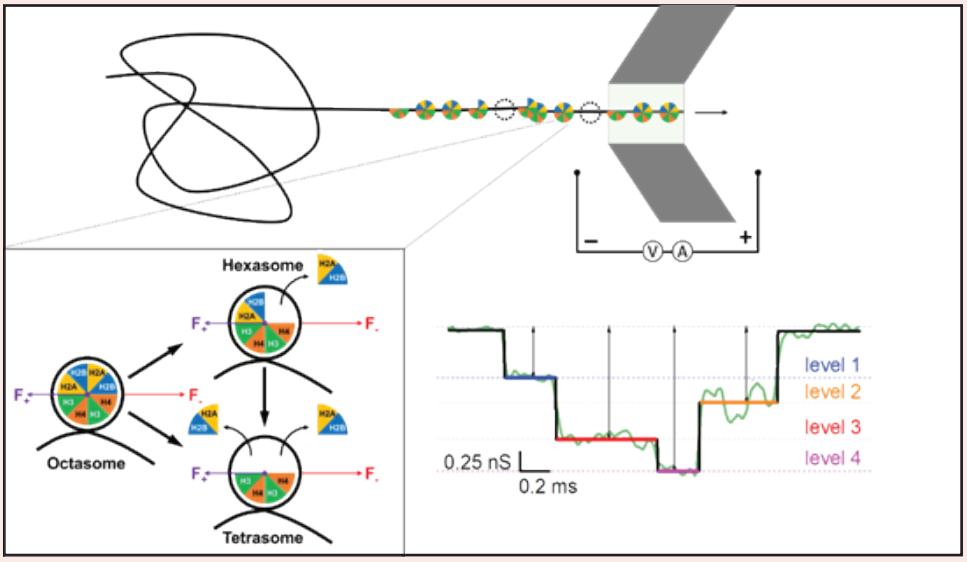

Figure 2: Rupture of single molecules of DNA-nucleosome structures in a voltage dependent manner [2]

Selected Publications:

1. Temperature dependent in vitro binding and release of target DNA by Cas9 enzyme; Serene Rose David*, Sumanth Kumar Maheshwaram*, Divya Shet, Mahesh B. Lakshminarayana & Gautam V. Soni; Scientific Reports (2022) 12, 15243

2. Nanopore sensing of DNA-histone complexes on nucleosome arrays; Sumanth K M, Divya S, Serene R D, Mahesh B L and G V Soni; ACS Sensors, 7 (12), 3876–3884 (2022)

Cell Biophysics

Physicists are making major strides in describing the complex process of life at scales ranging from proteins to cells to whole organisms using increasingly advanced experimental techniques and mathematical modelling.

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The ability of cells to divide, regulate their shape, and locomote is fundamental to the process of life. For this, living cells not only need to generate forces and flows, but also need to be able to switch between fluid-like and solid-like states 'on demand'. This is accomplished by a unique biological matrix called the cytoskeleton, which is composed of highly dynamic biopolymers and associated protein nano-machines called molecular motors. Understanding the dynamics and mechanics of this matrix is critical in learning how living cells function. Taking an inter-disciplinary approach that combines ideas and techniques from biology and physics has resulted in vastly improving our understanding the unique properties of such active systems. Defects in proteins that make up this matrix leads to a wide variety of diseases ranging from cancer to neurodegeneration.

One of the focus areas of the Biophysics activity at RRI is to understand how the cytoskeleton regulates the morphology and dynamics of axons of neuronal cells. In axons, this composite matrix (cytoskeleton) is believed to be maintained in a dynamic steady state, where the filaments undergo polymerisation-depolymerisation cycles and are bi-directionally transported by molecular motors. Previous investigation done in the group has shown that upsetting this dynamics leads to a variety of shape instabilities that resemble those seen under neurodegenerative conditions.

The group had also shown that axons possess unique mechanical properties, imparted by the presence of molecular shock absorbers, which enable them to withstand large stretch deformations. Continuing in these directions, during the last year, the group has now investigated how the composite mature of the axonal cytoskeleton influences its overall mechanics. Using the occurrence of axonal buckling seen upon slackening an axon as a read out we are working on a model that takes into account the differential viscoelastic responses of axonal structural components. Axonal membrane, too, is subjected to fast stretch and excess tension build up and we have recently found that rapid fusion of synaptic vesicles can buffer membrane tension and provide protection. We have also initiated a new project to understand the roles of microtubules *(Figure 1)* in axon degeneration, in particular that caused by chemotherapeutic drugs.

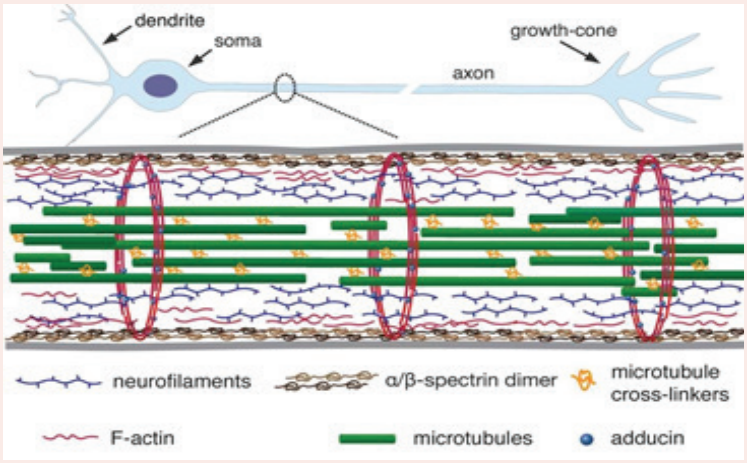

Figure 1: A highly simplified schematic of the axonal cytoskeleton. It consists of periodically arranged rings of actin filaments interconnected by spectrin tetramers, longitudinally aligned microtubules, and neurofilaments. These filaments are interconnected by passive cross-linking proteins and force generating molecular motor proteins. In mature axons, the cytoskeleton is likely maintained in a dynamic steady state, and the stability of the axon is thought to depend on the balance of stresses arising out of polymerisation dynamics and molecular motor activity. Some of the goals of the lab is to understand the mechanical responses of this complex structure and to elucidate the dynamic interactions that influence stability of the axon.

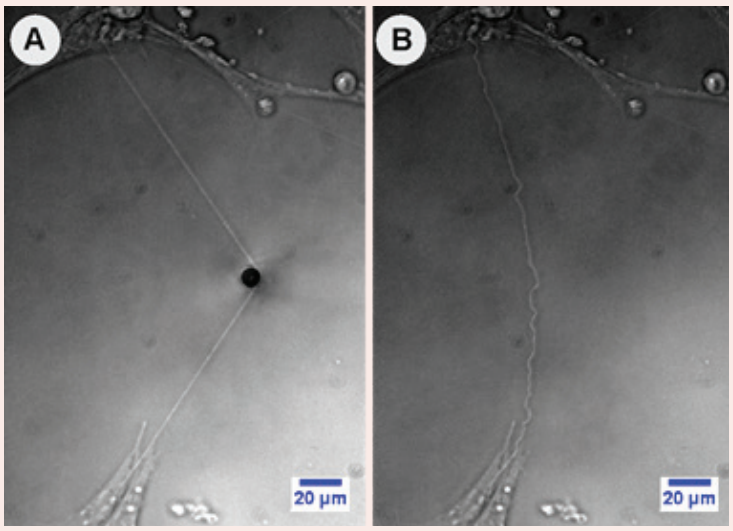

Figure 2: Buckling seen in axons which has been stretched and then released after a 10 min. waiting time. Such buckling is not seen when the axon is released immediately after stretching. Such experiments inform us on the unique structural properties of the axonal cytoskeleton that allows it to cope with stretch deformations.

Selected Publications:

1. The role of mechanics in axonal stability and development; Aurnab Ghose and Pramod Pullarkat; Seminars in Cell and Development Biology (2022), DOI: 10.1016/j.semcdb.2022.06.006

2. The axonal actin-spectrin lattice acts as a tension buffering shock absorber; Sushil Dubey, Nishita Bhembre, Aurnab Ghose, Andrew Callan-Jones, Pramod A Pullarkat; eLife, vol. 9, pp e51772, (2020).

3. The roles of microtubules and membrane tension in axonal beading, retraction, and atrophy; Anagha Datar, Jaishabanu Ameeramja, Alka Bhat, Roli Srivastava, Ashish Mishra, Roberto Bernal, Jacques Prost, Andrew Callan-Jones, and Pramod A Pullarkat; Biophysical Journal, vol. 117, pp 880, (2019).

4. The role of mechanics in axonal stability and development; Aurnab Ghose and Pramod Pullarkat; Review: Seminars in Cell and Development Biology, vol. 140, pp22 (2022).

5. Mechanical role of the submembrane spectrin scaffold in red blood cells and neurons; Christophe Leterrier and Pramod A Pullarkat; Review: Journal of Cell Science, vol. 135, jcs259356 (2022)

Granular and colloidal suspension Rheology

Soft suspensions are characterised by structural complexity and mechanical flexibility. Their study is important from the points of view of their industrial applications and use as model systems.

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Soft materials are ubiquitous in therapeutic, food and personal care industries and serve as useful models in the study of hard condensed matter systems. The easy tunability of interactions between the constituent particles of soft materials easily allows modification of the latter's structure, dynamics and flow properties.

Furthermore, the structure-flow correlations in soft suspensions necessitates close scrutiny of their length scale dependent rheological properties (i.e. flow and deformation behaviours). Simultaneous rheology and dielectric measurements can help relate the bulk flow of the material with shear-induced dipolar fluctuations, thereby enabling the correlation of material properties over several decades in length and time.

The work published by C. Misra, P. Gadige and RB [1] shows that while the dynamics of a microgel suspension slow down considerably under oscillatory shears at nanometer length scales, presumably due to the shear-induced entanglement of individual polymer chains, their dynamics in bulk speed-up substantially due to the rupture of fragile microgel clusters that self-assemble spontaneously in the aqueous suspension.

The work by R Biswas, VRS Parmar, A Thambi and RB [2] employs optical tweezers to show that the microscopic rheology of an aging colloidal soft suspension is extremely sensitive to the size of a trapped probe bead whose nanometer-scale movements are measured accurately to sense the rheology of its environment.

While the above studies addressed fundamental questions related to the properties of soft materials, a clear understanding of the complex flow behaviours of the industrially-important soft materials is key in the control of displacements of soft slurries of , say, clay and cornstarch in the materials processing industry.

Another recent work (Palak, VRS Parmar, D Saha and RB, [3] showed how interfacial instabilities can be enhanced, suppressed and modified by tuning the properties of the displacing fluid and displaced suspension.

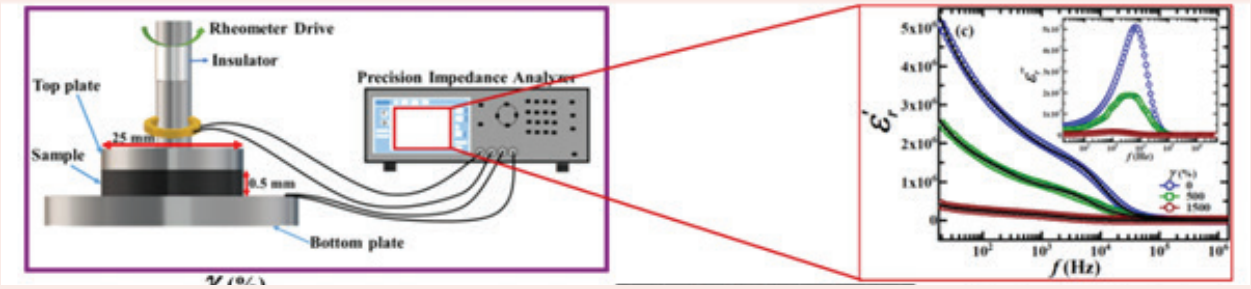

Figure 1: Simultaneous rheology and dielectric spectroscopy experimental setup.

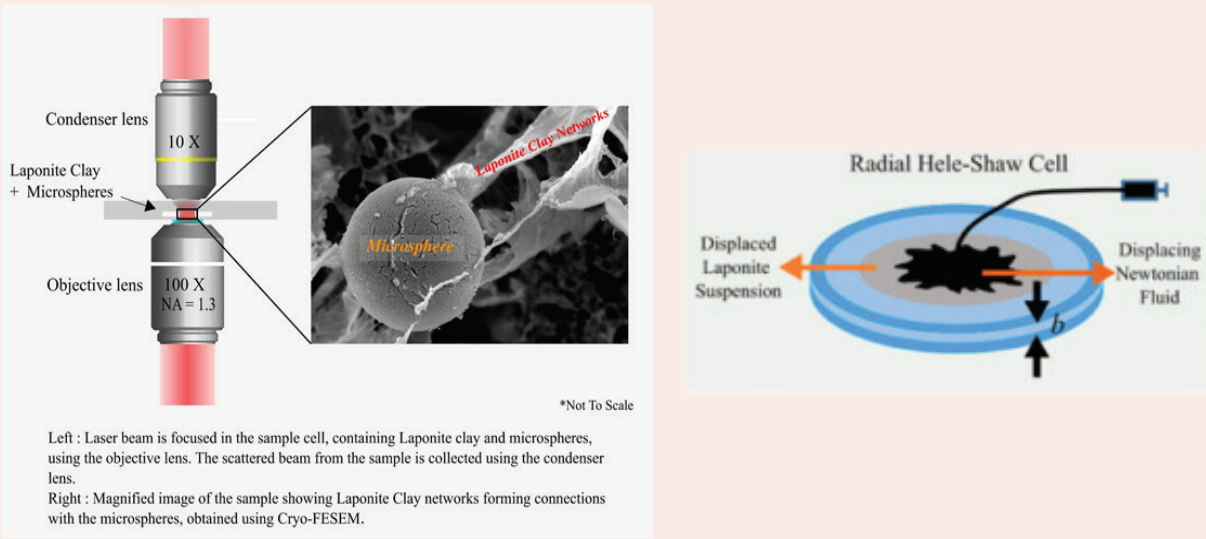

Figure 2: (left) Optical tweezer employed to study the active microrheology of soft glassy suspensions. (right) Hele Shaw cell to study material displacements in confined geometries.

Selected Publications:

1. Dichotomous behaviors of stress and dielectric relaxations in dense suspensions of swollen thermoreversible hydrogel microparticles; Misra C, Gadige P, Bandyopadhyay R; Journal of Colloid and Interface Science, 2023, Vol.630(Pt. A), p223.

2. Correlating microscopic viscoelasticity and structure of an aging colloidal gel using active microrheology and cryogenic scanning electron microscopy; Biswas R, Parmar VRS, Thambi AG, Bandyopadhyay R; Soft Matter, 2023, Vol.19, p2407

3. Pattern selection in radial displacements of a confined aging viscoelastic fluid; Palak, Parmar VRS, Saha D, Bandyopadhyay R; Journal of Colloid and Interface Science Open, 2022, Vol. 6, p100047

Shear induced solidification and relaxation in dense particulate suspensions

The study of transient stress relaxation behaviours of shear jamming states of materials can help them turn smart in nature, with scope of applications in automobile industries, batteries, etc.

Shear stress induced reversible increase in viscosity in dense particulate suspensions have huge potential in designing smart and adaptive materials capable of autonomously tuning their mechanical properties depending on external stimuli. This includes applications in the field of automobile industries, space technologies, stabilizing lithium ion batteries as flexible shock absorbing materials. In many of these applications, understanding the complex relaxation behaviour of these systems is extremely crucial.

Since these materials are close to the jamming transition, the particle-scale dynamics is expected to play an important role. However, the effect of such dynamics in controlling the bulk relaxation remained unknown. Here, we study transient stress relaxation behaviour of shear jamming states formed by a well-characterized dense suspension formed by polystyrene particles in PEG under a step strain perturbation. We observe a strongly non-exponential relaxation that develops a sharp discontinuous stress drop at short time for high enough peak-stress values. High resolution boundary imaging and normal stress measurements confirm that such stress discontinuity originates from the localized plastic events, whereas system spanning dilation controls the slower relaxation process. We also find an intriguing correlation between the nature of transient relaxation and the steady state shear jamming phase diagram obtained from the Wyart-Cates Model.

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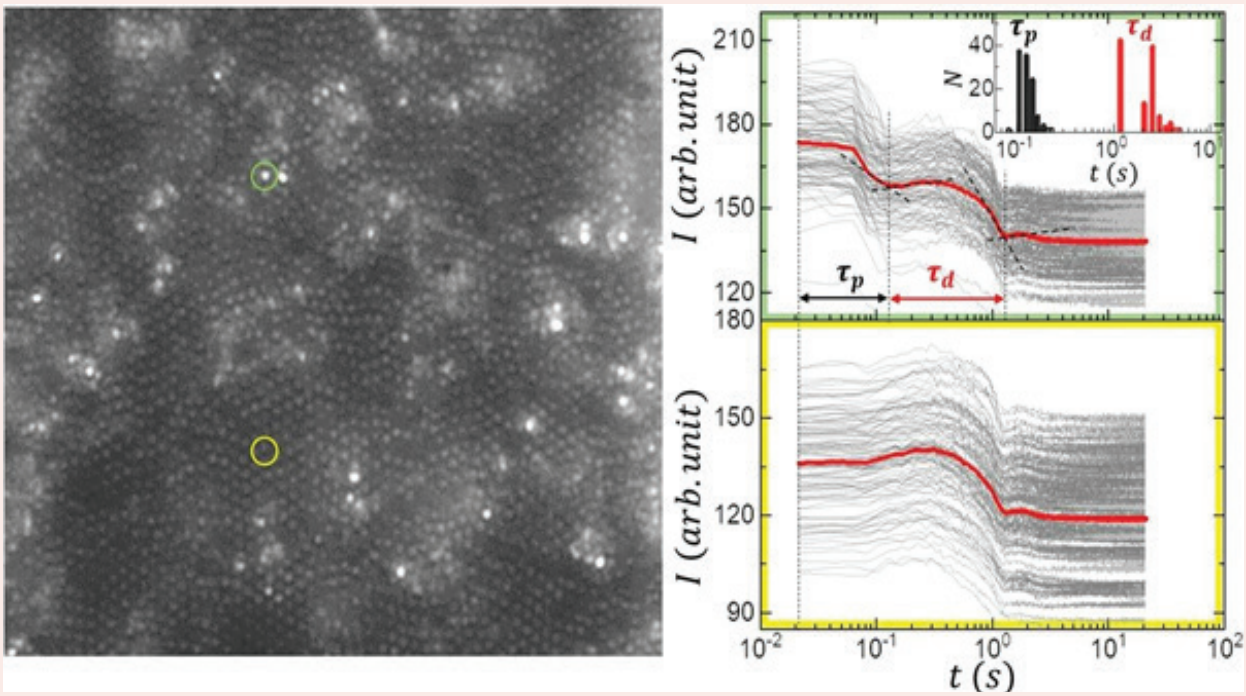
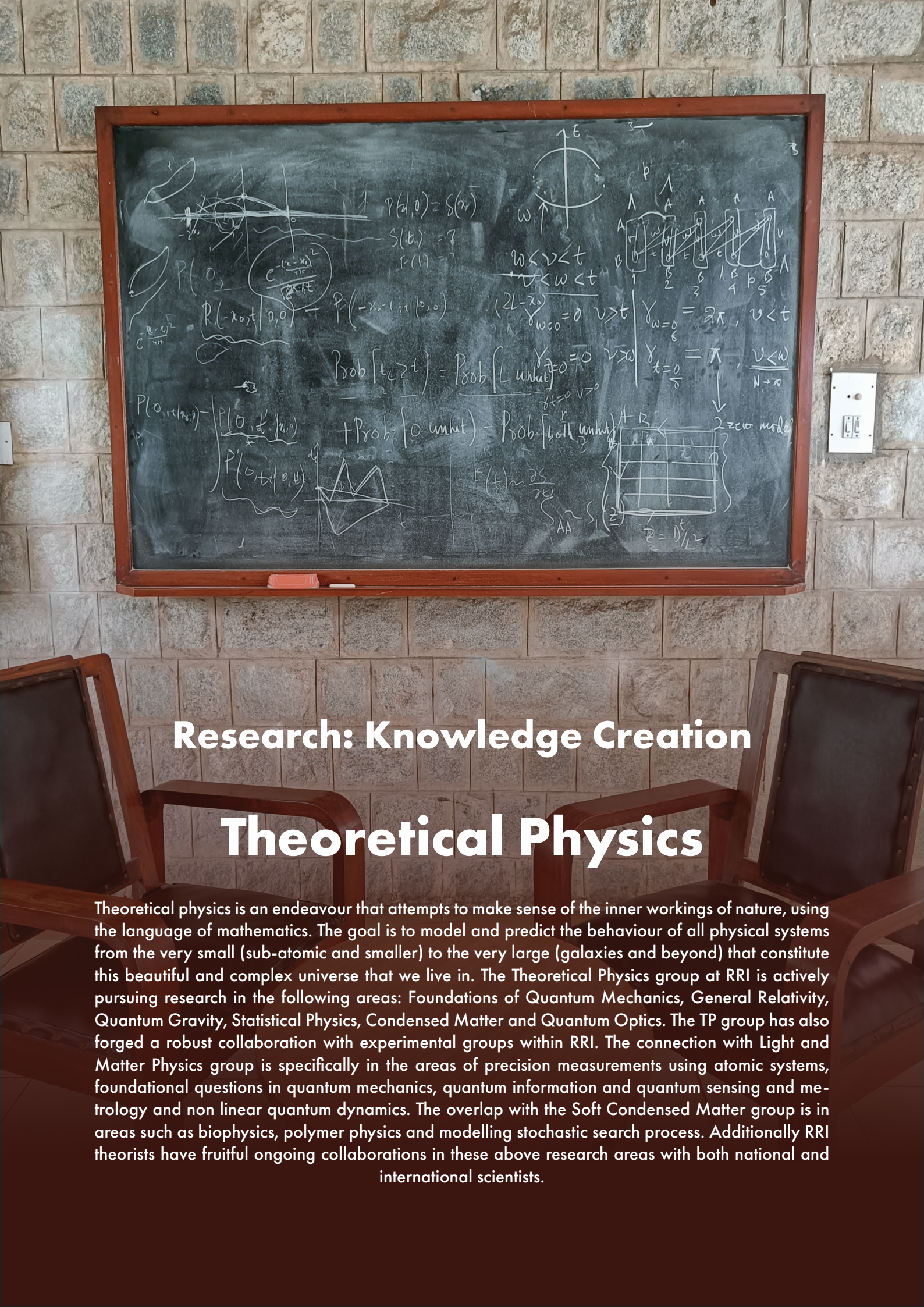


Figure: (Left panel) Typical boundary image of the dense suspension of polystyrene particles in PEG just after applying a step shear strain. The region marked by a green circle contains a plastic center and region encircled by yellow does not have a plastic center. (Right panel, top) the intensity relaxation in regions containing a plastic center and (Right panel, bottom) represents the same for regions that do not contain a plastic center. The size of the particles shown in the left panel is 2.7 μm.

Selected Publication:

Origin of Two Distinct Stress Relaxation Regimes in Shear Jammed Dense Suspensions; Sachidananda Barik and Sayantan Majumdar; Phys. Rev. Lett., 128, 258002, 2022.



Research: Knowledge Creation

Theoretical Physics

Theoretical physics is an endeavour that attempts to make sense of the inner workings of nature, using the language of mathematics. The goal is to model and predict the behaviour of all physical systems from the very small (sub-atomic and smaller) to the very large (galaxies and beyond) that constitute this beautiful and complex universe that we live in. The Theoretical Physics group at RRI is actively pursuing research in the following areas: Foundations of Quantum Mechanics, General Relativity, Quantum Gravity, Statistical Physics, Condensed Matter and Quantum Optics. The TP group has also forged a robust collaboration with experimental groups within RRI. The connection with Light and Matter Physics group is specifically in the areas of precision measurements using atomic systems, foundational questions in quantum mechanics, quantum information and quantum sensing and metrology and non linear quantum dynamics. The overlap with the Soft Condensed Matter group is in areas such as biophysics, polymer physics and modelling stochastic search process. Additionally RRI theorists have fruitful ongoing collaborations in these above research areas with both national and international scientists.

Quantum Chaos

Discovery of a new mechanism for quantum chaotic behavior in periodically modulated one dimensional systems of interacting fermions and bosons.

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Many-body quantum chaos is the relatively new direction of physics research aimed to establish a relationship between the universal spectral (energy level) fluctuations of chaotic quantum systems and the random matrix theory (RMT) for nonintegrable many-particle systems. Recent works have analytically derived the spectral form factor (SFF) characterizing spectral fluctuations in various complex dynamical systems. The computed SFF shows a good match with the suitable RMT form, which is solely determined by the symmetry of underlying dynamical systems.

The study of quantum chaos and its connection to RMT is essential in describing ergodicity and thermalization in closed quantum systems.

We have analytically computed the SFF in periodically kicked fermionic and bosonic [1] chains. We consider a family of models where free fermion or boson Hamiltonian with the nearest neighbor hopping and pairing terms is kicked with the terms diagonal in the Fock space basis, including random chemical potentials and pair-wise interactions. The absence and presence of pairing terms generate particle number conservation and violation, respectively. For intermediate range interactions, random phase approximation can be used to rewrite the SFF in terms of a bi stochastic many-body process generated by an effective bosonic Hamiltonian. In the absence of pairing terms, the effective Hamiltonian has a non-abelian SU(2) or SU(1,1) symmetry respectively for fermionic or bosonic models, resulting in universal quadratic system-size scaling of the Thouless time. The role of these universal non-abelian symmetries in determining the features of spectral fluctuations is the main finding of our studies. In the presence of pairing terms, we find a nontrivial systematic system-size dependence of the Thouless time in the bosonic kicked chains, in contrast to no system-size dependence in the fermionic kicked chains.

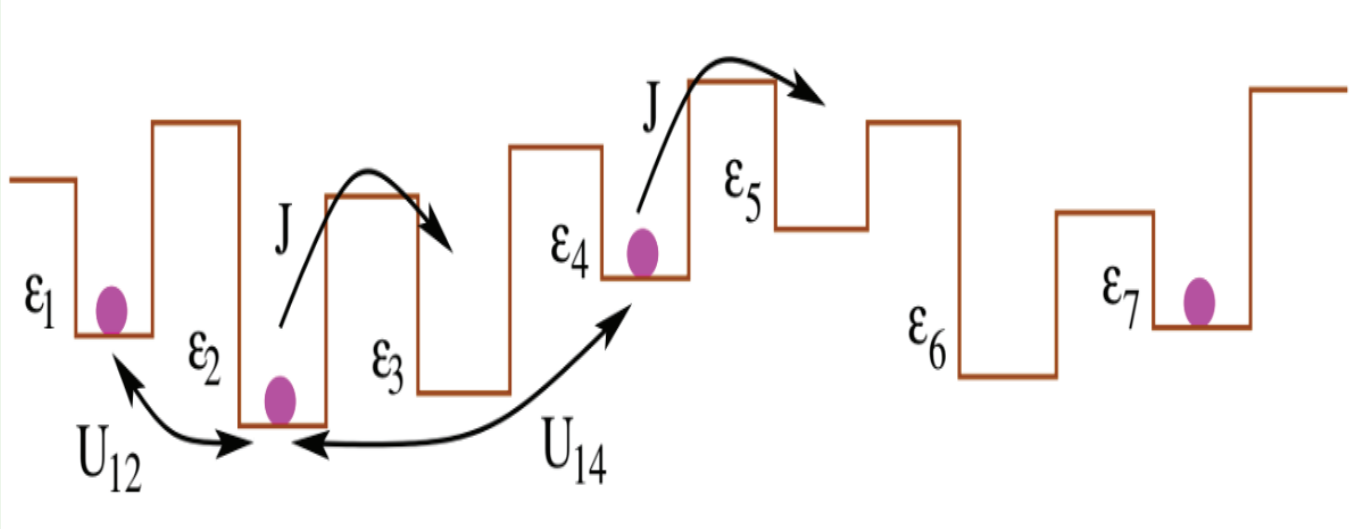


Figure: A one-dimensional lattice of four interacting spinless fermions or bosons (solid dots) in a random potential (ε) and a time-periodic kicking in the nearest-neighbor coupling (e.g., hopping). Here, Uij and J denote interaction between particles and hopping of particle.

Selected Publication:

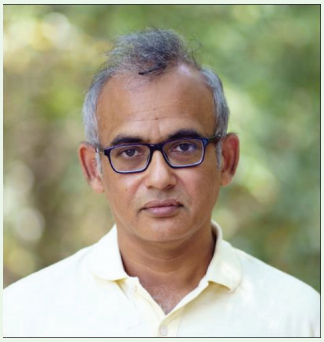
Spectral form factor in a minimal bosonic model of many-body quantum chaos, Dibyendu Roy, Divij Mishra, and Tomaz Prosen, Phys. Rev. E 1 06 , 024208 (2022)

Loop Quantum Gravity

The absence of a preferred time in quantum gravity implies that all choices of time evolution of 3D quantum space are admitted and must be mutually consistent so as to provide a single coherent emergent 4D quantum spacetime.

Gravity in the context of the time dimension replaced by an extra space dimension is called Euclidean gravity. Prior work provided evidence of emergence of 4D quantum space from the 3D quantum space of Loop Quantum Gravity in Euclidean gravity. In order to build on this work, so as to confront this issue in the physically relevant context of gravity with a time dimension, certain technical improvements to the construction are essential. These improvements would also facilitate a generalization to the case of Euclidean gravity with a cosmological constant.

The preliminary ground work is completed for these improvements and further developments constitute work in progress.



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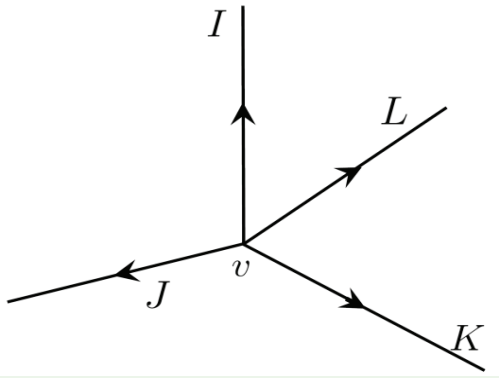

Figure 1: An initial quantum state of the Euclidean gravitational field.

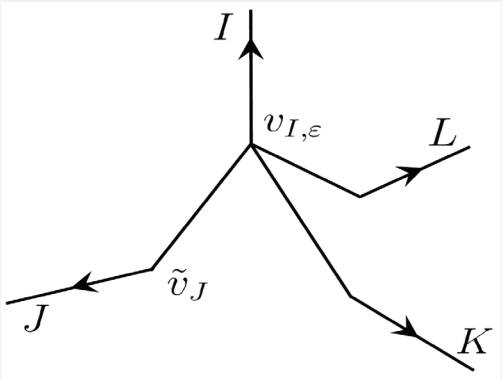

Figure 2

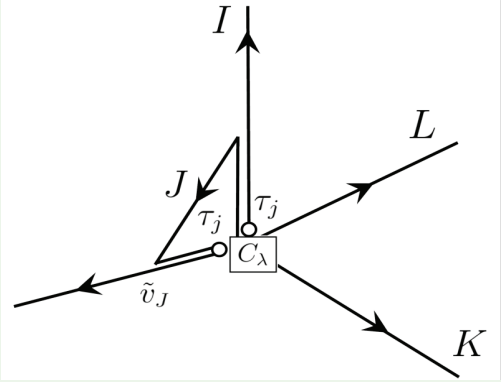

Figure 3

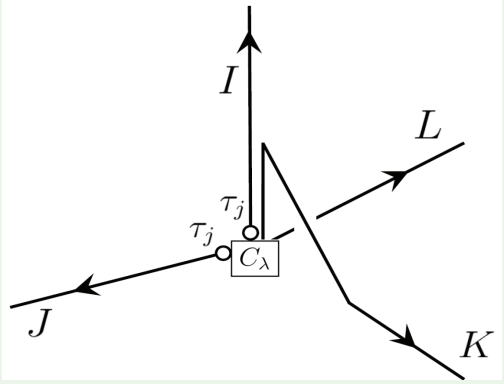

Figure 4

Figure 2, 3, 4: The various states it evolves to under the quantum dynamics. Taken together they depict the evolution of a small (approximately (10^{-33} cm^3) volume of quantum space.

Nonequilibrium systems and stochastic processes

The effect of stochastic resetting on Brownian motion with stochastic diffusion coefficient and the long-time behavior of run-and-tumble particles in two dimensions display novel features.

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The position distribution of a Brownian particle with a stochastically evolving diffusion coefficient admits a scaling form with a ballistic scaling in arbitrary dimensions, where the scaling function has a universal exponential tail. When subjected to resetting dynamics, where at a constant rate, both the position and the diffusion coefficient are reset to zero, the process eventually reaches a nonequilibrium stationary state.

In stark contrast to ordinary Brownian motion under resetting, the stationary position distribution in one dimension has a logarithmic divergence at the origin. However, the divergence disappears for higher dimensions, and the distribution attains a dimension-dependent constant value at the origin that can be computed exactly. The distribution has a generic stretched exponential tail in all dimensions, in contrast to an exponential tail for an ordinary Brownian particle with a constant diffusion coefficient. As time increases, an inner core region around the origin attains the stationary state, while the outer region still has a transient distribution -- this inner stationary region grows with a constant acceleration, much faster than ordinary Brownian motion.

The long-time asymptotic behavior of the position distribution of a run-and-tumble particle (RTP) in two dimensions can be expressed as a perturbative series in the ratio of the persistence time of the RTP to the observation time. The higher order corrections to the leading order Gaussian distribution generically satisfy an inhomogeneous diffusion equation where the source term depends on the previous order solutions. The explicit solution of the inhomogeneous equation requires the position moments, which can again be computed using a recursive formalism.

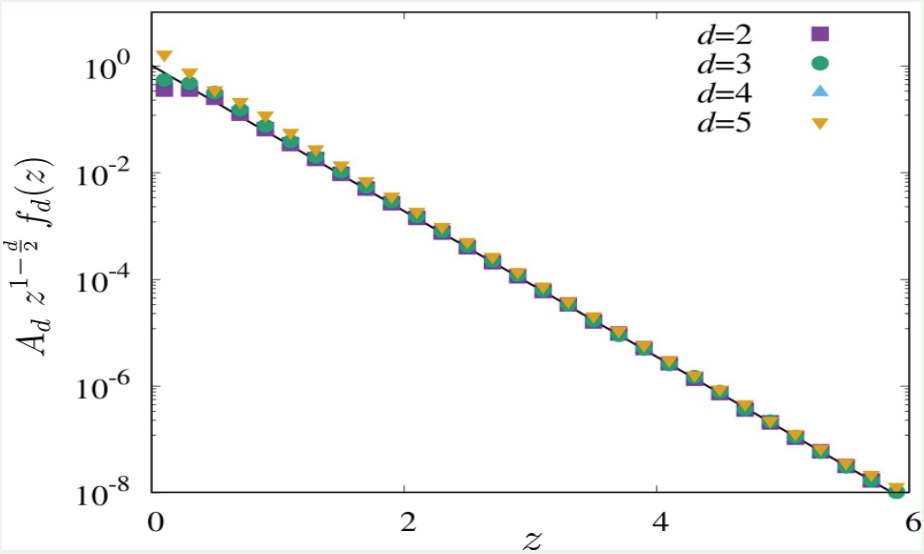

Figure 1: The scaled marginal position distributions of a Brownian particle with a stochastically evolving diffusion coefficient for different dimensions obtained from numerical simulations are indicated by points. The solid black line indicates the universal theoretical exponential tail.

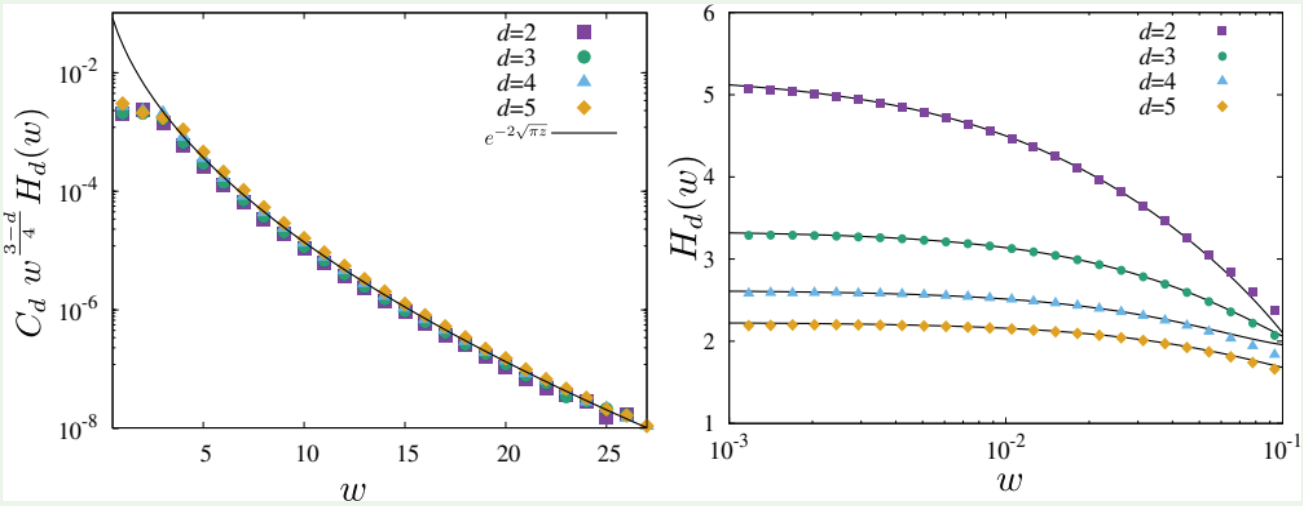

Figure 2: Plot of a Brownian particle's scaled stationary radial distribution with a stochastically evolving diffusion coefficient subjecting to reset. Left panel compares the distribution obtained from numerical simulation (symbols) with the analytical prediction (solid black line). The right panel magnifies the region near the origin to compare the analytical prediction (solid black lines) with numerical simulations (symbols).

Selected Publications:

1. Ion Santra, Urna Basu, and Sanjib Sabhapandit, J. Phys. A: Math. Theor. 55, 414002 (2022)

2. Ion Santra, Urna Basu, and Sanjib Sabhapandit, J. Stat. Mech. (2023) 033203

Open Quantum Systems

Understanding the emergent dynamics of quantum particles in contact with an environment is at the forefront of modern physics, with a potential to unlock new-age technologies

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"Quantum technologies" are all the rage nowadays. Indeed, being able to manipulate microscopic quantum particles can lead to revolutionary technologies such as quantum computers. Nonetheless, it is a bit surprising that we are not there yet, considering that the foundations of quantum mechanics were laid down almost a century ago. One of the main roadblocks has been that, like everything else, quantum systems are not isolated, but in some environment. As a result, useful quantum information can leak out over a short timescale, making their dynamics much harder to control and understand. Our recent work explores two different facets of this problem: how one can design environmental coupling to stabilise genuine quantum properties and how familiar dynamical phenomena of the macro world emerge from an underlying quantum system.

1. Entanglement among quantum bits (qubits) is a necessary ingredient for quantum information processing. Two particles are called entangled if they behave as one unit even while far apart. Stabilising such a truly quantum resource in the presence of an external coupling is very challenging. We found a class of star-shaped networks of qubits that can be externally driven at the centre to create entanglement throughout the network, and project the outermost qubits onto maximally-entangled states (Figure 1). This set-up may be realisable in superconducting-circuit labs and complements our earlier work utilising symmetry [1] and timed pulses [2].

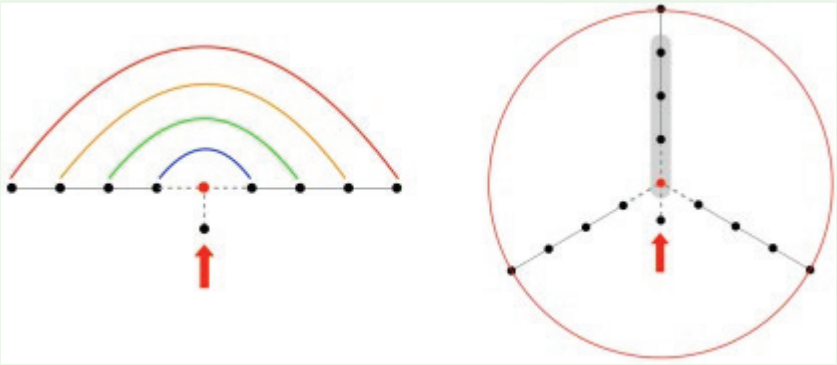

Figure 1: Sketch showing how a central drive can produce many Bell pairs (left) or maximally entangled qubits (right). The scheme works for arbitrary number of legs.

2. Macroscopic or classical systems exhibit a rich array of dynamical features. In particular, two iconic phenomena are persistent limit-cycle oscillations and critical slowing down at the onset of such oscillations, where the system relaxes algebraically in time. On the contrary, open quantum systems are known to relax exponentially in time, approaching a unique steady state. By identifying the normal modes in the classical limit, we were able to explain how persistent oscillations and algebraic decay can arise in a quantum system governed by a Markovian master equation (Figure 2).

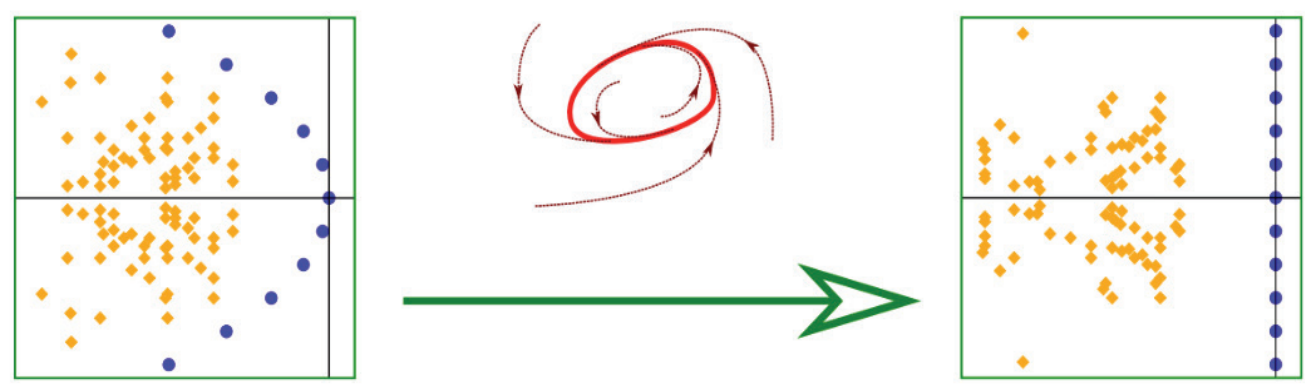

Figure 2: Sketch of how persistent oscillations emerge in the classical limit as a branch of purely imaginary (non-decaying) eigenvalues of the quantum generator. The algebraic decay at the onset of such oscillations is realised by a spectral collapse (not shown).

Selected Publications:

1. Long-Range Coherence and Multiple Steady States in a Lossy Qubit Array Dutta, Shovan and Cooper, Nigel R; Physical Review Letters, 2020, Vol. 125, p240404

2. Generating Symmetry-Protected Long-Range Entanglement; Dutta, Shovan, Kuhr, Stefan, and Cooper, Nigel R; ArXiv:2201.10564

Quantum Gravity

Uncovering the deep structure of spacetime is the key challenge facing the quantisation of gravity. Significant advances have been made using the casual set approach, where spacetime atoms are ordered by causality.

In causal set theory the gravitational path integral is replaced by a path-sum over causal sets. An outstanding question that we have addressed is, to find the mathematical conditions under which the most entropic contributions to this path sum are suppressed. This is important because the overwhelming contribution comes from causal sets that have no resemblance to spacetime. In an earlier work with my PhD and VSP students, we had shown a physically reasonable parameter regime in which these contributions are suppressed when using a simplified ``Link" action. More recently we have shown, using extensive combinatorial arguments, that the full discrete Einstein-Hilbert action in any spacetime dimension reduces to the Link action to leading order. It thus becomes plausible that continuum behavior emerges from causal set quantum theory.

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Another key question in quantum gravity, that has been explored, is related to the entanglement entropy (EE) of a free Gaussian scalar quantum field on causal sets with horizons. As suggested by Sorkin in the late 1980s, EE could source black hole entropy. The latter has been conjectured to be proportional to the black hole area, but its origin remains a key mystery in quantum gravity. Based on an extensive work done earlier, we suggest that the non-locality of causal sets leads to a fundamental volume law with the area law being emergent at the continuum meso-scale.

Progress has also been made in the geometric reconstruction program with a proposal to define null geodesics in terms of spacetime atoms. It was shown in 2D spacetime that "ladder molecules" , whose rungs are horizon bi-atoms "trap" a ribbon of null geodesics in the continuum and hence correspond to a thickened or fuzzed out horizon. We find an analogue of Penrose's uniqueness result for null geodesics between horismotically related events in the continuum.

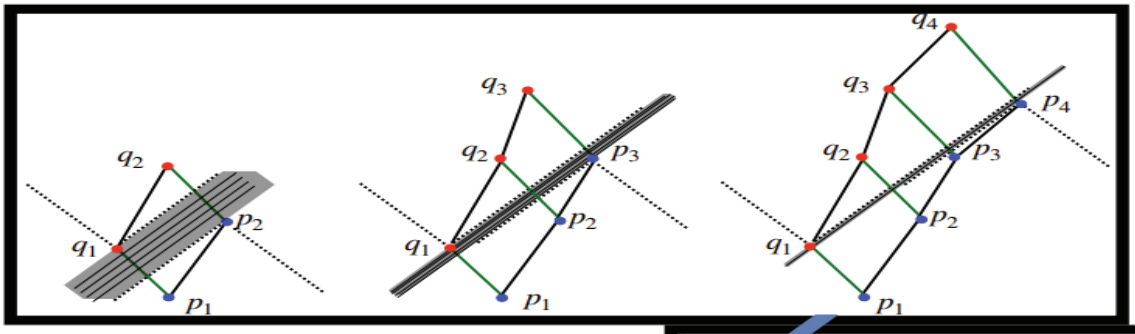


Figure 1: Illustrations of ladder molecules L2, L3, L4 and the associated ribbons ofnull geodesics. As more rungs are added the ribbons become narrower.

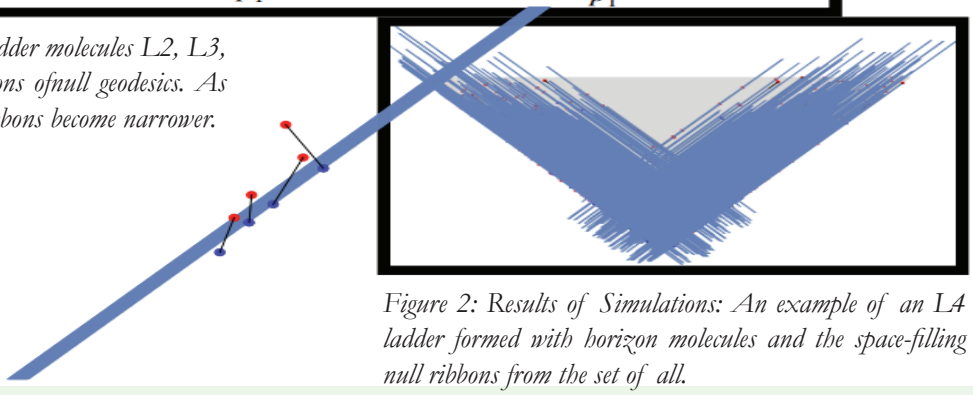


Figure 2: Results of Simulations: An example of an L4 ladder formed with horizon molecules and the space-filling null ribbons from the set of all.

Selected Publications:

1. Path integral suppression of badly behaved causal sets, Carlip, P., Carlip, S. and Surya, S*., Class. Quantum Grav. 40, 095004 (2023)

2. Spacetime entanglement entropy: covariance and discreteness, Mathur, A., Surya, S.*, Nomaan, X. GRG 54, 74 (2022)

3. Null geodesics from ladder molecules, Bhattacharya, A., Mathur, A. and Surya, S.*, GRG 55, 32 (2023)

Publications

Scientific staff and students of the Raman Research Institute publish their research activities carried out over the year in reputed national and international peer-reviewed journals. Each of the four research groups at RRI publishes their work in renowned journals that focus on their specific research area.

145 papers with RRI members as authors and/or co-authors were published during 2022-23. There were 3 publications in conference proceedings and 19 in press.

Members of the Institute also regularly publish books and articles for popular science magazines to reach a wider audience beyond that of specialized technical and scientific journals. During the past year, RRI members wrote 3 miscellaneous articles, a general science book in regional language and a book chapter.

A complete list of publications by each of the Institute members is in Appendix I.

Astronomy and Astrophysics

Astronomy and Astrophysics, Astrophysical Bulletin, Astrophysical Journal, Astrophysical Journal Supplement Series, Astrophysics, Bulletin of the American Astronomical Society, Journal of Astrophysics and Astronomy, Monthly Notices of the Royal Astronomical Society, Nature Astronomy, New Astronomy, Open Astronomy, Publications of the Astronomical Society of Australia, Sadhana, Universe, Union Radio-Scientifique Internationale (URSI)

Light and Matter Physics

Ceramics International, EPJ Web of Conferences, Journal of Electronic Materials, Journal of Photochemistry and Photobiology A: Chemistry, Measurement Science and Technology, Molecules, Optical Materials, Optics and Lasers in Engineering, Optik - International Journal for Light and Electron Optics, Physica A, Physical Review A, Physical Review Research, Physica Scripta, Resonance

Soft Condensed Matter Physics

ACS Applied Materials and Interfaces, Acta Crystallographica Section E, Applied Organometallic Chemistry, ChemPhysChem, Chemistry: An Asian Journal, Chemistry Select, Chemosphere, Colloids and Surfaces A, Communications Physics, European Journal of Medicinal Chemistry, Inorganic Chemistry Communications, Journal of Colloid and Interface Science (JCIS) Open, Journal of Alloys and Compounds, Journal of Cell Science, Journal of Chemical Physics, Journal of Chemical Sciences, Journal of Colloid and Interface Science, Journal of Fluorine Chemistry, Journal of Molecular Liquids, Liquid Crystals, Materials Science and Engineering B, New Journal of Chemistry, Physical Review E, Physical Review Letters, Physical Review Materials, Physics of Fluids, PLoS ONE, Proteins Pyrene: Chemistry, Properties and Uses, Scientific Reports, Soft Matter

Theoretical Physics

Applied Mathematics, Classical and Quantum Gravity, Europhysics Letters, General Relativity and Gravitation, International Journal of Modern Physics B, Journal of Physics A: Mathematical and Theoretical, Journal of Physics: Complexity, Journal of Statistical Mechanics, Physical Review B, Physical Review E, Reports on Mathematical Physics, SciPost Physics, Universe

Grants, Fellowships and Awards

Name	Extramural grant	Details
Biswajit Paul	ISRO grant for POLIX	Project title: Development of "X-ray Polarimeter experiment (POLIX) Payload" Total grant money: INR 8,50,00,000 Received so far: INR 7,65,00,000 Project started in September 2017
Gautam Soni	TDP/BDTD/08/2019	Protoype for electronic mass screening device for point of care diagnostic of sickle cell disease technology development programme Total grant money: INR 46,49,632 Received so far: INR 45,14,816 Project started in August 2019
Mayuri S Rao	PRATUSH - Project under future astronomy	Project Title: Pre-project activities for PRATUSH (Probing ReionizATion of the Universe using Signal from Hydrogen) Grant Amount: INR 56,06,000 Received so far: INR 56,06,000 Project started in March 13, 2019
Pramod Pullarkat	BT/PR23724 BRB/10/1606/2017	Project title: Mechanobiology of cell adhesion under dynamic shear. PI – Namrata Gundiah (IISc, Bangalore), CoPI's – Pramod Pullarkat, Gautam Menon (IMSc, Chennai) Total amount: 36,23,800 Received so far: 20,57,000 Project started in May 2018
	IA-DBT-Wellcome Trust	Project title: A microtubule centric approach to talking chemotherapy-induced peripheral neuropathy Total amount: 9,99,84,689 Received so far: 2,11,30,470 Project started in October 2021
Urbasi Sinha	ISRO - QKD grant	Development of a prototype for satellite based secure quantum communication Total grant money: INR 15,12,69,000 Received so far: INR 12,92,52,890 Project started in Spetember 2017
	India Trento Programme of Advanced Research (ITPAR)	Project title: A cheap, light, integrated source for QKD in an integrated photonic circuit PI: Urbasi Sinha Co-PI: Dipankar Home, Guruprasad Kar, Prasanta Panigrahi Total grant money: INR 1,59,63,520 Received so far: INR 1,08,13,556 Project started in February 2019
	DST – QuEST	Project title: Long distance quantum communications: Repeater and Relay technologies PI: Urbasi Sinha Co-PI: Arun K Pati, Ujjwal Sen, Aditi Sen-De Total grant money: INR 2,01,50,000 Received so far: INR 1,60,03,140 Project started in March 2019

Name	Extramural grant	Details
	MEITY	Project title: Centre for Excellence in Quantum Technology PI (from RRI): Urbasi Sinha Co-PI (from RRI): Saptarishi Chaudhuri, Sadiq Rangwala, Dibyendu Roy Total grant money: INR 10,12,72,000 Received so far: INR 8,46,43,029 Project started in March 2020
Sanjukta Roy	SR/WOA-A-PM-59/2019(G)	Project title: Spin Correlation spectroscopy and its applications in atomic systems Total grant money: INR 37,53,21 Received so far: INR 28,38,400 Project started in December 2020
Beryl Chandra Mohan Das	DST/WOS-A/PM-97/2021 DT 12/01/2023	Project title: Investigation of linear and nonlinear optical properties of naturally occurring dyes extracted from selected bio-resources Total amount: 27,65,311 Received so far: 12,91,975

Name	Fellowship	Details
Sayantan Majumdar	SERB Ramanujan Fellowship	Total research grant amount: INR 38,00,000 Received so far: INR 27,85,000 Project started in May 2018 Duration: 5 years
Barry Cyril Sanders	VAJRA Faculty scheme collaborative research visit	Total research grant amount: INR 13,27,196 Received so far: INR 11,45,700 Project started in May 2018 Duration: 5 years
Satya N Majumdar	VAJRA Faculty scheme collaborative research visit	Total research grant amount: INR 17,06,343 Received so far: INR 17,06,343 Project started in February 2019 Duration: 5 years
V A Raghunathan	INSA Fellowship	Total research grant amount: INR 13,80,000 Received so far: INR 4,45,206 Project started in January 2021 Durtaion: 3 years
Sarvesh K Y	SERB- National Post Doctotal Fellowship	Total research grant amount: INR 22,36,800 Received so far: INR 11,18,400 Project started in December 2022 Durtaion: 2 years

Awards and Distinctions

Sadiq Rangwala got excellent rating on his CEFIPRA project LORIC: Long range interactions in ultra-cold gases.

Beryl C got selected under the Women Scientist Scheme of DST and will work with Reji Philip in the Ultrafast and Nonlinear Optics (UNO) lab.

Anson G. Thambi, PhD student, Soft Condensed Matter, won the 'Best Poster Presentation' award at the Complex Fluids Symposium 2022, IIT Kharagpur, held during December 19 - 21, 2022.

Mehak Layal, Research Assistant, Light and Matter Physics, won a certificate of merit during the poster presentation competition at the Women in Optics and Photonics in India (WOPI) - 2022 conference held at RRI between December 5 – 7.

Chandeshwar Misra, PhD Student, Soft Condensed Matter, was adjudged as the 'Young Researcher Award - 2022' by the Institute of Scholars (INSC), India.

Urbasi Sinha was awarded with the Simons Emmy Noether Fellowship which will fund her visits to Perimeter Insitute from 2021 to 2023 and her session "Smart Women-Drivers of the Modern Era!" was adjudged as the best session during 'COSMOS - India@75: Shaping for India@100' conclave at IIT-Bombay.

Saurabh Singh won Lancelot M. Berkeley – New York Community Trust Prize for Meritorious Work in Astronomy.

Research Facilities

Electronics Engineering Group

The Electronics Engineering Group (EEG) has been the backbone of many engineering activities undertaken by the scientific groups of the Institute. It has developed earlier several state-of-the-art instrumentations, both generic and purpose-built, for applications in radio astronomy, cosmology, light and matter interaction experiments, and detecting polarized X-Rays from cosmic sources. The instruments cover a wide range of fields like antenna, RF and Microwave, and digital signal processing. In addition, development of firmware in FPGAs for signal processing and algorithms for data analysis also form major part of the work.

Over the past several years, members of the EEG have gained significant expertise in designing and building instruments that can be flown to space for carrying out space-based experiments.

The EEG has been i) supporting all the engineering requirements of the scientific experiments of the Raman Research Institute and ii) involved in the development of new technology in digital and analog domains.

Briefed below are the various projects in which EEG is involved and their progress -

1. A two element Interferometer – A precursor to Low Frequency Radio Telescope

The low frequency radio telescope (LFRT) is a new initiative of the Raman Research Institute (RRI) for exploring the radio sky at low frequencies (30 -360 MHz). A wide band single polarization radio receiver as a precursor to LFRT has been built by EEG to operate in the above frequency range using wideband antennas developed in-house, compact delay lines and high dynamic range frontend and backend receivers.

Validation of various designs has been done by deploying the receiver in the field and observing the sky in single-antenna and phased-array modes.

Figures 1- 4 below show the wideband antennas deployed in the field along with analog and digital receiver systems and the measured galactic foreground signal.

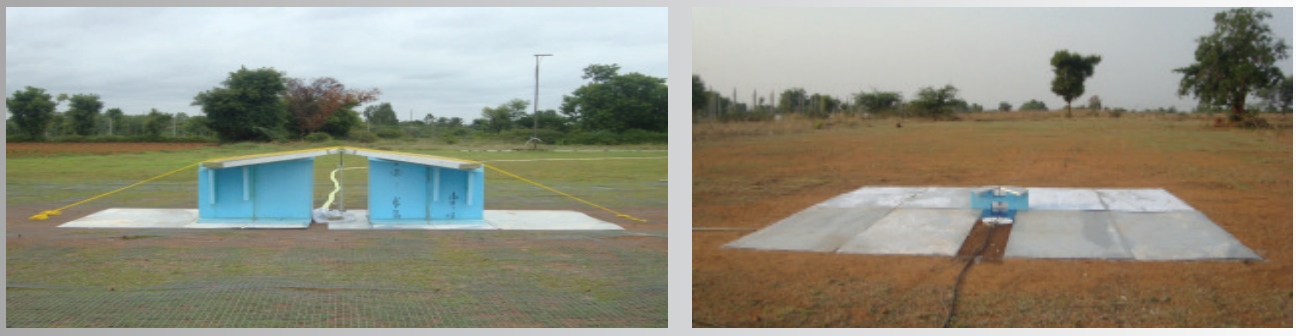


Figure1: The 30-90 MHz and 120-360 MHz antennas deployed in the Gauribidanur observatory to make sky observation.

Figure 2: Two cylinders housing the front end electronics of the radio receiver.

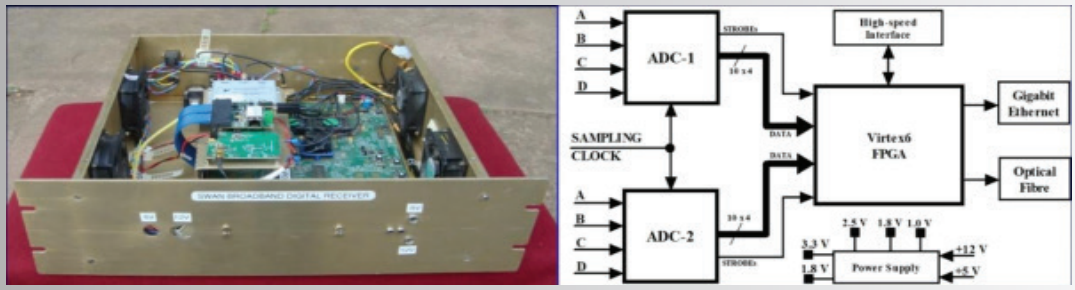


Figure 3: (left)Precision spectrometer (pSPEC) card. (right) The schematic diagram of the card indicating the ADC and the FPGA device.

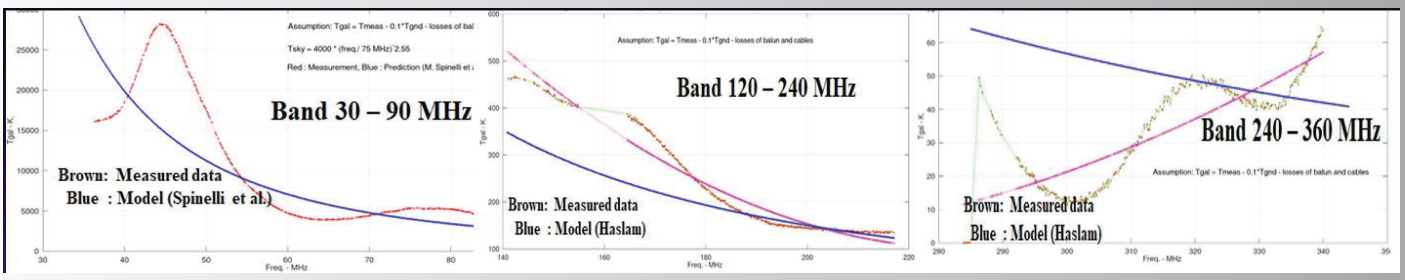


Figure 4: The measured response (orange curve) to the Galactic foreground in 30-90 MHz band (Left panel), 120-240 MHz band (Middle panel) and 270 - 360 MHz band (Right panel). Blue curve represents the expected response according to the sky model.

Figure 5 shows the antennas deployed in the phased-array mode. An in-house developed water based compact delay line as shown in Fig.6 was used to demonstrate beam shift. (Refer Fig. 7). Generation of fringe was also demonstrated (Refer Fig. 8) using a pair of antennas separated by several wavelengths at the highest frequency.

Figure 5: Two antennas in 30-90 MHz and 120-360 MHz bands deployed in the Gauribidanur observatory in the phased array mode for making sky observation.

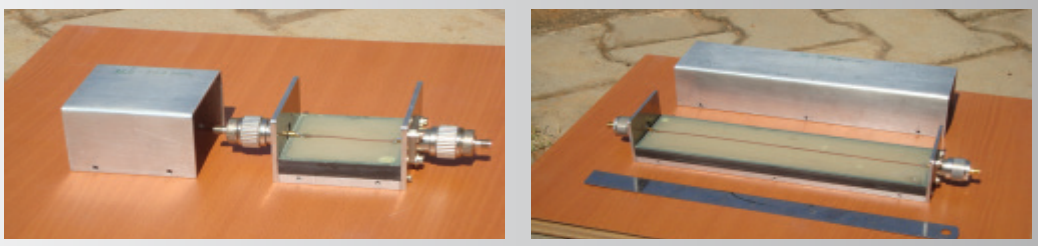


Figure 6: Prototypes of analog delay lines implemented on water based high dielectric constant substrate. Left panel: Delay line for 1.4 ns. Right panel: Delay line for 4.5 ns delay.

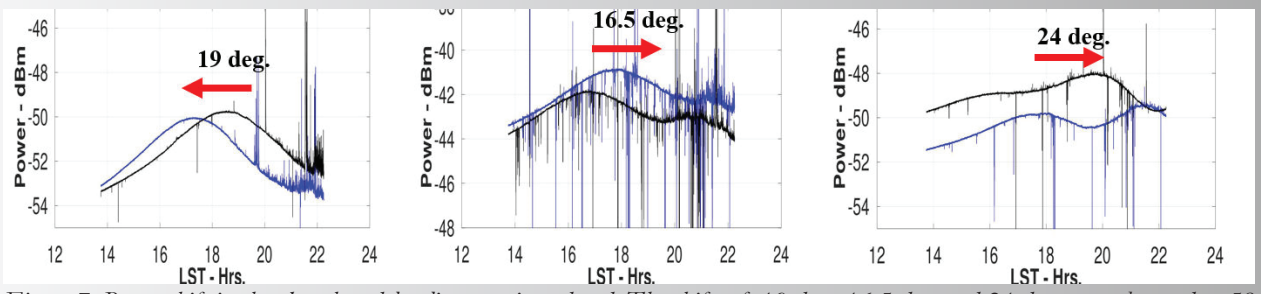


Figure 7: Beam shift in the sky when delay lines are introduced. The shifts of 19 deg., 16.5 deg. and 24 deg. were observed at 58 MHz,179 MHz and 295 MHz respectively.

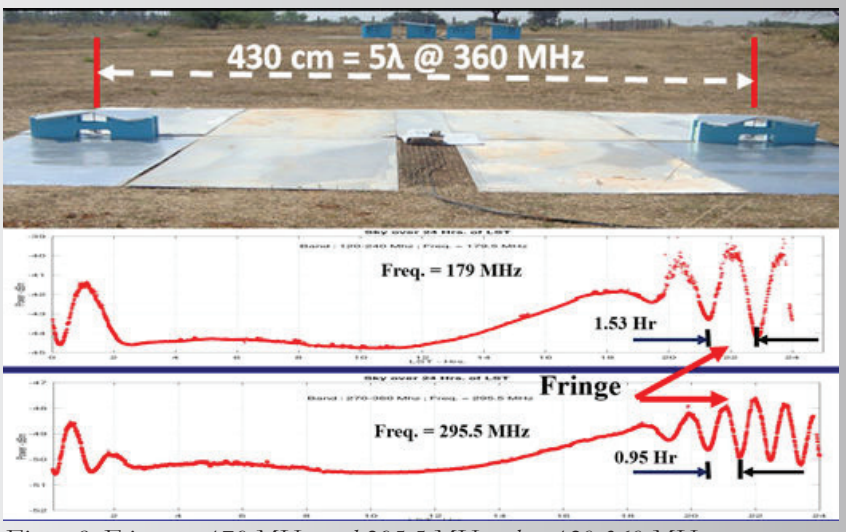


Figure 8: Fringes at 179 MHz and 295.5 MHz when 120-360 MHz antennas are separated by about five wavelengths at the highest frequency.

2. Design and development of new non-galvanic isolation strategies

The conventional optic fiber modules used for galvanic isolation between RF front-end and back-end electronics in radiometers are found to have inherent gain jumps and temperature drifts. As an alternative, operational amplifiers (Op-Amp) and RF amplifiers with good reverse isolation characteristics have been developed. The prototype of the Op-Amp and its electrical characteristics are shown in Fig. 9.

The EoR receiver output expressed in temperature and the residuals obtained after fitting the response when op-Amp and RF amplifiers were used for isolation are shown in Fig. 10 and 11 respectively. From the results observed, Op-Amp appears promising for use as a replacement for the optic fiber module.

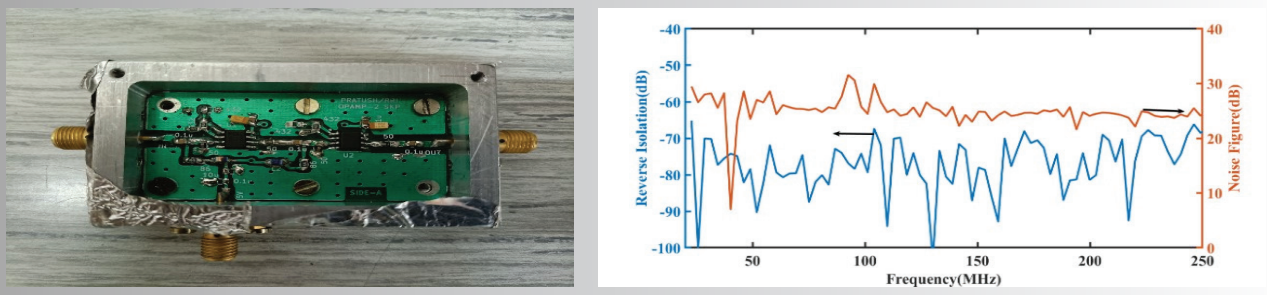


Figure 9: (left) Operational amplifier isolation module. (right) The reverse isolation and noise figure characteristics

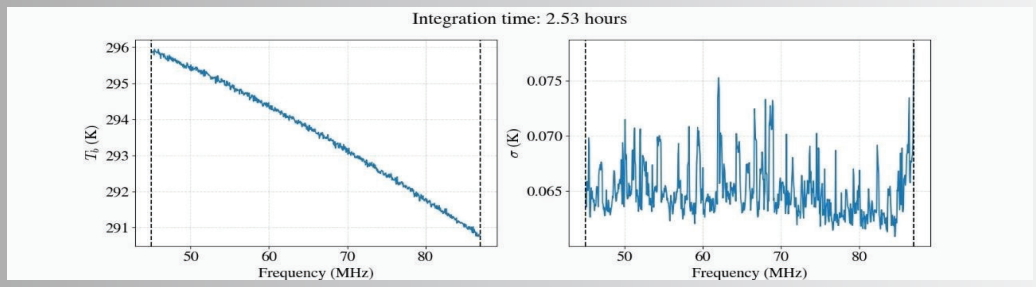


Figure 10: The receiver temperature (left) and the residuals obtained after fitting the response (right) when the Operational amplifier is used for the isolation.

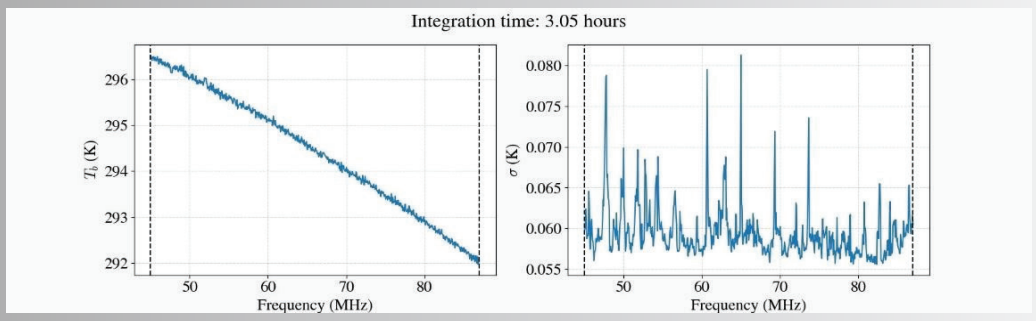


Figure 11: The receiver temperature (left) and the residuals obtained after fitting the response (right) when in Optical module.

3. Polarimeter Instrument in X-rays (POLIX) in space

The development and testing of POLIX Flight Model (FM) subsystems are complete. The POLIX FM detectors have been prepared and calibrated. The FM cards were tested, integrated into back-end (BE) packages and integrated full system was also tested. The FM harness was done and tested. The ground checkout system had several upgrades. The FM subsystems underwent several acceptance tests like thermo-vac, vibration, acoustic and EMI-EMC at URSC. Preparations for satellite integrated tests are underway.

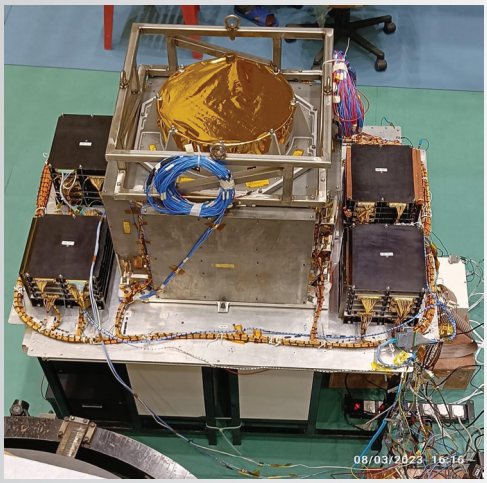


Figure 12: POLIX system undergoing integrated tests.

Mechanical Engineering Services

Mechanical Engineering Services (MES) at RRI is a diverse and versatile department consisting of four sections: Basement workshop, Sheet metal workshop, Painting and Carpentry. MES plays key roles in a wide range of activities like interior wooden/metal furnishing to manufacturing of precision components for experimental science, for example, CNC machined components used as critical flight hardware in payload for space qualified equipments.

We have a qualified and skilled team of employees working in unison, equipped with modern CNC machines and CAD-CAM software. This helps at visualization of final product and also reduces considerable number of iterations before the final product is manufactured to specification.

1. Coaxial micro injector and Capillary storage

A coaxial micro injector is a device used for precise injection of liquids onto glass slides used in the SCM lab. It is made of five parts that are machined from brass and fitted with an O-ring to prevent leaks. The capillary of the injector is used to introduce a small amount of liquid and the device is then inserted into the target area for injection. This allows for precise control of the volume of liquid that is injected.

Capillary storage is another important component and it is used to store small amounts of liquid samples for analysis or injection. The volume of liquid that is stored can be precisely controlled and to allow for visual feedback on the amount of liquid stored, the capillary is machined from acrylic.

Figure 1: Coaxial micro injector and Capillary storage

2. 2D MOT (Magneto-Optical Trap) coil Assembly

2D MOT coil assembly is used for trapping of ultracold atoms for scientific research. It consists of a two-dimensional array of magnetic coils that produce a magnetic field with a specific geometry, which allows for the trapping and cooling of atoms.

Four coil formers were manufactured with aluminum and it provided a framework for the coils to be wound and arranged in a two-dimensional pattern.

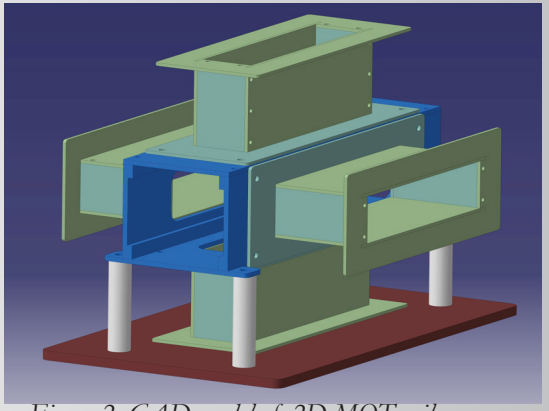


Figure 2: CAD model of 2D MOT coil

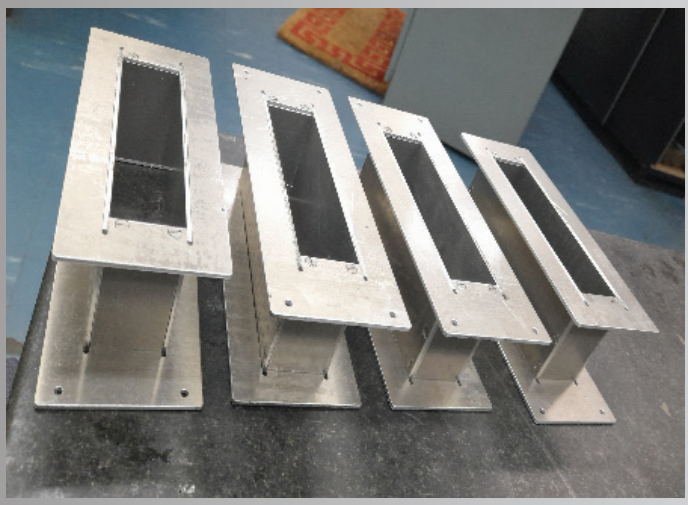


Figure 3(a): Aluminum former for 2D MOT coil

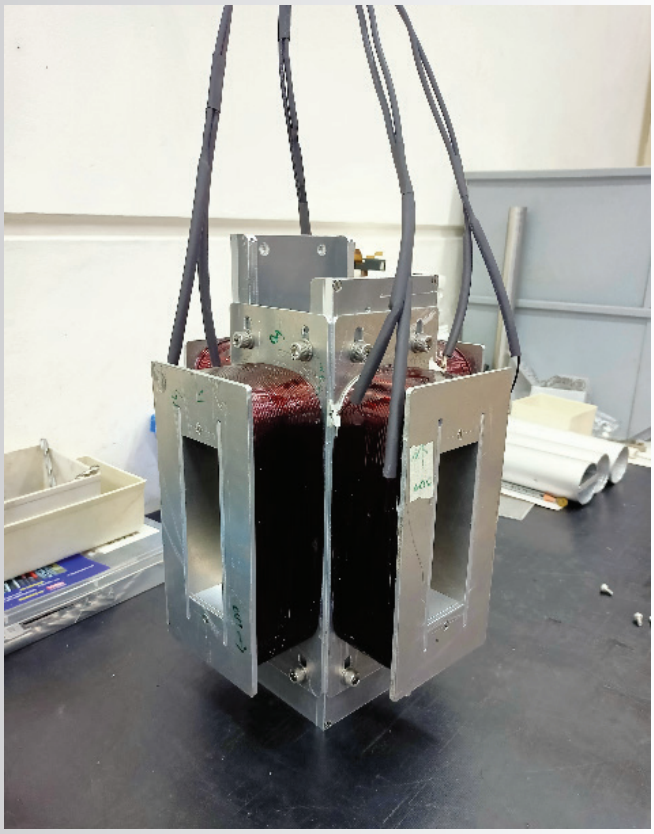


Figure 3(b): A 2D MOT coil

3. 30 - 90 MHz Low Frequency Radio Telescope

The 30-90 MHz aperture dipole antenna serves as a low-frequency radio telescope, enabling the detection of radio signals emanating from celestial objects. The antenna structure is made of aluminum sheets, which are fabricated using a CNC laser cutting process to ensure precise sizing and internal structure. The internal structure of the antenna is laser-cut into an interlocking pattern, providing increased structural stability and reduced weight. Assembly of the antenna is carried out using M3 screws.

To support the antenna, a lightweight and rigid base is provided using a Styrofoam structure. This stand plays a crucial role in maintaining the stability of the antenna and minimizing any interference that could affect its performance.

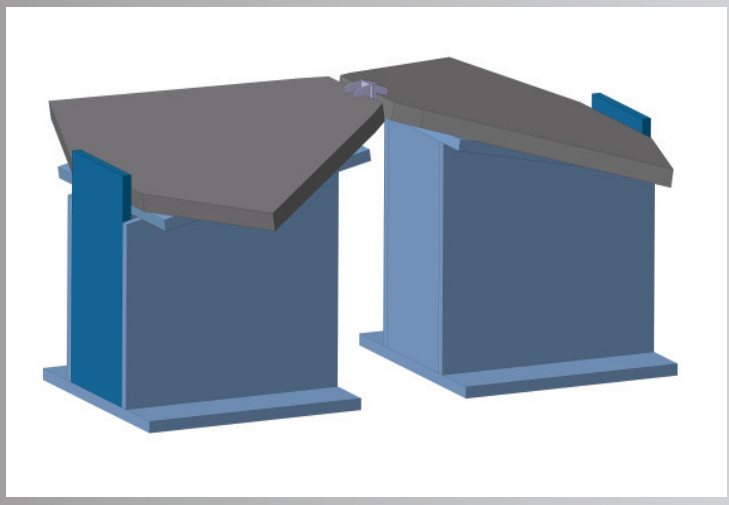


Figure 4(a): CAM model assembly of antenna

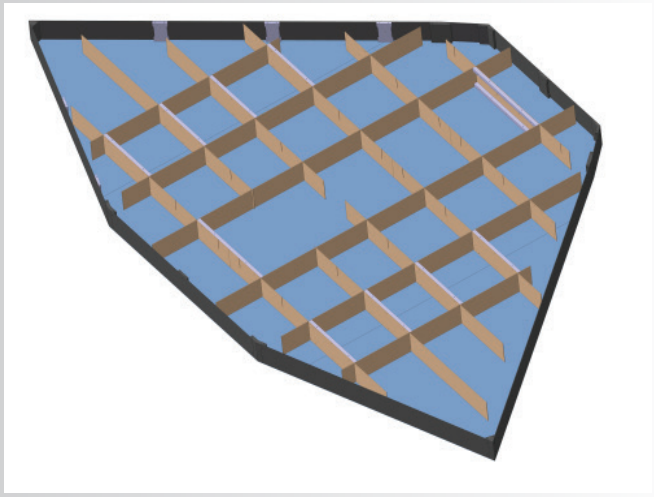


Figure 4(b): CAD model of internal structure

Figure 5: 30-90 MHz low frequency radio telescope

4. Water-based coaxial cable

The water-based coaxial cable was constructed using a PVC structure. A flexible PCB was fixed onto the PVC structure using Anabond glue and the entire structure was filled with distilled water. An aluminium enclosure was used to enclose the whole structure.

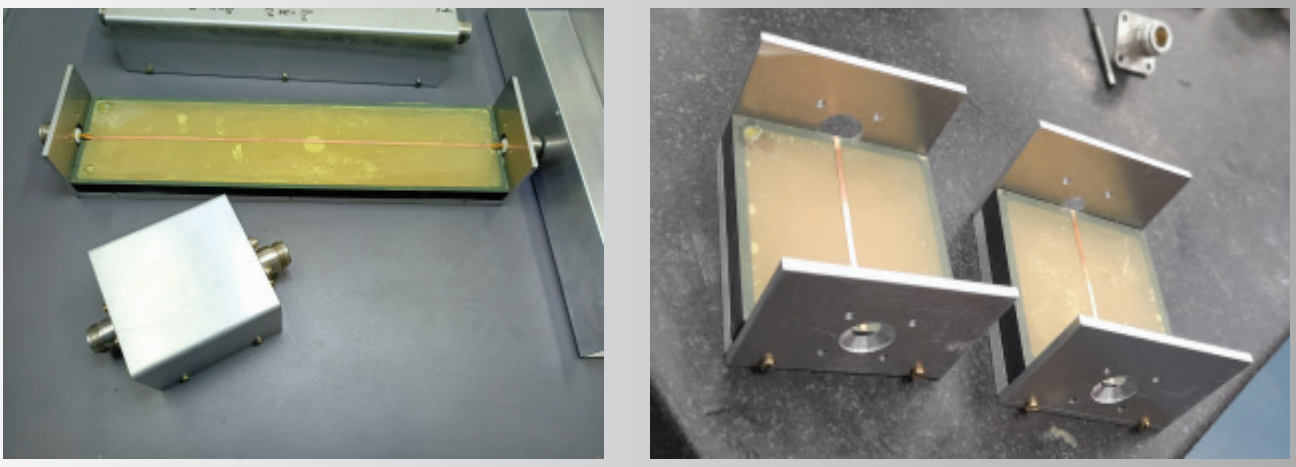


Figure 6: Water-based coaxial cable

5. Experimental setup to demonstarate Raman Effect

Raman Scattering experiment is a scientific apparatus made with aluminum profile channel and coated with matt black color paint used for studying the Raman scattering phenomenon. The setup consists of several components, including a laser source, a red filter glass mounted on slots for sliding, a sample cuvette holder with liquid sample and a lens for focussing.

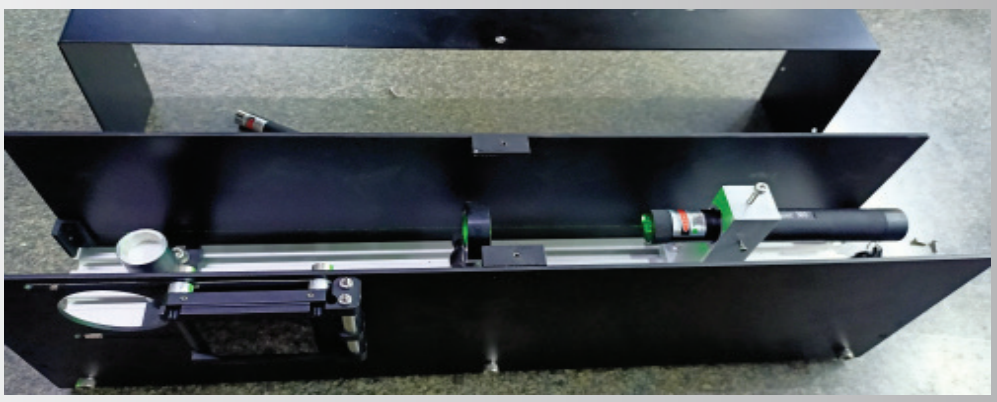


Figure 7: Raman effect experimental setup

Library

The RRI Library, founded by Sir C V Raman in 1948, started functioning with his personal collection of books and journals. This library has both print and electronic information resources. The library is central to all the research activities and science communication of the Institute. The library caters to both general and specialized information needs of its users. The library has a total collection of 71,673 books and bound journal volumes. Of this, 29,803 are books and 41,870 are journal-bound volumes. The library subscribed to 12 e-journals and ten print journals last year.

Library activities during 2022-2023 - A renewed partnership of RRI Library with the National Knowledge Resource Consortium (NKRC) for 2023 has brought-in online access to 4,600 journals. RRI library is a content partner to the National Digital Library of India project of IIT- Kharagpur. The research output of RRI is hosted on https://ndl.iitkgp.ac.in/, which acts as a single window to the nation's scholarship. The library web page is continuously monitored to keep it current and provide access to both subscribed and open-source content of research interest. A plagiarism check of 15 theses submitted for the doctoral degree award was done at the library, in addition to 25 research papers, Ph.D. synopsis and a few dissertations. The researcher ID of the entire faculty was updated regularly. Article processing charges for 16 papers were handled and paid through the library. Several Inter Library Loan (ILL) requests were attended by getting articles from other libraries. Also, through ILL, articles were sent to other libraries. The Grammarly software to aid writing skills has been renewed for the current year.

Library automation and Digital Library - The library uses KOHA – open-source software. The functions of the software are constantly getting improvised with more facilities and features enabling better services. The Raman Research Institute Digital Repository, also known as e-Sangrah, is an active repository of various information related to the Institute. The digital repository is currently hosted on version 6.0 of DSpace. Scholarly publications are uploaded regularly. Digitization of archival materials, photographs, and audio/video continued during the past year. Theses submitted to RRI were also uploaded to the repository. The number of uploads during 2022-23 was 200. The total records on RRI Digital Repository currently stand at 10,849. "Imprints-collection," an offshoot of the RRI digital repository, continues to thrive with regularly updated information.

Other Events

1. Grammarly orientation was conducted on 18th July 2022, and Sci-Finder onsite training was arranged on 29 August 2022.
2. RRI library has maintained the tradition of supporting manpower development programs by giving internship training to the students. During the current year, two students from Documentation Research and Training Centre (DRTC) were trained. A one week industrial training was given to a Lecturer Department of Library and Information Science, Government Polytechnic for Women, Bengaluru
3. RRI Archival Gallery was inaugurated by Dr. K. Kasturirangan on National Science Day, 2023.

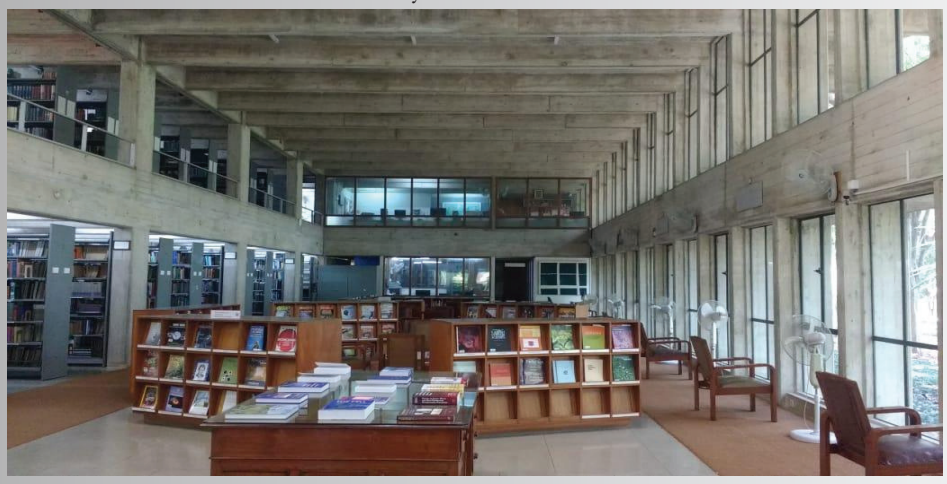


Figure: Dr. K.Kasturirangan, former ISRO chairman, inaugurated the RRI Archival Gallery.

IT & Computing

The Computer Group manages and maintains the IT infrastructure and assets in the campus. An IT and Computing Review Committee was set up by the Director to review the IT infrastructure on the campus. The Committee submitted a report regarding the IT infrastructure and tenders were published based on the recommendations for the upgrade and augmenting the critical IT infrastructure. Purchase orders were placed for the upgrade of network equipment, firewall and servers and storage. New computers were installed in the auditorium, lecture hall and council room and enabled it for audio and video conferencing. PhD 2022 online application was hosted using NoPaperForms Software-As-A-Service portal. Applications were received and processed. BSNL FTTH 300Mbps broadband internet connection was provided in both the hostels for the students to work remotely.

RRI subscribed to the 'Google Workspace for Education' for the email service. E-mail accounts of first and second year PhD students were migrated and accounts were created for the new temporary staff. Mail server was upgraded with a new server, OS and Zimbra version. All the accounts and e-mails were restored. ID Card templates were re-designed using an open source software Scribus. Wireless access points were installed in the Auditorium, SCM lecture hall for dedicated WiFi access. Zoom and Cisco Webex licenses were procured for video conferencing needs.

Knowledge Communication

PhD Programme

RRI has a comprehensive PhD programme that gives enthusiastic and motivated students the opportunity to join the highly competitive global research community. The PhD programme is an organic process aimed at challenging graduate students to rise to their full creative potential and develop the ability to conduct research. RRI offers an exceedingly high degree of intellectual freedom to students allowing them to pursue their individual interests within the four broader areas of research conducted at the Institute. This level of freedom coupled with proper guidance in the form of constant formal and informal interactions with scientific staff and other students encourages the students to not only think for themselves but also critically question others. A regular exchange of ideas and knowledge promotes an open-minded approach towards science and a willingness to learn which is, as acknowledged everywhere, extremely important for success in the academic arena. Apart from the academic members within the Institute itself, graduate students under the PhD programme are also exposed to the larger and more diverse scientific community through attendance of relevant national and international conferences and workshops where they get a perspective on a bigger picture in their field of research.

Students at RRI are registered for their PhD degree with Jawaharlal Nehru University, New Delhi. RRI is also a participant in the Joint Astronomy Programme (JAP) with the Indian Institute of Science, Bengaluru. Further details on the PhD programme, admission requirements and procedure can be found on the Institute website.

During 2022-23, 87 students from all over India were enrolled in the PhD programme and conducted research with scientific staff members from the four broad research themes at the Institute.

During the year, four PhD theses were completed and submitted for review:

Name	Thesis Title
Anindya Chowdhury	Effect of salt and polyelectrolytes on self-assembled structures of ionic amphiphiles.
Rajkumar Biswas	Probing the nonequilibrium dynamics of driven soft matter systems
Palak	Experimental studies of the non-equilibrium dynamics and complex flows in dense suspensions
Alkesh Yadav	Cellular trade-offs in the non-equilibrium synthesis of complex molecular information

Six PhD theses were defended:

Name	Thesis Title
Abhishek Mathur	Quantum Fields from Causal Order
Chandeshwar Misra	An experimental study of the jamming dynamics in suspensions of soft colloidal particles
Chowkampally Saichand	Novel Wall Defects In Lamellar Soft Matter
Maheswar Swar	Developing a novel, non-invasive detection technique in hot and cold atomic systems based on spin noise spectroscopy (SNS)
Maheshwaram Sumanth Kumar	Understanding physical mechanisms in chromatin folding
Subhadip Gosh	Experimental studies on crystal polymorphism and self-assembled structures in soft matter

Ten PhD theses were awarded:

Name	Thesis Title
Adwaith.K.V	Coherent microwave-to-optical conversion with dilute gaseous atoms
Avik Kumar Das	Multi-wavelength Study of Blazar Flares
Buti Suryabrahmam	Studies on the mechanical properties and phase behavior of lipid bilayers in the presence of some alcohols and oxysterols
Irla Sivakumar	Synthesis and characterization of new liquid crystalline compounds derived from novel aromatic ring structures
Kaushik Joarder	Deploying single photons towards experimental tests of complementarity, Quantun Key Distribution and Macrorealism
Marichandran V	Synthesis and Characterization of Some Novel Heterocyclic Discotic Mesogens
Nancy Verma	Laser Ablation and Surface Structuring of Selected Solid Targets
Niranjan Myneni	Ultracold Ion-Atom Scattering
SK Raj Hossein	Transport, clustering and chemical kinetics of cell surface molecules influenced by actomyosin cortex
Surya Narayan Sahoo	On weak measurements and foundational experiments in quantum mechanics

Postdoctoral Fellowship Programme

RRI offers a postdoctoral fellowship programme, which is open for applications through the year. This fellowship is initially offered for a period of two years and usually extended to three, following review. Postdoctoral fellows are expected to work independently and have complete academic freedom in the sense that they can choose their own research problem and collaborator. It is not mandatory that a postdoctoral fellow works under the purview of any of the four broad research groups at RRI, or is attached to a specific scientific staff at the Institute. However, it is desirable that their professional research interests and previous experience in research has a significant overlap with the ongoing and envisaged research plans of the Institute. A healthy amount of mutually beneficial interaction with the scientific staff is desired so that collaborations can be struck up. Also, participation of the Fellows in the academic activities of the Institute and student supervision as co-guides is encouraged even though there are no teaching responsibilities.

Candidates who have at least one year of experience as a postdoctoral researcher and have a proven track record of being able to conduct original and independent research can apply for a limited number of Pancharatnam Fellowships offered at RRI. Here too, applications are accepted throughout the year and the processing takes about 4 to 6 months. The fellowship is for 1+1+1 years. Further details about the Postdoctoral and Pancharatnam Fellowships can be found on the RRI website.

During the year 2022-23 there were 13 Postdoctoral, 1 Pancharatnam Fellow and 1 National Postdoctoral Fellow NPDF) at RRI.

Research Assistants Programme

This Programme provides opportunities for graduates (BSc/BE/BTech) and post-graduates (MSc/MTech) to participate in the research of the Institute and assist in the research by joining our research staff in one of the professional research works. These opportunities arise when research activity requires specialized help that is technical, computational or analysis and cannot be done by the scientific and technical members of the Research Facilities of the Institute. Research Assistants are appointed when research activity requires specialized assistance in the research work, which may be for durations up to two years. The specialized assistance may include engineering and computational skills that are either not currently available in the Electronics, Computing and Mechanical engineering groups of the Institute, or where the quantum of work required at that instance overwhelms the resources of the Institute. The participation is intended to motivate the Research Assistant to pursue careers in research, research support, develop technical skills, particularly in hands-on experimental.

During the year of this report, 16 personnel were involved in research activities via the Research Assistants programme.

Visiting Student Programme (VSP)

The Programme is aimed at offering research experience to highly motivated students who are presently pursuing their Undergraduate, Masters Studies or who are in a gap year, that is, within a year of their completion of these degrees. Exceptional high school students may also be accepted as interns under this scheme. The purpose of the programme is to expose these students to the research of the Institute and motivate them to take up research as a career. Research Staff at RRI accept VSP students so that significant numbers of Undergraduate and Masters students are given an experience of experimental, phenomenological and theoretical physics/astronomy and thereby gain motivation to enter into research careers. In particular, experimental laboratories at RRI provide students the opportunity to participate in activities that invent, design, develop, build, and commission complex systems that explore frontier areas in the physical sciences, together with learning theoretical tools necessary to understand the complex systems and their purposeful design for the science goals. Enrollment to the Visiting Student Programme is open throughout the year.

Undergraduate and postgraduate students currently enrolled in Universities may undertake their research credits at RRI by working with a research staff member in a research project of the Institute as a separate part of the VSP scheme.

During the year 2022-23, 35 students availed of this programme. A complete list of VSP students who interned at the Institute during the year is given in Appendix V.

Academic Activities

Conferences

Institute members visit various other institutions in India and overseas to attend conferences and workshops. These events play an important role in providing an opportunity to exchange ideas with the scientific community at large and thus set the stage for future collaborations with researchers from other institutions. Last year, scientific staff and students of the Institute attended numerous conferences in India, Austria, Brazil, Canada, France, Germany, UK, USA and many other countries.

In addition, scientific staff members gave lectures and invited talks at various workshops, international conferences, multinational project meetings and training programmes. As a part of the outreach activities of RRI, members also visited colleges around the country and organized special workshops on different research topics, delivering lectures, talks and presentations.

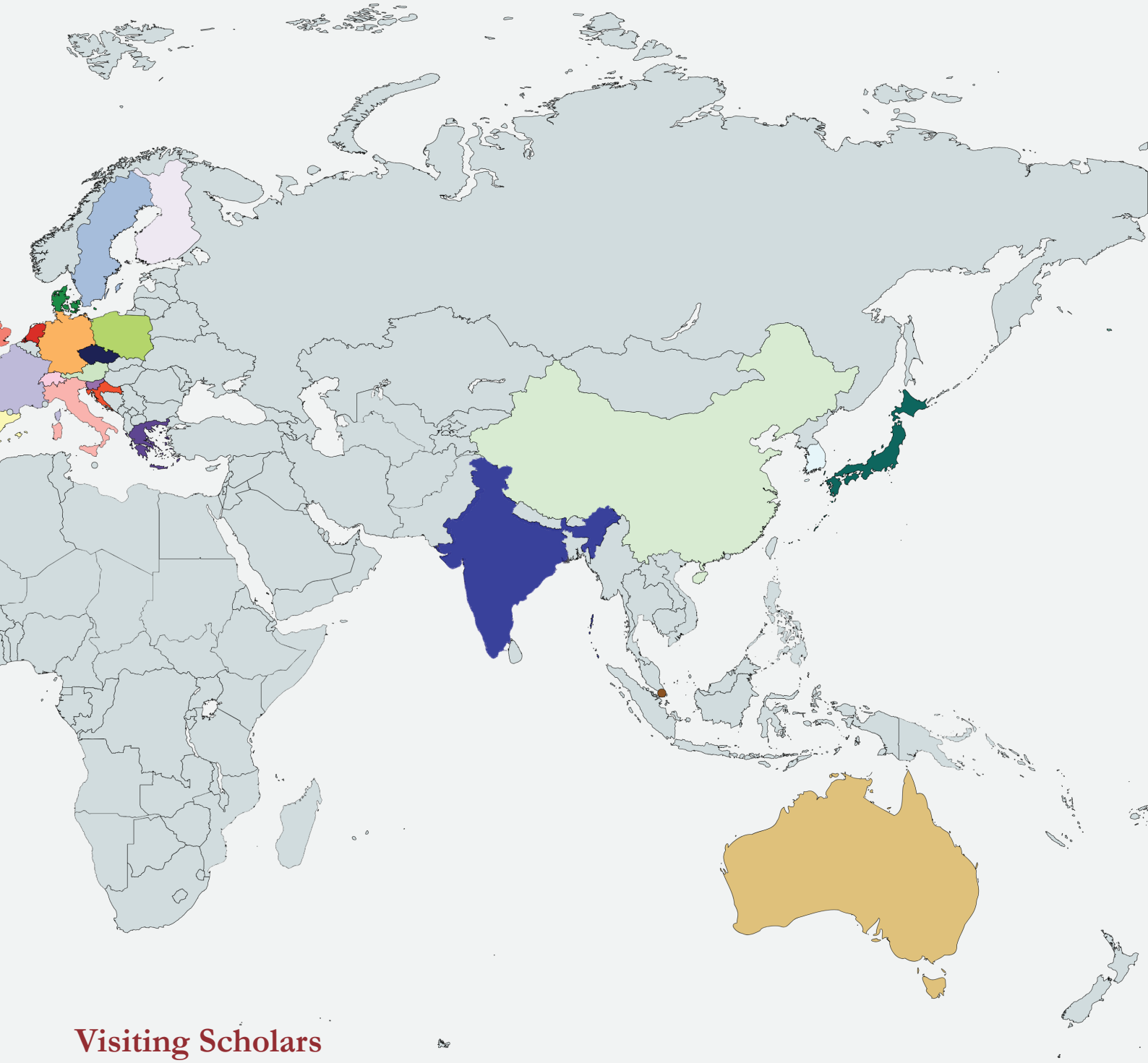
A complete list of conferences attended by the Institute members is available in Appendix II.

Seminars and Colloquia

Seminars are regularly organized at the Institute to keep all members abreast of the research being done on specific research topics. They are delivered by visiting researchers from other institutions and are intended to generate discussions on topics that are of particular interest to RRI members and also constitute collaborative projects between RRI and the visitor's institution.

The Thursday colloquium is an event held at the Institute to promote further interaction not only between the various research groups within RRI but also between RRI and the invited speaker and his or her affiliated institution. The colloquium aims to cover emerging science topics and bring an interdisciplinary flavour to the event by introducing themes from various other disciplines to the members of the RRI community.

During the last year, RRI invited speakers from all over India and the world to deliver the seminars and colloquia. A complete list of speakers and the diverse topics presented is given in Appendix III.



Visiting Scholars

With an aim to further augment the interaction between the members of the Institute and scholars belonging to other institutions, RRI actively encourages visits from a large number of scientists, researchers and engineers. These scholars visit the Institute and contribute new ideas and skills while also benefiting from the expertise of RRI's own members. Visits at RRI can last from a few days to a few months and often lead to fruitful collaborations and conceptualization of new and interesting projects for the Institute.

Last year, there were altogether 112 scholars who visited RRI from both Indian and international institutions. RRI is happy to have hosted so many academic visitors and thanks all of them for contributing to the wonderful diversity and dynamism of the research atmosphere at the Institute.

A list of all visitors, where they came from and when they visited RRI can be found in Appendix IV.

Highlighted: Countries visited by RRI members and home countires of international visitors and collabrators

Extramural Activities

RRI engages with the wider society for communications on science and related topics. RRI staff and students routinely organise and participate in popular seminars, talks, workshops and outreach events conducted by the GoI. RRI also invites and welcomes school and college students to visit the campus and interact with scientific staff of the Institute. Apart from these general interactions, over the years, many college students have gained hands-on experience working with sophisticated Radio Telescopes at the Gauribidanur field station. Additionally, RRI shares its latest research, events, activities and general news through Facebook, Twitter, Instagram, WordPress, YouTube and Newsletters. A comprehensive list of RRI member outreach activities in the form of popular talks, seminars and workshops is given in Appendix II. Other major outreach activities are discussed below.

Official Language Activities

The Official Language (OL) Department of the Institute is committed towards promoting the use and implementation of Hindi in day-to-day official work. The main responsibility of the department is to create awareness of the OL Act and help the Institute to achieve the targets as laid down in the Annual Programme issued by the Department of Official Language every year.

The following activities were undertaken during the year under report.

- General orders, notices, advertisement, press releases / notings, contracts, tender forms and tender notices were brought out bilingually. Section 3(3) of the OL Act was fully complied with.
- Letters received in Hindi were replied to in Hindi.
- All forms and Standard Formats being used in the Institute were made bilingual.
- The Quarterly Progress Reports regarding progressive use of Hindi are being sent to the Ministry of Science and Technology, Regional Implementation Office and the Town Official Language Implementation Committee periodically.
- The Annual Report has been published both in English and Hindi versions.
- Hindi workshops were conducted periodically and lectures were delivered by experts on (a) The official Language policy of the Union and Correspondence in Hindi (b) A health talk in Hindi on 'Lifestyle is Medicine: Treatment of lifestyle related diseases'. The faculty for the workshops were drawn from experts such as Shri Sushil Kumar Goel, Assistant Director (OL), O/o the CPMG, Bengaluru; Dr. Mythri Shankar, Lead Consultant, Nuclear Medicine, Aster, CMI Hospital, Bengaluru. Officers and staff from RRI and IAS actively participated in these interactive workshops. In addition to this, Table workshops and Internal Inspections were conducted regularly for all the Departments.
- Screening of a short Documentary film "Samvidhaan: The Making of the Constitution of India" directed by Shyam Benegal was organized.
- Hindi Divas was organized on September 29, 2022. The Chief Guest of the function, Lt Col Vinod Kumar a certified counselor and life skill trainer at the World of Mind Dynamics presented a lecture on 'Our National flag - Our identity'. The results of various Hindi competitions held this week were also declared. Winners of various competitions were felicitated. A cultural program was presented by the In-house talent. Hindi Divas was celebrated too.
- Meetings of the Official Language Implementation Committee were conducted periodically with specific agendas. Concrete actions on the decisions taken in the meeting were ensured.
- The Institute actively participated in the Town official language implementation committee Meetings conducted during the year.
- In a new initiative, 'Quote of the day' and 'Word of the day' in English with its Hindi equivalent is displayed on the bulletin board daily, across the Institute.
- Ten phrases in English with its Hindi equivalents were displayed on the main bulletin boards every month for use by officials.
- To promote Official language, a special initiative was taken by the staff of RRI to write a word a day on the newly erected board at the reception counter.

Others

During 2022-23, RRI organized virtual meetings and workshops described in detail under the section titled "Events." Other events include high teas on superannuation of regular staff, sports tournaments, concerts and a variety of cultural programs, both with invited performers and RRI members themselves.

Science Outreach @ RRI

This year, the Raman Research Institute (RRI) scaled-up and strengthened its efforts towards science popularisation and outreach, both within the institute and outside, especially after the Covid-19-posed challenges during the past two years.

A dedicated team of science communicators, with the help of colleagues in the institute directorate, undertook numerous activities at the Institute. They organised visits for 1,000 – 1,200 school and college students during the year ; arranged interactive sessions for these students with the faculty and scientists ; facilitated visits and guided tours to the laboratories, the institute campus, the RRI Archival Gallery and the RRI Museum.

The Science Communication and Outreach team coordinated and remained an integral part of the organising team for three national and International scientific conferences, organised to mark the Institute's Platinum Jubilee year. These were Showcasing RRI, Women in Photonics and Optics in India and Frontiers in Cosmology.

In addition, they assisted in writing post-conference reports, making posters, preparing and sharing regular posts via the Institute's social media channels like Twitter, Facebook, Instagram along with YouTube coverage for all the major events, prestigious name lectures, scientific talks, colloquia, seminars, conferences, etc.

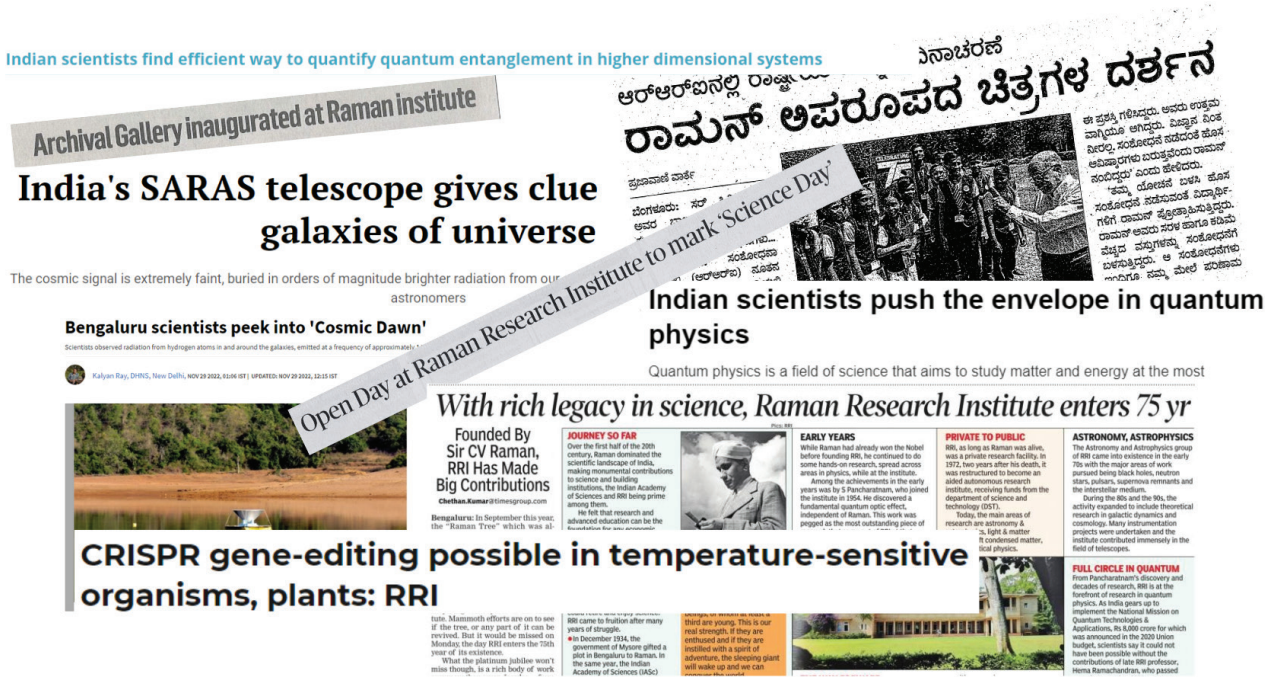
Between 1st April, 2022 and 31st March, 2023 there have been 172 Facebook posts, 262 Tweets, 43 Instagram posts and 12 blog posts. Many of the posts and Tweets were liked and retweeted by DST's official Facebook page and Twitter handles. RRI now has upwards of 11,000 people following us on Facebook and 9,421 people on Twitter reading and commenting on our posts. The RRI YouTube channel was launched in 2018. Since then, the channel has grown to include 34 playlists with 306 videos that are open for public viewing with a subscribers count of 3,217.

Several popular science articles, aimed at disseminating the research findings to the general public at large, were prepared by this team. Over ten reports were shared to the local and national media for the wider publicity of research and developments from the Institute. During this year, leading national and regional newspapers, online platforms and TV news channels featured multiple prominent research works, projects and missions spanning a breathe-taking range from the cosmos to the quantum --- the Cosmic Dawn, quantum-enabled technologies, shear-thickening fluids, early warning systems to minimise damages caused due to earthquake, the applications of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) in cutting DNA at low temperatures, and many more.

As representatives of RRI at the India International Science Festival, Bhopal, held in January 2023, the team presented the research and latest scientific strides to the visitors at the Institute's stall. This year, RRI's stall bagged the 'Best Conceptual Pavilion' award among 150 participating stalls.

There were two stargazing sessions, one organised for the benefit of students and officials of the Bhabha Atomic Research Centre, and other for local college students at Gauribidanur. During the session, the participants were enthralled with the citing of Andromeda galaxy, star clusters, Orion Nebula along with Jupiter, Mars and deep sky objects.

RRI's Science Communication and Outreach team has bigger plans in the months ahead. We hope to optimise our efforts and diversify our roles in the interest of science and its popularisation.



Indian scientists find efficient way to quantify quantum entanglement in higher dimensional systems

Archival Gallery inaugurated at Raman institute

India's SARAS telescope gives clue galaxies of universe

The cosmic signal is extremely faint, buried in orders of magnitude brighter radiation from our astronomers

Bengaluru scientists peek into 'Cosmic Dawn'

Open Day at Raman Research Institute to mark 'Science Day'

ರಾಮನ್ ಅಪರೂಪದ ಚಿತ್ರಗಳ ದರ್ಶನ

Indian scientists push the envelope in quantum physics

Quantum physics is a field of science that aims to study matter and energy at the most

With rich legacy in science, Raman Research Institute enters 75 yr

Founded By Sir CV Raman, RRI Has Made Big Contributions

CRISPR gene-editing possible in temperature-sensitive organisms, plants: RRI


RAMAN RESEARCH INSTITUTE
रामन अनुसंधान संस्थान


RAMAN RESEARCH INSTITUTE
रामन अनुसंधान संस्थान

Events @ RRI

Colloquia

Organisers: Ranjini Bandopadhyay, Sanjib Sabhapandit, Urbasi Sinha, Vikram Rana
Secretary: R. Mamtha Bai

12 May 2022
The Curious Case of Planet 9
Jihad Touma
American University of Beirut, Beirut, Lebanon

16 June 2022
X-ray Variability of Black Hole Systems: The AstroSat Advantage
Ranjeev Misra
IUCAA, Pune

20 June 2022
Revisiting Diffraction
Rajaram Nityananda
Azim Premji University, Bangalore

18 October 2022
Multidimensional quantum sensing and spectroscopy
Konstantin E. Dorfman
East China Normal University, Shanghai, China

03 November 2022
Our Quantum Centuries
Barry C. Sanders
University of Calgary, Canada
VAJRA Faculty, RRI

17 November 2022
Unveiling the Dusty Universe
A. N. Ramaprakash
IUCAA, Pune

18 November 2022
Pulsed production of antihydrogen and other antiprotonic systems for precisions tests of fundamental symmetries
Michael Doser

28 November 2022
Quantum Sensors in Cosmic Archaeology and Electron-Photon Entanglement
Swapan Chattopadhyay
Infosys Chair Visiting Professor, IISc, Bengaluru

05 January 2023
Status of the Concordance Model of Cosmology
Arman Shafieloo
Korea Astronomy and Space Science Institute (KASI), South Korea

Pancharatnam - Quarterly Lectures at RRI

2 June 2022
The Quantum Challenge: Realizing the Quantum Dreams
Prof. Rupamanjari Ghosh
School of Physical Sciences at Jawaharlal Nehru University, New Delhi

08 September 2022
The Entanglement Frontier
Sandip Trivedi
TIFR, Mumbai

23 February 2023
Seeing the High Energy Universe
Subir Sarkar
University of Oxford

Vignyana Kathegalu - Popular Science talks at RRI

20 April 2022
Cosmic Rays-How they are accelerated
Ramanath Cowsik
Washington University in St. Louis, USA

19 August 2022
Steven Weinberg: The Physicist and his physics
Prof. Rohini Godbole
IISc, Bangalore

27 September 2022
The Finite Part of Infinity
Joseph Samuel
ICTS, Bangalore

24 November 2022
The Nobel Prize in Physics 2022
Urbasi Sinha
RRI, Bangalore

15 February 2023
Astronomy Everywhere - Arts and Literature (Kannada)
B S Shylaja
Former Director, Jawaharlal Nehru Planetarium, Bengaluru

In - House Meeting

The third-year doctoral students (batch of 2019) organised the annual RRI In-House meeting - 2022 in a hybrid mode. Many of the sessions were organised offline while a few scientific talks were live-streamed on RRI's YouTube channel.

The three day-event was a gathering of students, faculty and other administrative staff of RRI. The event, additionally, had fun games and a cultural night organised. Over 40 scientific talks and 15 posters were presented this year.

Earth Day

On April 22, RRI observed 'Earth Day' by organising awareness talks on our environment. Nupur Tandon, the institute's consultant for waste management, shared the various recent initiatives adopted on the campus. The housekeeping staff were felicitated on the occasion.

International Day of Yoga

RRI celebrated the 8th International Day of Yoga on 21 June, 2022.

Yoga instructor Vasundhara Purushotham opened with a talk on 'Relevance of Yoga', which emphasized on the right ways to start the journey by focusing on body, breath and mind. The programme included demonstrations of Yoga Asanas.

As part of a CSR initiative for the noble cause – 'Yoga Seva' – an outreach programme was organized aimed to educate, engage and empower the students from the Government Girl's School, Malleswaram.

Equity Diversity and Inclusion

The newly constituted Equity Diversity and Inclusion (EDI) task force at RRI was launched on 11 July, 2022. The EDI aims to foster a culture of inclusion, mutual respect and fairness in the institute's work culture enabling everybody to thrive and showcase their optimum potential. Prof. Tarun Souradeep, Director, RRI, launched the EDI webpage, and emphasized the need for institutionalizing the efforts toward a fair and harmonious work environment.

76th Independence Day

RRI celebrated the 76th Independence Day. Prof. Tarun Souradeep, Director, RRI, hoisted the national flag. Seven awards recognised as the "Best Staff" were presented to the institute's support staff.

Cultural and Film clubs

To showcase the extracurricular talents, the student community united to form a cultural and film club. The clubs will organise cultural events, drama, dance and music performances.

The first event of the club was a student-led musical concert, RaagaBop, held in July. It covered a set-list of six songs, celebrating a fusion of Indian classical Raagas, Western Bebop, and Rock music.

Volleyball tournament

The 2019 batch organsied the RRI Volleyball tournament during 07-15 March, 2022. A total of 5 teams with 40 players competed in 12 matches. The final match was played between 'Team MS' and 'Savage Spikers' and the 'Team MS' emerged as the winners with scores -- 21-25, 25-22, 25-19, and 25-18. The Gold, Silver and Bronze medals were awarded to 'Team MS', 'Savage Spikers' and 'Net Ninjas' , respectively. Captain of the winner team , Mukesh Singh, accepted the trophy at the hands of Prof. Tarun Souradeep, Director, RRI.

Hindi Diwas

RRI staff celebrated the Hindi Diwas on 29 September, 2022. Lt Col Vinod Kumar (Rtd), a certified counselor and life skills trainer, was the chief guest for the event. Winners of numerous competitions organised during the Hindi fortnight were felicitated on the day.

Rashtriya Ekta Diwas

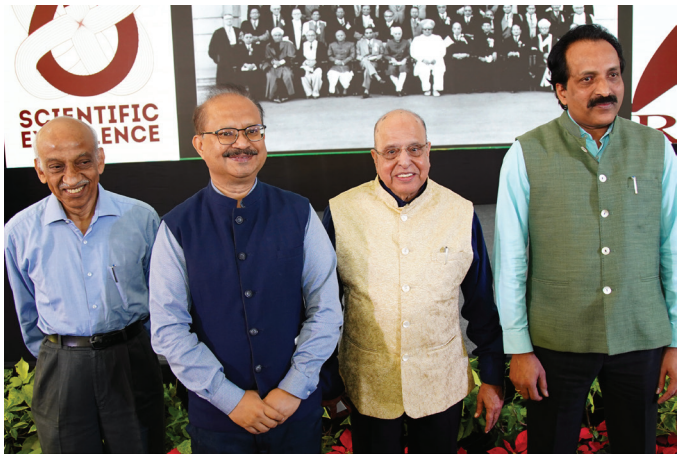
RRI observed the 'Rashtriya Ekta Diwas' or the National Unity Day on October 31. This day marks the birth anniversary of Sardar Vallabhbhai Patel, who is popularly known as 'Iron Man of India'. On this day, RRI staff took a pledge and participated in a 5 kms marathon.

Platinum Jubilee @Raman Research Institute

The Raman Research Institute (RRI) entered its 75th year on November 7, 2022, with the grand launch of the Platinum Jubilee Celebrations (PJC).

Dr Srivari Chandrashekhar, Secretary, Department of Science and Technology, presided (virtually) over the function as the chief guest. In his address, he hailed RRI for leading the research in emerging areas, particularly quantum communications and quantum-enabled technologies.

Also in attendance on the day were Dr K. Kasturirangan and Shri A S Kiran Kumar, former Chairmen of the former Indian Space Research Organisation (ISRO), Shri Somanath, Chairman, ISRO, Jyotsna Dhawan and Vivek Radhakrishnan who are the members of the RRI Trust. There were also several senior associates, directors of scientific institutions, faculty and students present on the day.



Showcasing RRI

The PJC celebration was launched by 'Showcasing RRI', a conference that united the past and present faculty and scientists who reminisced about the scientific contributions over the past 75 years.

Women in Optics and Photonics in India - 2022

RRI hosted a one-of-its-kind conference to promote women in STEM, especially those involved in the fields of Optics.

A two-day 'Women in Optics and Photonics in India - 2022', organised during December 6 - 7, 2022, was inaugurated by Shri A S Kiran Kumar, Chair, Governing Council, RRI, and former Chairman, Indian Space Research Organisation (ISRO).

Many eminent scientists highlighted the need for women researchers to develop leadership skills in order to assume lead roles at Institutions of Higher Education in India. The deliberations included sharing of new and emerging opportunities for women scientists in the industry.

Hands-on Teacher's training workshop

RRI and the members of the Square Kilometre Array (SKA) organised a day-long training workshop for Science teachers from schools in Gauribidanur, Bengaluru, in January. A total of 27 teachers and five students along with two Block Education Officers were trained during the session.

74th Republic Day

Prof. Tarun Souradeep, the Director, hoisted the national flag and led the 74th Republic Day celebrations at the Institute. RRI staff, their families and students united for the celebrations. For their exemplary contributions, the support staff was felicitated.

Frontiers in Cosmology

The five-day international conference, Frontiers in Cosmology, was held at RRI during February 20 - 24, 2023.

With over 100 participants, this meet was a platform which witnessed deliberations and discussions focusing on five broad themes – Inflation and Cosmic Microwave Background (CMB), Cosmic Dawn and Epoch of Reionisation, Low Redshift Cosmology, the Evolving Universe and the Next Generation Experiments. 25 best student posters were shortlisted and presented during the conference. A visit to RRI's Gauribidanur Radio Telescope facility was organised for the participants.

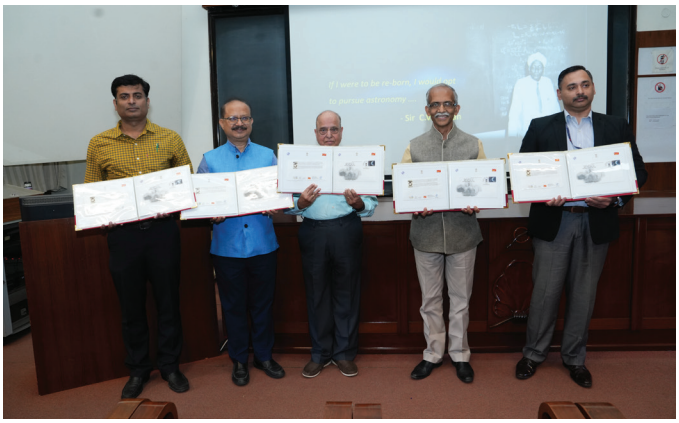
National Science Day celebrations

The National Science Day, this year, was a rendezvous of 30 scientific exhibits and models for over 800 visitors, including students. These models depicted some of the cutting-edge research ongoing at RRI.

On the day, Dr. K. Kasturirangan, former chairman, Indian Space Research Organisation (ISRO) inaugurated the Archival Gallery. In his address to the students, he shared stories from ISRO and the space agency's contributions towards nation building.

As the institute celebrates is platinum jubilee year, RRI along with the India Post, Department of Post, Government of India, released a special postal cover themed 'National Science Day', celebrated to commemorate the discovery of the Raman Effect by the institute's founder-director, Sir CV Raman. Prof. Tarun Souradeep, Director, RRI, Dr. Kasturirangan along with S. Rajendra Kumar, Chief Postmaster General, Karnataka, released the special cover on the occasion.

The final round of the 6th Raman Young Science Innovator (RYSI) - 2022 competition was held on this day. Nine best science models were presented with the RYSI - 2022 awards, jointly constituted by the RRI Trust and the Innovation and Science Promotion Foundation.



International Women's Day

RRI celebrated the International Women's Day with a special event hosting invited talks and a panel discussion.

This year, the invited panelists deliberated on 'DigitALL : Innovation and Technology for Gender Equality', aligned to the 2023 theme declared by the United Nations.

The panel, chaired by eminent physicist and RRI Governing Council Member Prof. Rupamanjari Ghosh, comprised Prof. Rohini Godbole (Indian Institute of Science); Dr. S. Seetha (Indian Space Research Organisation), Prof. Urbasi Sinha (RRI) and Anasua Bhowmik, Advanced Micro Devices.

Campus

The Institute campus is located in the northern part of Bengaluru. It covers an area of 20 acres replete with trees and shrubs. The hustle and bustle of the developing metropolis outside is left behind as one enters the Institute gates. The environment inside is a world apart: a campus that has landscaped greenery including a variety of species from near and far, patches of wilderness tended only by nature, together with the laboratories, workspaces and facilities. Distinctly a shade cooler, this sylvan setting is an attempt to create generative surroundings for the creative research and academic learning that goes on within the RRI. The campus hosts the buildings containing workspaces, laboratories, workshops, canteen, clinic and the guesthouse. And these are surrounded by aesthetically planned and well-kept vegetation that is very appropriate for a campus of a renowned research institute.

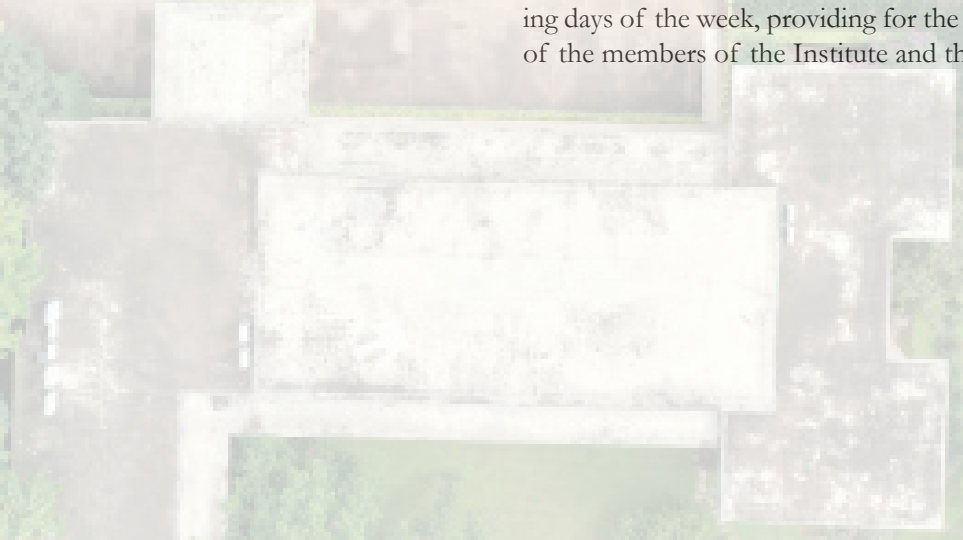
Indeed, it was Professor Raman who had himself landscaped much of the campus. At the center of the campus lies the iconic main building, which faces a manicured lawn flanked on both sides by majestic eucalyptus trees that seem to reach for the sky. The lawn is where Professor Raman was cremated, respecting his wishes, and a Tabebuia donnell-smithii grows here as a memorial. The Institute is proud and obliged to respect and protect this special environment.

The campus abounds in flowering trees and shrubs like the common Hibiscus, Ixora, Frangipani, Gulmuhar, Golden shower tree, Bougainvillea and many more, indeed a welcome sight for the discerning. Members of the Institute and a lucky few elderly neighbors are audience to nature's symphony The sensitive ear might differentiate the cooing of the koel, chirping of the mynah and bulbuls and many more sounds whose origin is lost within the protective embrace of the branches and leaves. Looking up at the source of the screeching sound heard in the early afternoon, one might find a parrot dangling from a branch with one foot, the other foot holding what passes off for a delicacy in the parrot world, which it then proceeds to peck into and relish with gusto. Along with birds that are indigenous to this part of the country, migratory birds from North India and beyond wintering on RRI campus are a familiar sight. However, do not walk along the well laid out pathways trying to catch a glimpse of bird life, lest you step on - a snail lumbering along or the myriad armies of ants and other insect life that we share our campus with.

The Guesthouse on campus is equipped with rooms blending modernity with ethnic elegance to comfortably accommodate distinguished visitors and visiting academics including visiting doctoral students. The Canteen on campus provides meals to all guests together with lunch and refreshments to all members of the Institute and also those who work at the Indian Academy of Sciences, which is also located in a corner of the campus.

Informal meetings, gatherings, concerts and dinners are usually organized at the "Village" - an ethnically designed area near the Canteen which provides a warm, rustic touch to the overall atmosphere on campus, or on the terrace of the Library building that is in the canopy.

Minimal sports facilities exist in the limited open spaces on campus: there are spaces for Badminton, Volleyball, Table Tennis plus a small Football/Cricket ground. The buildings adjacent to the Canteen houses a small Clinic where consultant medical practitioners pay visits at fixed hours on working days of the week, providing for the health and well-being of the members of the Institute and their families.



People at RRI

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Astronomy and Astrophysics

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Vikram Rana
Research Interests: X-ray instrumentation and observational X-ray astronomy. Experimental research involves development of X-ray detectors (CZT and CdTe) and focusing X-ray optics for measuring X-rays from various astronomical sources with high sensitivity and high resolution. My observational research mainly focuses on understanding the accretion processes, geometry and physical conditions in X-ray Binaries, Cataclysmic Variables (CVs) and Ultra-luminous X-ray sources (ULXs) utilizing their X-ray observations.
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Research Interests: making predictions for measuring the redshifted the HI 21-cm signal from the post-reionization era using the upcoming linear radio-interferometric array, namely the Ooty Wide Field Array (OWFA); physics of the large scale structure formation in the universe and the evolution of the HI 21-cm signal across different periods in the cosmic history
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List of Publications

1. Median Filters on FPGAs for Infinite Data and Large, Rectangular Windows
Sherwin, K.D.; Wang, K.I.-K.; Thiagaraj, P.; Stappers, B.; Sinnen, O.
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Kaddipujar, Manjunath; Rajan, Jacob; Kumbar, B.D.
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Sajeev, Y; Davis Kundu, Sramana; Prabhudesai, Vaibhav S.; Krishnakumar, E
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Sivakumar, Irla; Swamynathan, K; Ram, Dinesh; Raghunathan, V.A; Kumar, Sandeep
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Bhat Vanishree; Vadivel Marichandran; Singh Dharmendra; VA Raghunathan; Roy Arun; Kumar Sandeep
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Srinivasa, H. T.
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Anusha, Gokanapalli; Indira, Meeniga; Sivakumar, Irla; Sarma, Loka Subramanyam; Reddy, Kakarla Raghava; Reddy, Peddiahgari Vasu Govardhana; Aminabhavi, Tejraj M.
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Carlip, P; Carlip, S; Surya, S.
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Zaibudeen, A.W.; Bandyopadhyay, Ranjini
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35. Effect of adhesive interaction on strain stiffening and dissipation in granular gels undergoing yielding
Chattopadhyay, Sebanti; Nagaraja, Sharadhi; Majumdar, Sayantan
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Santra, Ion
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Mathur, Abhishek; Surya, Sumati; Nomaan, X
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38. Null geodesics from ladder molecules
Bhattacharya, Anish; Abhishek, Mathur; Surya, Sumati
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39. High surface wetting and conducting NiO/PANI nanocomposites as efficient electrode materials for supercapacitors
Naik, Yashwanth Venkatraman; Kariduraganavar, Mahadevappa Yallappa Srinivasa H T; Siddagangaiah, Palakshamurthy Bandrehalli
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40. Experimental and theoretical studies of hexylmeythylimidazolium tetrafluoroborate ionic liquid as cathodic corrosion inhibitor for mild steel
Kumar, Pankaj; Soni, Isha; Jayaprakash, Gururaj Kudur; Kumar, Sandeep; Rao, Srilatha; Flores-Moreno, Roberto; Sowmyashree, A.S.
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Bhattacharjee, Suraka; Mandal, Koushik; Sinha, Supurna
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Palak; Parmar, Vaibhav Raj Singh; Saha, Debasish; Bandyopadhyay, Ranjini
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43. The role of defects in the nonlinear optical absorption behavior of pristine and Co-doped V2O5 layered 2D nanostructures
Menon, P. Soumya; Thomas, Susmi Anna; Anjana, M.P.; Beryl, C; Sajan, D.; Vinitha, G.; Philip, Reji
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44. Nanohertz gravitational wave astronomy during SKA era: An InPTA perspective
Joshi, Bhal Chandra; Gopakumar, Achamveedu; Pandian, Arul; Prabu, T.; Dey, Lankeswar; Bagchi, Manjari; Desai, Shantanu; Tarafdar, Pratik; Rana, Prerna; Maan, Yogesh; Batra, Neelam Dhanda; Girgaonkar, Raghav; Agarwal, Nikita; Arumugam, Paramasivan; Basu, Avishek; Bathula, Adarsh; Dandapat, Subhajit; Gupta, Yashwant; Hisano, Shinnosuke; Kato, Ryo; Kharbanda, Divyansh; Kikunaga, Tomonosuke; Kolhe, Neel; Krishnakumar, M.A.; Manoharan, P.K.; Marmat, Piyush; Naidu, Arun; Banik, Sarmistha; Nobleson, K.; Paladi, Avinash Kumar; Pathak, Dhruv; Singha, Jaikhomba; rivastava, Aman S; Surnis, Mayuresh; Susarla, Sai Chaitanya; Susobhanan, Abhimanyu; Takahashi , Keitaro
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45. Detecting galaxies in a large Hi spectral cube
Shaw, Abinash Kumar; Jagannath, Manoj; Mazumder, Aishrila; Chakraborty, Arnab; Patra, Narendra Nath; Mondal, Rajesh; Choudhuri, Samir
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46. Change in spin-down rate and detection of emission line in HMXB 4U 2206+54 with AstroSat observation
Jain, Chetana; Yadav, Ajay; Sharma, Rahul
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Shaw, Abinash Kumar; Chakraborty, Arnab; Kamran, Mohd; Ghara, Raghunath; Choudhuri, Samir; Ali, Sk. Saiyad; Pal, Srijita; Ghosh, Abhik; Kumar, Jais; Dutta, Prasun; Sarkar, Anjan Kumar
Journal of Astrophysics and Astronomy, 2023, Vol. 44, Article No. 4

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Dash, Chandrachud B. V.; Sarkar, Tapomoy Guha; Sarkar, Anjan Kumar
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49. High-performance computing for SKA transient search: Use of FPGA-based accelerators
Aafreen, R.; Abhishek, R.; Ajithkumar, B.; Vaidyanathan, Arunkumar M.; Barve, Indrajit V.; Bhattramakki, Sahana; Bhat, Shashank; Girish, B.S.; Ghalame, Atul; Gupta, Y.; Hayatnagarkar, Harshal G.; Kamini, P.A.; Karastergiou, A.; Levin, L.; Madhavi, S.; Mekhala, M.; Mickaliger, M.; Mugundhan, V.; Naidu, Arun; Oppermann, J.; Arul Pandian, B.; Patra, N.; Raghunathan, A.; Roy, Jayanta; Sethi, Shiv; Shaw, B.; Sherwin, K.; Sinnen, O.; Sinha, S.K.; Srivani, K.S.; Stappers, B.; Subrahmanya, C.R.; Prabu, Thiagaraj; Vinutha, C.; Wadadekar, Y.G.; Wang, Haomiao; Williams, C.
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Rao, Mayuri Sathyanarayana; Shankar, N. Udaya; Subrahmanyan, Ravi; Singh, Saurabh
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52. India and the SKA: An overview
Gupta, Yashwant; Bhattacharya, D; Choudhury, T. Roy; Wadadekar, Y.; Prabu, T
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Girish, B.S.; Reddy, S. Harshavardhan; Sethi, Shiv; Srivani, K.S.; Abhishek, R.; Ajithkumar, B.; Bhattramakki, Sahana; Buch, Kaushal; Chaudhuri, Sandeep; Gupta, Yashwant; Kamini, P.A.; Kudale, Sanjay; Madhavi, S.; Muley, Mekhala; Prabu, T.; Raghunathan, A.; Shelton, G.J.
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Leterrier, Christophe; Pullarkat, Pramod A
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Chattopadhyay, Sebanti; Majumdar, Sayantan
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Optical Materials, 2023, Vol. 138, p113673

172. The role of mechanics in axonal stability and development
Ghose, Aurnab; Pullarkat, Pramod
Seminars in Cell and Development Biology, 2023, Vol. 140, p22

Conference Proceedings – In Press

173. Design of a Multilayer Microstrip Delay Line on a Water Based Composite Dielectric Medium
R. Agaram; K. Sathish; N. H. N, Deshpande, A. A.; Sethi, S.
2023 International Applied Computational Electromagnetics Society Symposium (ACES), Monterey/Seaside, CA, USA, 2023, p1

Conferences Attended & Institutions Visited

Name	Conferences Attended/ Institutions Visited, Date	Title of the Paper/ Talk
Abhishek Ghadai	Complex Fluids & Soft Matter (Compflu) 2022: IIT Kharagpur, December 19-21, 2022	Origin of steady state stress fluctuations in a shear-thinning worm-like micellar solution
Alakananda Patra	28th International Liquid Crystal Conference (ILCC) International Liquid Crystal Society (ILCS), NOVA School of Science and Technology, Lisbon, Portugal, July 24-29, 2022	Synthesis of novel regioisomeric phenanthro[a]phenazine derivatives through SNAr strategy and their self-assembly into columnar phases
	Institute of Organic Chemistry, Universität Stuttgart; Organized by Prof. Dr. Sabine Laschat, August 2, 2022	Invited talk
	Unité de Dynamique et Structure des Matériaux Moléculaires, Calais, France, organized by Dr Dharmendra Pratap Singh, August 3-7, 2022.	Invited talk and collaborative work
	29th National Conference on liquid crystals, The Centre for Nano and Soft Matter Sciences (CeNS) and Christ - Deemed to be University Bangalore, Karnataka, December 8-10, 2022	Effect of ring closure on the physical properties of heterocyclic discotic liquid crystals
Andal Narayanan	Alberta Quantum Summit, Calgary, Alberta Canada, October 12, 2022	Neutral atom mediated microwave to optical transduction
Anirban Misra	International Centre for Theoretical Sciences, Bengaluru, India, May 9-13, 2022	Physics with Trapped Atoms, Molecules and Ions (HYBRID)
	International School of Physics "Enrico Fermi", Course 211 on "Quantum Mixtures With Ultra-cold Atoms"Varenna, Lake Como, Italy, July 18-23, 2022	Simultaneous laser cooling of two alkali species towards Bose-Bose Quantum gas mixtures
	Minerva-Gentner Symposium on Coherent manipulation of few-body complexes, Weizmann Institute of Science, Rehovot, Israel, February 20-23, 2023	Measurement of dynamics in cold atomic mixture with tunable interatomic interaction
Anson G Thambi	International Conference on Complex Fluids and Soft Matter CompFlu 2022, December 19 - 21, 2022	Dynamical heterogeneities in 2-D granular poly-disperse systems. Won RSC (Royal Society of Chemistry) and ACS (American Chemical Society) award for the best poster for Dynamical heterogeneities in 2-D granular poly-disperse systems in 2022

Name	Conferences Attended/ Institutions Visited, Date	Title of the Paper/ Talk
	Indian Statistical Physics Community Meeting, ICTS Bengaluru, February 1-3, 2023	Dynamical heterogeneities in 2-D granular poly-disperse systems
Arun Roy	28th International Conference on Liquid Crystals (ILCC-2022), NOVA School of Science and Technology, Lisbon, Portugal, July 24-29, 2022.	The evidence of SmA to deVries SmA transition exhibited by bent-core hockey-stick shaped molecules
A Raghunathan	Astronomical Society of India, IIT Indore, March 1-5, 2023	Low frequency Radio Telescope
Biman B Nath	Bangladesh Astronomical Society, July 19, 2022	Online talk on James Webb Space Telescope
	Molecular Biology Unit, IISc, September 23, 2022	Invited popular science talk on Galactic outflows
	Department of Astronomy & Space Sciences, IIT Indore, November 18, 2022	Invited Colloquium
	Gas in Galaxies conference, Academy of Indian Sciences, Orange County, November 30, 2022	Invited review talk on Galactic Outflows
	National Space Science Seminar Public Outreach, Science City Auditorium, December 6, 2022	Public talk in Bengali
	National Space Science Seminar Public Outreach, December 8, 2022	Popular talk at IISER- Kolkata
	Panel discussion, National Space Science Seminar Public outreach, December 10, 2022	Science Adda
	Dept of Physics, Visva-Bharati, Santiniketan , December 13, 2022	The first galaxies in the Universe
	Solar Science and Aditya L1 mission workshop, St. Joseph's College, Bangalore, January 5, 2023	The discovery of Helium
	Dept of Physics, Assam University, Silchar, February 14, 2023	Supermassive blackholes
	Institute colloquium, IIT- Palakkad, March 15, 2023	Supermassive blackholes

Name	Conferences Attended/ Institutions Visited, Date	Title of the Paper/ Talk
Biswajit Paul	44th Committee on Space Research (COSPAR) Scientific Assembly, Athens, Greece , July 16-24, 2022	X-ray Polarimetry Satellite (XPo-Sat)
	RRI Platinum Jubilee - Showcasing RRI, November 8-11, 2022	Highs and Lows of Accreting Neutron Stars
	Colloquium at Christ University, January 31, 2023	Give and take between Stars in Binary Systems
Deepak Mehta	5th Biomembranes Symposium 2022 Department of Chemical Engineering @ 75, IISc, September 15-17, 2022	Osmotically Driven Vesicle Fusion In Axons
	The 45th Indian Biophysical Society Meeting, National Centre for Biological Sciences (NCBS), March 27-29, 2023	Tension induced vesicle fusion in the axonal membrane
Dibyendu Roy	School of Physical Sciences of the Indian Association for the Cultivation of Science (IACS), Kolkata, October 10, 2022 - November 12, 2022	Composite topological phases of non-Hermitian one-dimensional systems
	Structured Light and Spin-Orbit Photonics, ICTS, Bangalore, November 29 - December 02, 2022	Light-matter interactions in waveguide quantum electrodynamic systems
Dipak Patra	IIT Kharagpur, India, July 2022	Statistical Physics and Complex Systems
	IIT Kharagpur, India, July 2022	Nonlinear Physics and Statistical Physics
	29th National Conference on Liquid Crystals (NCLC-2022), Bangalore, India, December 8, 2022	Excluded volume effect induced chiral symmetry breaking in bent-core liquid crystal
Girish B S	U. R. Rao Space Centre (URSC), Bengaluru, June 8, 2022	Discussion related to PRATUSH project with the Communication group at URSC
	Space Application Centre (SAC), Ahmedabad, January 8-10, 2023	Architecture of digital correlation spectrometer for PRATUSH and expected data rates for various modes of operation of the spectrometer
Gourab Pal	Physics with trapped Atoms, Molecules and ions, ICTS, May 2022	
	Structured Light and Spin-orbit Photonics, ICTS, November 2022	Exploring the quantum many body physics of ultra-cold gas mixtures in spatially structured static and dynamic engineered potentials

Name	Conferences Attended/ Institutions Visited, Date	Title of the Paper/ Talk
	National Conference on Atomic and Molecular Physics, Indian Institute of Space Science and Technology, Space Physics Laboratory, India, February 2023	Exploring the quantum many body physics of Ultra-cold gas mixtures in spatially structured static and dynamic engineered potentials
	Pre-Conference School on overlapping areas of Atomic and Molecular Physics and Quantum Technology, IISER-TVM, February 2023	
	School on Light and Cold Atoms International Centre for Theoretical Physics - South American Institute for Fundamental Research (ICTP SAIFR), Brazil, March, 2023	Quantum many body dynamics in ultracold gas mixture in structured light created using MEMS device
	International Centre for Theoretical Physics - South American Institute for Fundamental Research (ICTP-SAIFR), Brazil, March, 2023	Very cold indeed: The nanokelvin physics of Bose-Einstein condensation
Jacob Rajan	DST office, New Delhi, August 26, 2022	Half-day interactive session on 'Cyber Security' DST
Madhavan Varadarajan	Black Hole Information Loss Workshop, Hvar, Croatia, June 20-24, 2022	Quantum Gravity and the Information Loss Problem for 2-dimensional black holes
	Loops 22, Lyon, France, July 18-22, 2022	LQG Dynamics: An Electric Shift in Perspective
	University of Warsaw, September 27 - October 12, 2022	i. New Dynamics for Euclidean LQG ii. Anomaly Free Commutators for Euclidean LQG
	Quantum Gravity and More in memory of Jerzy Jurkiewicz, Cracow, Poland, October 7-8, 2022	LQG: A structural review and some new results
	10th Tux Workshop on Quantum Gravity, Tux, Austria, February 13-17, 2023	Electric Shift mediated Quantum Dynamics for Euclidean LQG Invited
	Universidad Nacional Autónoma de México (UNAM), Morelia, February 22, 2023	LQG dynamics: An electric shift in perspective
Maitri Mandal	16th COMPLEX FLUIDS SYMPOSIUM 2022(CompFlu-2022), IIT, Kharagpur, India, December 19 - 21, 2022	

Name	Conferences Attended/ Institutions Visited, Date	Title of the Paper/ Talk
Mayuri S. Rao	Space Applications Centre (SAC) Ahmedabad, May 19-20, 2022	Memorandum of Understanding between RRI and SAC.
	Indian Institute of Technology Bombay, August 4, 2022	Precision Cosmology: Current generation experimental activities
	Global 21-cm workshop, Berkeley, October 18, 2022	PRATUSH: Current status & updates
	Workshop on 21-cm Cosmology in the SKA Era, October 31, 2022	Global HI 21-cm signal from space
	Lorentz Centre Workshop, November 1, 2022	APSERa: status and updates
	Frontiers in Cosmology, Raman Research Institute, February 24, 2023	PRATUSH : a space-based 21 cm experiment
	Less Traveled Path to the Dark Universe, International Centre for Theoretical Sciences, Bangalore, March 13-24 2023	Cosmology Experiments : The Present Landscape
Nayantara Gupta	Platinum Jubilee Celebration, November 9, 2022	Multi Messenger Astronomy: Progress and Problems
Pooja Joshi	International Centre for Theoretical Sciences (ICTS), March 15-18, 2022	SAPS Satellite Meeting
	International Centre for Theoretical Sciences (ICTS) program, July 11-22, 2022	Statistical Biological Physics
	Information And Communications Technology Project (ICTP) -IIT Bombay, November 28 - December 02, 2022	Conference on Stochastic Thermodynamics in Biology
	International Centre for Theoretical Physics - International Centre for Theoretical Sciences (ICTP-ICTS), December 06-17, 2022	Winter School on Quantitative System Biology
	International Conference, December 19-21, 2022	Complex Fluids and Soft Matter
	European Molecular Biology Organization - Indian Institute of Science (EMBO-IISC), February 15-16, 2023	Physics of Cell and Tissues
	National Centre for Biological Sciences - Tata Institute of Fundamental Research (NCBS-TIFR), March 25-29, 2023	The 45th Indian Biophysical Society Meeting
	Centre for Cellular and Molecular Platforms (C-CAMP), April 12-14, 2023	Online Basic Image Analysis Course

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Pramod A Pullarkat	C-DNA Conference, CeNSE, Indian Institute of Science (IISc), Bangalore, June 8-9, 2022	Probing the unique viscoelastic properties of axons of neuronal cells
	5th Biomembranes Symposium 2022, Department of Chemical Engineering @ 75, Indian Institute of Science, Bangalore, September 15-17, 2022	Responses of axons to excess membrane tension
	IIT-Bombay, September 2-5, 2022	Collaborative visit
	The international meeting Inter-disciplinary Approaches to Biological Sciences 2023, IACS, Kolkata, February 1-3, 2023	Mechanical properties of axons on 1st
	Physics of Cells and Tissues, IISc, February 15-16, 2023	Tension buffering mechanisms in axons
	IISER-Pune, February 21-24, 2023	Collaborative meetings
	Indian Biophysical Society meeting, March 25–29, 2023	Tension buffering mechanisms in axons
Rahul Sharma	Istanbul University, Turkey, Online (IU Observatory Astrophysics Talks series), April 11, 2022	AstroSAT view of the Accretion-powered Millisecond X-ray Pulsars
	Seven years of AstroSat conference at ISRO HQ, Bangalore, September 28-29, 2022	Accreting Neutron Stars of different Magnetic fields with AstroSat
	IISER Mohali (Online), February 01, 2023	AstroSat observation of the accreting millisecond X-ray pulsar SAX J1808.4–3658 during its 2019 outburst
Ranjini Bandyopadhyay	Jawaharlal Nehru Planetarium, Bengaluru, JNP Classroom course, June 2, 2022	Decoding the flow of lotions, paste and mayonnaise
	National Assembly of Researchers in Physics, IISER Bhopal, August 26, 2022	
	Asia-Pacific Condensed Matter Physics Conference 2022 (AC2MP), Tohoku University, Sendai, Japan, November 20-22, 2022	Interfacial pattern selection at a fluid-fluid interface
	Chennai Soft Matter Days, January 5-6, 2023	Dichotomous behaviours of stress and dielectric relaxations in dense suspensions of swollen thermoreversible microgel particles
	Indian Statistical Physics Community Meeting, February 1-3, 2023	

Name	Conferences Attended/ Institutions Visited, Date	Title of the Paper/ Talk
	Frontiers in Active and Soft Matter, University of Hyderabad, February 10-11, 2023	Emergence of transient reverse fingers during radial displacement of a dense granular suspension
	Steady state phenomena in soft matter, active and biological systems, SN Bose Centre for Basic Sciences, Kolkata, March 16-18, 2023	Correlating the microscopic viscoelasticity and structure of aging colloidal gel using optical tweezer based active microrheology and cryo-SEM experiments
Reji Philip	SD College Kanjirappally, May 06, 2022	
	International Conference on Materials - Properties, Measurements and Applications (ICMPMA 2022), Fatima Matha College, Kollam, May 09-13, 2022	
	Marian College Kuttikkanam, May 30, 2022	A Journey through Light: Research Frontiers
	National conference on Materials for Industrial and Societal Applications, St. Joseph's College Alleppey, June 04, 2022	Nonlinear optical properties of novel materials
	Physics Association Inauguration, St. Thomas College Palai, June 7, 2022	
	FDP, Theoretical Foundations of NLO, Reva University, September 30, 2022	
	UFS 2022 (9th theme meeting on Ultrafast Sciences) IISER Trivandrum, November 03-05, 2022	
	PJC Talk, RRI, November 08, 2022	
	International Winter School- 2022 on "Frontiers in Material Science", International Centre for Materials Science, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore December 05-09, 2022.	Optical limiting properties of the natural dye extracted from Tectona Grandis (Teak) Leaf Extract (Poster)
	Functional materials for Advanced technology (ICFMAT-1), Central University of Kerala, January 2-4, 2023	
	Research Training School in Physics, CUSAT, January 8-10, 2023	
	NSAMAP 2023, St. Thomas Kozhencherry, January 12-13, 2023	
	Dr. George M. Thomas Memorial Lecture 2023, CMS College Kottayam, January 13, 2023	

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	ICNAAS 23, Lady Doak College, February 2-3, 2023, Bishop Moore Mavelikara, February 8, 2023	
	MAPS-2013, Mar Thoma College Chungathara, February 22-24, 2023	
	National Science Day, Reva University, March 2, 2023	
	International Conference on Recent Trends in Materials Science (ICRTMS -2023), Kristu Jayanthi College, Bangalore, March 7, 2023	Comparative studies of the enhancement of LIBS spectra using fused silica substrates (Poster).
	Workshop on Material Characterization Techniques 2023, UC College Aluva, March 22-23, 2023	
	7th International Conference on Nanoscience and Nanotechnology 2023, SRM Institute of Science and Technology, Chennai, March 27-29, 2023	Nonlinear optical applications of 2D materials, (KeyNote Lecture)
Rishin P V	Ten Years of High-Energy Universe in Focus: NuSTAR 2022, Cagliari, Italy, June 20-22, 2022.	POLIX – The Thomson scattering X-ray polarimeter
	Committee on Space Research (COSPAR) 2022, 44th Scientific Assembly, Athens, Greece, July 16-24, 2022.	Tests, calibration and simulations of the X-ray polarimeter POLIX
	Astrophysical Polarimetry in the Time Domain Era, Politecnico di Milano - Polo territoriale di Lecco, Italy, August 28 - September 01, 2022	GEANT4 simulations of the scattering X-ray Polarimeter POLIX onboard the Indian mission XPoSAT
Sachinanda Barik	Complex Fluids & Soft Matter (COMPFLU), IIT Kharagpur, December 19-21, 2022	Role of frictional interaction controlling the universal scaling in shear thickening system
Sadiq Rangwala	Workshop on Cold Hybrid Ion-atom Systems, University of Warsaw, Poland, June 8-10, 2022	Collisions, exchange symmetry, and diffusion in ultra-cold ion-atom systems
	The Cold and Controlled Molecules and Ions Conference 2022, Durham University, UK, September 3-9, 2022	Hybrid Trap Experiments as Test Tube for Interactions in Cold Dilute Gases
	Raman Research Institute	Nobel Prize for Physics 2022
	Indian Academy of Sciences, 88th Annual Meeting, SRM University, Vijayavada, November 4-6, 2022	Nobel Prize for Physics 2022
	Showcasing RRI, Raman Research Institute, November 7-11, 2022	Interactions at RRI and their Measure

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	Bangalore University, January 5, 2023	Nobel Prize for Physics 2022
	National Conference on Atomic and Molecular Physics (NCAMP) 23: School, IISER Trivandrum, January 16-18, 2023	Lectures on Quantum Sensors
	23rd National Conference on Atomic and Molecular Physics, Indian Institute of Space Technology, Trivandrum, January 20-23, 2023	Hybrid Traps as Test Tube for Studying Interactions in Cold Dilute Gasses
Sanjib Sabhapandit	Progress in Quantum Science and Technologies (PiQuST), IIT Madras, January 23-27, 2023	Direction Reversing Active Brownian motion
	Large Deviations, Extremes and Anomalous Transport in Non-equilibrium Systems, Thematic Programme, Erwin Schrodinger, International Institute for Mathematics and Physics, Vienna, September 19, 2022 – October 14, 2022	Novel Features of Direction Reversing Active Brownian motion
	8th Indian statistical physics community meeting, February 1-3, 2023	
Saptarishi Chaudhuri	PHYSICS WITH TRAPPED ATOMS, MOLECULES AND IONS (HYBRID), ICTS, Bengaluru, May 09-13, 2022.	Experiments with Mixtures of Cold Atoms: Quantum Sensors
	Structured Light and Spin-Orbit Photonics, ICTS, Bengaluru from 29th, November 2022 - December 02, 2022	A Mixture of cold atoms in a structured optical potential
	DAE-BRNS National Laser Symposium (NLS-31), Indian Laser Association, IIT, Kharagpur, December 03-06, 2022	Laser cooled atomic mixture as quantum sensors
	Defense Institute of Advanced Technology, Pune, MH, India 411025, February 6, 2023	Colloquium : Quantum Technologies With Cold Atomic Mixtures
	Let There Be Light 2023 meeting, MAYUR THE KARMA Hospitality, Pench, Madhya Pradesh, February 19-22, 2023	Quantum phases of ultra-cold atoms in optical lattices
Saurabh Singh	URSI-RCRS, IIT Indore, India, 01-04 December, 2022	Towards unraveling cosmic dawn: SARAS and PRATUSH experiments
	Less Traveled Path to the Dark Universe, ICTS, Bangalore, India	Observing cosmic dawn through 21-cm signal
	Frontiers in Cosmology, RRI, Bangalore, 20-24 February 2023	Constraining high redshift astrophysics with SARAS
	Astronomical Society of India, IIT Indore, 01-05 March, 2023	Observing cosmic dawn through 21-cm signal

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Sayantan Chanda	Complex Fluids & Soft Matter (COMPFLU) 2022, IITKGP, Kolkata, December 19-21, 2022	
Sayantan Majumdar	International Conference on Smart Materials for sustainable technology, IIT, Bombay, Society for Interdisciplinary Research in Materials & Biology (SIRMB) and IIT BHU, October 13-16, 2022	Origin of two distinct stress relaxation regimes in shear jammed dense suspensions
	Complex Fluids Meeting, IIT Kharagpur and SOR, India, December 19-21, 2022	Origin of two distinct stress relaxation regimes in shear jammed dense suspensions
	Frontiers in Non-Equilibrium Physics, Institute of Mathematical Sciences, Chennai, India., January 17-20, 2023	Origin of two distinct stress relaxation regimes in shear jammed dense suspensions
	8th Indian Statistical Physics Community Meeting, ICTS, Bangalore, February 1-3, 2023	Origin of two distinct stress relaxation regimes in shear jammed dense suspensions
	Steady state phenomena in soft matter active and biological systems, Organized by S.N. Bose National Center for Basic Sciences, Kolkata, March 16-18, 2023	Origin of two distinct stress relaxation regimes in shear jammed dense suspensions
Sayari Majumder	Physics with Trapped atoms, molecules and ions, ICTS , May 2022	Spin Coherence in thermal and Ultra-Cold atomic ensembles as a probe of Quantum phase transition
	Structured light and Spin-Orbit Photonics, ICTS, November 2022	Towards Spatio-Temporal Spin Coherence Studies in Atomic Ensemble
	Wilhelm and Else Heraeus (WE-Heraeus) -Seminar on Quantum Control of Light at Bad Honnef, Germany, March 2023	Experimental Study of the Spin Properties of Cold Atomic Mixture
	Technical University of Kaiserslautern, Kaiserslautern, Germany, March 26-28, 2023	Experimental Study of Spin Correlation in Atomic Ensembles
	University of Heidelberg, Heidelberg, Germany, April 3-5, 2023	Experimental Study of Spin Correlation in Atomic Ensembles
	ICFO, Barcelona, Spain, April 5-6, 2023	Experimental Study of Spin Correlation in Atomic Ensembles
Sebanti Chattopadhyay	International soft matter conference, Poznan, Poland ,September 19-23, 2022	Effect of adhesive interaction on strain stiffening and dissipation in granular gels undergoing yielding
	Eidgenössische Technische Hochschule (ETH) Zurich, September 24-27, 2022	Yielding and memory formation in adhesive gels

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Shovan Dutta	Indian Statistical Physics Community Meeting 23, ICTS, Bangalore, February 1-3, 2023	Multipartite entanglement from local drive
	Institute of Mathematical Sciences, Chennai, March 12-14, 2023	Long-range multipartite entanglement from a local drive
Sk Jasim	16th COMPLEX FLUIDS SYMPOSIUM 2022(CompFlu-2022), IIT Kharagpur, December 19-21, 2022	
Sonali Sachdeva	In-house RRI, April 27-29, 2022	Dust in the Universe
	Astro workshop, May 4, 2022	Exploring galaxy formation with upcoming telescopes
	IUCAA Centre for Astronomy Research and Development (ICARD) Seminar, University of Delhi, July 28, 2022	Invited talk Science with JWST
	4th National Conference on High Energy Emission from AGN, Kerala University, August 12-14, 2022	Role of host morphology in the origin of jets from AGNs
	Indian Institute of Technology - Kanpur, January 3, 2023	Tracing the growth of galaxies since their formation
	Very Sirius Meetings, January 24, 2023	Evolution of galaxy luminosity function at redshift 8 to 15
Sonali Vasant Kawale	Women in Optics and Photonics in India 2022, RRI Bangalore, December 5-7, 2022	Study of swelling behavior of thermoresponsive core-shell microgels using dynamic light scattering
Soumen Bhukta	16th COMPLEX FLUIDS SYMPOSIUM 2022(CompFlu-2022), IIT Kharagpur, December 19-21, 2022	
Sourav Bhadra	COSPAR Scientific Assembly, July 2022	Cosmic Rays from massive star clusters: a close look at Westerlund 1
	Astronomical Society of India, IIT Indore, 01-05 March, 2023	Between the cosmic-ray 'knee' and the 'ankle': Contribution from Star clusters
Srivani K S	U.R. Rao Satellite Centre (URSC), Department of Space, Indian Space Research Organization, Bengaluru, June 7, 2022	PRATUSH payload and visit to communications group at URSC
	U.R. Rao Satellite Centre (URSC), Department of Space, Indian Space Research Organization, Bengaluru, September 30, 2022	Telemetry and Telecommand FPGA firmware(TMTC-PLD) for POLIX (X-RAY Polarimeter)

Name	Conferences Attended/ Institutions Visited, Date	Title of the Paper/ Talk
	Space Application Centre(SAC), Ahmedabad, January, 11-13, 2023	Technical discussions regarding PRATUSH payload with the SAC team comprising of antenna, analog/RF and Digital expertise
Sumati Surya	RRI Inhouse, April 2022	Quantum Fields on Causal Sets - Causality, Non-locality and Entanglement
	Informational Architecture of Spacetime, Okinawa Institute of Science and Technology, May 30 - June 3, 2022	Spacetime Entanglement Entropy: Discreteness and Covariance
	The Centre for Cosmology and Particle Physics Phenomenology - CP3 Origins, Odense University, Denmark, June 13, 2022	Beating Entropy in Causal Set Theory
	University of New Brunswick, October 18, 2022	Quantising the Causal Structure
	Eidgenössische Technische Hochschule (ETH) Zurich, November 2, 2022	Quantising the Causal Structure
	RRI Platinum Jubilee Celebration, November 7-11, 2022	Quantum Gravity from Discrete Causality
	Quantum Gravity and Random Geometry, Institut Henri Poincare, France, January 15-24, 2023	Entropy versus the Action in Causal Set Theory
	Causal Dynamical Triangulations (CDTs) and Friends, Radboud University, Netherlands, January 25-27, 2023	Quantum Dynamics of Causal Sets: Progress and Challenges
	Frontiers in Physics, Hyderabad University, 2023, March 3, 2023	Spacetime Causality and Quantum Gravity
	Perimeter Institute, March 9, 2023	Entropy versus the Action in Causal Set Theory
	Non-Regular Spacetime Geometry, Erwin Schrodinger Institute, Vienna, March 13-24, 2023	Causal Set Kinematics: Reconstructing Spacetime from Randomly Embedded Posets
T Prabu	IIT Roorkee, August 17-20, 2022	Pulsar timing array Busy week
	Workshop on 21-cm Cosmology in the Square Kilometer Array Era, ISI, Kolkata,October 31 - November 4, 2022	21-cm Instrumentation and design
	URSI Regional Conference on Radio Science (URSI - RCRS), IIT Indore, 1-4 December, 2022	Square Kilometer Array Pulsar Search Pipeline

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	Sapthagiri College of Engineering, Bangalore, December 10, 2022	Research and Entrepreneurship
	Conference at IMSc, Chennai, Lead session on: Science with SKA, February 01 - 08, 2023	Neutron Stars: The celestial clocks that probe extreme physics
	Astronomical Society of India, IIT Indore, March 01 - 05, 2023	Three posters on the SKA related works with colleagues
T R Vishnu	Indian Statistical Physics Community Meeting 2023, ICTS, Bangalore, February 01-03, 2023	Dynamical stability of a coupled scalar field theory: Different perspectives
Vaibhav Raj Singh Parmar	Complex Fluids Symposium 2022, December 19-21, 2022	An experimental study of desiccation cracks in an aging clay suspension
Vanishree Bhat S.	28th International Conference on Liquid Crystals (ILCC-2022) NOVA School of Science and Technology, Lisbon, Portugal, July 24-29, 2022	Synthesis and Characterization of Novel Heterocyclic Discotic mesogens
	Universität, Stuttgart, Germany and University of Dar es Salaam (UDSM), Calais, France., August 1-7, 2022	Synthesis and characterisation of novel sterol based mesogens and heterocyclic discotic mesogens
	29th National Conference on Liquid Crystals (NCLC-2022) Christ (deemed to be University), Bengaluru, December 08-10, 2022	Synthesis and Characterization of Novel Heterocyclic Discotic Mesogens
Vishnu Deo Mishra	International Liquid Crystal Conference, ILCC-2022, Lisbon, Portugal, July 2022	
	National Conference on Liquid Crystals, NCLC-2022, Bangalore, December 2022	
Yatheendran K. M.	Electron Microscopy Facility, National Center for Biological Sciences, TIFR Bangalore, October 10-12, 2022	Hands-on workshop on Scanning Electron Microscopy

Colloquia and Seminars

Name	Title	Date
Jithesh V University of Calicut	Spectral and Temporal Properties of X-ray Binaries	08 April, 2022
Darshan G Joshi Harvard University, USA	Strongly correlated phases in models with random interactions	11 April, 2022
Ragavendra H V IISER Kolkata	Constraining inflation across different scales	13 April, 2022
Vishnu T R Chennai Mathematical Institute	The KdV equation and inverse scattering theory	21 April, 2022
Rahul V. R. IIT Madras	Study of rotations of birefringent particles in optical tweezers and its applications to soft matter	21 April, 2022
Marichandran V RRI, Bengaluru	Synthesis and Characterization of Some Novel Heterocyclic Discotic Mesogens	02 May 2022
Buti Suryabrahmam RRI, Bengaluru	Studies on the mechanical properties and phase behavior of lipid bilayers in the presence of some alcohols and oxysterols	02 May, 2022
Gayathri V University of Florida, Gainesville, Florida, USA	Who ordered LIGO's most massive black hole?	09 May, 2022
Prof. Jihad Touma American University of Beirut, Beirut, Lebanon	The Curious Case of Planet 9	12 May, 2022
Kartik Prabhu University of California, Santa Barbara, USA	Infrared finite scattering in QFT & quantum gravity	13 May, 2022
Surajith Paul Pune University	The tale of the tailenders	30 May, 2022
Tousif Islam University of Massachusetts, Dartmouth, USA	High-accuracy inference of binary black hole source properties using numerical relativity surrogate models for gravitational waveform	14 June, 2022
Rouven Frassek University of Modena and Reggio Emilia, Italy	Non-compact spin chains and integrable particle processes	15 June, 2022
Prof. Ranjeev Mishra IUCAA, Pune	X-ray Variability of Black Hole Systems: The AstroSat Advantage	16 June, 2022
Prof. Rajaram Nityananda Azim Premji University, Bengaluru	Revisiting diffraction	20 June, 2022
Mithun Chowdhury IIT Bombay	Decoupled glassy dynamics in confined polymer films	21 June, 2022
Ashish Arora IISER Pune	Importance of magnetic fields in semiconductor physics explorations	21 June, 2022

Renu Maan Delft Technical University, The Netherlands	In-vitro Reconstitutions to understand cellular functions	04 July, 2022
Koushik Mandal S N Bose National Centre for Basic Sciences, Kolkata	Superconducting Pairing Mechanisms in Correlated Fermionic Systems	12 July, 2022
Vinutha H A Georgetown University, USA	Uncovering distinct contributions to the shear-stress of dense packings of soft spheres	03 August, 2022
Hariharan Krishnan University of Cape Town (UCT), South Africa & Arizona State University (ASU), USA	A RealTime Transient Imaging Correlator for Compact Radio Arrays	08 August, 2022
Varun Narasimhachar Nanyang Technological University, Singapore	Quantum thermodynamic resources from coherence to non-Markovianity	10 August, 2022
Mohit Bhardwaj McGill University, Canada	Deciphering the origins of FRBs using local Universe CHIME/FRB discoveries	11 August, 2022
Pushpita Das University of Amsterdam, The Netherlands	General relativistic magnetohydrodynamic (GRMHD) simulations of accreting neutron stars.	12 August, 2022
Anindya Chowdhary RRI, Bengaluru	Effect of salt and polyelectrolytes on self-assembled structures of ionic amphiphiles	16 August, 2022
Thirthankar Banerjee University of Cambridge, UK	Initial conditions and single-file diffusion: compressibility hyperuniformity and everlasting memory	17 August, 2022
Namrata Roy University of California, Santa Cruz, USA	Star formation suppression and feedback in nearby passive galaxies	18 August, 2022
Irla Sivakumar RRI, Bengaluru	Synthesis and characterization of new liquid crystalline compounds derived from novel aromatic ring structures	23 August, 2022
Siddardha Chelluri Johanner Gutenberg University, Mainz, Germany	Quantum cooperativity and rate analysis for atomic ensemble based quantum repeaters	24 August, 2022
Arup Bhowmick RRI, Bengaluru	Lattice of ion traps for quantum technology and thermal Rydberg quantum optics	29 August, 2022
Tejaswi Venumadhav Nerella University of California, Santa Barbara, USA	Parameter inference from gravitational wave signals emitted by compact binary mergers	30 August, 2022
Marichandran V RRI, Bengaluru	Synthesis and Characterization of Some Novel Heterocyclic Discotic Mesogens	09 September, 2022
Maheshwaram Sumanth Kumar RRI, Bengaluru	Understanding Physical Mechanisms in Chromatin Folding	12 September, 2022
Chandra Kant Mishra IIT Madras	Gravitational waves from eccentric mergers: source modeling and implications	16 September, 2022
Palak RRI, Bengaluru	Experimental studies of the non-equilibrium dynamics and complex flows in dense suspensions	22 September, 2022

Chandan Kumar	Glass-like to gel-like transition in 2D layers of lipid-nanoclay composites	28 September, 2022
Aru Beri IISER Mohali	Fast timing and multi-band look at X ray Binaries	29 September, 2022
Eitan Bachmat Ben-Gurion University of the Negev, Be'er Sheva, Israel	Applied space-time geometry	30 September, 2022
Divita Saraogi IIT Bombay	Localisation of Gamma Ray Burst using AstroSat Mass Model	30 September, 2022
Suman Bala IIT Bombay	GRB prompt emission polarimetry with proposed Indian high-energy transient monitor -Daksha	30 September, 2022
Chandeshwar Misra RRI, Bengaluru	An experimental study of the jamming dynamics in suspensions of soft colloidal particles	10 October, 2022
Saichand C RRI, Bengaluru	Novel Wall Defects in Lamellar Soft Matter	14 October, 2022
Prof. Konstantin E. Dorfman East China Normal University, Shanghai, China	Multidimensional quantum sensing and spectroscopy	18 October, 2022
Siddhartha Gupta University of Chicago, USA	Particle Acceleration at Astrophysical Shocks	19 October, 2022
Subhadip Ghosh RRI, Bengaluru	Experimental studies on crystal polymorphism and self-assembled structures in soft matter	21 October, 2022
Prof. Barry C Sanders University of Calgary, Canada	Our Quantum Centuries	03 November, 2022
Anshu Kumari University of Helsinki, Finland	Coronal Mass Ejections: From Observations to Simulations	03 November, 2022
Rajkumar Biswas RRI, Bengaluru	Probing the non-equilibrium dynamics of driven soft matter	04 November, 2022
Somrita Ray IIT Tirupati	To reset or not to reset, that is the question!	14 November, 2022
Irla Sivakumar RRI, Bengaluru	Synthesis and characterization of new liquid crystalline compounds derived from novel aromatic ring structures	14 November, 2022
Prakash Gaikwad Max Planck Institute for Astronomy, Heidelberg, Germany	Observational evidence for late reionization	15 November, 2022
Prof. Ramaprakarash IUCAA, Pune	Unveiling the dusty Universe	17 November, 2022
Debmalya Chakraborty Department of Physics and Astronomy, Uppsala University, Sweden	Three way interplay of strong correlations, topology, and disorder in high temperature superconductors	17 November, 2022
Michael Doser CERN, Geneva, Switzerland	Pulsed production of antihydrogen and other antiprotonic systems for precisions tests of fundamental symmetries	18 November, 2022

Dr. Uttam Singh Poland Academy of Sciences, Poland	Nonthe universality of coherent states as approximate pointer	22 November, 2022
Prof Swapan Chatterjee, IISc, TIFR (ICTS), Fermilab (USA), UC Berkeley, Stanford University	Quantum Sensors in Cosmic Archaeology and Electron-Photon Entanglement	28 November, 2022
Madhusmita Tripathy Technical University Darmstadt, Germany	Packing in Lipid Membranes and Functional Proteins: A Biophysical Perspective	30 November, 2022
Ekta Sharma National Astronomical Observatories of China, Beijing, China	Characterizing molecular clouds with kinematics & magnetic fields	02 December, 2022
Aneesh Dash GlobalFoundries, Bengaluru	Integrated Nano-Optomechanical Systems	16 December, 2022
Gayathri Raman Pennsylvania State University, USA	Targeted sub-threshold transient searches using Swift-BAT GUANO	19 December, 2022
Ranjani Seshadri Ben-Gurion University of the Negev, Be'er Sheva, Israel	Engineering Floquet topological phases using periodic driving	21 December, 2022
Suman Das University of Cologne, Germany	Biological evolution on a driven disordered fitness landscape	04 January, 2023
Prof. Arman Shafieloo Korea Astronomy and Space Science Institute, South Korea	Status of the Concordance Model of Cosmology	5 January, 2023
Matthias Lehmann University of Würzburg, Germany	Shape-Persistent Mesogens and Intrinsic Void – A New Design Tool for Complex Functional Liquid Crystal Materials	09 January, 2023
Krishanu Roychowdhury Saha Institute of Nuclear Physics, Kolkata	Entanglement dualities in supersymmetry	10 January, 2023
Smijesh N ELI Beamlines, Czech Republic	Ultrafast and attosecond AMO science	10 January, 2023
Alkesh Yadav RRI, Bengaluru	Cellular trade-offs in the non-equilibrium synthesis of complex molecular information	11 January, 2023
Anirban Ghosh IISER Mohali	Persistence in asymmetric Bronian particle	12 January, 2023
Soumavo Ghosh Max-Planck Institut für Astronomie (MPIA), Germany	Can spirals help the Milky Way 'breathe'? - A quest with simulations & Gaia mission	16 January, 2023
Debashis Saha IISER TVM	Quantum description of reality is fine-tuned	17 January, 2023
Subhadip Ghosh RRI, Bengaluru	Experimental studies on crystal polymorphism and self-assembled structures in soft matter	20 January, 2023
Maheshwaram Sumanth Kumar RRI, Bengaluru	Understanding Physical Mechanisms in Chromatin Folding	20 January, 2023

Sneha Puri IIT Bombay	Study of Microstructure-interfacial Rheology Relationship in Microcapsules using Electrode-formation Technique	27 January, 2023
A. Gopakumar TIFR, Mumbai	Promise of persistent multi messenger GW astronomy with sources like Blazar OJ287	30 January, 2023
Chandan Datta University of Warsaw, Poland	Entanglement catalysis for quantum states and noisy channels	01 February, 2023
Swapnamay Mondal Trinity College Dublin, Ireland	Black hole microstates in String Theory	01 February, 2023
Abhishek Mathur RRI, Bengaluru	Quantum Fields from Causal Order	13 February, 2023
Ajit Srivastava Institute of Physics, Bhubaneswar	Detecting gravitational waves with pulsars as resonant Weber detectors	14 February, 2023
Rahul Sawant M Squared Lasers Ltd., London, UK	The use of ultra-cold atoms and molecules in uncovering new aspects of physics	14 February, 2023
Sourabh Paul McGill University, Canada	First direct detection of the neutral hydrogen intensity mapping	17 February, 2023
Rajesh Mondal Tel Aviv University, Israel	The 21 cm cosmology	17 February, 2023
Prof. Swapna S. Nair Central University of Kerala, Kasaragod	Multifunctional Sensors and Energy harvesters for IoT and Health care	20 February, 2023
Karamveer Kaur The Racah Institute of Physics, Jerusalem, Israel	Global dynamical friction in cored galaxies	01 March, 2023
Kartick Chandra Sarkar Tel Aviv University, Israel	Supernovae feedback in galaxies and understanding multi-wavelength observations	03 March, 2023
Ganga Prasath Srinivasa Gopalakrishnan IIT Madras	Mechanics of totimorphic meta-materials	14 March, 2023
Raj Prince Center for Theoretical Physics, Warsaw, Poland	Hubble Tension: Recruiting quasars in cosmology	17 March, 2023
Maitraiyee Tiwari University of Maryland, USA	Understanding stellar feedback in our Galaxy through observations and unsupervised machine learning	24 March, 2023
Chandeshwar Misra RRI, Bengaluru	An experimental study of the jamming dynamics in suspensions of soft colloidal particles	27 March, 2023
Saichand C RRI, Bengaluru	Novel Wall Defects in Lamellar Soft Matter	30 March, 2023
Projjwal Banerjee IIT Palakkad	Constraining R-process Nucleosynthesis Using 129I and 247Cm in the Early Solar System	31 March, 2023

Visitors

Name	Duration of Stay
Kartick Chandra Sarkar Tel Aviv University, Israel	01 - 06 March, 2022
Raj Prince Polish Academy of Sciences, Warsaw, Poland	14 - 21 March, 2022
Darshan G Joshi Harvard University, USA	11 - 12 April, 2022
Tanneru Narasimhaswami Central Leather Research Institute, Chennai	17 - 18 April, 2022
Shovan Dutta Max Planck Institute for the Physics of complex system, Dresden, Germany	17 - 19 April, 2022
Emile Emery Erole Normale Superieure, France	20 April - 01 August, 2022
Prof. Jihad Touma American University of Beirut, Beirut, Lebanon	23 April - 14 May, 2022
Rajorshi Sushovan Chandra IUCAA, Pune	25 April - 31 December, 2022
Koushik Mandal S N Bose National Centre for Basic Sciences, Kolkata	01 May - 01 August, 2022
Gayathri V University of Florida, Gainesville, USA	08 - 10 May, 2022
Arijit Sharma IIT Tirupati	09 - 10 May, 2022
Md Asad IISER Mohali	11 May - 14 August, 2022
Urna Basu S N Bose National Centre for Basic Science, Kolkata	12 - 29 May, 2022
Prof. Sanker Day Saha Institute of Nuclear Physics, Kolkata	14 - 17 May, 2022
Priyabrata Seth Saha Institute of Nuclear Physics, Kolkata	14 - 17 May, 2022
Sujay TIFR, Mumbai	17 - 30 May, 2022
Prof. Varun Bhalerao IIT Bombay	25 - 27 May, 2022
Shriharsh Tendulkar TIFR, Mumbai & NCRA, Pune	25 - 27 May, 2022
Surajit Paul University of Pune	29 - 31 May, 2022

Deepshika Malkar Institute of " Jozef Stefan" Stovenia, Slovenia	05 - 11 June, 2022
Tamal Mukherjee IIT Madras	08 - 28 June, 2022
Tousif Islam University of Massachusetts, Dartmouth, USA	14 - 15 June, 2022
Prof. Ranjeev Misra IUCAA, Pune	15 - 18 June, 2022
Subhadeep De IUCAA, Pune	16 - 17 June, 2022
Nishanth K Singh IUCAA, Pune	18 - 22 June, 2022
Mithun Chowdhury IIT Bombay	20 - 21 June, 2022
Prof. Rajaram Nityananda Azim Premji University, Bengaluru	20 - 23 June, 2022
Ashish Arora IISER Pune	21 June, 2022
Tridib Ray Laboratoire Kastler Brossel, Paris, France	23 - 25 June, 2022
Renu Maan Delft University of Technology, The Netherlands	04 - 05 July, 2022
SK Jahanur Hoque Charles University, Prague	24 - 27 July, 2022
Hariharan Krishnan University of Cape Town (UCT), South Africa & Arizona State University (ASU), USA	07 - 10 August, 2022
Varun Narasimhachar Nanyang Technological University, Singapore	10 August, 2022
Tirthankar Banerjee University of Cambridge, UK	10 - 12 August, 2022
Shailaja Kapoor Delhi University	10 - 23 August, 2022
Mohit Bhardwaj McGill University, Canada	11 - 16 August, 2022
Pushpita Das University of Amsterdam, The Netherlands	12 August, 2022
Namrata Roy University of California, Santa Cruz, USA	18 - 19 August, 2022
Siddardha Chelluri Johanner Gutenberg University, Mainz, Germany	23 - 25 August, 2022

Tejaswi Venumadhav Nerella University of California, Santa Barbara, USA	30 August, 2022
Subhadeep De IUCAA, Pune	06 - 07 September, 2022
Chandra Kant Mishra IIT Madras	16 - 19 September, 2022
Koushal GMRT & NCRA, Pune	17 - 22 September, 2022
Eitan Bachmat Ben Gurion University, Israel	22 - 24 September, 2022
Nipanjana Patra Curtin Institute of Radio Astronomy, Australia	25 September - 01 October, 2022
Prof. Varun Bhalerao IIT Bombay	27 - 29 September, 2022
Aru Beri IISER Mohali	29 September, 2022
Asha K Maharani's Government PU College, Mysore	29 September - 08 October, 2022
Devita Saraogi IIT Bombay	30 September, 2022
Suman Bala IIT Bombay	30 September - 01 October, 2022
Tanneru Narasimhaswami Central Leather Research Institute, Chennai	01 - 02 October, 2022
Siddhartha Gupta University of Chicago, USA	17 - 21 October, 2022
Prof. Konstantin E. Dorfman East China Normal University, Shanghai, China	18 October, 2022
Qutubuddin Md. MIT, Cambridge, USA	18 October, 2022
Debanjan Bose S N Bose National Centre for Basic Scienc Kolkata	31 October - 03 November, 2022
Samir Dhurde IUCAA, Pune	01 - 04 November, 2022
Anshu Kumari University of Helsinki, Finland	03 - 04 November, 2022
Sanskriti Das Stanford University, USA	07 - 10 November, 2022
Prof. Archan S Majumdar S N Bose National Centre for Basic Scienc, Kolkata	09 - 11 November, 2022
Md. Tousif Alam NISER, Bhubaneswar	09 November - 04 December, 2022

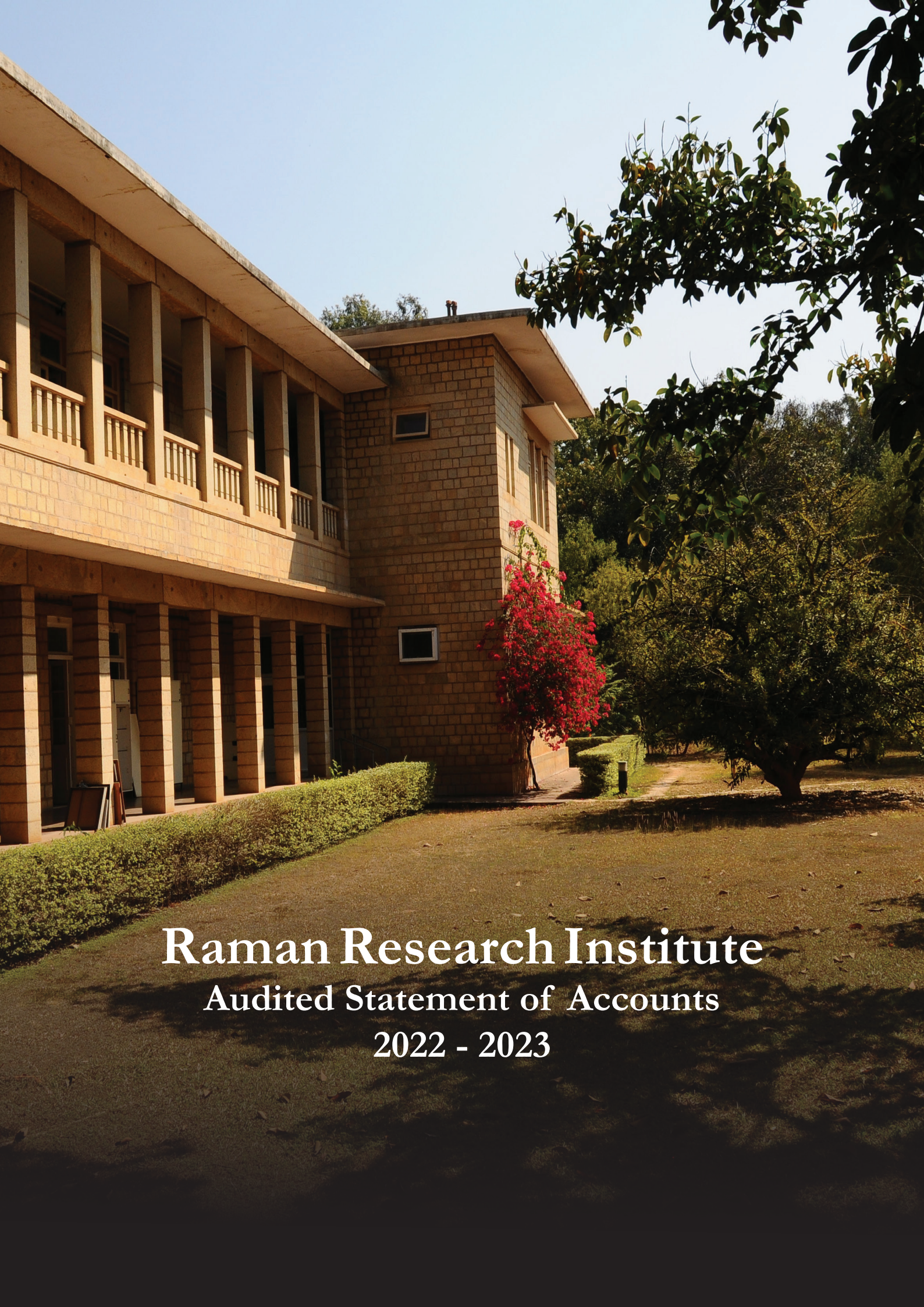
Prof. Bimalendu Deb Indian Association for the Cultivation of Science, Kolkata	10 - 12 November, 2022
Prof. Somshubhro Bandyopadhyay Bose Institute, Kolkata	10 - 12 November, 2022
Prof. Dipankar home Bose Institute, Kolkata	10 - 13 November, 2022
Prof. Vidyadhiraja N S JNCASR, Bengaluru	11 November, 2022
Somrita Ray IIT Tirupati	13 - 16 November, 2022
Prakash Gaikwad Max Planck Institute for Astronomy, Heidelberg, Germany	13 - 20 November, 2022
Debmalya Chakraborty Uppsala University, Sweden	16 - 18 November, 2022
Michael Doser CERN, Geneva, Switzerland	18 November, 2022
Uttam Singh Polish Academy of Sciences, Poland	19 - 24 November, 2022
Nivedita Mahesh California Institute of Technology, Pasadena, USA	28 - 30 November, 2022
Urna Basu S N Bose National Centre for Basic Science, Kolkata	11 - 18 December, 2022
Nikhil & Achu Mahatma Gandhi University, Kerala	13 - 30 December, 2022
Prof. Manas Mukherjee National University of Singapore, Singapore	14 December, 2022
Mr. Nilesh Dumre IISER Pune	14 December, 2022
Prof. Umakant D Rapol IISER Pune	14 December, 2022
Smijesh N Mahatma Gandhi University, Kerala	14 - 30 December, 2022
Kavya H Rao ELI Beamlines, Czech Republic	14 - 30 December, 2022
Aneesh Dash GlobalFoundries, Bengaluru	16 December, 2022
Sujay Mate TIFR, Mumbai	17 - 30 December, 2022
Gayathri Raman Pennsylvania State University, Pennsylvania, USA	19 - 20 December, 2022
Ranjani Seshadri Ben-Gurion University of the Negev, Be'ersheva, Israel	21 - 22 December, 2022

Suman Das University of Cologne, Germany	03 - 05 January, 2023
Prof. Arman Shafieloo Korea Astronomy and Space Science Institute, South Korea	04 - 08 January, 2023
Sh. Ziaur Rahman ADET Quantum Technologies Telecommunication Centre, Department of Telecommunications, New Delhi	07 - 09 January, 2023
Sh. Abdul Kayum ADET Quantum Technologies Telecommunication Centre, Department of Telecommunications, New Delhi	07 - 09 January, 2023
Rakesh Goyal ADET Quantum Technologies Telecommunication Centre, Department of Telecommunications, New Delhi	07 - 09 January, 2023
Bhooshan Gadre Utrecht University, The Netherlands	08 - 10 January, 2023
Matthias Lehmann University of Würzburg, Germany	08 - 12 January, 2023
Krishanu Roychowdhury Saha Institute of Nuclear Physics, Kolkata	09 - 10 January, 2023
Smijesh N ELI Beamlines, Czech Republic	10 - 12 January, 2023
Soumavo Ghosh Max-Planck-Institut fur Astronomie, Germany	15 - 18 January, 2023
Debashis Saha - Faculty applicant IISER TVM	16 - 17 January, 2023
Shivani Pethe IUCAA, Pune	16 - 20 January, 2023
Samir Dhurde IUCAA, Pune	16 - 20 January, 2023
Rupesh Labade IUCAA, Pune	18 - 20 January, 2023
Tanay Nag Uppsala University, Sweden	18 - 21 January, 2023
Sneha Puri IIT Bombay	27 January, 2023
Prof. Gopalkumar TIFR, Mumbai	27 - 31 January, 2023
Adwaith K V Wigner Research Center for Physics, Hungary	30 January - 01 February, 2023
Arnab Das Indian Association for the Cultivation of Science, Kolkata	30 January - 04 February, 2023
Chandan Datta University of Warsaw, Poland	31 January - 01 February, 2023

Urna Basu S N Bose National Centre for Basic Science, Kolkata	04 - 11 February, 2023
Alok Laddha Chennai Mathematical Institute	11 - 17 February, 2023
Ajit Srivastava Institute of Physics, Bhubaneswar	11 - 17 February, 2023
Rahul Sawant M Squared Lasers Ltd, London, UK	12 - 15 February, 2023
Prashanth Kumar Princeton University, New Jersey, USA	13 - 15 February, 2023
Prof. Swapna S Nair Central University of Kerala, Kasaragod	20 February, 2023
Prof. D.V.G.L.N. Rao University of Massachusetts, Boston, USA	03 March, 2023
Ganga Prasanth Srinivasa Gopalakrishnan IIT Madras	15 March, 2023
Manjuladevi V BITS Pilani	22 March, 2023
Tanmoy Ghosh IISER Kolkata	23 - 24 March, 2023
Mandar M Inamdar IIT Bombay	30 - 31 March, 2023

Visiting Students Programme

Mentors	Students
A. Raghunathan	Vishaka S Pandharpure
Andal Narayanan	J K Saaswath
Arun Roy	V Prem Kumar
Biswajit Paul	Shwetha Nagesh
Dibyendu Roy	Adira Mohitha
Girish B S	Sudharshan M S
Mayuri S	Adarsh Kumar Dash Arun R. Patil Dhashin Krishna M Mohith P A Surya Kiran Desiraju Tamay Singh
Prabu T	Aniruddha Upreti Chandanva V. Priya Shukla Vijay Sakre
Pramod Pullarkat	Hareesh Ashok Kumar Neha Mohamad Pooja Yadav
Reji Philip	Deepjyoti Satpathy Sreelakshmi K Gopi
Sadiq A Rangwala	Dhruv Tandon
Saptarishi Chaudhuri	Abhay Singh Dutta Aishi Barui Krishna Nand Trivedi
Saurabh Singh	Abhijeet Sham Patil Pranav Hariharan
Sayantan Majumdar	Ankit Roy
Sumati Surya	Abhishek Ravishankar Alan Daniel Santhosh Anish Bhattacharya
Urbasi Sinha	Anand Nagesh Anitta Jomy Shashank Ravi
Vikram Rana	Aditya Bharadwaj



Raman Research Institute

Audited Statement of Accounts

2022 - 2023

S. JANARDHAN & ASSOCIATES
CHARTERED ACCOUNTANTS

VIJAY BHATIA, B.com., F.C.A.,
BALAKRISHNA S.BHAT, B.com., F.C.A .
B. ANAND, B.Sc.,F.C.A.,

Apt. No.103 & 106
Embassy Centre
No.11, Crescent Road
Bangalore - 560 001

Phone :22265438, 22260055
22202709 Fax: 22265572
E-mail : ca.sjassociates@gmail.com

INDEPENDENT AUDITORS REPORT

To
Members of Raman Research Institute

Opinion

We have audited the accompanying financial statements of M/s Raman Research Institute, ("Institute"), Sir C V Raman Avenue, Sadashiva Nagar, Bangalore 560080, which comprises of the balance sheet as at March 31st 2023, the Income &, Expenditure Account for the year then ended, the Receipts and Payment Account for the year then ended, and notes to the financial statements, including a summary of significant accounting policies

In our opinion and to the best of our information and according to the explanations given to us, except for the effects of the matter described in the Basis for Opinion section of our report, the accompanying financial statements give a true and fair view of the financial position of the Institute as at March 31, 2023, and of its financial performance and its receipts and payments for the year then ended in accordance with the Accounting Standards issued by the Institute of Chartered Accountants of India (ICAI).

Basis for Opinion

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the Institute in accordance with the Code of Ethics issued by ICAI and we have fulfilled our other ethical responsibilities in accordance with the Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Responsibilities of Management and those charged with Governance for the Financial Statements.

Institute's Management is responsible for the preparation of these financial statements that give a true und fair view of the state of affairs, results of operations and receipts and payments of the Institute in accordance with the accounting principles generally accepted in 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. In

preparing the financial statements, the Institute's management is responsible for assessing its ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of management either intends to accounting unless liquidate the Institute or to cease operations, or has no realistic alternative but to do so. Those charged with governance are responsible for overseeing the Institute's financial reporting process.

Auditor's Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

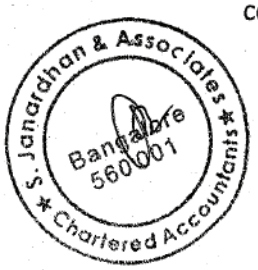
As part of an audit in accordance with SAs, we exercise professional judgment and maintain professional scepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Institute's internal control.

- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.

- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Institute's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Institute to cease to continue as a going concern.



We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards.

For S Janardhan & Associates
Chartered Accountants
Firm Registration No. 005310S

B Anand
Partner
Membership no 029146
UDIN:23029146BGWCXH6901

Place: Bangalore
Date: 5th July 2023

RAMAN RESEARCH INSTITUTE, BENGALURU

BALANCE SHEET AS AT 31ST MARCH 2023

UDIN-23029146BGWCXH6901

(Amount in INR)

CORPUS/CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
Corpus/Capital Fund	1	106,08,11,343	107,03,99,571
Reserves & Surplus	2	-	-
Earmarked & Endowment Funds	3	78,25,30,886	78,88,57,374
Secured Loans & Borrowings	4	-	-
Unsecured Loans & Borrowings	5	-	-
Deferred Credit Liabilities	6	-	-
Current Liabilities & Provisions	7	2,95,99,781	3,81,61,058
TOTAL		**187,29,42,010**	**189,74,18,003**
ASSETS			
Fixed Assets	8	84,51,38,974	86,81,99,897
Investments- from earmarked & endowment funds	9	84,33,85,814	90,09,46,279
Investments-Others	10	1,00,00,000	1,00,00,000
Current Assets, Loans & Advances	11	17,44,17,222	11,82,71,827
TOTAL		**187,29,42,010**	**189,74,18,003**
Significant Accounting Policies	24		
Contingent Liabilities and Notes on Accounts	25		

As per our report of even date

for M/s **S. JANARDHAN & ASSOCIATES**

Chartered Accountants

FRN 005310S

Sd/-

(Naresh V. S)

Administrative Officer (i/c)

Sd/-

(Tarun Souradeep Ghosh)

Director

S. Janardhan & Associates ★ Chartered Accountants ★ Bangalore 560 001

Sd/-

(B. Anand)

Partner

M No. 029146

BENGALURU / 05-07-23

RAMAN RESEARCH INSTITUTE, BENGALURU

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2023

UDIN-23029146BGWCXH6901

(Amount in INR)

INCOME	Schedule	Current Year	Previous Year
Income from Sales/Services	12	-	-
Grants/Subsidies	13	64,98,05,007	59,30,21,660
Fee/Subscriptions	14	-	-
Income from Investments for earmarked/endowment funds)	15	-	-
Income from Royalty	16	-	-
Interest Earned	17	30,05,516	35,76,374
Other Income	18	91,64,236	1,09,90,429
Increase/Decrease in stock of finished goods	19	-	-
TOTAL (A)		**66,19,74,759**	**60,75,88,463**
EXPENDITURE			
Establishment Expenses	20	41,04,36,087	40,82,99,075
Other Administrative Expenses	21	17,73,11,373	14,26,78,883
Expendtiture on Grants/Subsidies	22	4,337	-
Interest	23	-	-
Depreciation (Net as per Schedule 8)		7,29,05,007	6,43,21,660
TOTAL (B)		**66,06,56,804**	**61,52,99,618**
INTEREST ON GRANT BALANCES TRF TO BHARATKOSH - Sch 7(A)(1b)		**13,63,848**	**21,62,647**
BALANCE-SURPLUS/(DEFICIT) CARRIED TO CORPUS/CAPITAL FUND - Sch. 1(2b)		**(45,893)**	**(98,73,802)**
Significant Accounting Policies	24		
Contingent Liabilities and Notes on Accounts	25		

As per our report of even date

for M/s **S. JANARDHAN & ASSOCIATES**

Chartered Accountants

FRN 005310S

(Naresh V. S)
Administrative Officer (i/c)

(Tarun Souradeep Ghosh)
Director

S. Janardhan & Associates * Chartered Accountants * Bangalore 560 001

(B. Anand)
Partner
M No. 029146

BENGALURU / 05-07-23

RAMAN RESEARCH INSTITUTE, BENGALURU

RECEIPTS AND PAYMENTS STATEMENT FOR THE YEAR ENDED 31ST MARCH 2023

UDIN-23029146BGWCXH6901

(Amount in INR)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. Opening Balances			**I. Expenses**		
a) Cash in hand	-	17	a) Establishment Exp	41,04,36,087	40,82,99,075
b) Bank Balances	46,39,04,469	32,66,38,753	b) Admin Expenses	17,73,11,373	14,26,78,883
c) Deposits	67,03,484	2,33,89,167	c) PF-Final Settlement	65,83,983	1,00,27,365
d) Stamps (Franking M/C)	25,525	94	d) Pension Payout	1,56,13,198	1,25,04,258
II. Grants Received			**II. Payments made against projects**	7,43,66,705	3,04,04,248
a) From Govt. of India	64,03,00,000	62,80,00,000			
b) From State Govt.	-	-	**III. Investment and deposits made**		
c) From other sources	28,11,993	7,32,64,371	a) Out of earmarked funds	-	-
			b) Out of own funds (investment-others)	-	-
III. Income on Investments from					
a) Earmarked & Endowment Funds	-	-	**IV. Expenditure on Fixed Assets & CWIP**	9,80,61,017	5,07,67,569
b) Own Funds	-	-			
			V. Refund of surplus money / loans		
IV. Interest Received			a) To Govt. of India	-	-
a) On Bank deposits	1,87,33,192	2,35,61,834	b) To State Govt	-	-
b) on Loans, Advances etc.	1,09,625	59,360	c) To other fund providers	-	-
V. Other Income (Specify)	94,59,778	1,10,40,556	**VI. Finance charge (Interest)**	-	-
VI. Amount Borrowed	-	-	**VII. Other Payments (Specify)**	-	-
VII. Any other Receipts (Specify)			a) TDS Receivable	17,16,690	9,53,794
a) Advances	9,87,31,434	-	b) Advances	1,54,07,006	8,50,69,167
b) Receivables	72,20,078	46,79,986	c) Investments (Nett)	15,43,04,695	28,99,399
c) Accrued Interest	7,88,309	7,44,657	d) EMD, SD, CD (Deposits)	-	2,25,000
d) Investments (Nett)	91,83,540	12,53,67,151	e) Bills Payable	-	56,26,016

S. Janardhan & Associates ★ Chartered Accountants ★ Bangalore 560 001

RAMAN RESEARCH INSTITUTE, BENGALURU

RECEIPTS AND PAYMENTS STATEMENT FOR THE YEAR ENDED 31ST MARCH 2023

UDIN-23029146BGWCXH6901

(Amount in INR)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
e) Overheads	-	-	f) Payroll Recoveries	-	-
f) EMD, SD, CD (Deposits)	21,52,200	-	g) Deposits (for services)	-	-
g) Pension Corpus	-	-	h) Duties & Taxes	37,13,932	31,79,949
h) Employees's subscription	75,96,028	92,61,613	i) Provision	-	27,39,358
			j) PF-Withdrawals	-	-
			h) CPF (Emplyr Share)-Trf to Pension	-	-
			VIII. Closing Balances		
			a) Cash Balance	-	-
			b) Bank Balances		
			i) Deposit Accounts	29,85,38,148	46,39,04,469
			II) Current/Savings Account	1,16,38,272	67,03,484
			c) Postal franking machine	28,549	25,525
TOTAL	**126,77,19,655**	**122,60,07,559**		**126,77,19,655**	**122,60,07,559**

As per our report of even date

for M/s **S. JANARDHAN & ASSOCIATES**

Chartered Accountants

FRN 005310S

(Naresh V. S)
Administrative Officer (i/c)

(Tarun Souradeep Ghosh)
Director

S. Janardhan & Associates Chartered Accountants Bangalore 560 001

(B. Anand)
Partner
M No. 029146

BENGALURU / 05-07-23

RAMAN RESEARCH INSTITUTE, BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2023

(Amount in INR)

Schedule 1- Corpus/Capital Fund	Current Year		Previous Year	
(1) CAPITAL FUND REPRESENTING ASSETS CREATED OUT OF GRANTS				
As per last account	99,40,38,934		101,21,44,810	
Addition during the year	11,72,15,546		12,64,73,817	
Less: Deductions during the year *(Includes Capital Work-in-progress)*	1,91,91,857		8,02,58,033	
Less: Depreciation chargeable transferred to Income and Expenditure A/c	7,29,05,007		6,43,21,660	
BALANCE AS AT THE YEAR END		101,91,57,616		99,40,38,934
(2) GRANT BALANCES				
(a) NON-RECURRING GRANT				
Balance as at the beginning of the year		7,63,14,744		2,77,82,313
Add: Contributions during the year		6,34,00,000		9,93,00,000
Less: Expenditure incurred during the year		9,80,61,017		5,07,67,569
BALANCE AS AT THE YEAR END		4,16,53,727		7,63,14,744
(b) RECURRING GRANT (NON-TSA)				
Balance as at the beginning of the year	45,893		99,19,695	
Transferred from Income & Expenditure-	(45,893)		(98,73,802)	
-Account for the year				
BALANCE AS AT THE YEAR END		-		45,893
TOTAL (1+2)		**106,08,11,343**		**107,03,99,571**

Schedule-2- Reserves & Surplus	Current Year		Previous Year	
NOT APPLICABLE		-		-
TOTAL		-		-

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RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2023

Schedule 3- Earmarked/Endowment Funds

(Amount in INR)

Sl No	Funding Agency	Project Name	Opening Balance	Additions during the year	Utilisation			Total Utilisation	Balance as on 31/03/23
					Capital Expenditure	Recurring Expenditure	Advances/ Receivables		
Funded by Government Agencies									
1	DBT	Joint Project-Dr. Pramod	(3,43,765)	-	-	-	-	-	(3,43,765)
2	DST	DST-BDTD Grant-Dr. Gautam	5,89,320	11,349	-	2,25,528	-	2,25,528	3,75,141
3		Ramanujan Fellowship- Dr Pramod	2,06,447	-	-	-	-	-	2,06,447
4		DST-QuST grant-Prof Urbasi	76,98,442	8,94,522	3,53,279	33,33,305	-	36,86,584	49,06,380
5		DST-Indo-Russia-Prof. Sandeep	4,28,361	-	-	-	-	-	4,28,361
6		DST-WOS-A-Dr. Sanjukta	7,40,776	(1,58,361)	-	9,07,197	-	9,07,197	(3,24,782)
7		DST-IndoItaly-Dr. Urbasi	47,29,169	(1,50,684)	-	7,63,661	3,21,992	10,85,653	34,92,832
8		CEFIPRA Grant- Dr. Sadiq Rangwala	79,867	-	-	-	-	-	79,867
9	ISRO	PRATUSH-Dr. Mayuri	7,59,969	-	-	7,58,816	-	7,58,816	1,153
10		ISRO-Polix Payload-Prof Biswajit	1,36,59,196	(12,56,933)	-	93,39,667	(15,13,662)	78,26,005	45,76,258
11		ISRO-QKD-Project-Dr. Urbasi	5,17,68,795	(4,43,398)	18,66,114	64,03,405	-	82,69,519	4,30,55,878
12	SERB	Ramanujan Fellowship- Dr Sayantan	4,64,009	2,55,000	-	3,49,868	-	3,49,868	4,09,141
13		Ramanujan Fellowship- Dr Urna Basu	6,04,740	(15,72,000)	-	(9,67,260)	-	(9,67,260)	-
14		Vajra Fellowship-Prof Satya Majumdar	(15,883)	-	-	-	-	-	(15,883)
15		SERB Grant-Dr. Ranjini	4,23,200	(31,46,500)	-	(27,23,300)	-	(27,23,300)	-
16		SERB Grant-Dr Sarvesh Yadav	-	11,26,288		3,44,199		3,44,199	7,82,089
17		Vajra Fellowship-Prof Sanders	(1,81,496)	-	-	5,79,617	-	5,79,617	(7,61,113)
18	MeITY	Joint Project-Dr. Urbasi	6,72,97,847	-	4,43,28,811	48,23,543	1,82,54,333	6,74,06,687	(1,08,840)
19	INSA	INSA-Fellowshp-Prof. Raghunathan	(4,45,206)	4,45,206	-	3,89,873	-	3,89,873	(3,89,873)
20	WT-DBT	WT-DBT-IA-Team Sc. Grant (Dr Pramod)	1,03,99,756	2,70,422	3,43,029	28,11,221	-	31,54,250	75,15,928
SUB TOTAL			**15,88,63,544**	**(36,85,089)**	**4,68,91,233**	**2,73,39,340**	**1,70,62,663**	**9,12,93,236**	**6,38,85,219**
Funded by other than Government Agencies									
1	IKP	GCE Grant-Dr. Gautam Soni	2,97,404	21,170	-	1,36,132	-	1,36,132	1,82,442
2	-	WOPI-22 Conference-Dr. Urbasi	-	8,51,926	-	-	-	-	8,51,926
SUB TOTAL			**2,97,404**	**8,73,096**	**-**	**1,36,132**	**-**	**1,36,132**	**10,34,368**
Retirement Funds									
		Gratuity Fund	8,78,87,676	71,06,774	-	-	(1,26,32,462)	(1,26,32,462)	10,76,26,912

Schedule 3- Earmarked/Endowment Funds

(Amount in INR)

Sl No	Funding Agency	Project Name	Opening Balance	Additions during the year	Utilisation			Total Utilisation	Balance as on 31/03/23
					Capital Expenditure	Recurring Expenditure	Advances/ Receivables		
2		Leave Salary Fund	8,88,95,805	71,13,632	-	-	(1,17,21,336)	(1,17,21,336)	10,77,30,773
3	-	Superannuation Fund	23,51,21,656	9,35,85,450	-	72,89,902	(1,07,82,875)	(34,92,973)	33,22,00,079
4		RRI Pension Fund	10,96,91,602	(3,97,59,931)	-	1,56,13,198	-	1,56,13,198	5,43,18,473
5		RRI Provident Fund	10,80,99,687	1,46,30,888	-	69,95,513	-	69,95,513	11,57,35,062
SUB TOTAL			**62,96,96,426**	**8,26,76,813**	**-**	**2,98,98,613**	**(3,51,36,673)**	**(52,38,060)**	**71,76,11,299**
GRAND TOTAL			**78,88,57,374**	**7,98,64,820**	**4,68,91,233**	**5,73,74,085**	**(1,80,74,010)**	**8,61,91,308**	**78,25,30,886**

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RAMAN RESEARCH INSTITUTE, BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2023

(Amount in INR)

Schedule 4- Secured Loans & Borrowings	Current Year		Previous Year	
NOT APPLICABLE	-	-	-	-
TOTAL		-		-

Schedule-5- Unsecured Loans & Borrowings	Current Year		Previous Year	
NOT APPLICABLE	-	-	-	-
TOTAL		-		-

Schedule 6- Deferred Credit Liabilities	Current Year		Previous Year	
NOT APPLICABLE	-	-	-	-
TOTAL		-		-

Schedule-7- Current Liabilities & Provisions	Current Year		Previous Year	
A. CURRENT LIABLITIES				
1. Sundry Creditors				
a) for goods	2,68,604		-	
b) Others	5,57,401	8,26,005		1,93,761
2. Earnest Money Deposit		9,37,200		6,63,000
3. Advances Received		1,00,00,000		1,00,00,000
4. Statutory Liabilities				
a) Overdue	-		-	
b) Others	-		-	
5. Other Current Liabilities **(Incl. Bharatkosh remittance pending)**	26,30,911	26,30,911	34,64,016	34,64,016
TOTAL (A)		**1,43,94,116**		**1,43,20,777**
B. PROVISIONS				
1. Gratuity	-		-	
2. Superannuation / Pension	-		-	
3. Accumulated Leave Encashment	-		-	
4. Others (Specify)	1,52,05,665		2,38,40,281	
TOTAL (B)		**1,52,05,665**		**2,38,40,281**
TOTAL (A+B)		**2,95,99,781**		**3,81,61,058**

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2023

Schedule 8- Fixed Asset (Amount in INR)

Description	Rate	GROSS BLOCK				DEPRECIATION				NET BLOCK	
		Cost /Valuation as at the beginning of theyear	Additions During the year	Deductions during the year	Cost / Valuation at the end of the year	As at the beginning of the year	On additions during the year (Incl. on the OB)	On deductions during the year	Total upto the year end	As at the end of current year	As at the end of Previous Year
A. Fixed Assets											
1. Land											
a) Freehold											
Malleshwaram	-	3,78,735	-	-	3,78,735	-	-	-	-	3,78,735	3,78,735
RMV II Stage	-	31,19,436	-	-	31,19,436	-	-	-	-	31,19,436	31,19,436
HMT Jalahalli	-	8,00,63,261	-	-	8,00,63,261	-	-	-	-	8,00,63,261	8,00,63,261
2. Buildings											
a) On freehold land	1.63	19,89,95,606	34,55,850	-	20,24,51,456	4,84,44,117	32,95,973	-	5,17,40,090	15,07,11,366	15,05,51,489
3. Canteen Infrastructure	4.75	45,59,799	5,37,158	-	50,96,957	24,73,746	2,42,105	-	27,15,851	23,81,106	20,86,053
4. Plant Machinery, Equipment	4.75	116,16,67,530	3,40,94,515	-	119,57,62,045	62,81,35,163	5,62,04,595	-	68,43,39,758	51,14,22,287	53,35,32,367
5. Vehicles	9.50	56,20,383	5,63,498	-	61,83,881	20,71,645	5,63,753	-	26,35,398	35,48,483	35,48,738
6. Furniture & Fixtures	6.33	1,65,87,701	12,27,051	-	1,78,14,752	1,40,94,697	10,98,962	-	1,51,93,659	26,21,093	24,93,004
7. Computer Peripherals	16.21	19,48,94,464	38,18,122	-	19,87,12,586	16,19,75,431	4,74,187	-	16,24,49,618	3,62,62,968	3,29,19,033
8. Library Books	4.75	23,20,12,677	9,44,209	37,328	23,29,19,558	17,68,66,444	1,10,62,760	37,328	18,78,91,876	4,50,27,682	5,51,46,233
Total Fixed Assets		**189,78,99,592**	**4,46,40,403**	**37,328**	**194,25,02,667**	**103,40,61,243**	**7,29,42,335**	**37,328**	**110,69,66,250**	**83,55,36,417**	**86,38,38,349**
B. Work in Progress											
Capital Assets		43,61,548	2,27,91,241	1,75,50,232	96,02,557	-	-	-	-	96,02,557	43,61,548
Total Capital Work in Progress		**43,61,548**	**2,27,91,241**	**1,75,50,232**	**96,02,557**	**-**	**-**	**-**	**-**	**96,02,557**	**43,61,548**
Grand Total		**190,22,61,140**	**6,74,31,644**	**1,75,87,560**	**195,21,05,224**	**103,40,61,243**	**7,29,42,335**	**37,328**	**110,69,66,250**	**84,51,38,974**	**86,81,99,897**
Previous Year		**181,92,14,891**	**12,93,83,977**	**4,63,37,728**	**190,22,61,140**	**96,97,39,583**	**6,99,39,275**	**56,17,615**	**103,40,61,243**	**86,81,99,897**	**84,94,75,308**

RAMAN RESEARCH INSTITUTE, BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2023

(Amount in INR)

Schedule 9- Investments from Earmarked/Endowment Funds	Current Year	Previous Year
1. In Fixed Deposits		
RRI Pension Fund	4,95,00,000	10,42,64,861
RRI Provident Fund	11,22,43,148	10,30,59,608
Other Grants & Funds	12,67,95,000	24,65,80,000
2. Other Approved Securities	-	-
3. Shares	-	-
4. Debentures / Bonds	-	-
5. Retirement funds invested in Life Insurance Corporation of India	54,75,57,764	41,19,05,137
Claim (to be submitted) pending towards settlements made during the year	72,89,902	3,51,36,673
TOTAL	**84,33,85,814**	**90,09,46,279**

Schedule-10 Investment (Others)	Current Year	Previous Year
1. In Government Securities	-	-
2. Other Approved Securities	-	-
3. Shares	-	-
4. Debentures / Bonds	-	-
5. Subsidiaries and Joint Ventures	-	-
6. Others (Specify)-Fixed Deposits	1,00,00,000	1,00,00,000
TOTAL	**1,00,00,000**	**1,00,00,000**

S. Janardhan & Associates * Chartered Accountants * Bengalore 560 001

RAMAN RESEARCH INSTITUTE, BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2023

(Amount in INR)

Schedule 11- Current Assets, Loans & Advances	Current Year		Previous Year	
A. CURRENT ASSETS				
1. Inventories		5,00,184		5,70,820
2. Cash balances in hand (Including cash imprest)		-		-
3. Unused stamp value on Postal Franking Machine		28,549		25,525
4. Bank Balances				
Main Account	28,11,975		4,75,589	
Pension Fund Account	36,06,295		26,47,666	
Provident Fund Account	23,75,408		26,27,697	
Extra Mural Grants	28,44,594	1,16,38,272	9,52,532	67,03,484
TOTAL (A)		**1,21,67,005**		**72,99,829**
B. LOANS/ADVANCES AND OTHER ASSETS				
1. Advances and other amounts recoverable in cash				
On Capital Account				
a) Land	9,25,90,600		9,25,90,600	
b) Capital Assets	4,98,21,230	14,24,11,830	16,41,625	9,42,32,225
Deposits		29,47,654		34,81,976
Others		1,12,90,423		25,06,794
2. Income Accrued				
Main Account	7,37,992		9,95,542	
Pension Fund Account	-		94,296	
Provident Fund Account	-		4,12,822	
Extra Mural Grants	2,28,547	9,66,539	20,84,566	35,87,226
3. Claims Receivable				
Main Account	12,91,423		19,74,542	
Pension Fund Account	12,12,178		17,84,780	
Provident Fund Account	11,46,677		20,07,983	
Extra Mural Grants	9,83,493	46,33,771	13,96,472	71,63,777
TOTAL (B)		**16,22,50,217**		**11,09,71,998**
TOTAL (A+B)		**17,44,17,222**		**11,82,71,827**

S. Janardhan & Associates * Chartered Accountants * Bangalore 560 001

RAMAN RESEARCH INSTITUTE, BENGALURU

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2023

(Amount in INR)

Schedule 12- Income from Sales/Service	Current Year	Previous Year
NOT APPLICABLE	-	-
Total	-	-

Schedule 13- Grants/Subsidies	Current Year	Previous Year
1. Central Government		
Grants-in-aid		
i) Non-Plan	-	-
ii) Deferred Grant (To the extent of depreciation chargeable)	7,29,05,007	6,43,21,660
iii) Recurring	57,69,00,000	52,87,00,000
Total	**64,98,05,007**	**59,30,21,660**

Schedule 14- Fees/Subscriptions	Current Year	Previous Year
NOT APPLICABLE	-	-
Total	-	-

Schedule 15- Income from Investments	Current Year	Previous Year
Interest on Investment from Earmarked / Endowment Fund	4,35,09,097	3,78,80,492
Less: Transferred to Earmarked / Endowment Fund	4,35,09,097	3,78,80,492
Total	-	-

Schedule 16- Income from Royalty/Publication	Current Year	Previous Year
NOT APPLICABLE	-	-
Total	-	-

Schedule 17- Interest Earned	Current Year	Previous Year
1) On Term Deposits		
a) With scheduled banks	-	-
2) On accounts with banks		
a) Attributable to Core grant funds **(transferable to Bharatkosh)**	13,63,848	21,62,647
b) Attributable to Own/other funds	15,32,043	13,54,367
3) On Loans/Advances		
a) Employees	1,09,625	59,360
Total	**30,05,516**	**35,76,374**

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RAMAN RESEARCH INSTITUTE, BENGALURU

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2023

(Amount in INR)

Schedule 18- Other Income	Current Year	Previous Year
1) Profit on sale/disposal of assets		
a) Own Assets	-	-
b) Assets acquired out of grants	-	-
2) Miscellaneous Income	91,64,236	1,09,90,429
Total	**91,64,236**	**1,09,90,429**

Schedule 19- Increase/(Decrease) in stock of finished goods	Current Year	Previous Year
NOT APPLICABLE	-	-
Total	**-**	**-**

Schedule 20- Establishment Expenses	Current Year	Previous Year
a) Salaries & Wages	22,18,53,420	21,49,78,253
b) Allowances & Bonus	42,84,797	46,46,547
c) Contribution to NPS	78,47,352	93,62,874
d) Staff welfare expenditure	1,48,03,428	1,49,73,575
e) Retirement/Terminal benefits	16,16,47,090	16,43,37,826
Total	**41,04,36,087**	**40,82,99,075**

Schedule 21- Other administrative expenses	Current Year	Previous Year
1) Advertisement	2,69,463	7,48,847
2) Amenities	26,08,386	9,39,591
3) Audit Fee	1,50,745	55,755
4) Bank Charges	58,368	55,613
5) Campus Maintenance	4,30,83,529	4,45,71,637
6) Conveyance	98,918	1,99,996
7) Corporation Taxes	2,74,867	2,74,867
8) Creche	-	-
9) Electricity Charges	1,45,86,090	1,29,88,315

Continued on the next page

S. Janardhan & Associates Chartered Accountants Bangalore 560 001

Schedule 21- Other administrative expenses (Continued)	Current Year	Previous Year
10) Entertainment & Hospitality	42,721	6,104
11) Freight	3,52,611	2,04,657
12) Honorarium & Professional Fee	1,01,76,630	74,53,231
13) Journal Subscription	31,70,176	57,63,176
14) Lease Rent (Gauribidanur)	6,24,490	5,92,970
15) Miscellaneous Expenses	11,20,489	8,32,904
16) Outreach	9,75,341	4,66,100
17) Patent Fee	3,91,066	3,04,390
18) Payroll Processing Charges	4,99,029	4,52,880
19) Ph.D Programme Expenditure	10,96,920	16,03,048
20) Postage & Courier Charges	53,956	28,102
21) Printing & Stationery	3,02,457	4,07,476
22) Repairs & Maintenance	1,29,60,321	1,25,59,746
23) Security Charges	1,18,43,647	1,06,21,017
24) Seminar/Conference	74,90,795	2,80,021
25) Stores & Consumables	4,44,36,190	3,52,23,381
26) Telephone & Communication	17,01,953	18,94,642
27) Travel Expenditure	1,14,01,724	1,21,667
28) Uniform & Livery	41,805	29,539
29) University Affiliation Fee	12,00,000	6,00,000
30) Vehicle Maintenance	34,54,953	21,21,432
31) Visiting Students Programme	23,97,341	8,59,842
32) Water Charges	4,46,392	4,17,937
Total	**17,73,11,373**	**14,26,78,883**

Schedule 22- Expenditure on Grants / Subsidies	Current Year	Previous Year
Grant-in-Aid-GENERAL- **reversed on TSA**	4,337	-
Total	**4,337**	**-**

Schedule 23- Interest	Current Year	Previous Year
NOT APPLICABLE	-	-
Total	**-**	**-**

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Schedule-24

SIGNIFICANT ACCOUNTING POLICIES

1. General

The Financial Statements have been prepared under the historical cost convention, on accrual basis of accounting and in accordance with generally accepted accounting principles. The presentation of final accounts is as per the Uniform Accounting Format for Central Autonomous Bodies as prescribed by Controller General of Accounts, Government of India.

2. Fixed Assets

Fixed Assets are stated at cost of acquisition that includes inward freight, duties, taxes and incidental expense to bring the asset to use. To confirm with presentation in the Uniform Accounting Format, advance payments for procurement of capital assets have been shown in Schedule-8 (fixed assets) Capital work-in-progress. No depreciation is charged on such items. Utilisation of grants received under the component, grants for Creation of Capital Assets is shown in Schedule-1 (Capital Fund). The value of assets, as stated in Schedule-8, is nett of depreciation.

3. Depreciation

Depreciation is charged on **STRAIGHT LINE BASIS** at the following rates

a. Buildings @ 1.63 %
b. Capital Equipment, Canteen Infrastructure and Books @ 4.75%
c. Computer & Peripherals @ 16.21%
d. Vehicles @ 9.50%
e. Furniture and Fixtures @ 6.33%

Depreciation is charged in the Income & Expenditure account. Full depreciation is charged on assets added before 30th September. Depreciation on assets added after 30th September is charged at 50%. In respect of asset blocks that end with a book value less than Re 1/- on applying depreciation, the book balance is closed with a notional value of Re 1/- by limiting depreciation charged to the notional book value.

4. Inventory

Stock on hand, such as spares, stationery and consumables are valued at cost

5. Government Grants

Grants received from Department of Science & Technology, Govt. of India under **SALARIES, GENERAL** and **CREATION OF CAPITAL ASSETS** is Accounted for as Core Grants.

Grants with specific sanction for recurring expenditure is shown under Income & Expenditure Account. Unspent balance, which is nett of expenditure incurred during the year, is reported in the balance sheet under Schedule 1 (Grant Balances-Recurring Grant).

Grants received for Creation of Capital Assets received during the year is added to the previous year's balance in the Balance Sheet. Unspent balance, which is nett of utilisation during the year, is shown under Schedule-1 (Grant Balances-Non Recurring Grant). Funds utilised to Create Capital Assets is shown as an addition in the Capital Fund as per AS-12.

The Institute also receives Extra Mural Grants from various funding agencies. Such grants are shown as part of Schedule 3 (Earmarked / Endowment Funds).

6. Foreign Currency Transactions

Transactions denominated in Foreign Currency are accounted for at the rates prevailing on the date of actual transaction. No provision is made to account for gains and losses arising out of exchange fluctuations.

S. Janardhan & Associates ★ Chartered Accountants ★ Bangalore 560 001

7.	Retirement Benefits	The Institute's contribution to Provident Fund and Pension Fund are charged to Income & Expenditure Account. Deficit, if any, in the Provident Fund and Pension Account is being provided for in the books to the extent not met out of reserves

Schedule-25

CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS

A. Contingent Liabilities

1.	Claims against the Institute not acknowledged as debt	NIL
2.	Bank guarantees given by the Institute	NIL
3.	Disputed demands in respect of taxes	There are no outstanding claims against the Institute.

B. Notes on Accounts

1.	Current Assets, Advances & Deposits	Current Assets, Advances and Deposits have a value on realisation in the ordinary course of activities. The extent of realisation is equal atleast to the aggregate amount appearing in the Balance Sheet. An amount of **Rs. 46,33,771/-** is outstanding in the books as TDS receivable. Income tax department, vide **DIN CPC/2223/A7/326948241 dated 02-06-2023** has advised a refund of **Rs. 23,56,270/-** that pertains to financial year 2021-22 and would be credited in due course. Balance would be accounted as and when returns are processed by the department and refund credited to our account.
2.	Employees' Retirement Benefits	a. Institute's contribution to the Provident Fund account are charged to Income & Expenditure Account of the institute b. As prescribed by the Govt. of India, the Institute has subscribed to funds managed by Life Insurance Corporation of India, in respect of quantifiable liabilities of service benefits like Gratuity and Cash equivalent of Earned Leave. The Institute has also covered its liabilities for Commuted Value of Pension c. The amounts standing to the credit of the funds in Life Insurance Corporation of India are held in the name of the Institute in a fiduciary capacity. Balances appearing in the fund statements as at the close of financial year is shown under Schedule-3 (Earmarked/Endowment Funds-Retirement Funds). Interest earned, if any, during the year is treated as an Addition to the fund and reported accordingly in Schedule-3. Payouts on retirement on account of Gratuity, Cash equivalent of Earned Leave and Commuted value of Pension is through the fund. d. The institution has stopped further contributions to Retirement Funds since 2011 as the existing investments representing the retirement funds are earning interest. In view of implementation of 7th CPC for regular staff members of the Institute, contributions to the fund have been made during the year in respect of incremental liability based on an actuarial valuation conducted by Life Insurance Corporation of India. Benefits are paid to the retiring employees out of the institutional funds. Institution treats the pay-outs as expenses of the year if the funds are not drawn by way of reimbursement from the retirement funds. As at 31-3-2023, there is a reimbursement amount pending in respect of retirement benefits paid during the year and is disclosed separately under the

Investments from Earmarked Funds.

e. In pursuance of the directions of the Council, the amount representing Institute's contribution to the CPF in respect of eligible Scientific and Technical staff members (who joined the Institute before 01/01/2004) on contractual terms are allowed to exercise an option to opt for the Institute's pension scheme, on periodic renewal of their contracts for continuous engagement in the Institute upto superannuation. In FY20, in accordance with **clause 2(i) of DoPPW OM 4/1/87-P&PU (PIS-II) dated 23-07-1996**, those Scientific and Technical personnel who joined the Institute after 01-08-1992 and are bound on CPF scheme, PF balances standing to the credit of such members is transferred to the Pension corpus. Accordingly, only GPF ledger account will continue in the PF A/c. The income generated on the corpus is used to partially fund the pension liability. Deficit, if any, is met out of regular grants-in-aid.

f. Employees who have joined the Institute after **01/01/2004**, are compulsorily enrolled under the New Pension Scheme

3. Advance for purchase of land

The Institute has deposited **Rs. 8,89,61,800/-** with M/s Hindustan Machine Tools Limited, being full value of a land, in pursuance of a sale agreement entered into between the Institute and HMT Limited on **13th March 2009.** The Institute, on **16/05/2018**, has remitted **Rs. 36,28,800/-** towards additional **1014 SFT** of land. With this, the total remittance to M/s HMT Limited stands at **Rs. 9,25,90,600/-.** Government of India has formally communicated their decision to transfer land to the Institute. The conveyance deed is yet to be signed pending clearance from Government of Karnataka.

It is to be noted that a part of this land is earmarked for Indian Academy of Sciences. The Academy has made a token remittance of **Rs. 1,00,00,000/-.** This is shown as part of Schedule 7 (A)-Sundry Creditors (for others) that forms part of the Balance Sheet. A matching current asset, in form of an investment, has been created in the books as shown in Schedule 10.1

4. Funds of Core grants were kept in common bank account. Hence, the interest amount to be credited to Bharatkosh in compliance of rule 230(8) of GFR 2017 amounting to **Rs. 13,63,868/-** has been apportioned on the basis of monthly outstanding unspent grant balances

5. Vehicle insurance premium is expensed out in the financial year during which the premium is actually paid. The coverage is not apportioned to different financial years proportionate to the time period during which the insurance is covered.

6. Schedules 1 to 25 are annexed to and form an integral part of the Balance Sheet as at **31st March 2023** and the Income & Expenditure Account for the year ended on that date.

7. Previous year's figures have been regrouped/reclassified, wherever necessary, to correspond with the current year's classification/disclosure

As per our report of even date
For **M/s S. JANARDHAN & ASSOCIATES**
Chartered Accountants
FRN 005310S

(Naresh V. S)
Administrative Officer (i/c)

(Tarun Souradeep Ghosh)
Director

S. Janardhan & Associates ★ Chartered Accountants ★ Bangalore 560 001

(B. Anand)
Partner
M. No. 029146

BANGALORE / 05-07-2023

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