



RAMAN RESEARCH INSTITUTE
2021 - 22
ANNUAL REPORT





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From the Director

It gives me immense pleasure to present the 2021-22 Annual Report of the Institute. I took charge as Director in mid-January 2022. I consider this as both an honour and a privilege to be at the helm of an Institute with a rich heritage and legacy of demonstrated research excellence in niche areas of fundamental physics under contemporary research themes. RRI has nurtured a healthy balance of top-end research, together with technological capability that holds great promise for future frontier endeavour at par with the best in the world. The first couple of months of my tenure have indeed been exciting and happening – both scientific and otherwise. The institution has launched a major recruitment drive for research faculty. This holds out immense promise for rejuvenation of existing research themes and the creation of new initiatives. For me, it has been a time to form the first thoughts on the unique role that RRI plays both in the S&T ecosystem within the Department of Science and Technology, and at large, in the national and international arena.

This report is a synopsis of the research and academic activities at the Institute during the period 1st April 2021 to 31st March 2022. 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 scientific journals, PhD degrees awarded and other scientific activities such as seminars, colloquia and webinars held at the Institute.

A total of 93 students are enrolled in the Institute's vibrant PhD program. Eight of them received PhD degrees and five submitted their PhD theses over the past year. Over the same period 131 research papers were published in refereed journals, most of them known for their high impact factors. Other publications include 3 papers in conference proceedings, some book chapters and popular science articles. These publications showcase the rich variety of scientific work at the Institute covering a breathtaking range of physical phenomena from the cosmos to the quantum.

On National Science Day the Institute hosted children from neighbouring schools who enthusiastically participated

in the day's festivities. The day also witnessed the launch of "Vignyana Kathegalu" – a series of popular talks in science. This year the International Women's Day was celebrated by a day-long, publicly webcast event that featured thought-provoking talks under the theme "Women of RRI". The first two months of my tenure also saw the first meet and greet with the excellent faculty of RRI in which I shared my vision and stressed upon the importance of thoughtfully planned individual research efforts and nurturing extensive interactions with peers that will seed larger collaborative research programs - a happy balance of supporting existing individual excellence and catering to contemporary expectations of leadership in frontier science research fields.

The Institute will enter into the 75th year of its existence in November 2022 – plans for year long celebrations with major international conferences, prestigious lecture series and many other events are being envisaged.

In closing, I would like to record my deep gratitude to the many unacknowledged people whose efforts have ensured a smooth transition into my role and I look forward to reporting on the various activities – academic and otherwise at the Institute in the coming years.

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 basic 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 the 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 research in basic sciences is today in selected themes of Astronomy and Astrophysics, Light and Matter Physics, Soft Condensed Matter Physics, and Theoretical Physics.

Research Laboratories

- X-ray Astronomy Laboratory
- Molecular Astronomy Laboratory
- Cosmological Recombination & Reionization Laboratory
- Sky Watch Array Network
- 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
- Electrochemistry and Surface Science
- 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 Lab
 - Photophysical Studies Lab
- **Mechanical Engineering Services**
 - Mechanical Workshop
 - Sheet metal, paint and carpentry facility
- **Electronics Engineering Services**

- **Gauribidanur Field Station**
- **Library**
- **IT & Computing Services**
- **Amenities & 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.

Till 31st October 2021	From 1st November 2021
<p>Prof. A.K. Sood (Chair) Year of Science Professor, Department of Physics, Indian Institute of Science, Bengaluru 560012.</p>	<p>Shri. A. S. Kiran Kumar (Chair) Former Chairman, ISRO ISRO HQ., Antariksh Bhavan, New BEL Road Bengaluru 560 094.</p>
<p>Dr. K. Kasturirangan Former Chairman , ISRO Chairman, National Steering Committee for National Curriculum Framework, Raman Research Institute Bengaluru 560 080.</p>	<p>Dr. K. Kasturirangan Former Chairman , ISRO Chairman, National Steering Committee for National Curriculum Framework, Raman Research Institute Bengaluru 560 080.</p>
<p>Prof. Ashutosh Sharma Secretary, Department of Science & Technology, Ministry of Science & Technology, New Delhi 110016.</p>	<p>Prof. Vijay P Bhatkar Chancellor of Nalanda University Chairman of ETH Research Lab, National President of Vijnan Bharati, Bavdhan, Off Mumbai-Bengaluru Bypass, Pune - 411021.</p>
<p>Shri B. Anand Additional Secretary & Financial Advisor, Department of Science & Technology, Ministry of Science & Technology Government of India, New Delhi 110016.</p>	<p>Prof. Annapurni Subramaniam Director, Indian Institute of Astrophysics 2nd Block, 100 Feet Road, Koramangala, Bengaluru – 560034.</p>
<p>Prof. R. Rajaraman Emeritus Professor, Theoretical Physics, School of Physical Sciences, Jawaharlal Nehru University, New Delhi 110067.</p>	<p>Dr. Srivari Chandrasekhar Secretary, Department of Science & Technology Ministry of Science & Technology, Technology Bhavan, New Mehrauli Road, New Delhi - 110 016</p>
<p>Prof. Vijay Bhatkar Chancellor of Nalanda University Chairman of ETH Research Lab, National President of Vijnan Bharati, Bavdhan, Off Mumbai-Bengaluru Bypass, Pune - 411021.</p>	<p>Shri Vishvajit Sahay The Additional Secretary & Financial Adviser Department of Science & Technology, Ministry of Science & Technology, Technology Bhavan New Mehrauli Road, New Delhi - 110 016.</p>
<p>Prof. H.S. Mani Adjunct Professor, Chennai Mathematical Institute, H1, SIPCOT IT Park, Kelambakkam, Siruseri, Tamil Nadu 603103.</p>	<p>Prof. Rupamanjari Ghosh Former Vice-Chancellor Shiv Nadar University, Dadri, Gautam Buddha Nagar Uttar Pradesh - 201 314.</p>
<p>Prof. S Sridhar Director (i/c) Raman Research Institute, Bangalore 560 080.</p>	<p>Prof. S Sridhar (till 30 Nov 2021) Director (i/c)</p>
	<p>Prof. Madhavan Varadarajan (till 19 Jan 2022) Director (i/c)</p>
	<p>Prof. Tarun Souradeep (from 20 Jan 2022) Director Raman Research Institute, Bangalore 560 080.</p>

Finance Committee

Till 31st October 2021	From 1st November 2021
<p>Prof A.K. Sood (Chair) Year of Science Professor, Department of Physics, Indian Institute of Science, Bengaluru 560012.</p> <p>Shri B. Anand Additional Secretary & Financial Advisor, Department of Science & Technology, Ministry of Science & Technology Government of India, New Delhi 110016.</p> <p>Prof. H.S. Mani Adjunct Professor, Chennai Mathematical Institute, H1, SIPCOT IT Park, Kelambakkam, Siruseri, Tamil Nadu 603103.</p> <p>Prof. S Sridhar Director (i/c) Raman Research Institute, Bangalore 560 080.</p>	<p>Shri. A. S. Kiran Kumar (Chair) Former Chairman, ISRO ISRO HQ., Antariksh Bhavan, New BEL Road Bengaluru 560 094.</p> <p>Shri Vishvajit Sahay Additional Secretary & Financial Adviser Department of Science & Technology Ministry of Science & Technology, Technology Bhavan New Mehrauli Road, New Delhi - 110 016.</p> <p>Prof. Rupamanjari Ghosh Former Vice-Chancellor Shiv Nadar University, Dadri, Gautam Buddha Nagar Uttar Pradesh - 201 314.</p> <p>Prof. S Sridhar (till 30 Nov 2021) Director (i/c)</p> <p>Prof. Madhavan Varadarajan (till 19 Jan 2022) Director (i/c)</p> <p>Prof. Tarun Souradeep (from 20 Jan 2022) Director Raman Research Institute, Bangalore 560 080.</p>

Academic Committee

Prof. S Sridhar (till 30 Nov 2021)
Director (i/c)

Prof. Madhavan Varadarajan (till 19 Jan 2022)
Director (i/c)

Prof. Tarun Souradeep (from 20 Jan 2022)
Director
Raman Research Institute, Bangalore 560 080.

Prof. Sadiqali Rangwala, Member
Chairperson, Students Academic Affairs Committee, RRI
Dr. Sayantan Majumdar, Member
Coordinator, Admissions Committee, RRI.

Prof. Arun Mangalam, Member
Prof. & 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.

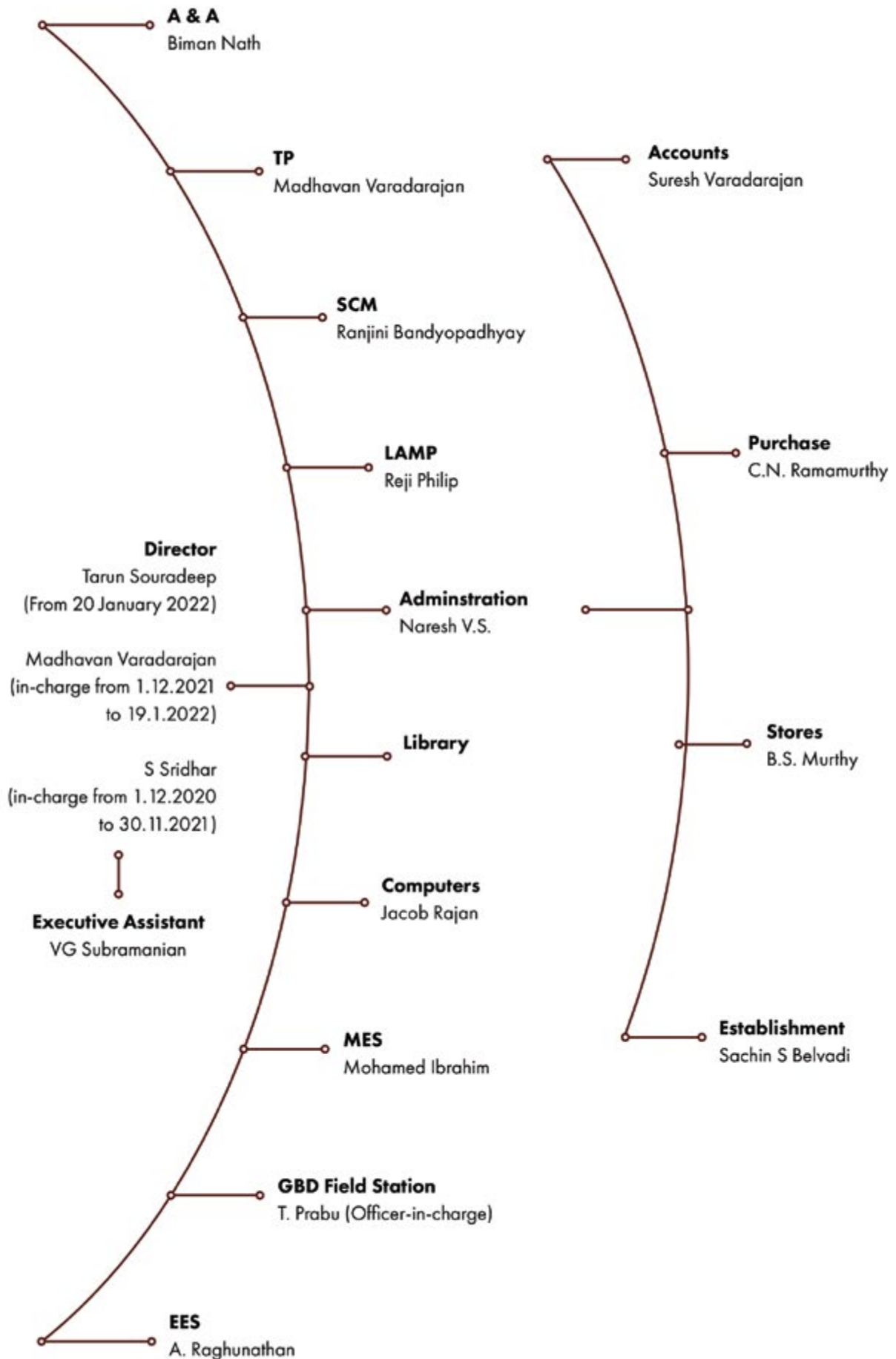
Prof. B.K. Kanaujia, Member
School of Biotechnology, Jawaharlal Nehru University
New Delhi 110 067.

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)
Raman Research Institute, C.V.Raman Avenue,
Sadashivanagar, Bengaluru 560 080.

Organisation



Faculty Academic Affairs Coordinator

Biman Nath (Admin. Associate - V G Subramanian)

Research Program & Facilities Coordinator

Biswajit Paul (Admin. Associate - V G Subramanian)

Doctoral and Postdoctoral Program Coordinator

Sadiqali Rangwala (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

Reji Philip, Ranjini Bandyopadhyay

Students Academic Affairs Committee

Sadiq Rangwala (Chair), Pramod Pullarkat, Shiv Sethi, Reji Philip, Sanjib Sabhapandit

In-House meeting

PhD students - 3rd year

Joint Astronomy Programme Representative of RRI

Vikram Rana

Complaints Committee

Srivani K S(Chair), Naresh VS, Vasudha KN, 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

Library Committee

Supurna Sinha, Nayantara Gupta, Andal Narayanan, Ranjini Bandyopadhyay

RRI Official Language Implementation Committee

Naresh VS, Suresh Varadarajan, CN Ramamurthy, B Srinivasamurthy, Shailaja V S, Gayathri G, Harini Kumari, Mamatha Bai R. Chaithanya MS, Savitha M Deshpande, Manjunath M, Nagaraj M N, Jacob Rajan, Vidyamani V.

Sports Committee

Sayantan Majumdar (Chair), Bapan Debnath, Sachin Belvadi, Saumya Ranjan Behera, Subramanian V G

Anti-ragging Committee

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

Canteen Committee

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

Research Facilities Committee

Biswajit Paul (Chair), Reji Philip, Pramod Pullarkat, A Raghunathan



Research: Knowledge Creation

Astronomy and 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.

Galaxies

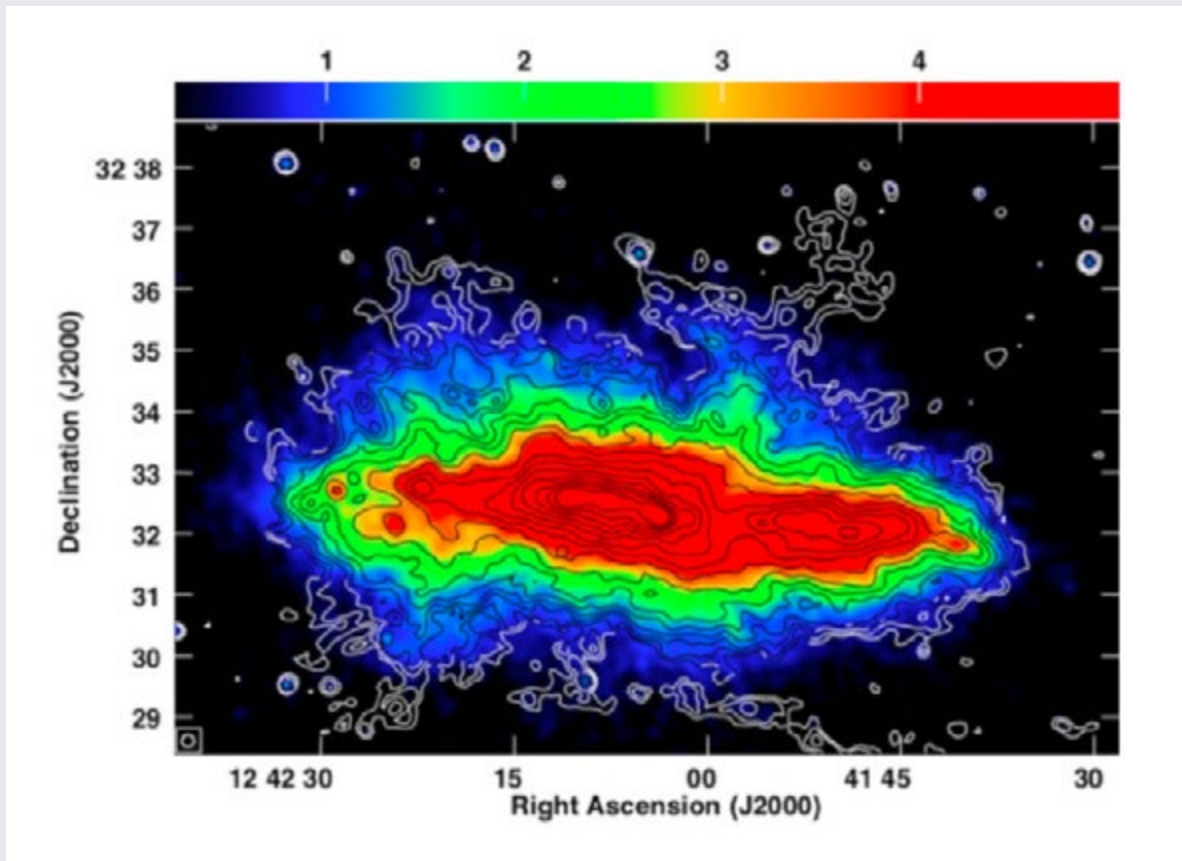
The study of galaxies, their dynamics and evolution, offers a link between the local stellar environment and the evolution of the universe.



Biman Nath
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Termed as the building blocks of the universe, galaxies are made up of stars, gas, dust, and dark matter. These constituents interact with themselves in a complex manner, which are important to understand the evolution of galaxies. When stars form in certain regions of a galaxy, the ensuing explosion of massive stars can drive a portion of the gas out of the galaxy. This process can stall further formation of stars. Simulations carried out at RRI have studied in detail the mechanism of such galactic outflows, and how observations in different wavebands (optical, X-ray, radio) can be explained. Even a mildly star forming galaxy like ours (the Milky Way) shows a structure, known as the Fermi Bubble, seen in gamma-rays and other wavebands. Research at the Institute has shown how this can be understood as a result of star formation and black hole activity in the center of the Galaxy. RRI members have also been studying the tenuous gas that surrounds the visible part of the galaxy. This highly dilute gas does

not emit but leaves absorption imprints in the spectra of background galaxies, and such observations give clue to the physical state of this so-called 'circumgalactic medium'. Cosmic rays are an important component of galaxies, and their origin, especially that of high energy (1-100 PeV) particles, is still not understood. Research at RRI has shown that massive compact star clusters can be sites of acceleration of such cosmic rays. This model has been able to explain a hitherto unexplained isotope ratio of Neon nuclei in cosmic rays. Another crucial component of galaxies is dust. RRI astronomers have recently shown that the distribution of dust in star forming regions of galaxies is a crucial factor in explaining the attenuation of starlight in galaxies.



Radio image of NGC 4631 at 745 MHz (contours) from uGMRT overlaid on the image at 315 MHz (colour). This is an edge-on star forming galaxy at a distance of 9 Mpc. The authors had first simulated how a star forming spiral galaxy should look in radio wavebands, using theoretical ideas of energy injection due to stellar explosions and how cosmic rays accelerated in such shocks would radiate in different radio frequencies. In order to test these ideas, they used the uGMRT to observe NGC 4631. The analysis of the data supported the basic results from simulations, and has give some extra inputs with which one can improve upon the simulations. (from Aditi Vijayan, K. S. Dwarkanath, Biman B. Nath, Ruta Kale, 2022, MNRAS, 511, 3150)

Selected Publications:

Aditi Vijayan, K S Dwarkanath, Biman B Nath, Ruta Kale, "Radio halo of NGC 4631: comparing observations and simulations " MNRAS, 511, 3150 (2022)

X-ray Astronomy

X-ray Astronomy is a branch of astronomy that deals with the study of extreme processes like accretion onto a compact object (White Dwarf, Neutron Star, and Black Hole) via Imaging, timing and Spectroscopic techniques.



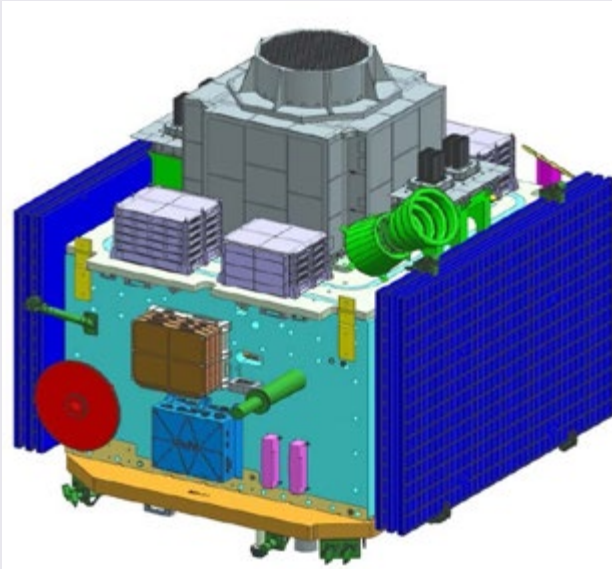
Biswajit Paul
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Vikram Rana
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Research in the X-ray astronomy group is mainly focused on Experimental as well as Observational aspects to study astronomical sources at X-ray energies. X-ray polarimetry is a powerful tool that promises to reveal unique and crucial information about physical process and geometry of almost all classes of astronomical sources. POLIX, an X-ray polarimeter, is the main instrument onboard the soon to be launched ISRO satellite XPoSat. POLIX is designed and built at RRI. The qualification tests have been successfully conducted on the Qualification Model (QM) of POLIX. Assembly and tests of the Flight Model (FM) of POLIX including four detectors and four electronics packages are ongoing. Space qualification tests of the payload FM, integration of POLIX with the spacecraft, and spacecraft-integrated tests will also be carried out in near future. In addition, we are also actively involved in development of focusing X-ray optics for future X-ray mission. Focusing capability for X-rays (specially >10 keV) has tremendous potential to open a new discovery window in high energy astronomy. Fabrication of such hard X-ray telescope is an ambitious project, hence a collaborative effort has been initiated between RRI, PRL Ahmedabad and URSC, ISRO to develop technology for hard X-ray telescope.

Observational research includes study of X-ray binaries (containing neutron star or black hole), Ultraluminous X-ray sources (ULXs) and Cataclysmic Variables (CVs). The intense gravitation field of the compact star causes matter from the companion star to accrete onto the compact star, producing X-rays. X-ray astronomy is a powerful tool to study such objects. In X-ray binaries, investigations include orbital evolution, X-ray reprocessing in the binary environment, cyclotron absorption features, quasi-periodic and periodic intensity variations etc. ULXs are studied to shed light on nature of compact object and their transient behavior. For CVs, broadband X-ray characteristics are studied. Data from various X-ray observatories like Astrosat, NuSTAR, Chandra, XMM-Newton, Swift etc. are used for this research.



XPOsat drawing showing different component of the satellite. Polix is the main scientific instrument located at the center of the satellite. (Right) POLIX qualification model taken just before environmental tests at UR Rao Satellite Center, ISRO.

Selected Publications:

Dutta, Anirban; Rana, Vikram "A broadband X-ray study of the asynchronous polar CD Ind",; MNRAS, 2022, 511, 4981

Devaraj, Ashwin; Paul, Biswajit Paul "NuSTAR discovery of a cyclotron line in GRO J1750-27", MNRAS Letters, 2022, 514, L46

Rikame, Ketan; Paul, Biswajit;, Pradhan, Pragati; Paul, K T "Discovery of quasi-periodic oscillations in the persistent X-ray emission of accreting binary X-ray pulsar LMC X-4", MNRAS, 2022, 512, 4792

Experimental Cosmology

Little is known about the “Cosmic Dawn,” a period over which the first stars and galaxies formed, including when exactly they formed, what they looked like, and what type of radiation they emitted.



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Standard cosmology predicts that the first stars and galaxies in the Universe formed from a bath of neutral hydrogen over a period known as the Cosmic Dawn. How and when these first stars and galaxies formed and what their properties were, are questions that CMB DISTORTION Lab at RRI is seeking to answer.

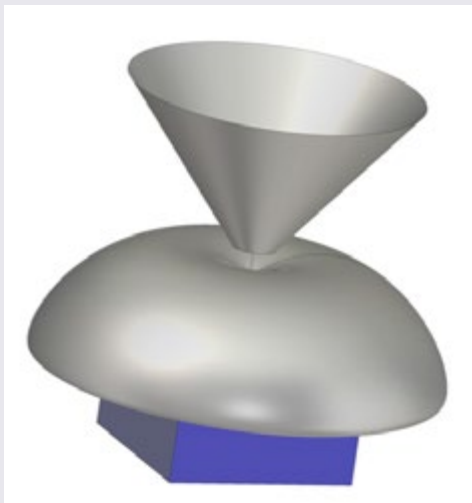
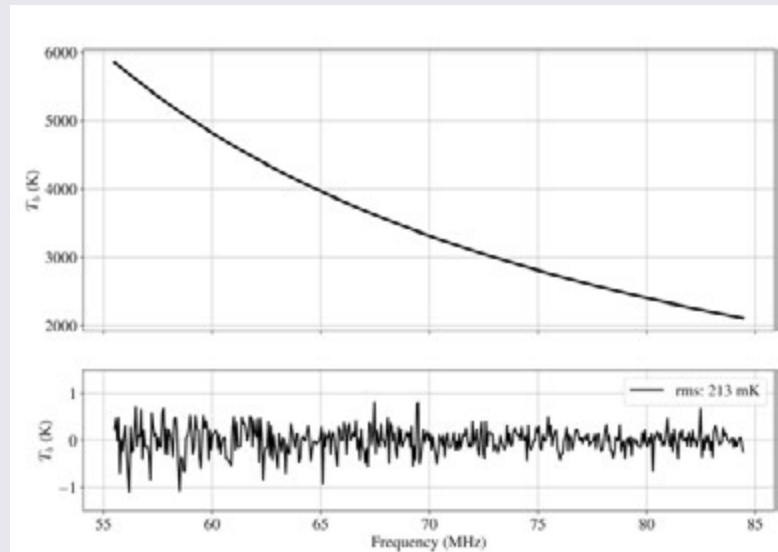
By measuring the 21-cm radiation emitted by neutral hydrogen and studying the average evolution of the signal’s brightness against the cosmic microwave background radiation that fills the Universe, we aim to understand the “Cosmic Dawn”. To make a conclusive detection of this elusive signal, RRI has two experiments leading the way in ground and future space-based efforts.



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Over 2021-22, SARAS became the first and only experiment in the world to rule out an anomalous signal detection claim by a competing experiment ‘EDGES,’ led by astronomers from Arizona State University and MIT, USA. The claimed detection was at odds with the standard predictions and required devising exotic physics. SARAS-3 telescope, observing the radio sky over 55-85 MHz, has conclusively refuted the cosmological origins of the signal detected by EDGES and restored faith in standard physics and cosmology. SARAS continues to strive towards 21-cm signal detection from the first stars from the ground.

To complement SARAS’s ground-based measurements for a high confidence signal detection, RRI has been developing what might be India’s first space-based cosmology experiment – PRATUSH. PRATUSH will aim to operate in pristine environments in space, initially in orbit around Earth, followed by observing in the radio-quiet environs of the lunar farside. In 2021, PRATUSH was recommended to move to project mode from the study phase by an ISRO-appointed review committee. The concept model of PRATUSH is now under testing. It is expected to lead to an engineering and flight model in the coming years.



(Top Left) SARAS 3 telescope deployed on Sharavati backwaters, Karnataka. (Top Right) Measurement of radio sky spectrum by SARAS 3 telescope. Top panel shows the spectrum, and the bottom panel shows thermal noise. (Bottom Left) A 3-dimensional rendering of the PRATUSH experiment concept. The grey cone and reflector form the antenna, which sits above the blue cuboid structure containing payload and satellite electronics. (Bottom Right) The concept model of PRATUSH being assembled. PRATUSH seeks to detect the faint signal from the first stars from space.

Selected Publications:

Saurabh Singh, Jishnu Nambissan T., Ravi Subrahmanyam, N. Udaya Shankar, B. S. Girish, A. Raghunathan, R. Somashekar, K. S. Srivani and Mayuri Sathyanarayana Rao, "On the detection of a cosmic dawn signal in the radio background" *Nature Astronomy*, VOL 6, 617 (2022)

Cosmic Ray, Gamma Ray and Neutrino Astronomy with Galactic and Extragalactic Objects

This field started more than a century ago. Currently exciting results are coming up as the high energy universe is visible by multi-wavelength and multi-messenger astronomy.

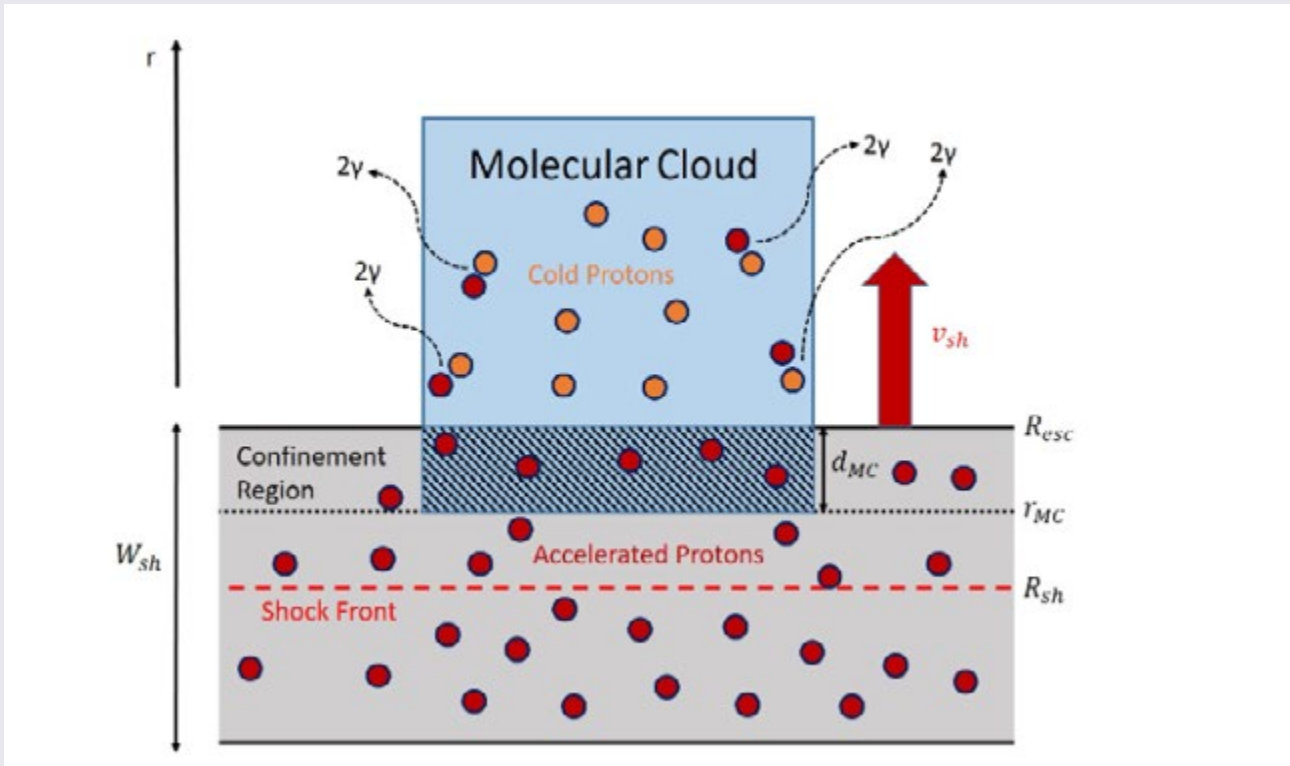


Nayantara Gupta
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The high energy astrophysics group has worked on blazars, Galactic gamma-ray binary, low luminosity Active Galactic Nuclei (AGN) and IceCube detected astrophysical neutrino events in the past year.

The nature of low luminosity AGN were explored. They are abundant in our neighbourhood but less explored due to their low luminosity. The nature of an unidentified Galactic source HESS J1828-099 was obtained with multi-wavelength data and theoretical modeling. The detailed modeling of several ultra-high energy gamma ray sources LHAASO J2108+5157, LHAASO J3041+5258 and LHAASO J 1908+0621 detected by the LHAASO (Large High Altitude Air Shower Observatory) in China were completed.

The cosmogenic neutrino flux from blazars which are possibly emitting astrophysical neutrinos were calculated. Future neutrino telescopes like IceCube Gen 2 would be able to detect cosmogenic neutrinos from them.



Schematic diagram showing interaction between the SNR and associated MCs, following Makino et al. (2019). The radially outward direction from the cavity center is signified by the vertical axis. For the sake of simplicity, we assume that the shock front is a plane and the MC is an uniform cuboid, and the distribution of the CRs inside the cloud is one-dimensional (Makino et al. 2019). The CRs have been assumed to be confined in a region around the shock front with a width of W_{sh} which is shown with a grey region in the figure. r_{sh} , r_{MC} and r_{esc} signifies the radius of the shock front, the distance of the surrounding MCs and the escaping radius from the cavity center respectively. The confined region moves outward with a velocity of v_{sh} and the overlapped region between the MC and the confinement region is given by d_{MC} . Part of the accelerated protons, marked with red circles escapes the confinement region through R_{esc} and seeps into the MC. These escaped protons further interact with the cold protons inside the MC (marked with orange circles) and produce gamma rays.

Selected Publications:

Saikat Das, Soebur Razzaque, Nayantara Gupta "Cosmogenic gamma-ray and neutrino fluxes from blazars associated with IceCube events" *Astronomy and Astrophysics Letters* 658, L6 (2022)

Agnibha De Sarkar, Nirupam Roy, Pratik Majumdar, Nayantara Gupta, Andreas Brunthaler, Karl M. Menten, Sergio A. Dzib, Sac Nicté X. Medina, Friedrich Wyrowski, "Possible TeV -ray binary origin of HESS J1828-099" *ApJ Letters* 927, L35 (2022)

Alokananda Kar, Nayantara Gupta, "Ultra-high Energy Gamma-rays from Past Explosions in our Galaxy" *ApJ* 926, 110 (2022)

Astrophysics with the Square Kilometre Array

Square Kilometre Array (SKA) is the world's largest and most sensitive radio interferometer telescope built by the scientific communities across nations, including critical contributions from the Raman Research Institute. The unprecedented sensitivity of this telescope will aid in investigating areas as diverse as the formation of Earth-like planets, the detection of gravitational distortions of Space-Time, the origin of cosmic magnetic fields, and the formation and growth of Black Holes.



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The first phase of the SKA will commission 197 dish antenna arrays in South Africa and 1,31,072 element aperture arrays in Western Australia. SKA will observe an extensive frequency range from 50 MHz to about 15 GHz and produce very high volume imaging and non-imaging data streams for exploring a variety of radio astronomy problems. It is an international scientific effort that delineates a giant leap in technology and research, with significant involvement of communities across nations, including the Raman Research Institute.

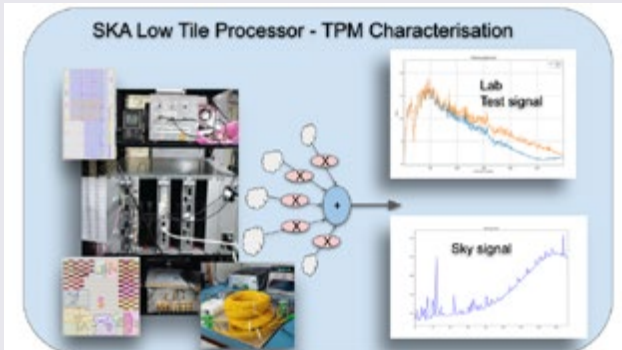


Prabu T
prabu@rri.res.in

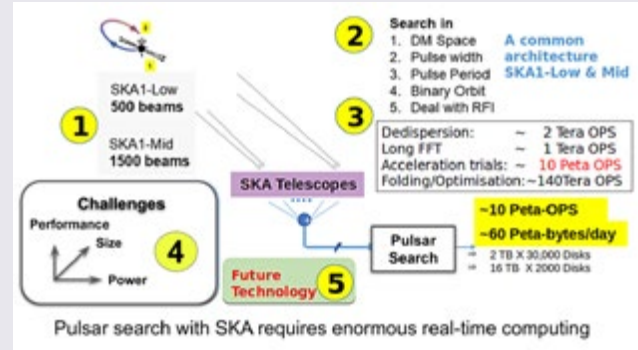
The SKA construction is happening in an incremental manner providing early science opportunities. SKA will help investigate how the small pebbles in the disk surrounding young stars ultimately coalesce into a planet. Hydrogen is the most abundant element in the Universe; it produces 21 cm emissions from various distances and directions. Probing these signals helps investigate the history of the Universe. SKA is sensitive to detecting several highly accelerated binary pulsars. The timing study of these pulsars opens a new window to study the space-time metrics. Magnetism is ubiquitous in our Universe, and SKA will enable learning the three-dimensional magnetic map of the Universe by measuring the magnetic components in varying directions and distances.

Institute members are developing a new multi-beamforming mode for the SKA Western Australian telescope. The team also characterizes the digital beamforming platform, the tile processing module (TPM). We have contributed to developing a binary pulsar search engine (PSS) for the SKA. Presently, it is being optimized for performance and integration, and characterization works are in progress.

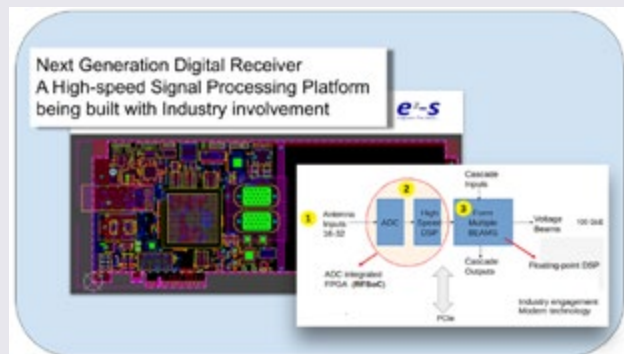
We are engaged also in developing a state-of-the-art FPGA-based integrated prototype hardware (IPB) to deliver a high-speed digital signal processing platform with beamforming capabilities for future radio telescope projects. Students are involved in laboratory activities, covering advanced electronics design, signal processing firmware design, validation, machine learning and data analysis.



SKS Tile Processing platform (TPM) being characterised in the lab



Pulsar search with SKA requires enormous real-time computing



State of the art high-speed digital processing platform being designed

Selected Publications:

“High-Performance Computing for SKA Transient Search: Use of FPGA based Accelerators – a brief review” T. Prabu (led), K.S. Srivani, B.S. Grish, A Raghunathan and Shiv K. Sethi et al along with SKA Collaborators, In press, JoA special issue, 2022. <https://doi.org/10.48550/arXiv.2207.07054>

“Nanohertz Gravitational Wave Astronomy during the SKA Era: An InPTA perspective”, Paper with pulsar timing collaboration: Bhal Chandra Joshi, Achamveedu Gopakumar, Arul Pandian, Thiagaraj Prabu et al., In press, JoA special issue, 2022. <https://doi.org/10.48550/arXiv.2207.06461>

“Median filters on FPGAs for infinite data and large, rectangular windows”, Krystine Dawn Sherwin, Kevin I-Kai Wang, Prabu Thiagaraj, Ben Stappers, and Oliver Sinnen, ACM Transactions on Reconfigurable Technology and Systems, Accepted, April 2022. <https://dl.acm.org/doi/10.1145/35302>





GROUND STATION 2

GROUND STATION 1 (IRRI, INDIA)

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 Mixtures

At ultra-cold temperatures of micro and nano Kelvins, the quantum correlations between matter can be utilized in developing quantum technologies such as quantum sensors, and engineering novel quantum materials.



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Laser cooled atoms are ideal test beds for developing modern quantum technologies, since at ultra-low temperatures of micro and nano Kelvins atoms no longer behave as classical point-like particles, and the full quantum structure of the atom becomes available to the experimenters. Members of the Quantum Mixture laboratory at RRI, cool and trap neutral Sodium, Potassium and Rubidium atoms using laser light and magnetic fields and exploit the quantum properties to develop quantum sensor as well as perform high precision spectroscopy to learn more about the exotic properties of these ultra-cold atoms.

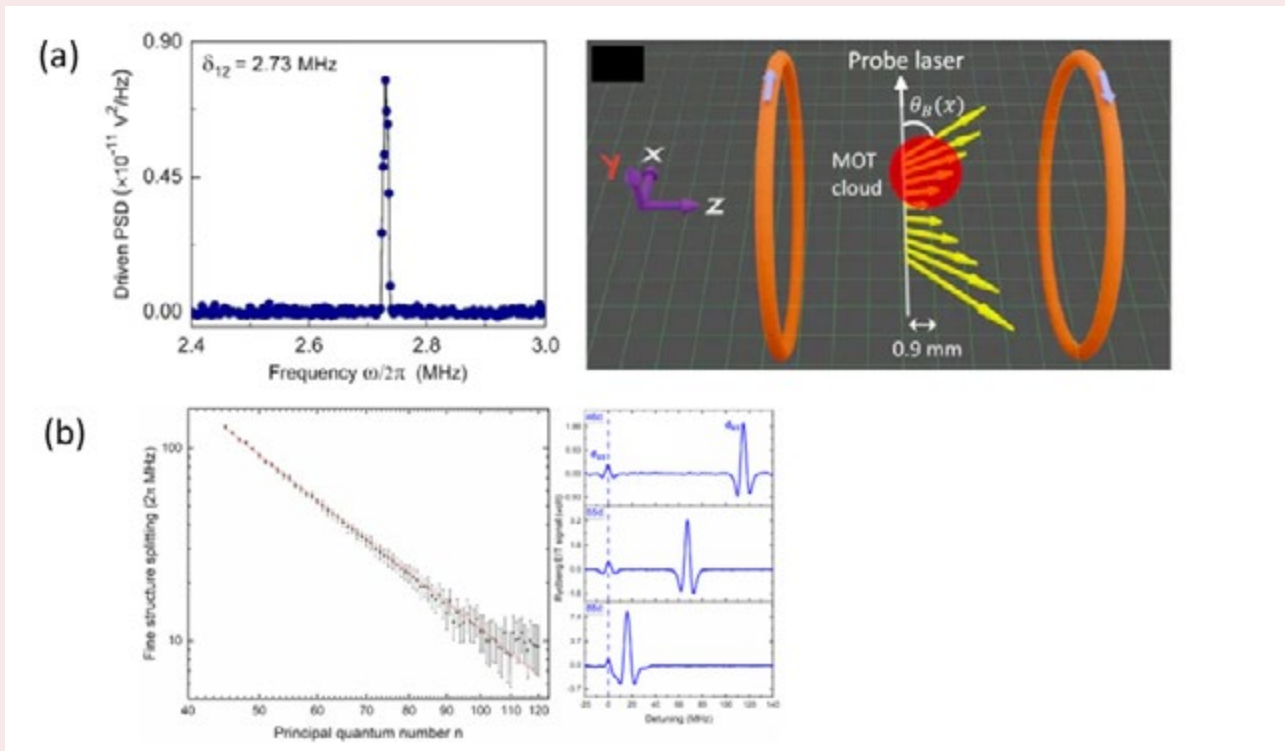


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The spin fluctuations of cold atoms have been experimentally studied using a novel technique of coherently driven spin noise spectroscopy, developed in the laboratory. The results (summarized in fig (a)) indicate that the cold spins can be used as extremely high precision magnetic field sensors, via Faraday rotation fluctuation measurements.

In another set of measurements, the researchers performed a high precision spectroscopy of Rubidium atoms excited to very high- n Rydberg states, with exaggerated properties such as high lifetime, large size and strong inter-atomic interactions. These “giant” atoms can now be utilized for studies on macroscopic quantum entanglement, ultimately leading to developments in quantum information sciences.

Motion of heavy particles in a bath of lighter particles is a subject of fundamental curiosity, originally studied by Einstein. This problem was approached using a generalized Langevin equation view-point and experimentally recording the motion of laser cooled atoms in a bath of laser light or photons. The experimental observations were compared with their theory predictions and a self-consistent description of the response function of the cold atoms in a photon bath were obtained.



(a) Spin dynamics in cold atoms studied via measurements of polarization fluctuation of the probe laser, Right: A schematic of the experimental arrangements. (b) Fine structure energy splitting of Rydberg states with the principal quantum number, n (left), Fine structure splitting for three different principal quantum numbers depicting the decrease in the splitting for higher Rydberg states (right).

Selected Publications:

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

Subhajit Bhar, Maheswar Swar, Urbashi Satpathi, Supurna Sinha, Rafael Sorkin, Saptarishi Chaudhuri, Sanjukta Roy "Measurements and analysis of response function of cold atoms in optical molasses" *Optics Continuum* 1 (2), 171-188 (2022)

Maheswar Swar, Dibyendu Roy, Subhajit Bhar, Sanjukta Roy, and Saptarishi Chaudhuri "Detection of spin coherence in cold atoms via Faraday rotation fluctuations" *Phys. Rev. Research* 3, 043171 (2021)

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 was 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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Einstein had famously asked: Do you really believe that the moon isn't there when nobody looks? This profoundly debated question concerns the notion of realism, namely that a system with well-defined properties is in a definite state at any instant, even when not measured. Remarkably, this notion has been catapulted from the domain of speculation to experimental physics through the testable algebraic inequalities derived by Bell and Leggett-Garg respectively. The former has enabled testing realism when combined with the idea of locality (i.e. no action at a distance), a concept known as local realism. A fully conclusive experimental falsification of local realism using photons has only recently been accomplished (2015).

On the other hand, the Leggett-Garg inequality (LGI) enables testing realism in conjunction with the idea that a measurement can be done, ensuring the effect on the system state to be arbitrarily small. It is this notion of classical realism that has been decisively refuted in a recent experiment by members of the QuIC lab at RRI through the violations of two different forms of such inequality, alongside perfect matching with the quantum mechanical predictions incorporating experimental non-idealities. Importantly, this experiment using single photons closes for the first time all the relevant loopholes through the various ingeniously developed strategies, thereby complementing the recent loophole-free testing of local realism using photons. This experiment has been hailed by experts as the "most watertight" experiment in the genre, thereby making it a landmark experiment in the rich history of LGI experiments. By providing the most decisive test for the quantumness of the single photon, it now sets the stage for various applications in secure quantum communications including more robust quantum cryptography.

The second major piece of work from the lab this year was in the domain of quantum computing. While the lab is generally invested towards higher dimensional approaches towards quantum computing and other information theoretic protocols, this year they worked on a very interesting experiment involving superconducting qubits.

While quantum computers are traditionally used to perform certain tasks at an exponentially faster rate than what may be possible using classical computers, here they were used for a different purpose i.e. to test the very

foundations of the theory on which their working is based. This is of interest because quantum computers are scalable quantum systems which provide a universal programmable setup for quantum experiments. Indeed, a quantum circuit, which is like a low-level program for quantum computers, is basically a Rosetta stone that allows one to translate experiments from one physical system to another.

Since the operation of a quantum computer is based on the postulates of quantum mechanics, in designing the circuits one has to avoid employing the assumptions that one is experimentally testing. Avoiding this cyclic logic was one of the main challenges of this work.

A practical application of this work is based on inverting its logic. Instead of using quantum computers to test whether quantum mechanics is true, we can alternatively assume that quantum mechanics is true and can use these tests as a benchmark to evaluate how well a quantum computer performs.

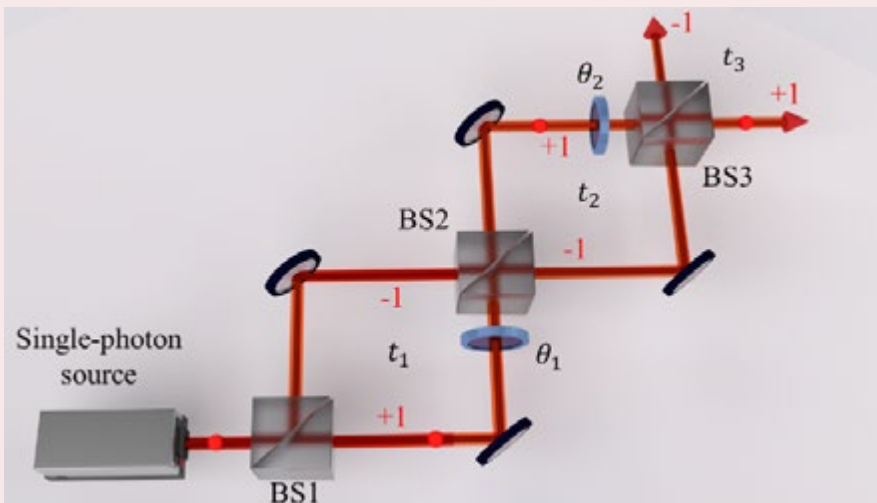


Figure 1: Basic schematic of the experimental set-up [PRX Quantum, 3, 010307, 2022]

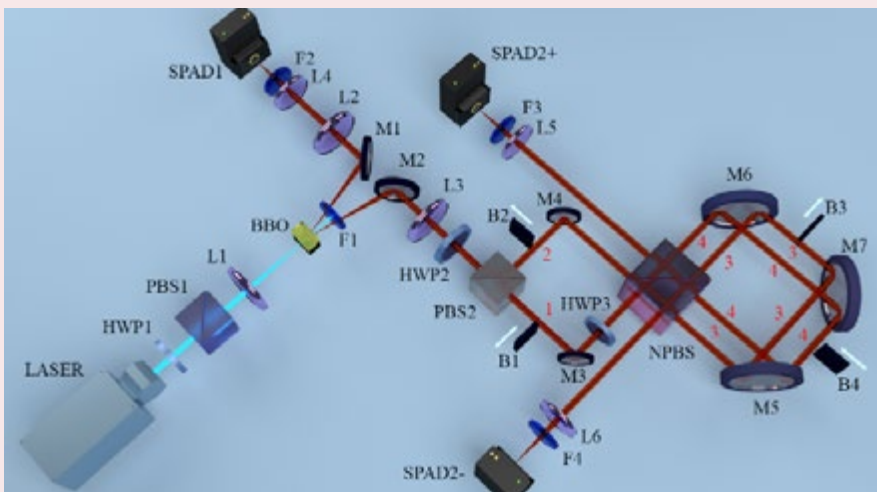


Figure 2: Modified schematic of the experimental set-up. This is the schematic on which the experiment is based [PRX Quantum, 3, 010307, 2022]

Selected Publications:

K.Joarder, D.Saha, D.Home, U.Sinha, "Loophole free interferometric test of macrorealism using heralded single photons", PRX Quantum, 3, 010307, 2022.

S. Sadana, L. Macconne, U.Sinha, "Testing quantum foundations with quantum computers", Physical Review Research 4 L022001, 2002.





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.

Liquid Crystals

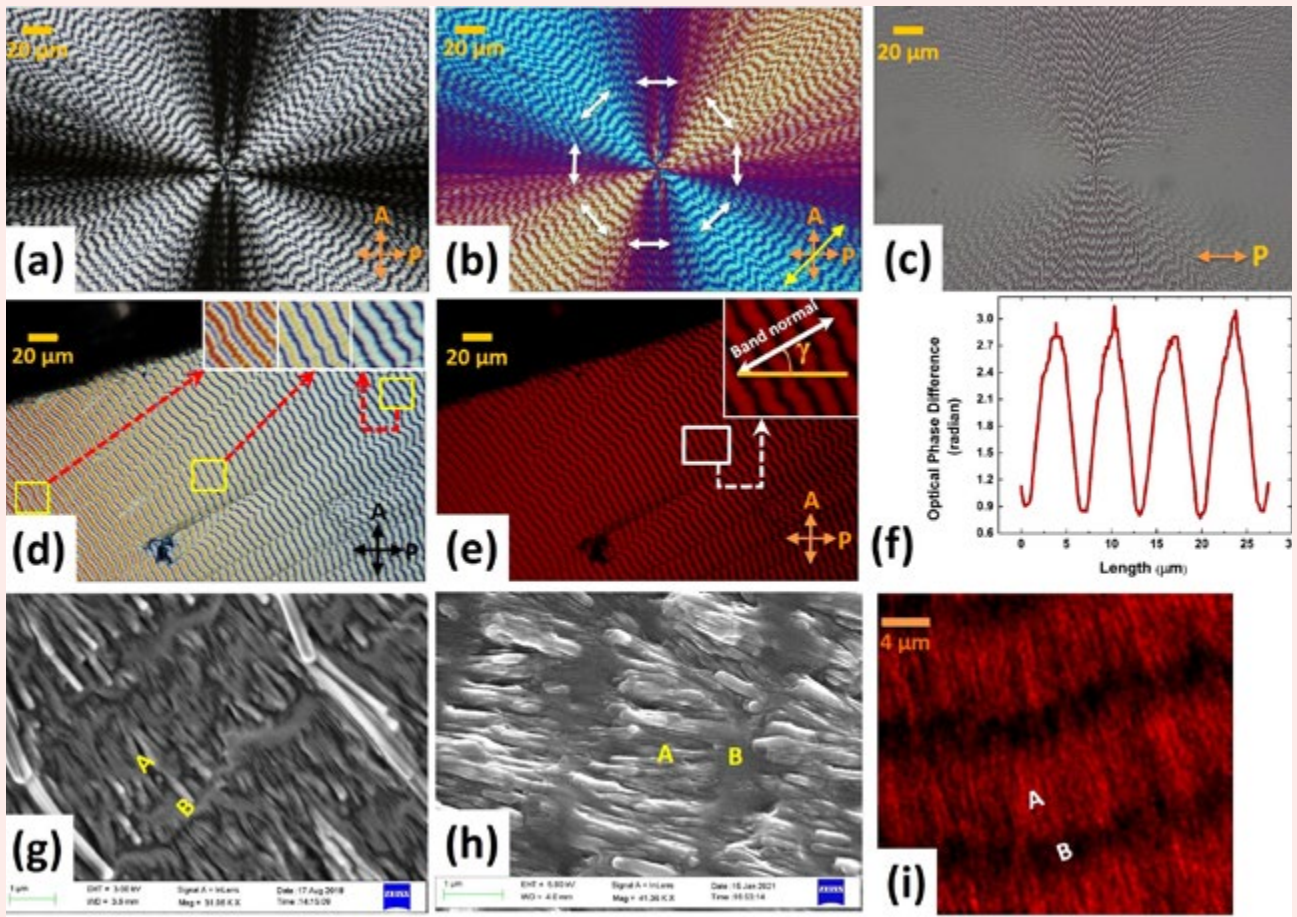
The discovery of liquid crystal phases as the intermediate state of some materials between their crystal and liquid phase led to fundamental developments in soft matter physics with applications in display devices, electro optics and photonics.



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Liquid crystals consisting of strongly anisotropic molecules is a major field of research in soft matter physics. The structural and functional properties of these materials are neither like pure liquids nor crystalline solids but somewhere in between them. They form a variety of self-assembled structures depending on the molecular shape, symmetry and interactions between the molecules. These materials exhibit physical properties which are easily tunable by applying external driving forces and have great potential for advanced applications in electro optics, display devices and in photonics. Efforts have been made towards studying different crystal polymorphs of a liquid crystalline compound (8OCB) consisting of strongly polar rod-like molecules. It was observed that the 8OCB liquid crystal has a stable CP

crystal phase. In addition, it also exhibits various metastable crystal phases. The metastable crystal state often found on cooling the sample from its melt was identified as PP phase which transforms to stable CP phase on ageing at room temperature. Interestingly, it was found that the stable CP crystal phase of 8OCB is not a single homogenous phase but is the coexistence of fibrillar nano crystallites embedded in an amorphous phase. The coexistence of crystallites and an amorphous phase as the stable ground state is remarkable for this pure compound consisting of relatively small rod-like molecules. It was also found that the growth of this CP crystal phase from its melt gives rise to banded spherulites. In most other materials, the banded spherulites are found to be formed by radially oriented periodically twisted fibrillar crystallites. However, in this sample an alternative mechanism for the formation of banded spherulite due to the rhythmic growth of concentric crystallite-rich and crystallite-poor bands was observed. This is the first report of the formation of banded spherulite for a pure compound consisting of strongly polar rod-like molecules. A time dependent Ginzberg-Landau model to account for the banded spherulitic growth in this sample separately was developed.



Microscopic textures of banded spherulite: (a), (b), (c), (d), (e) POM textures of banded spherulite of compound 8OCB in different conditions. (f) The variation of optical phase difference along the radial direction of the banded spherulite. (g), (h) FESEM image of the banded spherulite. (i) The fluorescent image of a dye doped banded spherulite. "A" and "B" represent the crystallite-rich and crystallite-poor bands respectively.

Selected Publications:

Subhadip Ghosh, Arun Roy, "Crystal Polymorphism of 8OCB liquid crystal consisting of strongly polar rod-like molecules", RSC adv., 11, 4958 (2021).

Subhadip Ghosh, Dipak Patra, Arun Roy, "Observation of banded spherulite in a pure compound by rhythmic growth" Phys. Rev. Materials, 6, 053401 (2022).

Nanoscale Biophysics

Biophysical forces play a vital role in cellular and molecular structure formation and its synergy with biological functions. 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.



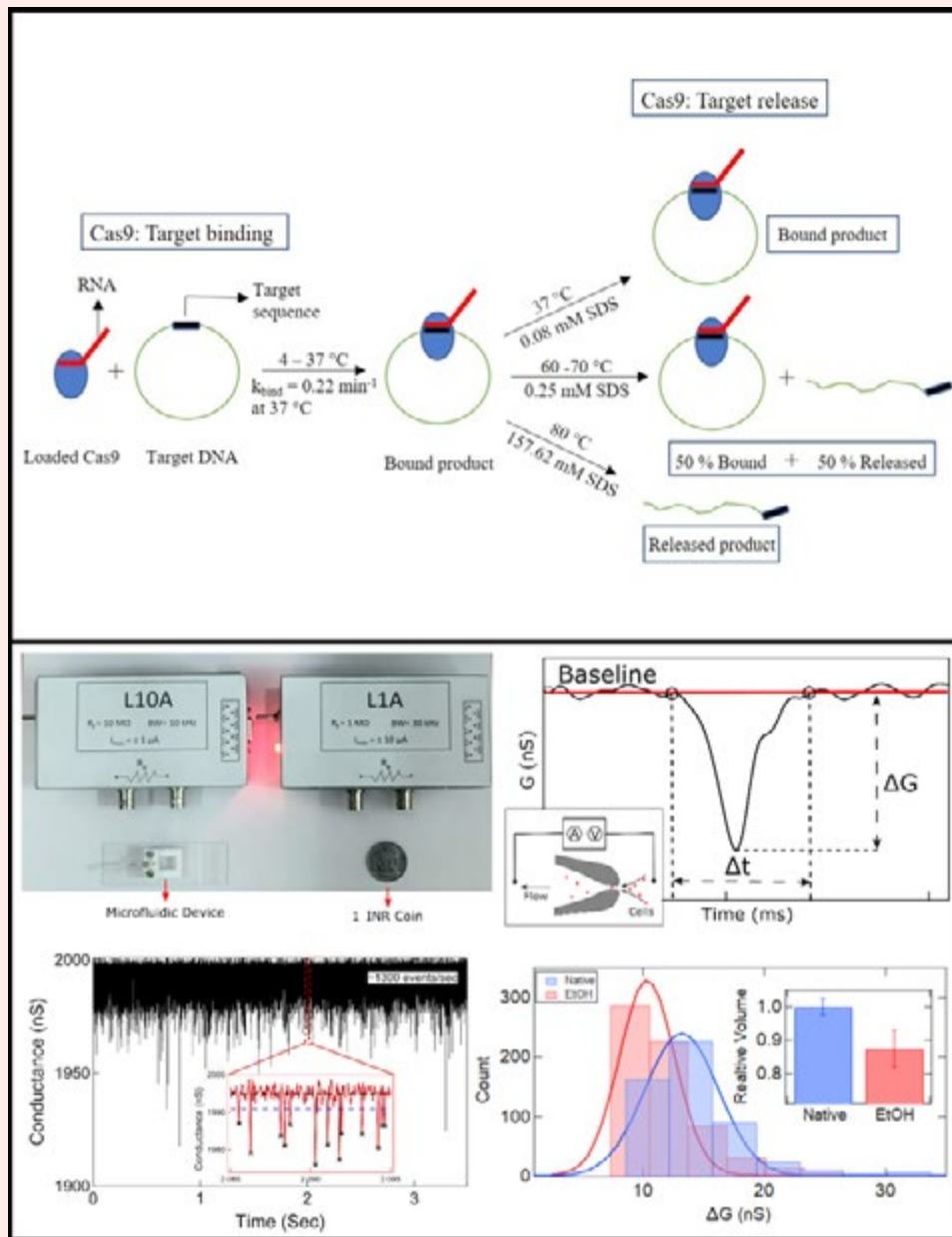
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The lab's research interests are primarily guided by the role of force in biophysical structure formation and its synergy with functional dynamics. Mechanisms of force-sensing as well as force-response of cells (whole cell mechano-sensing) and molecules (DNA-protein complexes) are studied. Novel bio-nano and micro scale tools to decipher biophysical principles governing the role of forces in these cellular as well as molecular assemblies are developed and used.

This year, the lab members are excited to report (1) work on temperature control of the CRISPR-Cas9 system (2) in-house development of a new low-cost electro-fluidic system to measure health state of biological cells.

The CRISPR-Cas9 system, a defense mechanism in bacteria, is a revolutionary tool in genome editing technology that has been successfully used in genome editing in agriculture, medicine and potential future therapies. For the first time, a detailed report on the temperature dependent binding & release of cleaved products by Cas9 enzyme was reported. It was shown that Cas9 enzyme can find and bind the target DNA sites at a temperature as low as 4°C! It also holds-on very strongly to the cleaved ends which can be controllably released in a temperature or denaturant dependent manner. This is a crucial advance of this platform into the forefront of bio-medical and analytical biotechnology in both in vivo and in vitro applications.

During the past year, the issue of lack of in-field diagnostic facilities or diagnosis tools that causes numerous casualties was tackled. Diseases like Tuberculosis, Tetanus, Cholera, Anthrax, Pneumonia, etc., are caused by bacterial infections, and often alcohol-based disinfectants are used to kill most bacterial cells. Physical understanding of changes in cell physiology with alcohol and pathogen resistance to it, requires sensitive detection of changes in cell physiology. In 2021-22, a low-cost electro-fluidic system (based on resistive pulse technique) that can be used in-field as a high-throughput cell counter (~1300 cells/sec) was developed. This system can also measure subtle changes in cell volumes with high-resolution. The group envisages that the quantitative knowledge of physiological changes in bacterial cells is a vital step in understanding their adaptive mechanism used to maintain the cellular integrity against certain alcohol-based disinfectants.



(Top) Scheme developed from temperature dependent study of target binding and release by the CRISPR-Cas9 system (Bottom) shows the in-house developed low-cost, high-throughput electro-fluidic system to measure physiological changes in cells (see publication for more details)

Selected Publications:

Kaushik S, Selvanathan P, Soni GV "Customized low-cost high-throughput amplifier for electro-fluidic detection of cell volume changes in point-of-care applications" PLoS ONE (2022), 17(4): e0267207

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 of 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 these 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 nature of the axonal cytoskeleton influences its overall mechanics. Using the occurrence of axonal buckling seen upon slackening an axon as a read out the lab members are working on a model that takes into account the differential viscoelastic responses of axonal structural components. They are also analysing the results showing a possible novel mechanism for generating contractile stresses in bundles of actin filaments confined within membrane nanotubes. Apart from these studies, an inter-institutional collaborative project aimed at understanding how the cytoskeleton and cell adhesion influences cell invasiveness was completed in the past year. This is relevant in understanding cell proliferation during cancer metastasis.

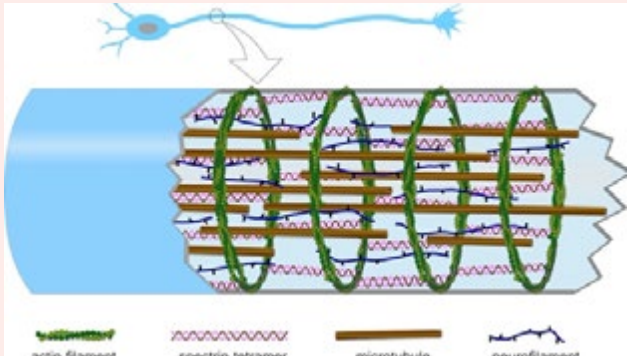
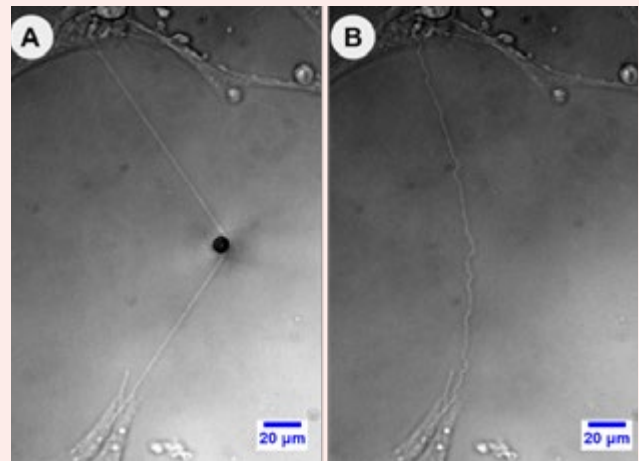


Figure 1: A highly simplified schematic of the axonal cytoskeleton consisting of periodically arranged rings of actin rings interconnected by spectrin tetramers and longitudinally aligned microtubules and neurofilaments. These filaments are interconnected by cross-linking proteins and molecular. The 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. The a main goal of the lab is to elucidate these dynamic interactions by combining novel experimental techniques, molecular biology and genetic tools, and theoretical analysis.

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



Selected Publications:

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

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

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

Neha Paddillaya, Kalyani Ingale, Chaitanya Gaikwad, Deepak Kumar Saini, Pramod Pullarkat, Paturu Kondaiiah, Gautam I. Menon, Namrata Gundiah "Cell adhesion strength and tractions are mechano-diagnostic features of cellular invasiveness" *Soft Matter* (2022); DOI: 10.1039/d2sm00015f

Non-equilibrium phenomena in driven aqueous suspensions

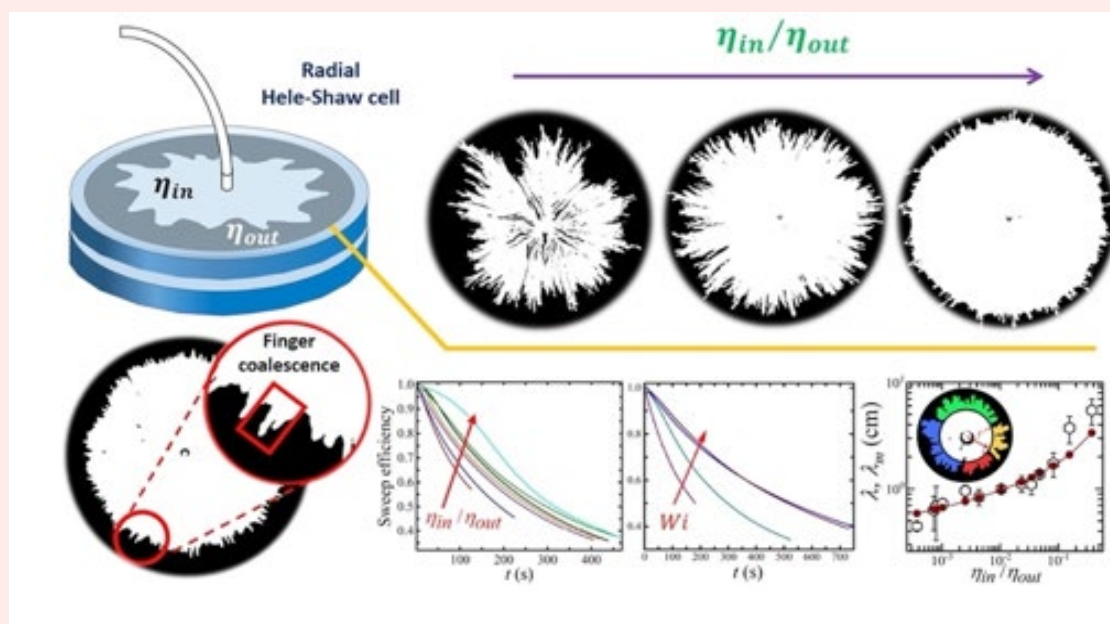
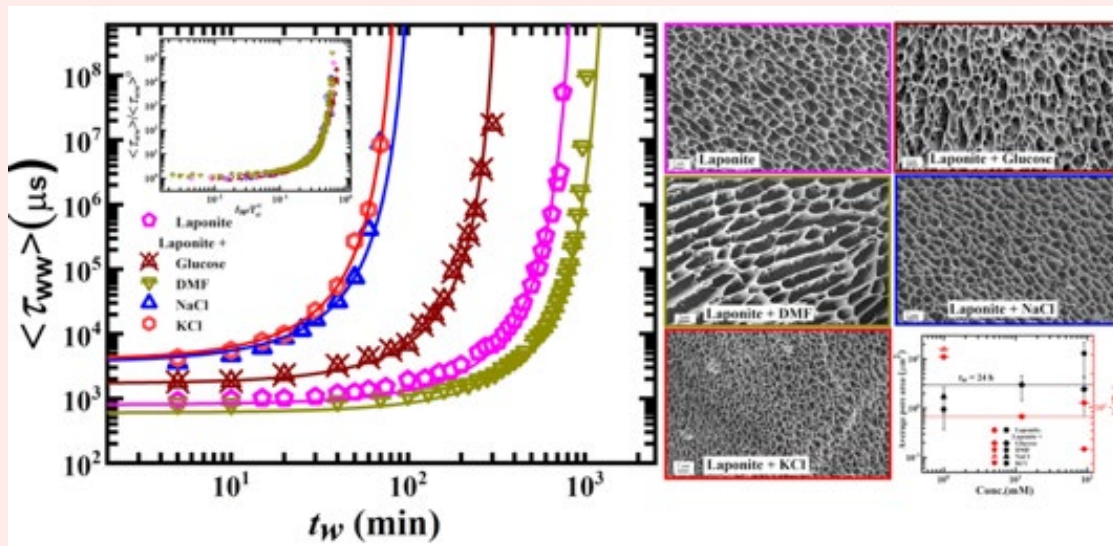
Driven soft matter serve as excellent 'scaled up' model systems to experimentally address problems in statistical physics. Jammed colloidal and granular suspensions can therefore be used to understand glassy dynamics.



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Laponite, a colloidal synthetic clay that shows physical aging in aqueous suspension due to the spontaneous evolution of inter-particle electrostatic interactions, is one such model colloid. The motion of millimeter-sized steel balls dropped in aqueous Laponite suspensions of different ages (i.e., time elapsed since sample preparation) are captured using a high-speed camera and the velocities of the ball centroids are estimated from the images. A mathematical model that accounts for rapid structural changes in the Laponite suspension, expected to be induced by the falling ball, matches the experimental data (Physics of Fluids). Even though the role of interparticle electrostatic interactions on the aging dynamics of aqueous colloidal suspensions has been evaluated extensively, the influence of water structure on their physicochemical properties has not been considered before. Laponite, a model

hectorite clay that acquires surface charges when dispersed in water, was used to study the relative contributions of dispersion medium structure and interparticle electrostatic interactions on the physicochemical properties of aging aqueous colloidal dispersions (Soft Matter). The displacement of a more viscous fluid by a less viscous fluid renders the fluid-fluid interface unstable and leads to intricate patterns called viscous fingers. Since the fluids experience shear during displacement, it should be possible to influence the emergence of patterns and instability dynamics through control of rheological parameters, such as elasticity or relaxation time in case of a viscoelastic fluid. The interfacial fingering patterns that emerge when a Newtonian fluid (glycerol-water mixtures of different viscosities) displaces a shear-thinning viscoelastic fluid (aqueous cornstarch suspensions of varying concentrations) and the suppression of instabilities under various conditions was investigated in a radial Hele-Shaw cell geometry (ColSurfA).



(Top) Dynamical aging and self-assembled structures of Laponite clay colloids in aqueous suspensions in the presence of various additives (Soft Matter). (Bottom) Instabilities can be suppressed by increasing the viscosity ratio of the inner Newtonian fluid and the outer non-Newtonian fluid in radial Hele Shaw experiments (ColSurfA).

Selected Publications:

Rajkumar Biswas, Debasish Saha and Ranjini Bandyopadhyay "Quantifying the destructuring of a thixotropic colloidal suspension using falling ball viscometry, *Physics of Fluids* 33, 013103 (2021); <https://doi.org/10.1063/5.0035093>

Chandeshwar Misra, Venketesh T Ranganathan and Ranjini Bandyopadhyay, "Influence of medium structure on the physicochemical properties of aging colloidal dispersions investigated using the synthetic clay LAPONITE *Soft Matter* 17, 9387 (2021); <https://doi.org/10.1039/D1SM00987G>

Palak, Rahul Sathyanath, Sreeram K. Kalpathy and Ranjini Bandyopadhyay, "Emergent patterns and stable interfaces in the radial displacement of a viscoelastic fluid" *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 629 127405 (2021); <https://doi.org/10.1016/j.colsurfa.2021.127405>

Memory formation in disordered materials

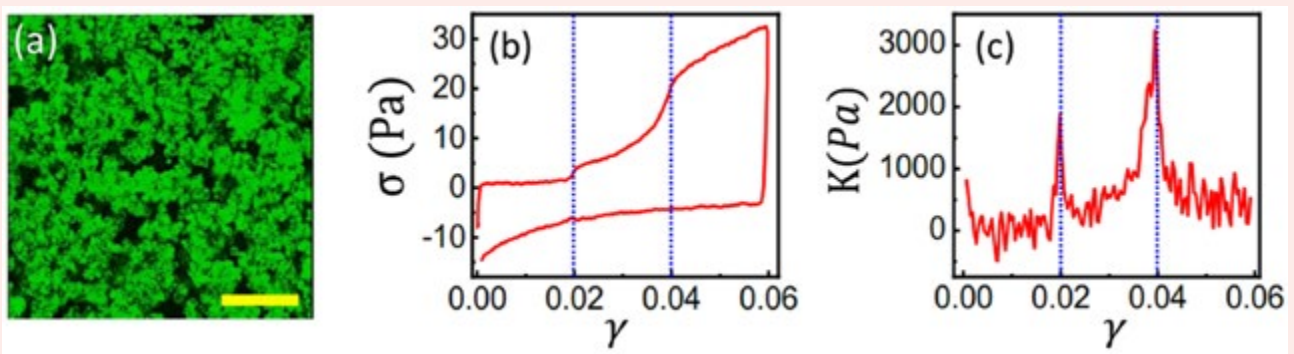
Out-of-equilibrium materials can remember the history of past perturbations. Such memory is stored in the material structure and can be revealed using a suitable protocol long after the perturbation is removed.



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Memory formation in disordered solids has attracted significant recent research interest. In spite of the diversity in microscopic structure, the presence of long-range correlations, and complex energy landscapes, these materials show very similar stress-induced localized rearrangements. Each of such events can be thought of as a transition between two local energy minima of the system. For amorphous solids it has been shown both experimentally and in numerical simulations that repeated/cyclic shearing can drive these systems to a steady-state encoding a memory of the applied strain amplitude. However, recent experiments find that the effect of such memory formation on the mechanical properties of the bulk material is rather weak.

Using shear rheology, the memory effect in a yield stress solid formed by a dense suspension of corn starch particles in paraffin oil was studied. Under cyclic shear, the system evolves towards a steady-state showing training-induced strain stiffening and plasticity. A readout reveals that the system encodes a strong memory of the training amplitude as indicated by a large change in the differential shear modulus. It was observed that memory can be encoded for a wide range of training amplitudes both above and below the yielding, albeit, the strength of the memory decreases with increasing amplitude. In-situ boundary imaging shows strain localization close to the shearing boundaries, while the bulk of the sample moves like a solid plug. In the steady-state, the average particle velocity inside the solid-like region slows down with respect to the moving plate as the training strain approaches the training amplitude, however, as the readout strain crosses the training amplitude, the average particle velocity suddenly increases. It was demonstrated that the inter-particle adhesive interaction is crucial for such a strong memory effect. Interestingly, the system can also remember more than one input only if the training strain with a smaller amplitude was applied last.



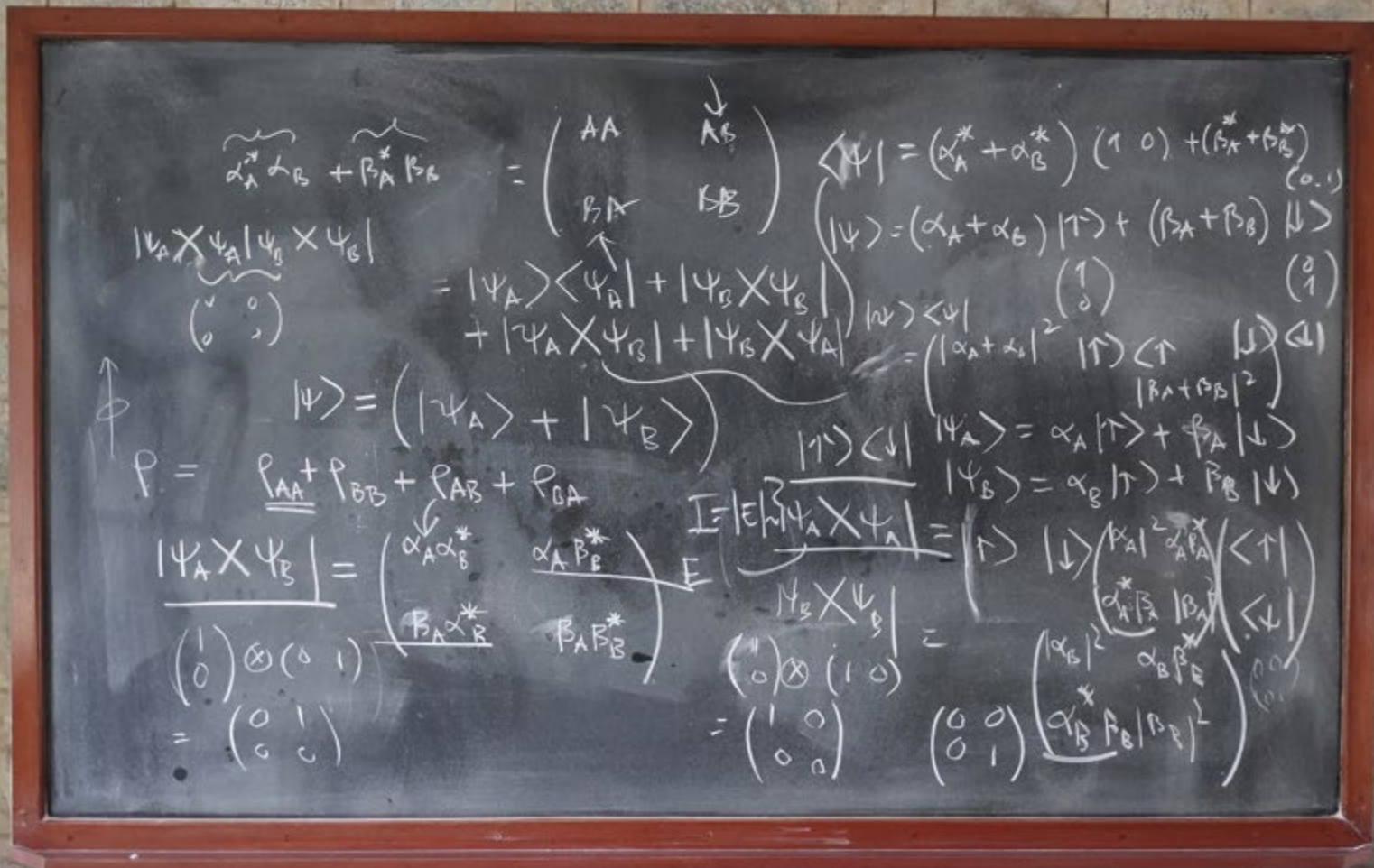
(a) Typical confocal image of a settled bed formed by CS particles in paraffin oil forming fractal clusters. Scale-bar: 150 μm . (b) Intra-cycle stress vs strain obtained from the readout for a sample trained at two strain amplitudes 0.02 and 0.04 showing signature of formation of two memories.

Selected Publications:

Effect of adhesive interaction on strain stiffening and dissipation in granular gels undergoing yielding;
 Sebanti Chattopadhyay, Sharadhi Nagaraja, and Sayantan Majumdar, *Communications Physics* 5 (1), 1-10 (2022).

Inter-particle adhesion induced strong mechanical memory in a dense granular suspension;
 Sebanti Chattopadhyay, and Sayantan Majumdar, *Journal of Chemical Physics* 156 (24), 241102 (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 meteorology 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.

Condensed Matter Physics

Discovery of novel phases with intriguing topological band-structure properties in one-dimensional non-conservative systems to engineering topological matter for better metrology and sensing (e.g., topological laser robust against imperfections)



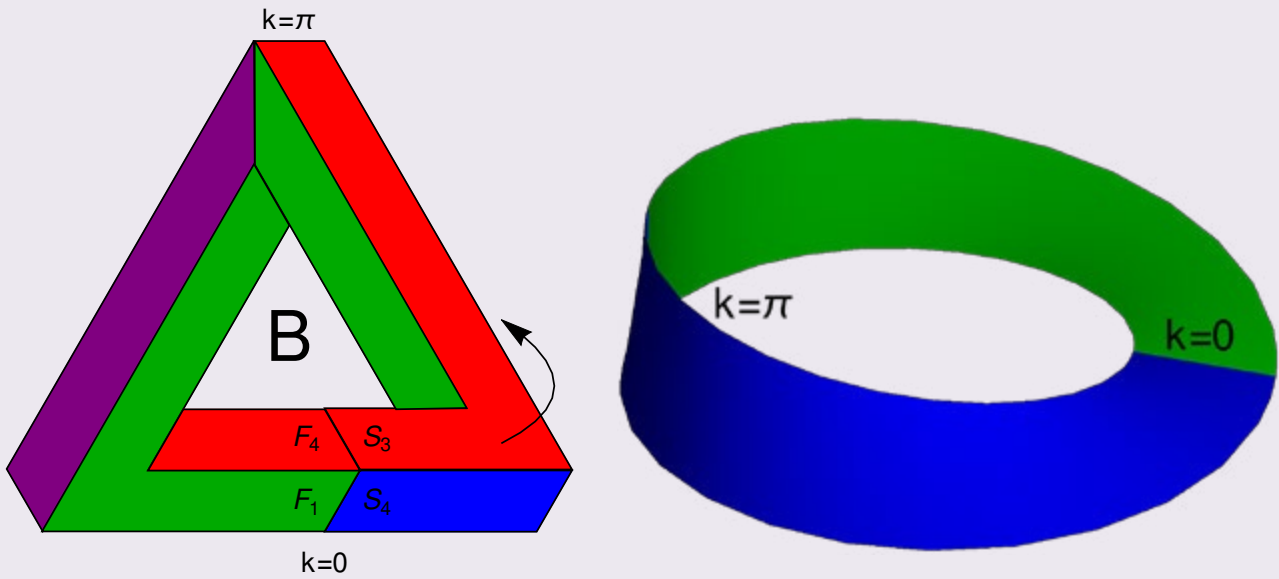
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Topology is a geometric property of an object that remains invariant under continuous deformations, such as stretching, twisting, and bending. Popular geometric objects with interesting topological properties are Möbius strips and Penrose triangles (see the image). Topological study has enormously succeeded in isolated quantum systems with conserved energy. The presence of dissipation, e.g., friction, viscous drag, resistance, and pumping of energy or particles to a system, makes it non-conservative or dissipative. Standard lasers and metallic electrons inside lattice vibrations are examples of non-conservative systems that are in abundance in nature. Therefore, an extension of the concepts of topology in conservative systems to their non-conservative counterparts is natural and vital.

The energy levels of an isolated quantum system are real numbers, and those of a quantum system in contact with an environment become complex numbers due to the exchange of energy between the system and environment. The complex-valued energy levels of dissipative lattices generate intriguing composite metallic and insulating phases with no analog in the conservative systems. These exotic phases have the topology of well-known geometric objects like the Möbius strip and Penrose triangle.

Previous works (e.g., a recent research by V. Vyas and D. Roy) have primarily focused on topological properties, such as topological phases and invariants to characterize those phases of dissipative lattices with each unit cell containing two sites/atoms.

A new research by Dibyendu Roy and his postdoc Ritu Nehra) provides a general framework to quantify the topology of phases in one-dimensional dissipative lattices, with each unit cell containing any number of sites/atoms. The researchers used a parametric space of real and imaginary parts of complex energies to characterize the topology of those complex energy levels of the quantum system in contact with an environment. In the research published in Physical Review they have discovered dissipative materials whose complex energies show the topology of Möbius strips and Penrose triangles.



Möbius strip (left) and Penrose triangle (right) as geometric realization of band-structure of composite insulating and metallic state of one-dimensional non-Hermitian quadripartite systems.

Selected Publications:

- [1] Topological aspects of periodically driven non-Hermitian Su-Schrieffer-Heeger model, Vivek M. Vyas and Dibyendu Roy, Phys. Rev. B 103, 075441 (2021)
- [2] Topology of multipartite non-Hermitian one-dimensional systems, Ritu Nehra and Dibyendu Roy, Phys. Rev. B 105, 195407 (2022)

Loop Quantum Gravity (LQG)

The construction of fully quantum mechanical description of the gravitational interaction remains the outstanding open problem in fundamental theoretical physics. LQG is an attempt at using conservative quantum mechanical techniques to resolve this problem.

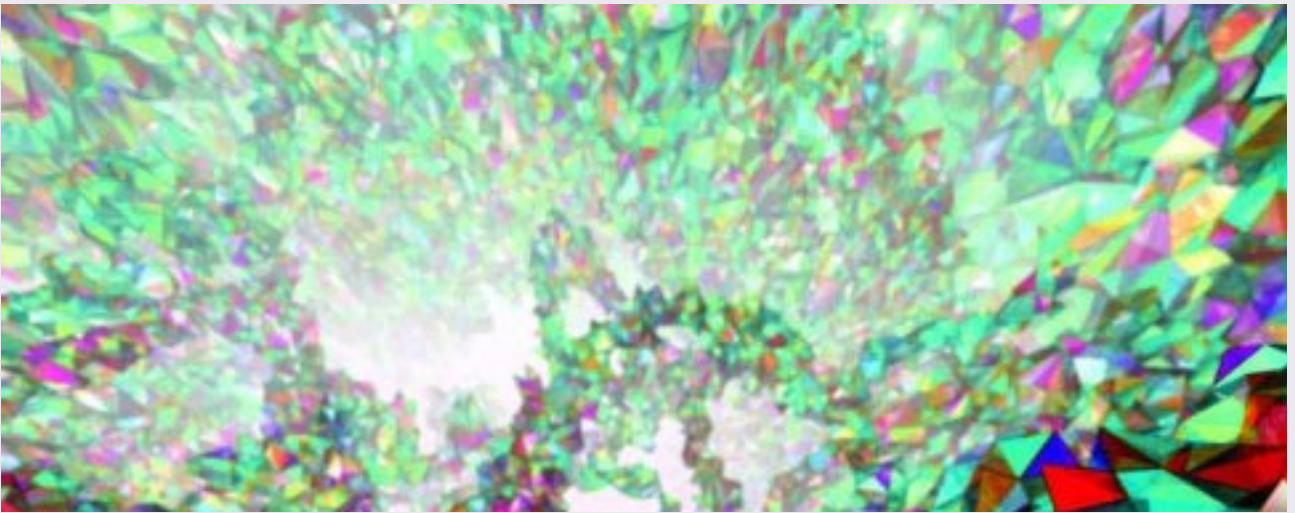


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The conservative techniques of LQG are those of canonical quantization wherein one splits space- time into space and time, reformulates the Einstein equations as Hamiltonian equations on phase space and seeks to replace Poisson brackets between functions by commutators between their operator correspondents. One key issue is then how to achieve this in a manner in which spacetime emerges from space and time in this Hamiltonian description. Since there is no preferred choice of background time, each choice of time corresponds to a distinct dynamical evolution and the emergence of classical spacetime is tied to the consistency of these (infinitely many) distinct dynamical evolutions. Demonstrating this consistency at the quantum level is a very difficult and open problem. Recent work by Madhavan Varadarajan, available in a 100 page preprint, demonstrates this quantum consistency for the Euclidean Loop Quantum Gravity and thus solves a key problem, open since the

inception of LQG more than 30 years ago.

Another key open problem is to show that LQG methods are consistent with the long distance propagation of quantum gravitational perturbations. Based on Madhavan's work on simpler systems, collaborative work with Thiemann accumulates very strong evidence for such propagation in LQG.



Thomas Thiemann, "The fabric of space: spin networks" in: Einstein Online Band 01 (2005), 01-1029

Selected Preprints:

Anomaly free quantum dynamics for Euclidean LQG, Madhavan Varadarajan, e-Print: 2205.10779 [gr-qc]

On propagation in Loop Quantum Gravity, Thomas Thiemann and Madhavan Varadarajan, e-Print: 2112.03992 [gr-qc]

Nonequilibrium statistical physics and stochastic processes

Modeling the bacterial motility and the dynamics of micro-catalytic-swimmers and understanding the statistical properties of these active motions starting from their microscopic dynamics; and records statistics of stochastic processes under resetting.



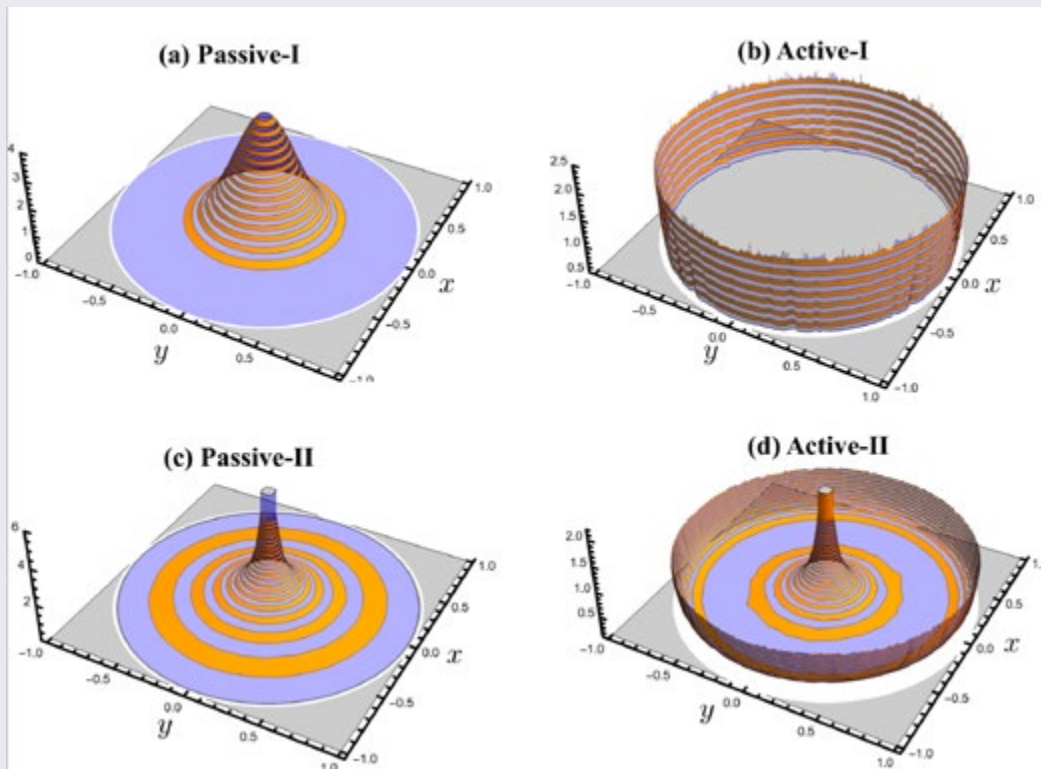
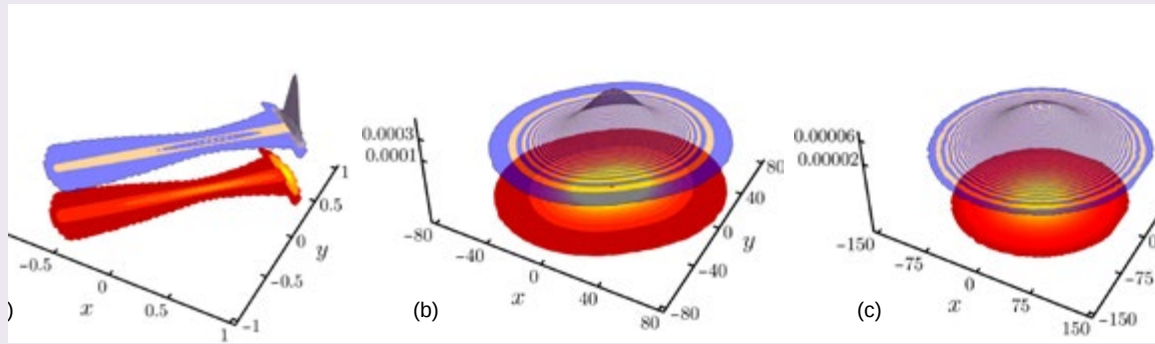
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Active Brownian motion with intermittent direction reversals is common in a class of bacteria like *Myxococcus Xanthus* and *Pseudomonas putida*. Researchers at RRI show that, for such a motion in two dimensions, the presence of the two time scales set by the rotational diffusion constant and the reversal rate gives rise to four distinct dynamical regimes showing distinct behaviors. They analytically compute the position distribution which shows a crossover from a strongly non-diffusive and anisotropic behavior at short-times to a diffusive isotropic behavior via an intermediate regime, and find that the marginal distribution in the intermediate regime shows an exponential or Gaussian behavior depending on relative strength of the two time scales. They also find the persistence exponents in the four regimes. The researchers further study this model in the presence of a harmonic trap and find four distinct phases in which

the system behaves either like passive or active systems.

In a 50 pages manuscript, the researchers further develop a general framework for studying the long-time behaviour for a class of active particle dynamics and illustrate it using the examples of run-and-tumble particle, active Ornstein-Uhlenbeck particle, active Brownian particle, and direction reversing active Brownian particle. Treating the ratio of the persistence-time to the observation time as the small parameter, they show that the position distribution generically satisfies the diffusion equation at the leading order. They further show that the sub-leading contributions, at each order, satisfies an inhomogeneous diffusion equation, where the source term depends on the previous order solutions. They explicitly obtain a few sub-leading contributions to the Gaussian position distribution. As a part of the framework, they also prescribe a way to find the position moments recursively and compute the first few explicitly for each model.

The researchers also studied the record statistics for random walks and Levy flights with resetting and find universal behavior for the mean number of records.



(Top) Dynamical evolution of the position distribution for the case showing the crossover from a strongly anisotropic and plateau-like structure around the origin accompanied by a single peak near along the initial orientation, at early times (a) to an eventual isotropic diffusive behavior (c) via an intermediate regime (b). (Bottom) Typical shape of the stationary position distribution of a direction reversing active Brownian particle in a harmonic potential.

Selected Publications and preprints:

“Active Brownian motion with directional reversals” Ion Santra, Urna Basu, and Sanjib Sabhapandit Phys. Rev. E 104, L012601 – Published 13 July 2021

“Direction reversing active Brownian particle in a harmonic potential” Ion Santra, Urna Basu, and Sanjib Sabhapandit, Soft Matter 17, 10108 (2021)

“Universal framework for the long-time position distribution of free active particles” Ion Santra, Urna Basu, Sanjib Sabhapandit, arXiv:2202.12117

“Record statistics for random walks and Lévy flights with resetting” Satya N Majumdar, Philippe Mounaix, Sanjib Sabhapandit and Grégory Schehr, Journal of Physics A: Mathematical and Theoretical, Volume 55, Number 3

Spacetime Entanglement Entropy

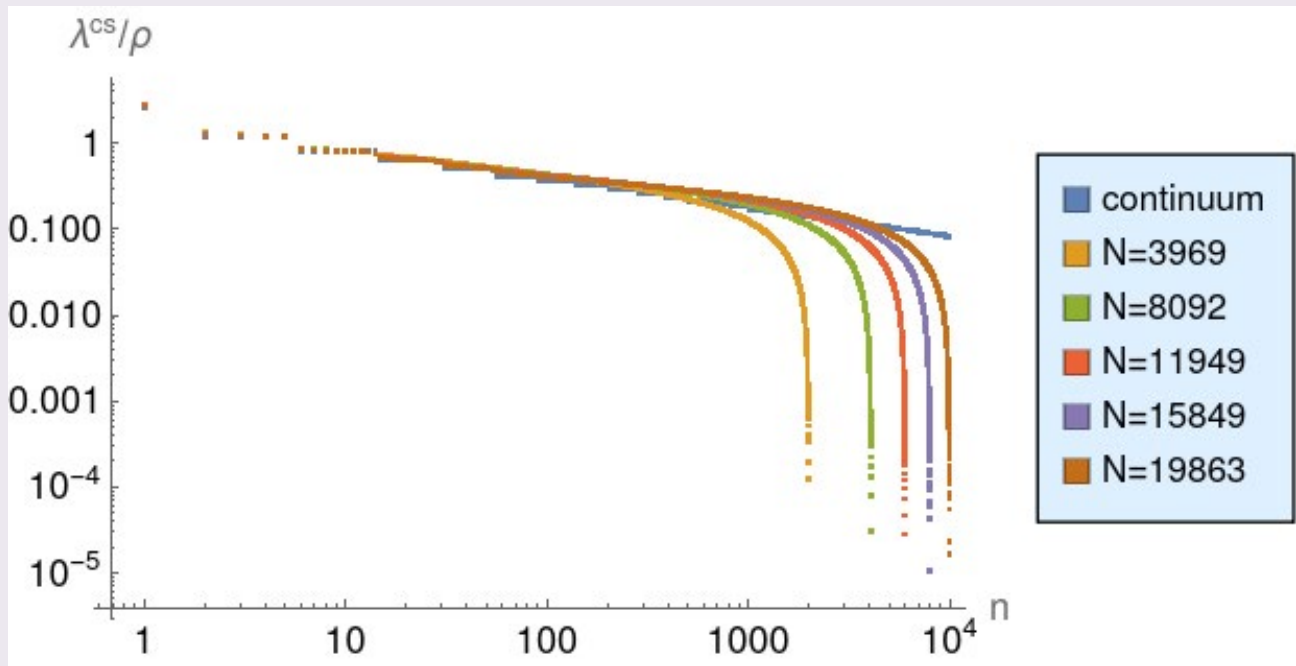
Recent progress on understanding Spacetime Entanglement Entropy has opened a new window into black hole physics.



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One of the most interesting open questions in quantum gravity is the origin of blackhole entropy. It was suggested in the late '80s that the entanglement of a quantum field could source black hole entropy, when a UV cut-off is imposed. About a decade ago, a space-time entanglement entropy (SSEE) was defined by Sorkin using field correlators for a free Gaussian scalar field, which makes it amenable to spacetimes that may not admit Cauchy hypersurfaces. As a follow up to earlier work on the SSEE for causal set horizons, a correspondence between the SSEE and von-Neumann was sought in the continuum. This establishes that the SSEE is a good measure of entanglement even in discrete spacetime. An analysis of the latter shows that there is an energy dependent behaviour for discrete horizons: in the deep UV one obtains a volume law whereas in the continuum regime the SSEE satisfies the

expected area law. This opens up many analogies between discrete quantum gravity and long range systems in condensed matter physics.



Our early and present universe is well described by de Sitter spacetime. The modes of a scalar field are shown for causal set discretisation at different densities and compared with the continuum. The deep UV behaviour (large n) is a result of discreteness and departs from the continuum scaling behaviour.

Selected Publications:

“Spacetime entanglement entropy of de Sitter and black hole horizons”, Abhishek Mathur, Sumati Surya, Nomaan X, *Class.Quant.Grav.* 39 (2022) 3, 035004

“A spacetime calculation of the Calabrese-Cardy entanglement entropy”, Abhishek Mathur, Sumati Surya, Nomaan X, *Phys.Lett.B* 820 (2021), 136567, *Physics Letters B.* 2021 Aug 8:136567

Quantum Brownian Motion

Brownian motion, is the random motion of particles suspended in a fluid. It has been studied extensively by many physicists. In recent years the focus is on Quantum Brownian Motion.



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Brownian motion is the random motion of particles suspended in a fluid resulting from their collision with fast-moving molecules in the fluid. At room temperature, the law of diffusion is given by the well known Einstein's law of diffusion in which the mean square displacement grows linearly with time. What happens to this law of diffusion as we lower the temperature to close to absolute zero and scale down the size of the Brownian particle, until we reach a regime where the diffusion is driven primarily by quantum zero point fluctuations? This is the question of interest. Initial investigations were started about three decades back ('Brownian Motion at Absolute Zero' Supurna Sinha and Rafael Sorkin, Physical Review B (1992)). Researchers at the Institute and collaborators have recently revisited the problem. The motivation was twofold: (a) Experimental contact: Recent technological advances have made experimental realisation possible. In the last two decades, light-matter interaction has given a new impetus to such questions, and one can now cool dilute atomic gases down to temperatures of the order of 100nK, where the transition to quantum degenerate regime can be observed. As mentioned below, recent advances in experimental technique have progressed to the point that quantal diffusion effects should now be observable and experiments related to predictions stemming from our work are indeed in progress at the Light and matter physics group at RRI (Subhajit Bhar, Saptarishi Chaudhuri, Sanjukta Roy and Maheswar Swar) (b) Going beyond the theoretical studies of neutral particles and studying Quantum Brownian motion of a charged particle in a magnetic field.

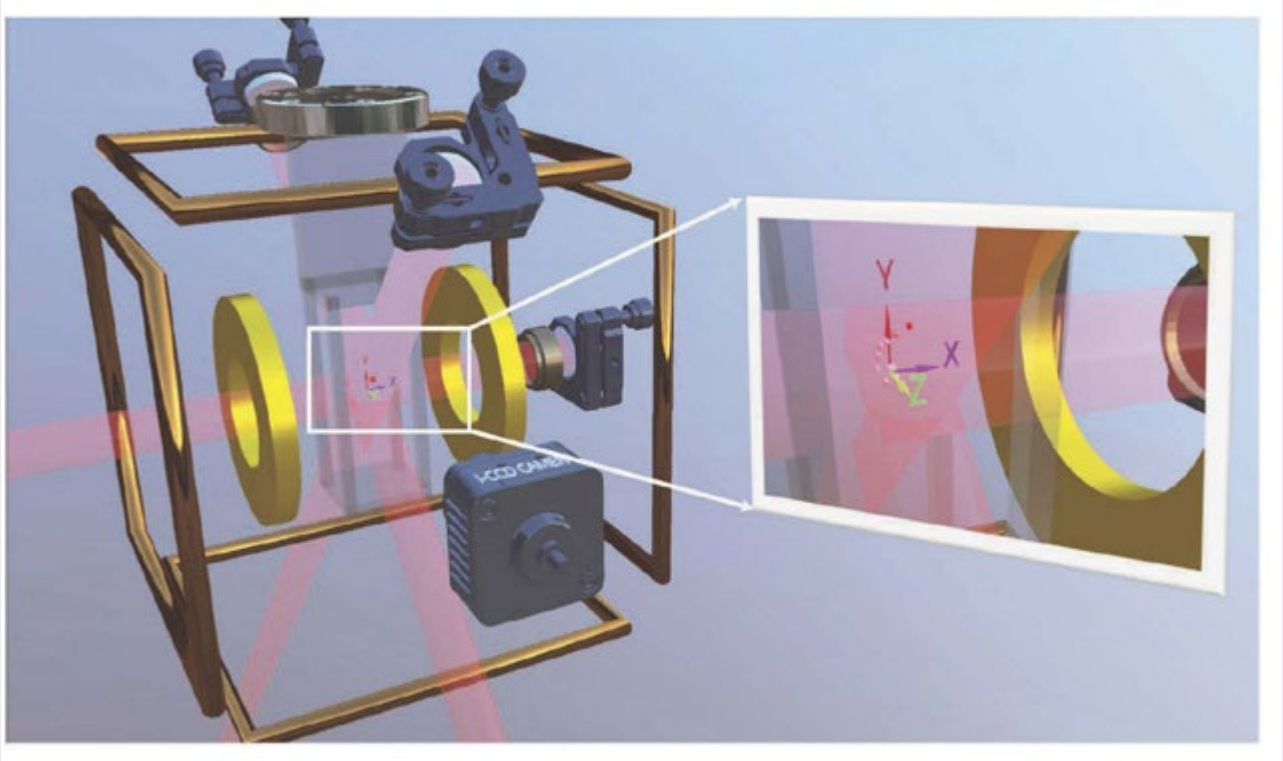


Diagram of the experimental setup where a cold atomic cloud is produced in a MOT. A magnified view near the cold atomic cloud is shown in the inset. The trajectory of the cold atomic cloud is shown as a series of atomic clouds at successive positions in the XY plane.

Selected Publications:

Measurements and analysis of response function of cold atoms in optical molasses Subhajit Bhar, Maheswar Swar, Urbashi Satpathi, Supurna Sinha, Rafael D. Sorkin, Saptarishi Chaudhuri, Sanjukta Roy, *Optics Continuum* Vol 1 (2), 171-188 (2022).

Quantum Langevin dynamics of a charged particle in a magnetic field : Response function, position velocity and velocity autocorrelation functions Suraka Bhattacharjee, Urbashi Satpathi, Supurna Sinha, *Pramana - J Phys* 96, 53 (2022).

Quantum Brownian Motion: Drude and Ohmic Baths as Continuum Limits of the Rubin Model Avijit Das, Abhishek Dhar, Ion Santra, Urbashi Satpathi, Supurna Sinha, *Phys. Rev. E* 102, 062130 (2020).



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.

111 papers with RRI members as authors and/or co-authors were published during 2021-22. There were 2 publications in conference proceedings and 23 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. 3 popular Science articles, 3 Miscellaneous articles, and 24 fortnightly columns on Science in a newspaper were published. During the past year, RRI members wrote 2 books; a monograph and a general science book in regional language.

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

Astronomy and Astrophysics

Astronomy and Astrophysics, Astrophysical Journal, Astrophysical Journal Letters, Bulletin of the American Astronomical Society, Current Science, Experimental Astronomy, Galaxies, IEEE Transactions on Antennas and Propagation, Journal of Astronomical Telescopes, Instruments, and Systems, Journal of Astrophysics and Astronomy, Journal of Cosmology and Astroparticle Physics, Monthly Notices of the Royal Astronomical Society, Nature Astronomy, Open Astronomy, Physics Uspekhi, Publications of the Astronomical Society of Australia, Sadhana, URSI GASS

Light and Matter Physics

Advanced Materials Interfaces, Applied Optics, Applied Physics Letters, Atoms, International Journal of Modern Physics D, Journal of Alloys and Compounds, Journal of Materials Science: Materials in Electronics, Journal of Molecular Structure, Journal of Optics, Journal of Physics A: Mathematical and Theoretical, Journal of Optical Society of America B, Journal of Materials Science: Materials in Electronics, Nanomaterials, Optical and Quantum Electronics, Optical Materials, Optics Continuum, Optics Express, OSA Continuum, Phase Transitions, Physical Review A, Physical Review E and Physical Review Letters.

Soft condensed Matter Physics

Applied Optics, Biochimica et Biophysica Acta (BBA), Chemistry: An Asian Journal, Colloids and Surfaces A: Physicochemical and Engineering Aspects, Dyes, and Pigments, JCIS Open, Journal of Molecular Liquids, Journal of Physical Chemistry B, Journal of Physics: Condensed Matter, Liquid Crystals, Materials Today: Proceedings, Pharmaceuticals, Physical Review Materials, Physical Review Research, Physics of Fluids, PLOS ONE

Theoretical Physics

Classical and Quantum Gravity, International Journal of Modern Physics D, Journal of Physics A: Mathematical and Theoretical, Journal of Statistical Physics, Physical Review A, Physical Review B, Physical Review D, Physical Review E, Physical Review Letters, Physics Letters B, Pramana- Journal of Physics, and PRX quantum

Grants, Fellowships and Awards

Name	Extramural grant	Details
Biswajit Paul	ISRO grant for POLIX	<p>Project title: Development of "X-ray Polarimeter experiment (POLIX) Payload"</p> <p>Total grant money: INR 9,50,00,000</p> <p>Received so far: INR 7,77,56,933</p> <p>Project started in September 2017</p>
Urbasi Sinha	ISRO – QKD grant	<p>Project title: Development of a prototype for satellite based secure quantum communication</p> <p>PI: Urbasi Sinha</p> <p>Total grant money: INR 27,00,00,000</p> <p>Received so far: INR 12,96,21,387</p> <p>Project started in December 2017</p>
	India Trento Programme of Advanced Research (ITPAR)	<p>Project title: A cheap, light, integrated source for QKD in an integrated photonic circuit</p> <p>PI: Urbasi Sinha</p> <p>Co-PI: Dipankar Home, Guruprasad Kar, Prasanta Panigrahi</p> <p>Total grant money: INR 1,61,13,520</p> <p>Received so far: INR 98,27,177</p> <p>Project started in February 2019</p>
	DST – QuEST	<p>Project title: Long distance quantum communications: Repeater and Relay technologies</p> <p>PI: Urbasi Sinha</p> <p>Co-PI: Arun K Pati, Ujjwal Sen, Aditi Sen-De</p> <p>Total grant money: INR 2,17,60,000</p> <p>Received so far: INR 1,52,84,000</p> <p>Project started in April 2019</p>
	MEITY	<p>Project title: Centre for Excellence in Quantum Technology</p> <p>PI (from RRI): Urbasi Sinha</p> <p>Co-PI (from RRI): Saptarishi Chaudhuri, Sadiq Rangwala, Dibyendu Roy</p> <p>Total grant money: INR 10,00,00,000</p> <p>Received so far: INR 10,12,72,000</p> <p>Project started in April 2020</p>
Gautam Soni	BDTD/08/2019	<p>Prototype for electronic mass screening device for Point-of-Care diagnostic of Sickle Cell Diseases</p> <p>Total grant money: INR 46,49,000</p> <p>Received so far: INR 45,14,816</p>

Name	Extramural grant	Details
Pramod Pullarkat	BT/PR23724/ BRB/10/1606/2017	<p>Project title: Mechanobiology of cell adhesion under dynamic shear.</p> <p>PI – Namrata Gundiah (IISc, Bangalore), CoPI's – Pramod Pullarkat, Gautam Menon (IMSc, Chennai)</p> <p>Total amount: 95,88,400</p> <p>Received so far: 20,57,000</p> <p>Project started in 17-05-2018 for three years</p> <p>DBT-Welcome, TeamScience Grant</p> <p>PI: Pramod Pullarkat, Aurnab Ghose (IISER-Pune) and Carsten Janke (Institut Curie, Paris)</p> <p>Total amount: INR 10,00,00,000</p> <p>Received so far: INR 2, 11,30,470</p>
Ranjini Bandyopadhyay	DST-SERB Grant EMR/2016/006757	<p>Project title: Understanding the jamming dynamics and nonlinear viscoelasticity of non-equilibrium viscous liquids with non-linear dielectric and rheo-dielectric studies".</p> <p>Co-PI: Paramesh Gadige, c SSIHL, Andhra Pradesh</p> <p>Total amount: INR 47,40,000</p> <p>Received so far: INR 31,46,500</p> <p>Project started in 2019</p>
Saurabh Singh, Mayuri S Rao, Jishnu Nambissan	ISRO Grant-in-Aid	<p>Project Title: Pre-project activities for PRATUSH (Probing ReionizATIOn of the Universe using Signal from Hydrogen)</p> <p>PIs: Saurabh Singh (RRI, McGill University), Mayuri S. Rao (RRI) and Jishnu Nambissan T. (RRI)</p> <p>Grant Amount: INR 56,06,000</p> <p>Received so far: INR 56,06,000</p> <p>Project started in March 13, 2019</p>
Reji Philip	SERB – TARE Program	<p>Project title: Femtosecond Laser-Induced Breakdown Spectroscopy (fs-LIBS) for Multi-elemental Compositional Analysis</p> <p>Mentor: Reji Philip</p> <p>Teachers Associate: Anoop KK</p> <p>Total amount: INR 18,30,000</p> <p>Received so far: INR 8,20,000</p> <p>Project started in 26.11.2018</p>
Sanjukta Roy	DST - Women in Science	Funds Received: INR 18,38,500

Name	Fellowship	Details
Urbasi Sinha	Simons Emmy Noether fellowship	This fellowship will fund visits to Perimeter Institute for a duration of upto one year.
Sayantan Majumdar	SERB Ramanujan Fellowship	Total research grant amount: INR 38,00,000 Received so far: INR 24,90,000 Project started in May 2018 for 5 years
E Krishnakumar	Raja Ramanna Fellowship	Total Fellowship Amount: 40,50,000 Received so far: 39,00,000 Duration: 3 years
Urna Basu	SERB Ramanujan Fellowship	Total research grant amount: INR 38,00,000 Received so far: INR 15,72,000 Duration: 5 years

Awards and Distinctions

Mayuri S Rao was confirmed as a life member of the Astronomical Society of India.

Recognitions for **Urbasi Sinha**

Invited country representative of the GESDA (Geneva Science and Diplomacy Anticipator) Open Quantum Initiative core task force, June 2021 onwards.

Invited Indian representative for the World Quantum Day Network, a global network of quantum physicists who are engaged in promoting and showcasing quantum science and technologies through diverse fora. ASSOCHAM Women in Cyber: Making a Difference award in the category: Cyber - Leading from the front, 2021.

Recognition as an Outstanding referee for Communications Physics (Nature) in October 2021.

Recognitions for **Sumati Surya**

Elected as the President of the IAGRG (Indian Association for General Relativity and Gravitation) for the coming term.

Appointed as an Adjunct Professor Dublin Institute of Advanced Studies, Ireland, for five years from Feb 2022.

Anson Thambi (PhD Scholar, SCM) has received the JPC-B (Journal of Physical Chemistry B, American Chemical Society) award for the best poster at the Complex Fluids Symposium 2022 (held jointly by the Indian Society of Rheology and IIT Gandhinagar).

The research article by **Saurabh Singh** and co-authors - "SARAS 2: A spectral radiometer for probing cosmic dawn and the epoch of reionization through detection of the global 21-cm signal" is one of the top 50 EXPA papers, with an average of 9.0 citations per year over the previous five years.

Research Facilities

Electronics Engineering Services

The Electronics Engineering Services (EES) 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 the 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 electronics engineering services have gained significant expertise in designing and building instruments that can be flown to space for carrying out space based experiments. In recent days, digital and analog groups of EES are working towards the development of i) high bandwidth antennas & compact analog beam formers for low frequency applications, ii) firmware in FPGA for producing multiple beams in the sky for Square Kilometer Array – Low (SKA-Low) project and iii) a generic digital hardware platform (Integrated prototype (IP) board) for digitization and real time signal processing of broadband radio astronomy signals.

1. Prototype broadband antenna for Square Kilometer Array – Low (SKA-Low) project

The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope over a square kilometre (one million square meter) of collecting area. The telescope is expected to address several fundamental questions in radio astronomy. RRI is developing state of the art in technology and using it to i) build in-house facility for carrying out research in observational astronomy and ii) validate the hardware and software being developed by RRI for SKA digital work. As part of development, broad band antennas and compact analog beam formers are being designed by EES. Antennas are being designed to get maximum operating bandwidth in the frequency range 50- 450 MHz with smooth spectral response and frequency independent radiation patterns. Reflector dipole antenna was considered due to its simplistic geometric configuration. Its structural parameters were optimized in WIPL-D and CST microwave electromagnetic software to meet the required specifications. The optimization resulted in a structure which is planar, sinusoidally profiled, and tilted symmetrically around the antenna axis. The prototype antenna built in-house is shown in Fig. 1 in three different views. The antenna is supported by an electromagnetically transparent Styrofoam material.



Fig. 1 Prototype of the reflector based shaped planar dipole antenna designed to operate in the band 120-360 MHz. Shown on the left, center and right are different views of the antenna.

The reflection coefficient characteristics (Refer Fig. 2) was measured to be spectrally smooth with a moderate value less than -4 dB throughout the operating band. The radiation patterns are measured to be frequency independent and are shown at frequencies 120 Mhz,

240 MHz, 330 MHz, and 360 MHz in Figs. 3 - 6, respectively. The measurement results match well with the simulation results.

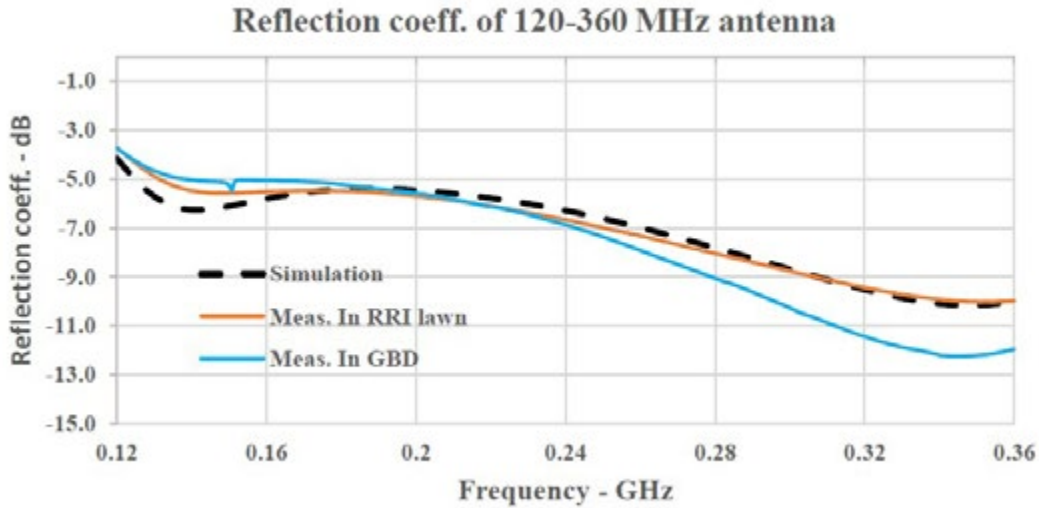


Fig. 2 Measurement result of the reflection coefficient of 120-360 MHz antenna in comparison with the simulation results.

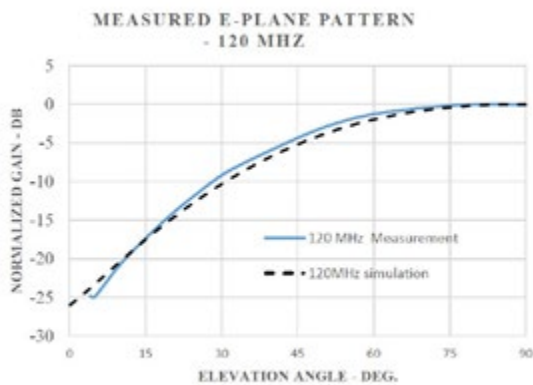


Fig. 3 E-Plane radiation pattern of the antenna at 120 MHz.

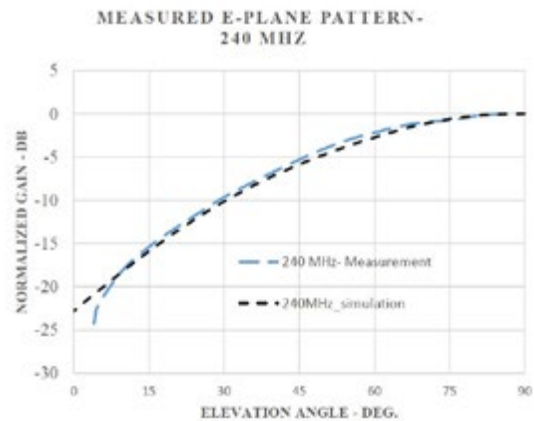


Fig. 4 E-plane radiation pattern of the antenna at 240 MHz.

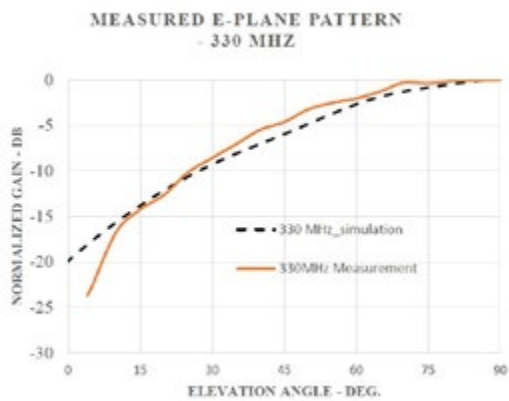


Fig. 5 E-plane radiation pattern of the antenna at 330 MHz.

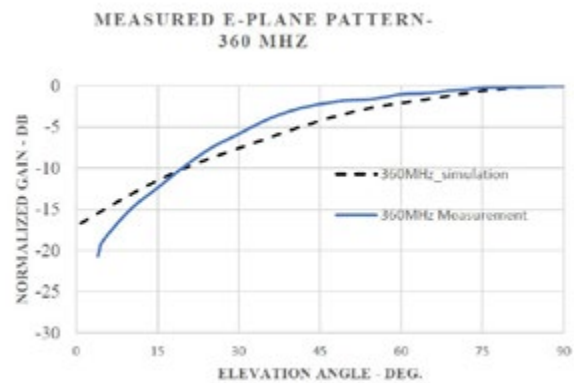


Fig. 6 E-plane radiation pattern of the antenna at 360 MHz.

2. Development of a composite dielectric material with very high dielectric constant

Delay line is one of the main components in any analog beam formers. Physical length of the line is decided by the delay required for a given phase change. Since the length of the line for a given phase change is wavelength dependent, implementing it at low frequencies will become impractical due to unmanageable physical size. So developmental activity was undertaken to minimize the overall length by using a material of higher dielectric constant on which delay line could be designed. Water was chosen in the development of a composite dielectric medium since that is known to have very high (~80) dielectric constant. Transmission line

on this composite dielectric medium was extensively studied for their electrical characteristics like insertion loss, delay and impedance mismatch effects etc. After thorough simulation in both WIPL-D and CST microwave electromagnetic simulation tools, transmission lines were implemented on three types of composite media as shown in Figs. 8 – 13. They use FR4 laminates of 0.25mm, 0.1mm and 0.05mm thick, respectively, along with 10 mm distilled water. It was successfully demonstrated that reduction in physical dimension could be achieved when transmission line is implemented on high dielectric constant medium. Typical delay line implemented on water based composite medium is shown in Fig. 7. The medium consists of 0.1 mm thick FR4 laminate with 10mm thick distilled water.



Fig. 7 RF transmission line of 205mm long on pcb = 0.1 mm thick + 10mm water is equivalent to 772 mm long RF cable.

It is showing that the RF transmission line of 205mm long implemented on a pcb of 0.1mm thick placed on 10mm water is expected to exhibit similar electrical

performance of a long RF cable of 772 mm thus resulting in a reduction in size by a factor of approx.3.8.

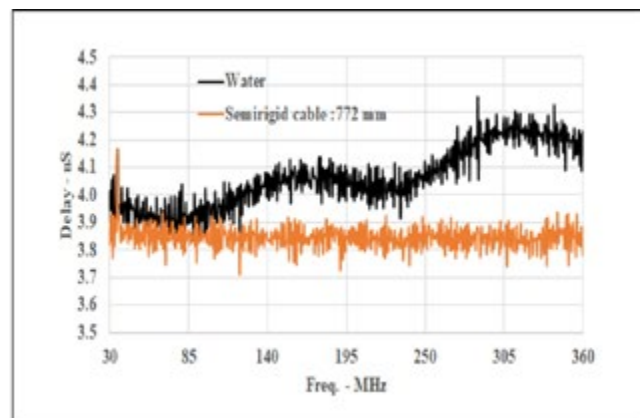
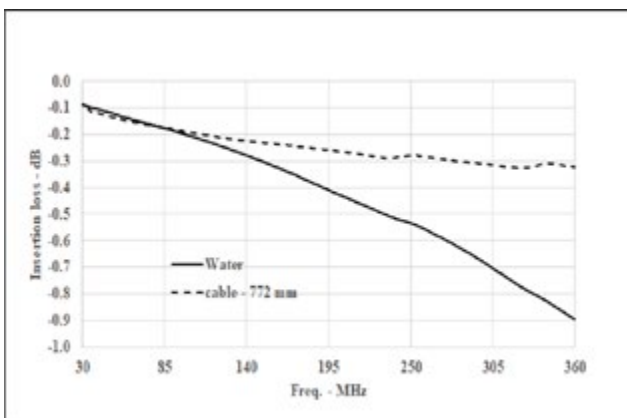


Fig. 8 Typical insertion loss and delay characteristics of a delay line shown in Fig. 7

Fig. 8 shows the insertion loss and delay characteristics of a delay line implemented on a composite dielectric medium consisting of 10mm distilled water and 0.1mm thick FR4 laminate. The insertion loss is found to vary almost linearly with frequency. Similarly, delay is also found to increase with frequency sinusoidally varying component in it. Table.1 lists insertion loss and delay

characteristics of a transmission line implemented on three types of composite dielectric medium consisting of 10mm water and FR4 laminates of 0.25mm, 0.1mm and 0.05mm thicknesses. As we observe, with 0.05mm thick pcb, effective dielectric constant as high as 33.6 could be achieved which could result in the reduction of physical dimension of a delay line in vacuum by a factor of 5.79.

Sl. No	Pcb thickness	Effective Dielec. Constant	Reduction in size w.r.t vacuum	Insertion Loss – dB Over 20-360 band	Delay – nS/200 mm - variation
1.	0.25mm	14.74	3.8	0.1 – 0.7	2.6 - 2.7
2.	0.1mm	26.88	5.18	0.1 – 0.9	3.9 - 4.2
3.	0.05mm	33.6	5.79	0.2 – 1.1	4.5 – 5.0

Table.1 Showing insertion loss and delay characteristics of a transmission line implemented on three types of composite dielectric medium consisting of 10mm water and FR4 laminate of three different thicknesses.

3. Polarimeter Instrument in X-rays (POLIX) in space: For studying the polarization of X-Rays from cosmic sources

The Thomson X-ray Polarimeter instrument POLIX is in advanced stage of development. POLIX is designed and built inhouse at RRI. During the last year, environmental tests and shock tests have been conducted successfully on the Qualification Model (QM) of POLIX at the U. R. Rao Satellite Centre (URSC) of ISRO. Some observations

made during the environmental tests have been corrected for and further tests have been conducted successfully at URSC. Critical Design Review (CDR) of POLIX has been completed successfully. Assembly and tests have been completed for all the four Front End (FE) electronics units for the Flight Model (FM) of POLIX. Assembly and tests have been completed for most of the PCBs for the four Back End (BE) electronics units for the FM of POLIX. Some corrective work is ongoing for the FM detectors of POLIX.



Fig.9a and Fig.9b Qualification Model Detectors and Electronics of POLIX

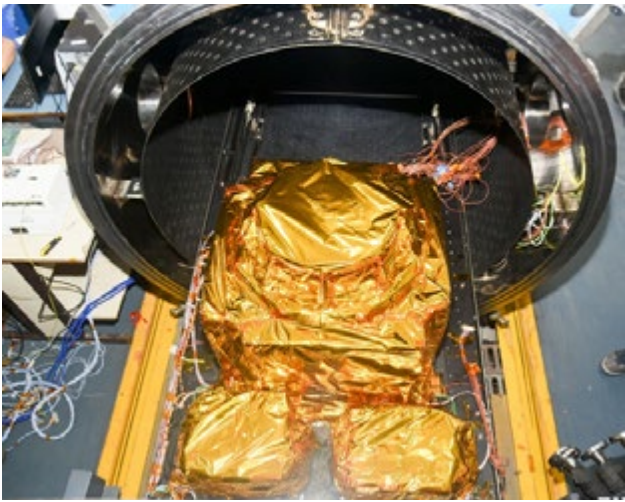


Fig.10 Qualification Model Detectors and Electronics of POLIX during the environmental qualification tests.

4. Indigenous development of a cost effective RF over fiber transmitter and receiver

Cost effective RF over fiber transmitters and receivers have been developed in-house, which have similar performance as that of highly priced commercially available modules. The salient features of the modules developed are: i) absence of Switched-mode power supply (SMPS) which is the main source of conductive radio frequency interference, and ii) incorporation of automatic power control mechanism to stabilize the laser power output against temperature fluctuations. These modules are designed to have very low time varying systematics for improving the sensitivity of a typical radio receiver. Laser modules developed in-house are shown in Fig.11.

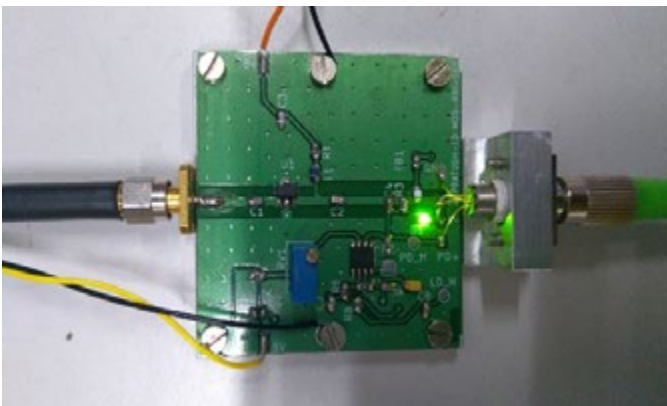


Fig.11. a) Laser transmitter b) Photodiode Receiver.

5. Highly compact RF-front-end receiver for SKA application

A highly compact RF front-end receiver has been built in-house for using along with the tile processing module of SKA-Low digital receiver. It operates in the frequency range 185 MHz to 350 MHz, with a signal gain of 53

dB, a noise figure of 1.35 dB and a dynamic range of 50 dB (Refer Fig. 12). The entire receiver is housed inside a compact cylinder (Refer Fig. 13) of diameter 50mm and 220mm long. Circuit layout and configurations were optimized to accommodate the entire receiver within the available volume of the cylinder.

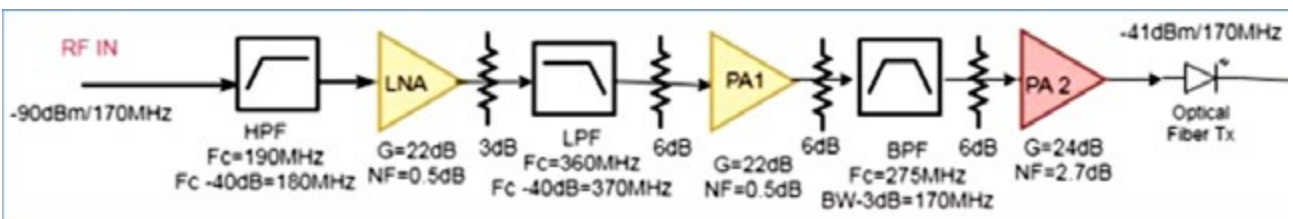


Fig.12 Block diagram of the compact RF Front-End Receiver



Fig.13 RF Front-End Receiver housed in a shielded cylindrical module of 50mm dia and 220mm length.

6. Square Kilometer Array – Low: Digital activities

EES is involved in testing and characterizing the Tile Processing Module (TPM) of SKA-Low digital receiver.

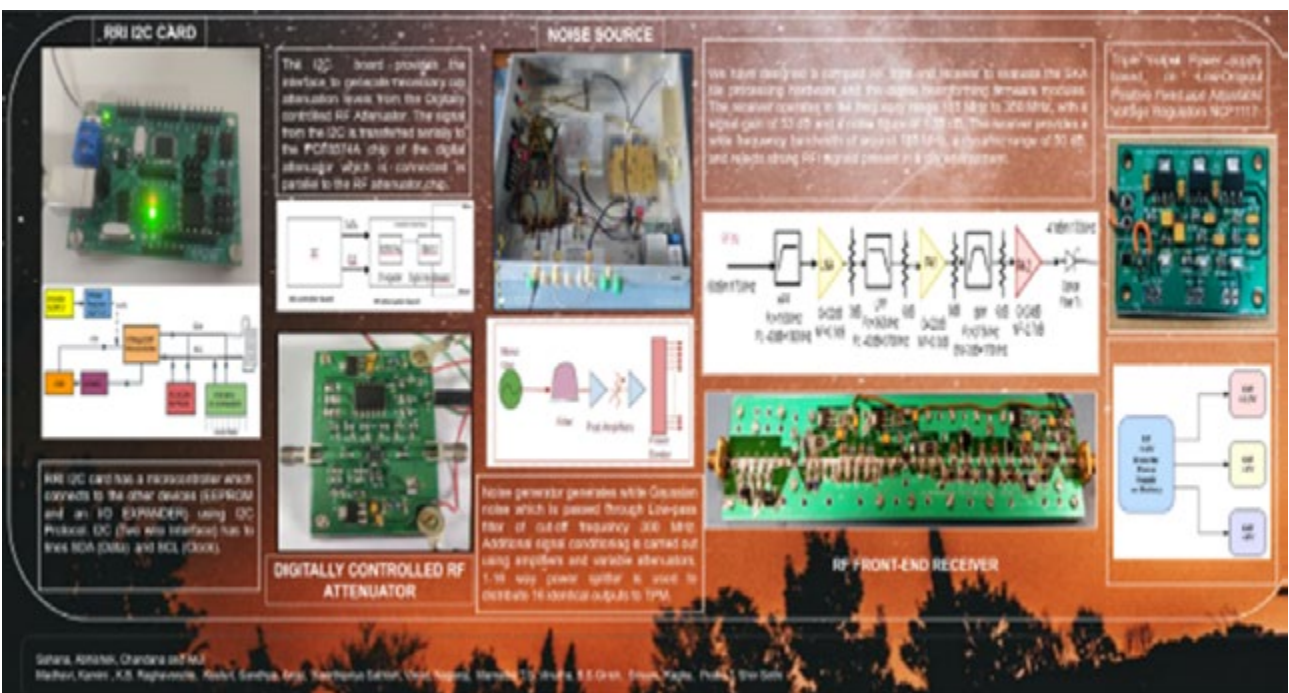


Fig.14 Different modules being developed by EEG for characterising the tile processing module.

7. Pulsar search - Science Data Processing

Contributions to the Pulsar Search System (PSS) of the science data processing package are also being made by EES for SKA. The PSS involves building a real-time pulsar search engine which is a highly compute-intensive (about 10 peta-OPS) task, involving implementing high-performance signal processing algorithms. Fig. 15 shows the complexity involved in the pulsar search with SKA in terms of number of a beams involved, different parameter space for searching like dispersion measure (DM), pulse width, pulse period, etc.

It is expected to receive signals from all antennas in the tile, process them and combine to produce different beams in the sky. The required hardware like I2C, noise generator, digital controlled attenuator and compact RF front end receiver are being developed in the laboratory for testing the TPM. I2C is a microcontroller card used for connecting computer with the peripheral devices like EEPROM, I/O expander, RF attenuator etc. Firmware is being developed to produce multiple beams in the sky using TPM. Fig. 14 shows both RF and digital modules being developed in the lab for testing the TPM.

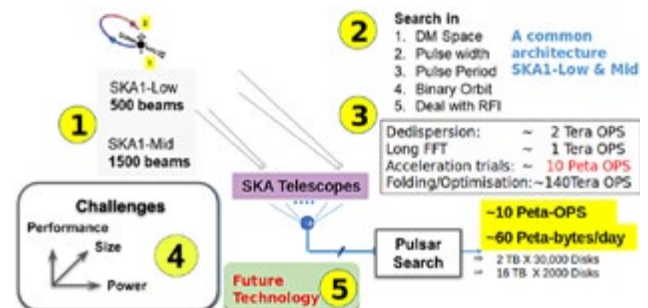


Fig.15. Pulsar search with SKA requires enormous real time computing.

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 at the Institute ranging from 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 for employees working in unison equipped with modern CNC machines and CAD-CAM software which helps at visualization of final product and also reduces considerable number of iteration before final product is manufactured to specification.



Fig. 1: Wire EDM machine

Below is a brief description of updates/activities undertaken by MES during 2021-22.

Acquired a CNC wire EDM machine. This has enhanced the capability of machining smaller components with a sharp inner radius.

Designed and fabricated a precision ion trap for quantum interactions and optical clock experiments. This trap will be used for studying the interactions of single trapped ions with atoms at room temperatures and will probe the boundary between classical and quantum interactions, entropy, and information.

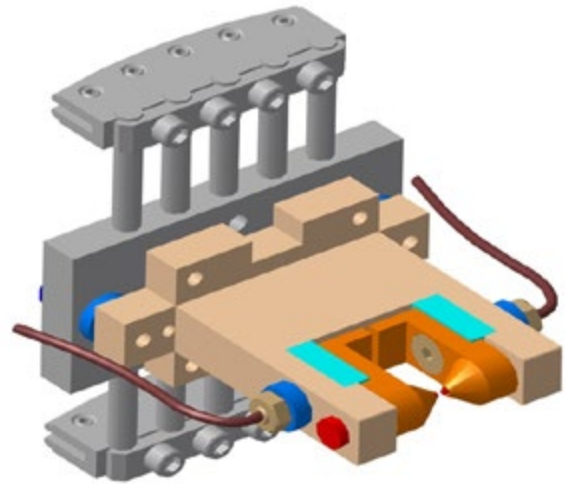


Fig. 2: CAD model of Precision Ion Trap for Quantum Interaction and Optical Clock Experiments

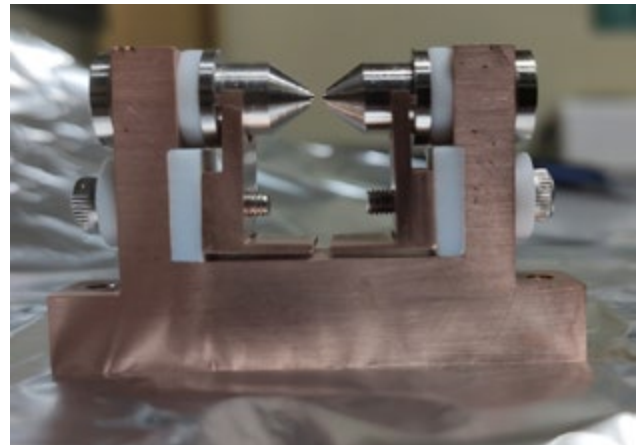


Fig. 3: Prototype of Precision Ion Trap for Quantum Interaction and Optical Clock Experiments

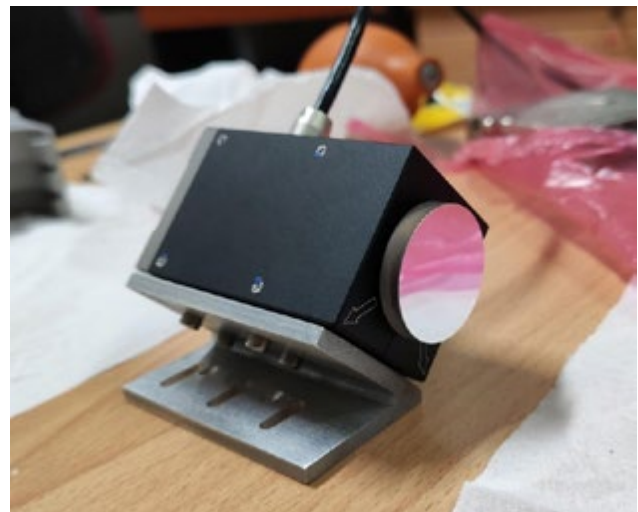


Fig. 4: Aluminum angular mounts Piezo Mirror stage for S-335 Piezo Tip/Tilt Platform.

Fabricated an angular aluminium stage using a CNC Wire EDM machine. The angular requirement was critical. Raw materials were machined to the required dimensions and then cut on CNC Wire EDM machine to the required angle. The Piezo Mirror stage for S-335 Piezo Tip/Tilt Platform was assembled on top of aluminium stage using M3 Allen socket head screws. The system was used for Beam Steering with Very Large Deflection Angles for Mirrors and Optics.

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 caters to both general and specialized information needs of its users. Currently, the library has a total collection of 71416 comprising of books and bound volumes of journals. Of this, 29635 are books and 41781 are journal-bound volumes. During the past year, the library subscribed to 15 e-journals, 16 print journals.

Library activities during 2021-22 - a renewed partnership of RRI Library with the National Knowledge Resource Consortium for the next three years from 2020 has brought online access to 4600 journals published by 15 publishers. 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. 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 10 theses submitted for the doctoral degree award was done at the library in addition to 20 research papers and few dissertations. ResearcherID of the entire faculty was updated regularly. Article processing charges of 9 papers were handled by RRI library. Several Inter Library Loan (ILL) requests are attended by getting articles from other libraries. Also, through ILL, articles were sent to other libraries. Grammarly software to aid writing skills has been renewed for the current year. Stock verification of books was done in the year 2021 and many books were trace.

Raman Research Institute archival gallery is being viewed by many visitors and the general public. During the National Science day celebrations on 28th February 2021, students and teachers from different schools visited RRI archival gallery. The Library video conference room is being used regularly.

Library automation and Digital Library -The library has migrated totally to KOHA – open-source software. The functions of the software are constantly getting improvised with more facilities and features enabling better services. All the KOHA related activities were done in-house. The Raman Research Institute Digital Repository, also known as e-Sangrah, is an active repository of a variety of 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 2020-21 was 419. The total records on RRI Digital Repository currently stands at 10649. "Imprints-collection," an offshoot of RRI digital repository, continues to thrive with regularly updated information.

Other Events

1. The library had a theme display of books on the occasion of Independence Day of India and international women's day 2022.
2. RRI library has kept up the tradition of supporting manpower development programs by giving internship training to the students. During the current year, five students from Bangalore university were trained.

IT & Computing

The group managed and maintained the IT infrastructure and assets on the campus. It also helped and assisted the staff and students in using the IT infrastructure and troubleshooting problems with it. Installed and configured new computers, laptops and printers.

A new mail server with latest OS and application Zimbra Collaboration Software was installed. We also subscribed to Google Workspace for Education

Fundamentals for providing mailing service to students and temporary staff.

Drupal Content Management System was installed and configured in a new web server for hosting the re-designed website. A new Institute's website was designed and developed by a website committee chaired by Sanjib Sabhapandit and it was released on the National Science Day. The contents and the software were updated regularly.

An 86-inch UHD 4K TV was procured and installed in the Council Room to replace the old projector. Payments in the Canteen was made cashless by the introduction of smart cards. Canteen Management System software for managing the same was installed in a virtual server. Ph.D. 2021 programme online application was hosted using No Paper Forms Software As-A-Service portal. The group was involved in the Ph.D. 2021 admission process; set up a repository of applications and documents of shortlisted candidates for the reference of

interview panel members during interview. Scheduled Zoom meetings for Ph.D. online interviews. Provided assistance and support during video conferences by setting up camera, display and computer. The group assisted in connecting the new IP security cameras to the LAN and making it accessible. Renewal of softwares and SSL certificates was done. Mathematica Academic Site License was procured which allowed the faculty and students to install Mathematica in their official and personal computers on their own. Online forms were created for various openings. The Institute is in the process of procuring a new ERP. Inputs were provided for the Staff Recruitment module and Admissions module of the ERP. Network cabling was carried out in new labs and rooms to provide network connectivity.

Two engineers - Mr.Ranjith Kumar and Mr.Phanindra Kumar Choubey - joined the group for providing IT support.

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 2021-22, 93 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 Five PhD thesis were completed and submitted for review

Name	Thesis Title
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
Maheswar Swar	Developing a novel, non-invasive detection technique in hot and cold atomic systems based on Spin Noise Spectroscopy (SNS)
Nancy Verma	Laser Ablation and Surface Structuring of Selected Solid Targets
Niranjan Myneni	Ultracold Ion-Atom Scattering

Three PhD thesis were defended:

Name	Thesis Title
Kaushik Joarder	Deploying single photons towards experimental tests of complementarity, Quantum Key Distribution and Macrorealism
SK Raj Hossein	Transport, clustering and chemical kinetics of cell surface molecules influenced by actomyosin cortex
Adwaith.K.V	Coherent microwave-to-optical conversion with dilute gaseous atoms

Eight PhD thesis were awarded

Name	Thesis Title
Sreeja Sasidharan	Influence of some Bioactive molecules on the structure and phase behavior of lipid-membranes
Saikat Das	The Origin and Propagation of Ultrahigh Energy Cosmic Ray Particles
Santanu Das	Non-equilibrium behavior in self-driven systems
Nomaan X.	Aspects of quantum fields on Causal sets
Deepshika Malkar	Investigation on molecular organization and physical properties of asymmetric bent core liquid crystals
Ashutosh Singh	Creation, characterization and manipulation of quantum entanglement in a photonic system
Akash Kumar Patwa	Detecting the 21 cm signal from the Epoch of Reionization using Drift Scans
Ranita Jana	The interaction of galaxies and their surroundings through cosmic rays

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 either 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 2+1 years. Further details about the Postdoctoral and Pancharatnam Fellowships can be found on the RRI website.

During the year 2021-22 there were 13 Postdoctoral and 2 Pancharatnam Fellows 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 for when research activity requires specialized assistance in the research work, which may be for durations up to 2 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 methods and move on to higher learning empowered by the in-house experience.

During the year of this report, 10 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 or 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 2021-22, 16 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, Belgium, Canada, France, Germany, and USA.

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.

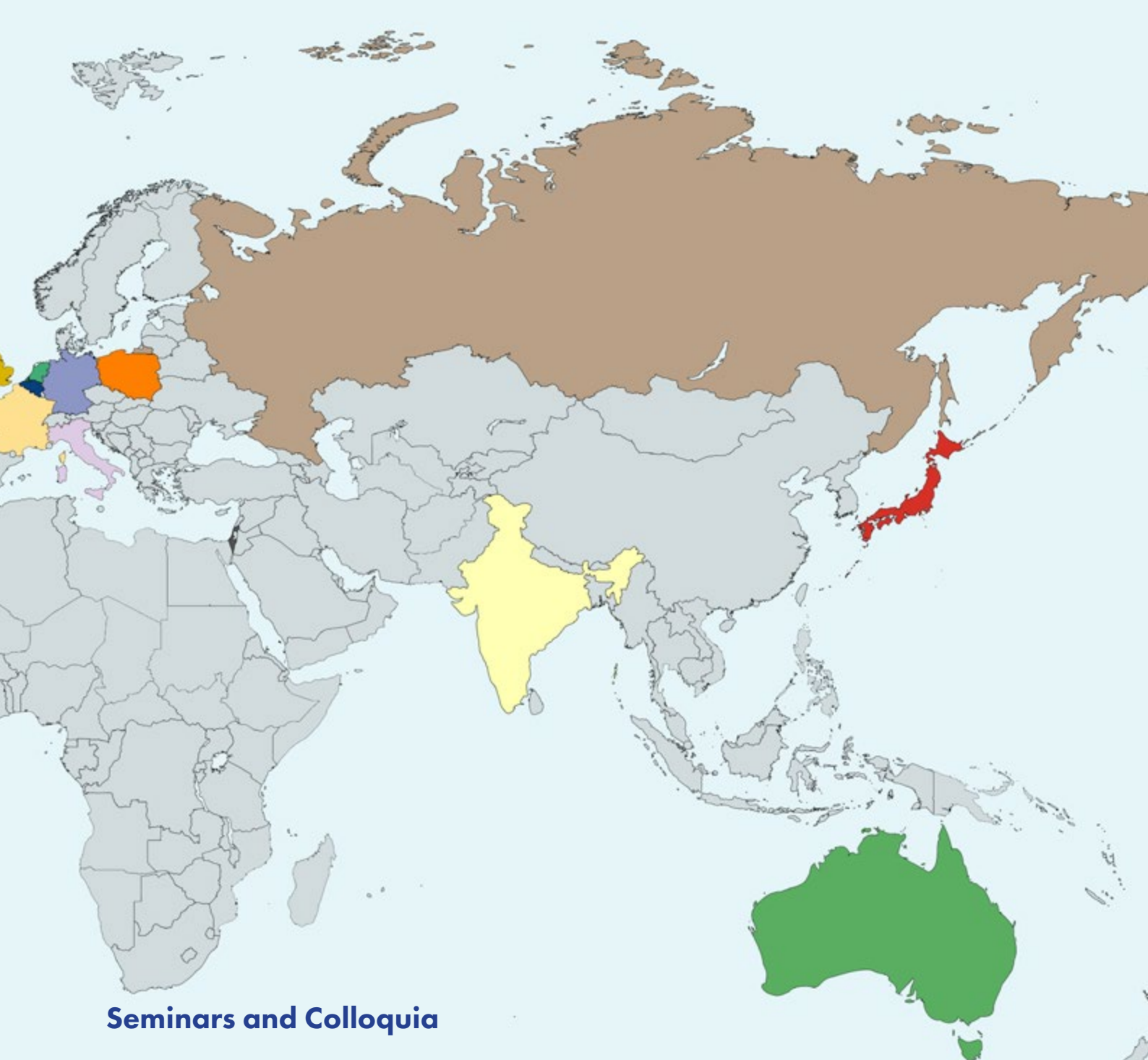
A complete list of conferences attended by the Institute members is available in Appendix II.

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, interesting projects for the Institute.

Last year there were altogether 12 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.



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.

Highlighted: Countries visited by RRI members and home countries of international visitors and collaborators.

Extramural Activities

RRI engages with the wider society for communications on science and related topics. RRI staff and students routinely organize and participate in popular seminars, talks, workshops and outreach events conducted by the Govt. 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, blogposts, 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.



RRI at the India International Science Festival, 2021

The sixth edition of the India International Science Festival (IISF, 2021) jointly organised by the Ministry of Science and Technology and Ministry of Earth Science and Vijnana Bharati was held virtually between 10-13th December 2021. RRI has been participating in this mega event every year since 2016 by setting up pavilions that showcase the current research areas and research highlights from the past year. The 2021 edition of the India International Science Festival was held in Goa. RRI participated in this yearly event in the hybrid mode by putting up a pavilion. The pavilion consisted of panels that highlighted the life and science of the Institute's founder Sir C V Raman. The major focus was on communicating the Institute's recent research in a language that is understandable to school children. The pavilion also included an "Ask a Scientist" booth with RRI PhD students on call to answer any questions that the visitors to the booth may have. Additionally, various digital content on the Institute and its science was made available to the visitors for downloading and reading at their convenience. IISF served as a platform for meaningful interactions and exchange of ideas between RRI representatives and the wider society.

RRI in the media

The professional pursuit of science may be a relatively personal enterprise, or a joint activity of a few scientists collaborating with each other towards a common goal, or an enterprise involving hundreds and even thousands of scientists who may be distributed worldwide. Any insight gained or phenomena discovered are then communicated in the form of publications that are intended mainly for fellow scientists. On the other end of the spectrum is the general public whose money more often than not enables these scientific pursuits, but are none the wiser for it. Human beings have this innate curiosity to know and understand the natural world they live in and it would ultimately serve science well to kindle this curiosity, particularly in impressionable young minds. Whatever be the reason, communication of "hi-fi" scientific research couched in language that is easily understandable to one and all is highly desired. Additionally, these popular science articles, snippets and news may be disseminated in such a way as to have maximum outreach. The Raman Research Institute is attempting to bridge this gap by posting general write-ups based on research publications by

RRI research staffs and students on Facebook, Twitter and blogposts. During 2017-18, RRI continued its commitment to research communication by launching the official RRI YouTube channel. The channel playlists contain lectures, talks, workshops, student and postdoc videos, and archival videos. Along with adding new playlists, existing playlists will be periodically updated with new videos. Between April 1st 2021 and March 3rd 2022 there have been 21 Facebook posts, 161 tweets and 12 blog posts. Many of our posts and tweets have been liked and retweeted by DST from their official Facebook and Twitter pages. We now have upwards of 9200 people following us on Facebook and 7841 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 25 playlists with 219 videos that are open for public viewing.

To enable better outreach and communication of science, DST, DBT, etc, through Vigyan Prasar launched Vigyan Samachar, an official platform for dissemination of research from autonomous bodies. RRI actively shares its recent research with DST which are published in Vigyan Samachar's and DST's websites. In 2021-22, twelve stories have been prepared on RRI research. This has spawned multiple articles in news and print media. RRI science and events stories have appeared in all major newspapers like The Hindu, Times of India, Deccan Herald, Financial Times, Indian Express etc. while their presence in online media is through Indus Dictum and Research Matters among others.

The biannual RRI Newsletter is another such endeavour that highlights recent research at the Institute through its science articles. The articles are written in a language that enables sharing the Institute's exciting research with the wider community. The Newsletter also serves the purpose of updating RRI members, collaborators and the general public on recent news and diverse activities that are part of daily functioning of the Institute. To enable easy access to all these posts, tweets, blogs, videos and newsletter a link "RRI in the media" has been created on the RRI homepage.

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, Advertisements, 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.
- The Quarterly Progress Reports regarding the 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 varied topics viz. (a) "Measures for effective implementation of Official language policy-a progressive approach". (b) "Structure of Official Language Hindi and Templates of routine official formats in Hindi" (c) "Implementation of Official Language in Government Offices – Compliance and Requirements". In addition to this, Table workshops and Internal Inspections were conducted regularly for all the Departments.
- On 30.09.2021, an online Hindi Divas was organized as a part of Hindi Pakhwada Valedictory Ceremony.
- 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's official language implementation committee Meetings conducted during the year.
- Quote of the day and Word of the day in English with its Hindi equivalent were 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.

Others

During 2021-22, 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.



Events at RRI



COLLOQUIA

Organisers: Ranjini Bandyopadhyay, Sanjib Sabhapandit, Urbasi Sinha, Vikram Rana
Secretary: R. Mamatha Bai

11 March 2021
Self-assembly of colloidal
diamond for photonics
David Pine
New York University, USA



1 April 2021
FRBs at the bottom
Shri Kulkarni
California Institute of
Technology, USA



14 April 2021
Quantum Information
Charles H. Bennett
IBM Fellow at IBM Research,
USA



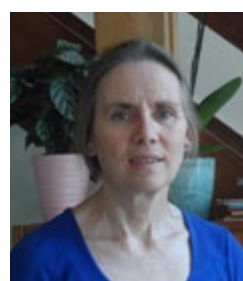
29 April 2021
Marginally stable economies?
Jean-Philippe BOUCHAUD
Capital Fund Management
and French Academy of
Sciences, France



13 May 2021
Quantum circuits, and the
future of quantum technology
in the cloud
Jay M. Gambetta
IBM Fellow and VP of
Quantum Computing, IBM
Quantum, USA



27 May 2021
Self-propelled Topological
Defects
Julia M Yeomans
The Rudolf Peierls Centre for
Theoretical Physics, UK



15 June 2021
From Analogue to Emergent
Gravity: three small lessons
Stefano Liberati
SISSA, Italy



29 July 2021
The rapidly expanding
thickening universe: critical
points, dethickening,
superthickening, and meta
material liquids
Itai Cohen
Cornell University, USA



12 August 2021
Universal matter-wave
interferometry: Experiments
at the quantum-classical
interface and on biomolecule
metrology
Markus Arndt
University of Vienna, Austria



26 August 2021
Directed aging: using memory
and nature's greed as a new
principle for materials design
Sidney Nagel
The University of Chicago,
USA



16 September 2021
The Athena Space X-ray
Observatory
Didier Barret
Director of Research, French
Research Council



28 October 2021
Competitive growth on a
rugged front
Mehran Kardar
MIT, USA



11 November 2021
Impact of structural
ordering in supercooled
liquids on vitrification and
crystallization
Hajime Tanaka
The University of Tokyo,
Japan



25 November 2021
Privacy for the paranoid ones -
the ultimate limits of secrecy
Artur Ekert
University of Oxford, UK

2 December 2021
Informatic versus
Thermodynamic Entropy
Production in Active Systems
Mike Cates
University of Cambridge, UK



16 December 2021
Instabilities and flow-induced
structures in lyotropic
chromonic liquid crystals
Irmgard Bischofberger
MIT, USA



21 February 2022
Resonances in general relativity
Béatrice Bonga
Radboud University, Netherlands



**" VIGNYANA KATHEGALU " -
POPULAR SCIENCE TALKS AT RRI**



28 February 2022
Comprehending the Cosmos
Tarun Souradeep
RRI



DYNAMICAL QUANTUM SYSTEMS WEBINAR

Organiser: Dibyendu Roy Secretary: Gayathri G, Chaitanya

5 April 2021
Time travels with quantum
computer
Nikolai Sinitsyn
Los Alamos National
Laboratory, USA



22 April 2021
Bringing noble-gas spins into
the light
Ofer Firstenberg
Weizmann Institute of Science,
Israel



8 September 2021
Microwave Quantum Optics with
Artificial Atoms
Christopher Wilson
U. Waterloo, Canada



PANEL DISCUSSION

Organisers: Pramod Pullarkat, Ranjini Bandyopadhyay and Sanjib Sabhapandit. Secretary: R. Mamatha Bai

An online panel discussion on Covid-19 was organised on April 5th 2021. The panel included eminent doctors and scientists Gangadeep Kang, Gautam Menon and Satyajit Rath and was moderated by the well-known journalist Priyanka Pulla. The panelists each gave an initial talk on a couple of the most compelling questions that were related to the second wave of the pandemic. Then the floor was opened for discussions. The discussion was live streamed via YouTube and zoom. Around 400 people tuned into the live streaming and interacted with the panelists with insightful questions.

PANELISTS:



Gagandeep Kang
FRS, MBBS, MD, PhD
Virologist, Professor of Microbiology,
Christian Medical College, Vellore.



Gautam Menon
PhD
Professor of Physics and Biology
Ashoka University, Sonapat, and
Institute of Mathematical Sciences, Chennai.



Satyajit Rath
MBBS, MD
Immunologist, Adjunct Faculty of Biology
Indian Institute of Science and Education Research, Pune.



Priyanka Pulla [Moderator]
Freelance journalist
Writes on science & health.

Organized by: Raman Research Institute, Bengaluru 



RRI VERY SIRIUS MEETINGS SPECIAL LECTURE SERIES

Organisers: AA PhD students

21 September 2021
Cracking the Supernova
Neutrino Code
Basudeb Dasgupta
TIFR, Mumbai



28 September 2021
Gravitational lensing of gravita-
tional waves: A new frontier
Ajith Parameswaran
ICTS Bangalore



21 October 2021
Seeing the accretion discs
around compact objects-A
two temperature description
Indranil Chattopadhyay
ARIES, Nainital



26 October 2021
Interplay between the Accretion
disk and Hot corona in Active
Galactic Nuclei
Gulab Dewangan
IUCAA, Pune



RRI QUANTUM SCIENCE AND TECHNOLOGY WEBINAR

Organiser: Urbasi Sinha Secretary: Savitha Deshpande

2 November 2021
Software simulator for noisy
quantum circuits
Apoorva Patel
Indian Institute of Science,
Bangalore



17 November 2021
Quantum Information and Spin
Chains
Sougato Bose
University College London, UK



23 February 2022
Single-electron devices:
applications in quantum
information
Jonathan Baugh
University College London,
UK



4 August 2021
Quantum Entanglement: Ap-
plications in Communication &
Cryptography
Mark M. Wilde
Louisiana State University,
USA

28 April 2021
Structured Photons – Their Application
in Quantum Photonics
Ebrahim Karimi
University of Ottawa, Canada



ASTRONOMY AND ASTROPHYSICS WEBINAR

7 January 2022
On the detection of a cosmic
dawn signal in the radio
background
Saurabh Singh
RRI



27 January 2022
Constraining the Cosmology
with Quasars
Raj Prince
Polish Academy of Sciences,
Poland

8 February 2022
New Results on Galaxy Mergers: Galaxy
Formation, Cosmology, and Gravitational
Waves
Christopher J. Conselice
University of Manchester, UK



National Science Day Celebrations

National Science Day celebrations was commenced with the launch of "Vignyana Kathegalu" - a series of popular talks. The first talk was delivered by Tarun Souradeep, on the topic "Comprehending the Cosmos". This talk and all the other events were live streamed on the RRI YouTube channel. Around 40 students and accompanying teachers, from neighbouring schools participated in the day's programme, which included a guided tour of the Raman Museum and a visit to the Archival Gallery. As a part of the programme, four short popular talks were organized on the topics "Peering into the Universe" by Saurabh Singh (AA); "Randomness and Large Numbers" by Ion Santra (TP); "The most powerful computer ever" by Deepak Mehta (SCM); "Trapping tiny particles using LASER" by Vaibhav Singh Parmar (SCM). The quiz program that followed witnessed enthusiastic participation from the students. The day's festivities concluded with 'Ask a Scientist'. A panel consisting of Sumati Surya (TP), Pramod Pullarkat (SCM), Shiv Sethi (AA) and Sadiqali Rangwala (LAMP) answered a variety of questions posed by the visiting students. The entire event was coordinated by Sonali Sachdeva (PDF, AA) with excellent support from students and staff.

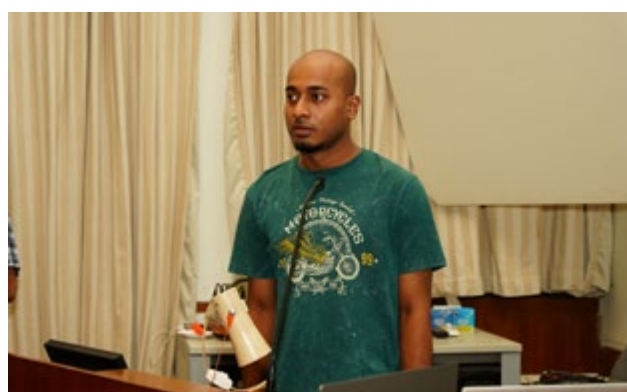


In-House Meeting

The RRI In-house meeting is a three-day annual event that aims to bring together the members of the institute, engaged in research and related activities in the different research groups, to share their scientific work. Like all other events, pandemic put a halt to the in-house meeting for the year 2020. As things were still not looking much better this time around also, and with the second wave of the pandemic looming large, the third-year doctoral students (batch of 2018) decided to organize this year's in-house in a full online mode from 7 - 9th April 2021

There was an active participation from the PhD students, post-doctoral fellows, faculty members and all other research staff in the event which had 42 talks from the different departments. Members of the institute enjoyed a peek and glimpse of the different areas of research going on around the institute, which was like a breath of fresh air amidst the still raging pandemic. The three-day event also had online 'an open-house' discussion meeting, where the members addressed and tried to resolve the problems faced at RRI through discussions. Important decisions like revision of the existing book grant and canteen menu were taken, which was implemented during the year.

The online event was not only about scientific talks and serious discussions, online gaming and quizzing events were organized in the evenings of the first two days. The final day evening was kept aside for a cultural program, which despite of the online format it was a great success with a lot of members, even former members who joined from abroad, chipping in with songs, music and recitals.



Bangalore School on Statistical Physics-XII

Organisers: Sanjib Sabhapandit (RRI) and Abhishek Dhar (ICTS, TIFR)

The Bangalore school on statistical Physics-XII was conducted between 28th June to 9th July via online lectures. This is the twelfth in the yearly series of lectures organised jointly by Sanjib Sabhapandit from RRI and Abhishek Dhar from ICTS-TIFR, Bangalore. This is a pedagogical school, aimed at bridging the gap between masters-level courses and topics in statistical physics at the frontline of current research. It is intended for Ph.D. students, post-doctoral fellows and interested faculty members at the college and university level. The school included courses on statistical field theories of athermal systems, out of equilibrium dynamics of complex systems, introduction to open quantum systems, Dyson brownian motion, free fermions and connections to RMT, non-equilibrium and periodically driven quantum systems and Markov processes and applications.

RRI Annual Cricket Tournament

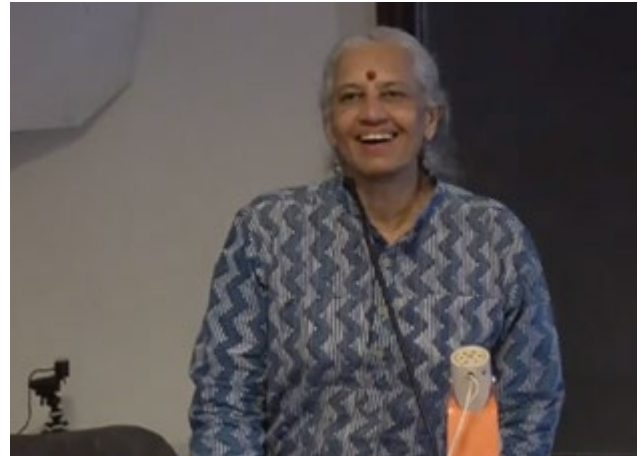
The auction for the Annual RRI Cricket tournament was held on 26 February 2022. Abhishek Ghadai, Anand Prakash, Soumya Ranjan Behera and Sharath were captains of the four student teams named Pratibadh, Samanvay, Valor and Ee Sala Cup Namde (ESCN) respectively. Participation of Administration along with teams from Workshop and Gardeners of the institute made this year's tournament more exciting. Their teams were Lagaan, MES and Garden Greens led by Subramanian, Anand and Loksha respectively. The round robin matches of the tournament were held in March and April. Two student teams and Garden Greens were eliminated after the round robin, leaving top 4 teams for the league matches, which were held in December after a break due to COVID. Lagaan won the Eliminator match against MES. Qualifier-1 was played between the top two student teams (ESCN and Pratibadh). Pratibadh won and qualified for the finals. Qualifier-2 was won by ESCN against Laagan. The student team Pratibadh under the captaincy of first-time captain Abhishek Ghadai (PhD, SCM) won the tournament.



International Women's Day Celebrations

RRI celebrated International Women's Day with a day-long program with talks covering a wide spectrum of topics under the theme "Women of RRI". Ranjini Bandyopadhyay successfully coordinated the event. The program commenced with Tarun Souradeep delivering

the Director's Address. The forenoon session also included talks by faculty Andal Naryanan (LAMP) on "The Life and Science of Hema Ramachandran" and Supurna Sinha (TP) on "The Life of a scientist: Purnima Sinha". This was followed by a popular talk by Gunjan Tomar (PhD Scholar, AA) titled "Bullets from Space" and "My journey through Space and Time" by Sonali Sachdeva (PDF, AA). The session closed with "Sports Women in RRI", a talk by Sebanti Chattopadhyay (PhD Scholar, SCM). The afternoon session started with a talk by Nupur Tandon, Founding Director, Pro Waste Concepts, titled "My journey to becoming a Social Entrepreneur" followed by a science talk by Palak (PhD scholar, SCM) titled "Control of Interfacial Instabilities using Non-Newtonian fluids". The last speaker for the day, Prajval Shastri, Retired Professor IIA, spoke on, "Anna Mani: The story of a pioneering scientist". All talks were telecast live on the official RRI YouTube channel.



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 campus.

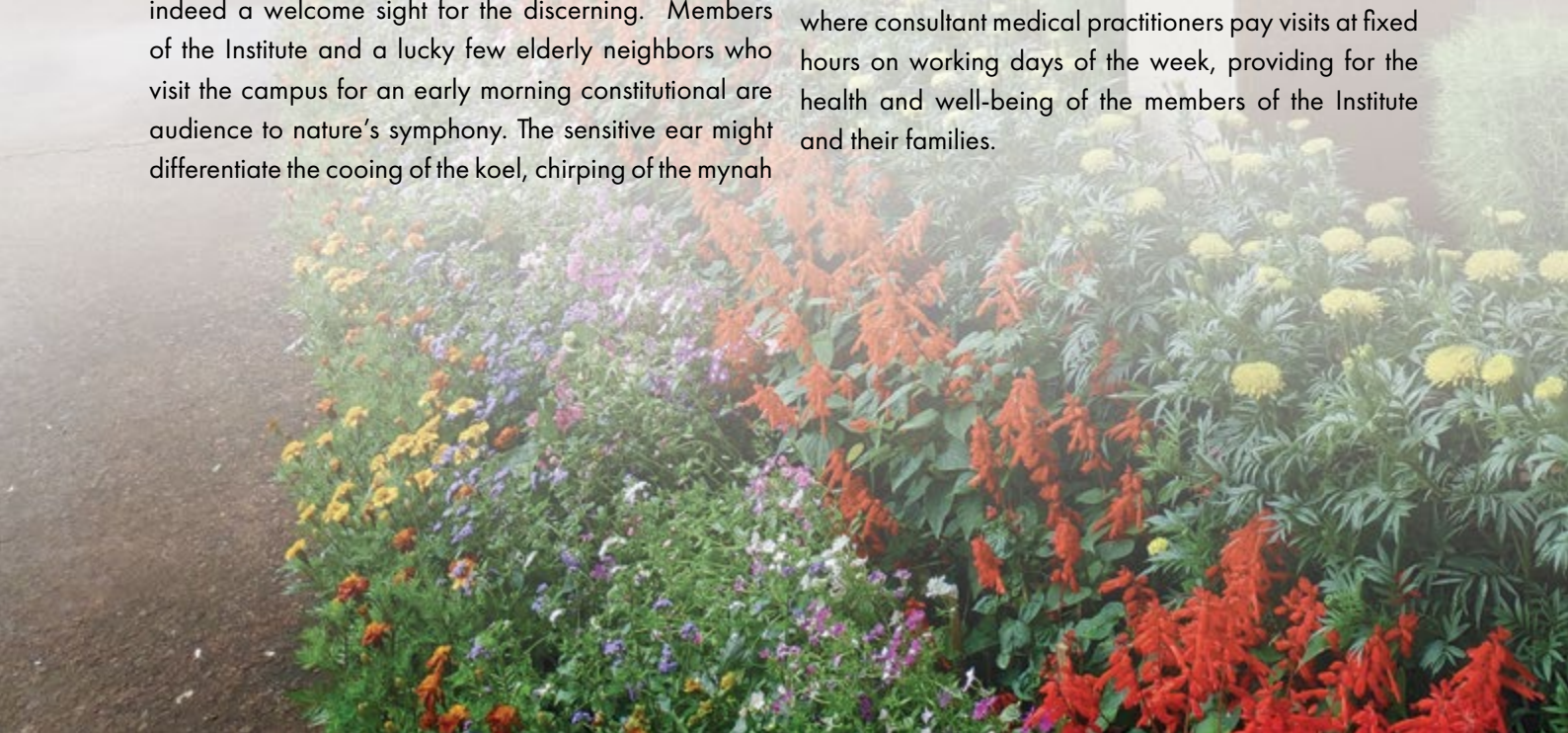
The campus hosts the buildings containing workspaces, laboratories, workshops, canteen, clinic and the guesthouse. And these are surrounded by aesthetically planned and well-kept vegetation that is very appropriate for a campus of a renowned research institute. Indeed, it was Professor Raman who had 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 who visit the campus for an early morning constitutional 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

Academic Staff

Astronomy and Astrophysics

Tarun Souradeep (Director from-20.01.2022)

Research Interests: Cosmology, Cosmic Microwave Background (CMB), Large-Scale Structure in the Universe, Primordial cosmological perturbations from Inflation, Early Universe and applications of QFT in curved spacetime. Gravitational wave (GW) Physics & Astronomy

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S Sridhar (Director i/c till 30.11.2021)

Emeritus Professor from 1.12.2021

Research Interests: Exoplanetary dynamics, stellar dynamics in galactic nuclei

E-mail: ssridhar@rri.res.in

Biman Nath (Coordinator – from 23.03.2021)

Research Interests: Interaction of diffuse gas with galaxies; galactic outflows; cosmic rays; intracluster medium

E-mail: biman@rri.res.in

B Ramesh (Retired on 30.06.202)

Research Interests: Diffuse matter in our and other galaxies, analog & digital signal processing, instrumentation and techniques for astronomy; brain computer interfaces and patient assistant systems

E-mail: ramesh@rri.res.in

Biswajit Paul

Research Interests: Developmental work for an X-ray polarimeter, ASTROSAT and an X-ray pulsar based interplanetary navigation system and investigation of various aspects of compact X-ray sources

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Nayantara Gupta

Research Interests: Neutrino and gamma ray astronomy, origin and propagation of cosmic rays, astroparticle physics

E-mail: nayana@rri.res.in

S Seetha (Emeritus Scientist till 28.02.2022)

Research Interests: Variable stars and stellar systems; development, testing and calibration of instrumentation for space science which will be flown on satellites; work with data obtained in optical and X-ray bands

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Shiv Kumar Sethi

Research Interests: Cosmology

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C.R. Subrahmanya (Honorary Professor till 31.05.2021)

Research Interests: Cosmology, extragalactic radio sources, surveys, instrumentation and signal processing

E-mail: crs@rri.res.in

N Udaya Shankar (Emeritus Scientist till 30.04.2021)

Research Interests: Detection of Epoch of Reionisation (EoR), an array for the detection of epoch of recombination, instrumentation and signal processing for radio astronomy

E-mail: uday@rri.res.in

KS Dwarakanath (Emeritus Scientist till 31.05.2021)

Research Interests: Groups and clusters of galaxies, HI at high z

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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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Mayuri S (Scientist)

Research Interests: Simulation and feasibility studies to experimentally detect spectral signatures from the Epoch of Recombination, application of maximally smooth fitting algorithm for foreground modeling towards the recovery of the 21-cm global Epoch of

Reionization signal from synthetic sky spectrum
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Saurabh Singh C (Scientist)

Research Interests: Radio astronomy, in particular epoch of reionization and the SARAS experiment
E-mail: saurabhs@rri.res.in

Jishnu Nambissan T (Scientist)

Research Interests: Experimental detection and foreground modelling of Epoch of Recombination
E-mail: jishnu@rri.res.in

Narendra Nath Patra (Pancharathnam Fellow till 25.11.2021)

Research Interests: Radio Astronomy, Extragalactic Astronomy, Galactic dynamic, Physics of the interstellar medium, etc.
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Aditi Agarwal (Post Doctoral Fellow)

Research Interests: multi-wavelength studies of active galactic nuclei (AGNs), data analysis/modeling and interpretation, spectroscopic & photometric variability in different classes of AGNs, multi-wavelength observational astrophysics.
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Anjan Kumar Sarkar (Post-Doctoral Fellow)

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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Rahul Sharma (Post-Doctoral Fellow from 01.12.2021)

Research Interests: X-ray Binaries, X-ray Pulsars, Neutron Stars, Black holes, X-ray spectroscopy, X-ray Bursts.
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Sonali Sachdeva (Post-Doctoral Fellow)

Research Interests: Correlation of the dust attenuation curve with other galaxy properties.

Origin and maintenance of relativistic jets in low mass AGNs.

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Light and Matter Physics

Reji Philip (Coordinator – from 30.03.2021)

Research Interests: Nonlinear optics, laser produced plasmas and ultrafast phenomena
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Andal Narayanan

Research Interests: Quantum optics with atoms and light, quantum measurements in atom-quantum-optical systems
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Prof. E. Krishnakumar (Emeritus Scientist – Raja Ramanna Fellow till 09.07.2021)

Research Interests: Atomic collision physics, electron-controlled chemistry, negative ions, cold collisions, electron and ion spectroscopy, momentum imaging, high harmonic generation and attosecond physics
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Sadiq Rangwala

Research Interests: Quantum interactions in cold, dilute gas ensembles, atom-cavity interactions, cavity QED
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Saptarishi Chaudhuri

Research Interests: Ultra-cold atoms and molecules in optical and magnetic traps; quantum simulation of condensed matter physics using degenerate gases; precision measurements
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Urbasi Sinha

Research Interests: Quantum information, quantum computation and quantum communication using single photons, experiments on quantum foundations
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Sachin Barthwal (Pancharathnam Fellow)

Research Interests: Cavity based atom interferometry and precision measurements
E-mail: sachin.b@rri.res.in

Animesh Sinha Roy (Post-Doctoral Fellow)

Research Interests: Theoretical development of the security analysis of quantum cryptography. In addition, I have an interest in the intra particle entanglement and its various possible applications in quantum information theory.

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Sushanta Kumar Pal (Post-Doctoral Fellow till 30.09.2021)**Sourdeep Sasmal** (Post-Doctoral Fellow till 31.03.2022)**Sanjukta Roy** (DST – Scientist - DST WOS-A project)

Research Interests :Quantum Simulation with ultra-cold quantum gases in optical lattices; Few-body physics with ultra-cold atoms ;Anderson localisation with ultra-cold quantum gases in disordered potentials; Quantum Entanglement with ultra-cold Rydberg atoms

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Sourav Chatterjee (Scientist C)

Research Interests: My current research expertise and interests lie in the field of quantum optics-based quantum information processing. More particularly, I am interested in performing proof-of-principle demonstration of novel protocols that facilitate secure quantum communication using discrete variable systems. Given this area of interest, my current work in Prof. Urbasi Sinha's lab highlights in-lab demonstration of novel quantum key distribution (QKD) protocols, and is aimed towards the realization of satellite-based QKD between two distant locations.

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Kaumudibikash Goswami (Scientist C – QKD ISRO from 14.02.2022)

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Dr. Satya Ranjan Behera (Scientist C)

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Dr. Mandira Pal (Research Scientist from 21.02.2022)

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Nagalakshmi A (Scientist B till 31.05.2021)

Research Interests: a. Semiconductor nanotechnology b. Applications of optoelectronics c. Digital electronics and logic design, Electronics and computational engineering

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Arup Bhowmick (Scientific Officer C MEITY)

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Soft Condensed Matter**Ranjini Bandyopadhyay** (Coordinator)

Research Interests: Structure, dynamics and rheology of non-Newtonian fluids; aging and soft glassy rheology; flow-structure correlations in complex fluids; micellar packings; controlled, targeted drug delivery using copolymer micelles as vehicles for drug delivery; interfacial instabilities; designing viscometers to measure complex flows; the stability and sedimentation of colloidal suspensions; physics of granular media

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Arun Roy

Research Interests: Soft condensed matter physics, phase transitions, electro-optics of liquid crystals, liquid crystals nano-particle composites, Micro Raman spectroscopy, phenomenological theories of liquid crystals

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Gautam Soni

Research Interests: Nano-bio-physics of chromatin

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Pramod Pullarkat

Research Interests: Soft condensed matter, in particular, mechanical properties and instabilities of axons and pattern formation in differentiating stem cells Cell Biophysics, Mechanical

properties of axons, Active suspensions

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Raghunathan VA (INSA Senior Scientist)

Research Interests: Lipid bilayers, amphiphiles in the presence of strongly bound polyelectrolytes, mechanical properties and phase behaviour of lipid-sterol membranes

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Sayantan Majumdar

Research Interests: Soft condensed matter physics, non-equilibrium statistical physics

Failures and non-monotonic stress relaxation in bio-polymer networks, microscopic origin of complex relaxation processes in shear jammed dense suspensions, energy dissipation and memory effect in out of equilibrium systems, low Reynolds number elastic instabilities.

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Yashodhan Hatwalne (Emeritus Scientist till 31.8.2021)

Research Interests: Phenomenological theory of liquid crystals, polycrystallites and membranes

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AW Zaibudeen (Post Doctoral Fellow)

Research Interests: My research work aims to understand the various aggregation patterns of colloidal nanorods on a solid substrate, achieved using evaporation induced self-assembly technique under different physio-chemical conditions

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Dr. Ayush Agrawal (Postdoctoral Fellow till 28.05.2021)

Pradip Kumar Bera (from 23.09.2020 till 25.03.2022)

Research Interests: Rheology of soft matter systems

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Rajkumar Khan (Post Doctoral Fellow)

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Sarika (Post-Doctoral Fellow till 17.03.2022)

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Tamal Sarkar (Post-Doctoral Fellow till 25.01.2022)

Research Interests: Nanocomposite hydrogel, Gelation Kinetics, Rheology, Water treatment

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Theoretical Physics

Madhavan Varadarajan (Coordinator – from 20.03.2021) (Director (i/c) - 1.12.2021 to 19.1.2022)

Research Interests: Classical and quantum gravity

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Dibyendu Roy

Research Interests: Theoretical condensed matter physics, statistical mechanics and atomic, molecular & optical physics

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Sanjib Sabhapandit

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Sumati Surya

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Supurna Sinha

Research interests: Theoretical physics; Equilibrium and Non-equilibrium Statistical Mechanics and Quantum Information

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Urna Basu (till 13.09.2022) - on lien

Research Interests: Statistical physics of systems away from equilibrium. In particular, fluctuations and response in nonequilibrium systems, nonequilibrium critical phenomena and properties of active particles.

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Ritu Nehra (Research Associate-Post Doctoral Fellow)

Research Interests: non-Hermitian quantum systems

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Suraka Bhattacharjee (Post-Doctoral Fellow)

Research Interests: My research interests are mainly focused on the study of Quantum dissipative systems including Quantum Brownian motion in presence if magnetic field. The position and velocity responses are studied for the corresponding systems connected to the Ohmic and Drude baths. The cyclotron frequency, damping rate and memory time scales play important roles in the determining the natures of the responses in the Classical and Quantum regimes. On the other hand, my research interest also includes the study and analysis of the non-Hermitian topological models like S.S.H and the Kitaev model for superconductivity. The open and periodic boundary conditions are studied for the driven models, which show many interesting features based on the non-Hermitian skin effect.

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Adjunct Professors

Rafael Sorkin (till feb 2022)

Perimeter Institute for Theoretical Physics, Canada

Fabien Bretenaker

Laboratoire Aimé Cotton, France

Barry Cyril Sanders (Vajra Adjunct faculty)

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Light and Matter Physics

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Soft Condensed Matter

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KN Vasudha

Vigilance Officer from 4.10.21

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Ramakrishna G

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R Shanthamma
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PhD Students

Astronomy and Astrophysics

Aditi Vijayan

Research Interests: Study of galaxy outflows using simulations

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Advisor: Biman Nath

Agnibha de Sarkar

Research Interests: High energy astroparticle physics

E-mail: agnibha@rri.res.in

Advisor: Nayantara Gupta

Ajith B

Research Interests: compact objects and general relativity

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Akash Kumar Patwa

Aman Upadhyay

Research Interests: Astrophysical aspects of black holes and compact objects

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Anirban Dutta

Research Interests: X-ray properties of cataclysmic variable stars

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Advisor: Vikram Rana

Ashwin Devaraj

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Advisor: Biswajit Paul

Avik Kumar Das

Research Interests: Theoretical modeling of astrophysical source

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Advisor: Nayantara Gupta

Hemanth M

Research Interests: Instrumentation for astronomical X-ray polarimetry

E-mail: hemanthm@rri.res.in

Advisor: Biswajit Paul

Gunjan Tomar

Research Interests: High Energy Astroparticle Physics
E-mail: gunjan@rri.res.in
Advisor: Nayantara Gupta

Kinjal Roy

Research Interests Analysis of X-ray spectral and timing data of accreting X-ray pulsars, from observatories like XMM-Newton and NuSTAR
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Advisor: Biswajit Paul

Manami Roy

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Advisor: Biman Nath

Manish Kumar

Research Interests: Ultra Luminous X-ray Pulsars (ULXP).
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Advisor: Biswajit Paul

Mukesh Singh Bisht

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Advisor: Biman Nath

Ranita Jana

Research Interests: Radioactive processes in ISM and IGM, heating of IGM by cosmic ray particles, morphology and dynamics of galaxies
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Advisor: Biman Nath

Saikat Das**Sanhita Kabiraj (JAP student)**

Research Interests: X-ray observation of compact binary stars; Timing and spectral analyses of X-ray sources to discover their physical properties and behaviour
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Advisor: Biswajit Paul

Sandeep Kumar Mondal

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Advisor: Nayantara Gupta

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Tanuman Ghosh

Research Interests: X-ray astronomy
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Light and Matter Physics**Abhishek Sadhu**

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Research Interests: Synthesis and NLO properties of 2D materials
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Research Interests: Weak measurements using single photons

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Vikas Kumar (from 8.11.2021 till 7.1.2022)

Soft Condensed Matter**Abhishek Ghadai**

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Advisors: Sayantan Majumdar

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Research Interests: Synthesis and characterization of liquid crystalline materials

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Advisor: Sandeep Kumar

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Research Interests: Liquid crystals,

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Advisor: VA Raghunathan

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Advisor: Ranjini Bandyopadhyay

Ashish Kumar Mishra

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Advisor: Pramod Pullarkat

Chandeshwar Misra

Research Interests: Study of the jamming dynamics in suspensions of soft colloidal particles.

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Irla Siva Kumar

Research Interests: Synthesis and characterization of liquid crystals (discotic) for technological applications and supramolecular chemistry

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Advisor: Pramod Pullarkat

Palak

Research Interests: Experimental studies of the non-equilibrium dynamics and complex flow in dense colloidal suspensions

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Pooja Joshi

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Advisor: Gautam Soni

Rajkumar Biswas

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Sachidananda Barik

Research Interests: Shear jamming in dense particulate suspension

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Saichand C.

Research Interests: Soft matter (theory)

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Sebanti Chattopadhyay

Research Interests: Jamming transition in non-Brownian dense suspensions

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Soumen Bhukta

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Subhadip Ghosh

Research Interests: The complex molecular systems are renowned for showing the different types of mesophases as well as polymorphic crystalline phases. We have used Raman Spectroscopy technique to probe the changes in molecular vibrational energy levels of different modes and their unique signatures in different phases of a highly polar complex molecular system. The other experimental techniques also have been used to probe the molecular system

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Advisor: Arun Roy

Swarnak Ray

Research Interests: Solubilization of liquid crystalline droplets in micellar solution and self-propelled motion of the droplets due to this solubilization. I also plan to study the collective behavior of such droplets and the effect of phase transition of liquid crystalline phase on such droplets.

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Vishnu Deo Mishra

Research Interests: Biophysics - bent-core liquid crystals
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Yogesh Arya

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Sumanth Kumar

Research Interests: Characterizing living cells based on their size and elasticity using glass micropores which would be helpful in disease diagnosis
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Advisor: Gautam Soni

Theoretical Physics

Abhishek Mathur

Research Interests: Quantum field theory, quantum gravity
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Archan Chattopadhyay

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Atul Vinu

Research Interests: Theory of open quantum systems in particular three level systems under particular environments like vacuum fields, thermal baths, or coherent and incoherent radiation fields. To study the evolution of the system population density of states and coherences under the influence of environment in both markovian as well as non markovian regimes
E-mail: atulv@rri.res.in
Advisor: Dibyendu Roy

Ion Santra

Research Interests: Non-equilibrium Statistical Physics
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Rupak Bag

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Shashank Prakash

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Muneeswaran

B.S.Chethan

K Bhoopalan

Gunashekar

S Sridhar (expired on 03.05.2021)

KN Srinivas

M Rajagopal

K G Narasimhalu

M Ramesh

C Lakshamma (till 31.10.2021)

T Murali

Narayana (expired on 25.05.2021)

V Venkatesh

Ramanna

Varalakshmi

A Ramanna

D Mahalinga

Rangalakshmi

D Krishna

T Mahadeva

G Krishnoji Rao

KS Kumaraswamy

Security

P Manjunath,

Consultant-Security In-charge

Suresha

K Pushparaj

OM Ramachandra

Transport

Matadeen, Consultant (till 31.08.2021)

M Balarama

CK Mohanan

Rahamath Pasha (till 31.01.2022)

G Raja

M Venkateshappa

Canteen & Guest House

N Narayanappa, Consultant (till 30.11.2021)

K Velayuthan

Shivamallu

Mangala Singh

Muniratna

T Naganna

DB Padmavathy

PC Prabhakar

N Puttaswamy

Sharadamma

Gauribidanur Field Station

RP Ramji Naik

NR Srinath

Medical Consultants

Dr. BV Sanjay Rao

Dr. N Sundari

Dr. Archana

Dr. B G Sridhar (from 16.10.2021)

Sharadamani, Consultant (Official Language implementation)

Nupur Tandon, Consultant, Waste Management

List of Publications

Appendix - I

1. Unambiguous Determination of Electrostatically Driven Molecular Packing in a Triphenylene–Surfactant Complex Monolayer
Mallik Samapika, Erimban Shakkira, Swamynathan K, Kumar Sandeep, Daschakraborty Snehasis, and Nayak Alpana
Advanced Materials Interfaces, 2021, Vol.8, Article No. 2100187
2. All acousto-optic modulator laser system for a 12 m fountain-type dual-species atom interferometer
He, Chuan; Yan, Sitong; Zhou, Lin; Barthwal, Sachin; Xu, Rundong; Zhou, Chao; Ji, Yuhang; Wang, Qi; Hou, Zhuo; Wang, Jin; Zhan, Mingsheng
Applied Optics, 2021, Vol.60, p5258-5265
3. Handedness control in polarization lattice fields by using spiral phase filters
Pal, Sushanta Kumar; Arora, Gauri; Ruchi; Senthilkumaran, P.
Applied Physics Letters, 2021, Vol.119, p221106
4. High precision measurements of interstellar dispersion measure with the upgraded GMRT
Krishnakumar, M.A.; Manoharan, P.K.; Joshi, B.C.; Girgaonkar, R.; Desai, S.; Bagchi, M.; Nobleson, K.; Dey, L.; Susobhanan, A.; Susarla, S.C.; Surnis, M.P.; Maan, Y.; Gopakumar, A.; Basu, A.; Batra, N.D.; Choudhary, A.; De, K.; Gupta, Y.; Naidu, A.K.; Pathak, D.; Singha, J.; Prabu, T.
Astronomy and Astrophysics, 2021, Vol.651, Article No. A5
5. Multiwavelength analysis and modeling of OJ 287 during 2017–2020
Prince, Raj; Agarwal, Aditi; Gupta, Nayantara; Majumdar, Pratik; Czerny, Bożena; Cellone, Sergio A.; Andruchow, I.
Astronomy and Astrophysics, 2021, Vol.654, Article No. A38
6. Cosmogenic gamma-ray and neutrino fluxes from blazars associated with IceCube events
Das, Saikat; Razzaque, Soebur; Gupta, Nayantara
Astronomy and Astrophysics, 2022, Vol.658, Article No. L6
7. PeV–EeV Neutrinos from Gamma-Ray Blazars due to Ultrahigh-energy Cosmic-Ray Propagation
Das, Saikat; Gupta, Nayantara; Razzaque, Soebur
Astrophysical Journal, 2021, Vol. 910, p100
8. Comparing the Inner and Outer Star-forming Complexes in the Nearby Spiral Galaxies NGC 628, NGC 5457, and NGC 6946 Using UVIT Observations
Yadav, Jyoti; Das, Mousumi; Patra, Narendra Nath; Dwarakanath, K. S.; Rahna, P. T.; McGaugh, Stacy S.; James Schombert, Stacy S.; Murthy, Jayant
Astrophysical Journal, 2021, Vol.914, p54
9. Study of Temporal and Spectral variability for Blazar PKS 1830-211 with Multiwavelength Data
Abhir, J.; Prince, Raj; Joseph, J.; Bose, D.; Gupta, Nayantara
Astrophysical Journal, 2021, Vol.915 p26
10. Broadband Modeling of Low-luminosity Active Galactic Nuclei Detected in Gamma Rays
Tomar, Gunjan; Gupta, Nayantara; Prince, Raj
Astrophysical Journal, 2021, Vol.919, p137
11. Multi-Wavelength Study of 4C+28.07
Das, Avik Kumar; Prince, Raj; Gupta, Nayantara
Astrophysical Journal, 2021, Vol. 920, p117

12. Spectral Modeling of Flares in Long-term Gamma-Ray Light Curve of PKS 0903-57
Mondal, Sandeep Kumar; Prince, Raj; Gupta, Nayantara; Das, Avik Kumar
Astrophysical Journal, 2021, Vol.922, p160
13. Ultrahigh-energy γ -Rays from Past Explosions in Our Galaxy
Kar, Alokanda; Gupta, Nayantara
Astrophysical Journal, 2022, Vol.926, p110
14. Giant Metrewave Radio Telescope Detection of Hi 21 cm Emission from Star-forming Galaxies at z approximate to 1.3
Chowdhury, Aditya; Kanekar, Nissim; Das, Barnali; Dwarakanath, K.S.; Sethi, S.K.
Astrophysical Journal Letters, 2021, Vol.913, pL24
15. Possible TeV -ray binary origin of HESS J1828-099
Sarkar, Agnibha De; Roy; Majumdar, Pratik; Gupta, Nayantara; Brunthaler, Andreas; Menten, Karl M; Dzib, Sergio A; Medina, Sac NictX; Wyrowski, Friedrich
Astrophysical Journal Letters, 2022, Vol.927 pL35
16. Analysis of Multipolar Linear Paul Traps for Ion-Atom Ultracold Collision Experiments
Niranjan, M.; Prakash, Anand; Rangwala, S.A.
Atoms, 2021, Vol.9, p38
17. Effect of pH on the phase behavior of DMPC bilayers
Chowdhury, Anindya; Sasidharan, Sreeja; Xavier, Pinchu; Viswanath, P.; Raghunathan, V.A.
Biochimica et Biophysica Acta (BBA) - Biomembranes, 2021, Vol. 1863, p183695
18. Entanglement entropy of causal set de Sitter horizons
Surya, Sumati; X, Nomaan; Yazdi K, Yasaman
Classical and Quantum Gravity, 2021, Vol. 38, p115001
19. Euclidean LQG dynamics: an electric shift in perspective
Varadarajan, Madhavan
Classical and Quantum Gravity, 2021, Vol.38, p135020
20. Spacetime entanglement entropy of de sitter and black hole horizons
Mathur, Abhishek; Surya, Sumati; X, Nomaan
Classical and Quantum Gravity, 2022, Vol. 39, p035004
21. Emergent patterns and stable interfaces during radial displacement of a viscoelastic fluid
Palak; Sathyanath, Rahul; Kalpathy, Sreeram K.; Bandyopadhyay, Ranjini
Colloids and Surfaces -A: Physicochemical and Engineering Aspects, 2021, Vol.629, Article -127405
22. DNA-mediated molecular assembly of a triphenylene-surfactant complex monolayer
Mallik, Samapika; Swamynathan, K.; Kumar, Sandeep; Nayak, Alpana
Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2021, Vol.630, Article No. 127569
23. Project AstroSat: five years of operations and continuing
Seetha, S; Girish, V; Rao, V. Koteswara
Current Science, 2021, Vol.121, p214-221
24. Design and synthesis of extended pyrene based discotic liquid crystalline dyes
Irla, Sivakumar; Pruthvi, Mahesh; Raghunathan, V.A.; Kumar, Sandeep
Dyes and Pigment, 2021, Vol. 194. p109574
25. A Possible Quasi-Periodic Oscillation in the X-ray Emission of 3C 120
Agarwal, Aditi; Rani, Priyanka; Raj Prince; Stalin, C S; Anupama, G C, and Agrawal, Vipul
Galaxies, 2021, Vol.9, p20

26. SARAS 3 CD/EoR radiometer: design and performance of the receiver
Nambissan Jishnu T, Subrahmanyam Ravi, Somashekar R., Udaya Shankar N., Singh Saurabh, Raghunathan A., Girish B. S., Srivani K. S., Rao Mayuri Sathyanarayana
Experimental Astronomy, 2021, Vol. 51, p 193
27. Peering into the dark (ages) with low-frequency space interferometers : Using the 21-cm signal of neutral hydrogen from the infant universe to probe fundamental (Astro)physics
Léon V. E. Koopmans; Rennan Barkana; Mark Bentum; Gianni Bernardi; Albert-Jan Boonstra; Judd Bowman; Jack Burns; Xuelei Chen; Abhirup Datta; Heino Falcke ; Anastasia Fialkov; Bharat Gehlot; Leonid Gurvits; Vibor Jelić; Marc Klein-Wolt; Joseph Lazio; Daan Meerburg; Garrelt Mellema; Florent Mertens; Andrei Mesinger; André Offringa; Jonathan Pritchard; Benoit Semelin; Ravi Subrahmanyam; Joseph Silk; Cathryn Trott; Harish Vedantham; Licia Verde; Saleem Zaroubi; Philippe Zarka
Experimental Astronomy, 2021, Vol. 51, p 1641
28. A Floating Octave Bandwidth Cone-Disk Antenna for Detection of Cosmic Dawn
Raghunathan, A; Subrahmanyam, Ravi; Udaya Shankar, N.; Singh, Saurabh; Nambissan, Jishnu; Kavitha, K; Mahesh, Nivedita; Somashekar, R.; Sindhu, Gaddam; Girish, B.S.; Srivani, K.S.; Rao, Mayuri S.
IEEE Transactions on antennas and propagation, 2021, Vo. 69, p6209-6217
29. Geometric phase for Dirac Hamiltonian under gravitational fields in the nonrelativistic regime
Ghosh, Tanuman; Mukhopadhyay, Banibrata
International Journal of Modern Physics D, 2021, Vol.30, Article Number – 2150090
30. Ab-initio investigations for structural, mechanical, optoelectronic, and thermoelectric properties of Ba₂SbXO₆ (Xdouble bondNb, Ta) compounds
Karwasara, Hansraj; Bhamu, K.C.; GuKang, Sung; Kushwaha, A.K.; Rai, D.P.; Sappati, Subrahmanyam; Sahariyag, J.; Soni, Amit
Journal of Alloys and Compounds, 2021, Vol.893, Article No.162332
31. Hydrogen Intensity and Real-Time Analysis Experiment: 256-element array status and overview
Devin Crichton, Moumita Aich, Mugundan V and +102 Co-Authors
Journal of Astronomical Telescopes, Instruments, and Systems, 2022, Vol. 8, 011019
32. AstroSat: Concept to achievements
Seetha, S; Kasturirangan, K
Journal of Astrophysics and Astronomy, 2021, Vol. 42, p19
33. AstroSat/SSM data pipeline
Ravishankar, B. T.; Vaishali, S.; Bhattacharya, D.; Ramadevi, M. C.; Sarwade, Abhilash; Seetha, S.
Journal of Astrophysics and Astronomy, 2021, Vol. 42, p56
34. Calibration of Scanning Sky Monitor (SSM) onboard AstroSat
Sarwade, Abhilash R.; Ramadevi, M. C.; Ravishankar, B. T.; Singh, Brajpal; Baby, Blessy Elizabeth; Bhattacharya, Dipankar; Seetha, S.
Journal of Astrophysics and Astronomy, 2021, Vol. 42, p70
35. Observations of AR Sco with Chandra and AstroSat soft X-ray telescope
Singh, K. P.; Girish, V.; Tiwari, J.; Barrett, P. E.; Buckley, D. A. H.; Potter, S. B.; Schlegel, E.; Rana, Vikram; Stewart, G.
Journal of Astrophysics and Astronomy, 2021, Vol. 42, p83
36. A comparison of the UV and HI properties of the extended UV (XUV) disk galaxies NGC 2541, NGC 5832 and ESO406-042
Das, A. M.; Yadav, J.; Patra, N.; Dwarakanath, K.S.; McGaugh, S.S.; Schombert, J.; Rahna, P.T.; Murthy, J.
Journal of Astrophysics and Astronomy, 2021, Vol.42, p85

37. Optical flux and spectral characterization of the blazar PG 1553 + 113 based on the past 15 years of data
Agarwal, Aditi; Mihov, B.; Andruchow, I.; Cellone, Sergio A.; Anupama, G.C.; Agrawal, V.; Zola, S.; Özdönmez, Aykut; Ege, Ergün
Journal of Astrophysics and Astronomy, 2022, Vol. 43, Article No. – 9
38. Using the redshift evolution of the Lyman-alpha effective opacity as a probe of dark matter models
Sarkar, Anjan Kumar; Pandey, Kanhaiya L.; Sethi, S.K.
Journal of Cosmology and Astroparticle Physics, 2021, Issue 10, 077
39. Structural, Morphological, Magnetic and Optical Limiting Performance of Ni Doped BaSnO₃
Jibi John, S. Suresh, S. Savitha Pillai, Reji Philip & V. P. Mahadevan Pillai
Journal of Electronic Materials, 2021, Vol. 50, p5868–5880
40. Effect of Fe doping on the structural, morphological, optical, magnetic and dielectric properties of BaSnO₃
John Jibi; S Suresh, Pillai S Savitha, Philip Reji, Mahadevan Pillai V.P.
Journal of Materials Science: Materials in Electronics, 2021, Vol. 32, p11763
41. DNA binding activity of novel discotic phenathridine derivative
Vadivel, Marichandran; Aravinda, T.; Swamynathan, K.; Kumar, B.V.; Kumar, Sandeep
Journal of Molecular Liquids, 2021, Vol. 332, p115798
42. Modification in different physical parameters of orthoconic antiferroelectric liquid crystal mixture via the dispersion of hexanethiol capped silver nanoparticles
Agrahari, Kaushlendra; Nautiyal, Vivek Kumar; Vimal, Tripti; Pandey, Shivani; Kumar, Sandeep; Manohar, Rajiv
Journal of Molecular Liquids, 2021, Vol. 332, p115840
43. Mesomorphism in H-bonded binary mixtures of guanazole with nonyloxy benzoic acid
Sunil, Dhanya; Salam, Abdul Ajees Abdul; Sinha, Rajeev K.; Rodrigues, Leon David; Swamynathan, K.; Bhagavath, Poornima
Journal of Molecular Liquids, 2021, Vol. 335, p116202
44. Solvation, rotational dynamics, photophysical properties study of aromatic asymmetric diketones: An experimental and theoretical approach
Melavanki, Raveendra; Muddapur, G.V.; Srinivasa, H.T.; Honnanagoudar, S.S.; Patil, N.R.
Journal of Molecular Liquids, 2021, Vol. 337, p116456
45. Synthesis and mesomorphic characterization of some novel steroidal mesogens: A structure-property correlation
Bhat, Vanishree S.; Raghunathan, V.A.; Kumar, Sandeep
Journal of Molecular Liquids, 2021, Vol. 340, Article Number 117219
46. Molecular ordering dependent charge transport in π -stacked triphenylene based discotic liquid crystals and its correlation with dielectric properties
Shah, Asmita; Singh, Dharmendra Pratap; Duponchel, Benoit; Krasinski, Freddy; Daoudi, Abdelylah; Kumar, Sandeep; Douali, Redouane
Journal of Molecular Liquids, 2021, Vol. 342, Article Number 117353
47. Discotic anthraquinones as novel corrosion inhibitor for mild steel surface
Sowmyashree, A.S.; Somya, Amita; Kumar, Sandeep; Rao, Srilatha; Kudur Jayaprakash, Gururaj
Journal of Molecular Liquids, 2022, Vol.347, Article No.118194

48. Vibrational spectra, linear and nonlinear optical investigations on 3-chloro 4-fluoro aniline and 2-iodo aniline for optical limiting applications
George, Merin; Sajan, D; Sankar, Pranitha; Philip, Reji
Journal of Molecular Structure, 2021, Vol. 1238, p130412
49. Helicity inversion and generation of orthogonal, degenerate index states of generic C points
Komal, Baby; Deepa, S; Pal, S.K.; Ram, B S Bhargava; Kumar, Sunil; Senthilkumaran, P
Journal of Optics, 2021, Vol. 23, Article No. 114001
50. Soft matter research in India
Bandyopadhyay, Ranjini; Horbach, Jurgen
Journal of Physics: Condensed Matter, 2022, Vol.34, Article No.-090402
51. Brownian motion under intermittent harmonic potentials
Santra, Ion; Das, Santanu; Nath, Sujit Kumar
Journal of Physics A: Mathematical and Theoretical, 2021, Vol. 54, p334001
52. Record statistics for random walks and levy flights with resetting
Majumdar, Satya N; Mouniax, Philippe; Sabhapandit, Sanjib; Schehr, Gregory
Journal of Physics A: Mathematical and Theoretical, 2022, Vol. 55, p034002
53. Ambipolar Charge Transport Properties of Naphthophenanthridine Discotic Liquid Crystals
Vadivel, Marichandran; Singh, Singh; Singh, Dharmendra Pratap; Raghunathan, V.A.; Kumar, Sandeep
Journal of Physical Chemistry B, 2021, Vol.125, p10364-10372
54. Emergence of Aggregation Induced Emission (AIE), Room-Temperature Phosphorescence (RTP), and Multistimuli Response from a Single Organic Luminogen by Directed Structural Modification
Chatterjee, Abhijit; Chatterjee, Joy; Sappati, Subrahmanyam; Sheikh, Tariq; Umesh, Rintu M.; Ambhore, Madan D.; Lahiri, Mayurika; Hazra, Partha
Journal of Physical Chemistry B, 2021, Vol. 125, p12832
55. Nonequilibrium Electrical, Thermal and Spin Transport in Open Quantum Systems of Topological Superconductors, Semiconductors and Metals
Bondyopadhaya, Nilanjan; Roy, Dibyendu
Journal of Statistical Physics, 2022, Vol. 187, Article No. 11
56. Analytical seven-wave model for wave propagation in a degenerate dual-pump fiber phase sensitive amplifier
Chatterjee, Debanuj; Yousra, Bouasria; Goldfarb, Fabienne; Bretenaker, Fabien
Journal of the Optical Society of America B, 2021, Vol. 38, p1112-1124
57. Imidazole and benzoimidazole derived new ionic liquid crystal compounds: synthesis, characterisation, mesomorphic properties and DFT computations
Mohammad, AbdulKarim-Talaq; Khalefa, Omar S.; Srinivasa, H.T.; Ameen, Wissam Ahmed
Liquid Crystals, 2021, Vol.48, p1140
58. Nanoribbons of discotic liquid crystal molecules
Joshi, Ashutosh; Manjuladevi, V.; Gupta, Raj Kumar; Kumar, Sandeep
Materials Today: Proceedings, 2021, Vol.46, p5866-5869
59. Dielectric spectroscopy studies of silver nanorod doped nematic liquid crystal
Mishra Shweta, Sontakke A.M., Gupta R.K., Kumar Sandeep, Manjuladevi V.
Materials Today: Proceedings, 2021, Vol. 50, p2587

60. Polar cyano/nitrile group-derived rod-shaped nematic liquid crystals: synthesis and characterizations
Srinivasa H T
Molecular Crystals and Liquid Crystals, 2021, Vol. 737, p11
61. A numerical approach to the non-uniqueness problem of cosmic ray two-fluid equations at shocks
Gupta, Siddhartha; Sharma, Prateek; Mignone, Andrea
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 502, p2733-2749
62. Non-thermal Sunyaev–Zeldovich signal from radio galaxy lobes
Acharya, Sandeep Kumar; Majumdar, Subhabrata; Nath, Biman
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 503, p5473-5484
63. Tracing the evolution of ultraluminous infrared galaxies into radio galaxies with low frequency radio observations
Nandi, S; Das, M; Dwarakanath, K.S.
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 503, p5746-5762
64. Extracting the 21 cm EoR signal using MWA drift scan data
Patwa, Akash K; Sethi, S; Dwarakanath, K.S.
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 504, p2062-2072
65. Super-Eddington accretion on to a stellar mass ultraluminous X-ray source NGC 4190 ULX1
Ghosh, Tanuman; Rana, Vikram
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 504, p974–982
66. Evidence for profile changes in PSR J1713+0747 using the uGMRT
Singha, Jaikhomba; Surnis, Mayuresh P.; Joshi, Bhal Chandra; Tarafdar, Pratik; Rana, Prerna; Susobhanan, Abhimanyu; Girgaonkar, Raghav; Kolhe, Neel; Agarwal, Nikita; Desai, Shantanu; Prabu, T.; Bathula, Adarsh; Dandapat, Subhajit; Dey, Lankeswar; Hisano, Shinnosuke; Kato, Ryo; Kharbanda, Divyansh; Kikunaga, Tomonosuke; Marmat, Piyush; Susarla, Sai Chaitanya; Bagchi, Manjari; Batra, Neelam Dhand; Choudhury, Arpita; Gopakumar, A.; Gupta, Yashwant; Krishnakumar, M.A.; Maan, Yogesh; Manoharan, P.K.; Nobleson, K.; Pandian, Arul; Pathak, Dhruv; Takahashi, Keitaro
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 507, L57-L61
67. A panoramic view of the circumgalactic medium in the photoionized precipitation model
Roy, Manami; Nath, Biman B; Voit, G.M.
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 507, p3849-3859
68. A comprehensive study of the 2019–2020 flare of OJ 287 using AstroSat, Swift and NuSTAR
Prince, Raj; Raman, Gayathri; Khatoon, Rukaiya; Agarwal, Aditi; Varun; Gupta, Nayantara; Czerny, Bożena; Majumdar, Pratik
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 508, p315
69. Mean field dynamo action in shearing flows – II. Fluctuating kinetic helicity with zero mean
Jingade, Naveen; Singh, Nishant K.
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 508, p5163
70. AstroSat detection of a mHz quasi-periodic oscillation and cyclotron line in IGR J19294+1816 during the 2019 outburst
Raman, Gayathri; Varun; Paul, Biswajit; Bhattacharya, Dipankar
Monthly Notices of the Royal Astronomical Society, 2021, Vol. 508, p5578
71. Spectral States of OJ 287 blazar from Multiwavelength Observations with AstroSat
Singh, K.P.; Kushwaha, P; Sinha, A; Pal, Main; Agarwal, Aditi; Dewangan, G.C.
Monthly Notices of the Royal Astronomical Society, 2022, Vol. 509, p2696-2706

72. X-ray spectra of circumgalactic medium around star forming galaxies: connecting simulations of observations
Vijayan, Aditi; Li, Miao
Monthly Notices of the Royal Astronomical Society, 2022, Vol. 510, p568-580
73. Cosmic rays from massive star clusters: a close look at Westerlund 1
Bhadra, Sourav; Gupta, Siddhartha; Nath, Biman B. and Sharma, Prateek
Monthly Notices of the Royal Astronomical Society, 2022, Vol. 510, p5579
74. Radio halo of NGC 4631: comparing observations and simulations
Vijayan, Aditi; Dwarakanath, K S; Nath, Biman B; Kale, Ruta
Monthly Notices of the Royal Astronomical Society, 2022, Vol. 511, p3150
75. Low-frequency wideband timing of InPTA pulsars observed with the uGMRT
Nobleson, K.; Agarwal, Nikita; Girgaonkar, Raghav; Pandian, Arul; Chandra Joshi, Bhal; Krishnakumar, M.A.; Susobhanan, Abhimanyu; Desai, Shantanu; Prabu, T.; Bathula, Adarsh; Pennucci, Timothy T.; Banik, Sarmistha; Bagchi, Manjari; Dhanda Batra, Neelam; Choudhary, Arpita; Dandapat, Subhajit; Dey, Lankeswar; Gupta, Yashwant; Hisano, Shinnosuke; Kato, Ryo; Kharbanda, Divyansh; Kikunaga, Tomonosuke; Kolhe, Neel; Maan, Yogesh; Marmat, Piyush; Arumugam, P.; Manoharan, P.K.; Pathak, Dhruv; Singha, Jaikhomba; Surnis, Mayuresh P.; Susarla, Sai Chaitanya; Takahashi, Keitaro
Monthly Notices of the Royal Astronomical Society, 2022, Vol. 512, p1234
76. Fabrication of Silver-Decorated Graphene Oxide Nanohybrids via Pulsed Laser Ablation with Excellent Antimicrobial and Optical Limiting Performance
Parvathy Nancy, Jiya Jose, Nithin Joy, Sivakumaran Valluvadasan, Reji Philip, Rodolphe Antoine, Sabu Thomas and Nandakumar Kalarikkal
Nanomaterials, 2021, Vol. 11, p880
77. Functionalized electrospun nanofibers integrated with Ag/Au nanoparticles as a platform for enhanced nonlinearity
Nisha George, Radhu Subha, N.L. Mary, Agnes George, V. Anoop.
Optical and Quantum Electronics, 2022, Vol. 54, p198
78. Optical limiting behavior of the natural dye extract from *Indigofera Tinctoria* leaves
Das, Beryl Chandramohan; Niranjana, Reji; Philip, Reji
Optical Materials, 2021, Vol. 114, p110925
79. Tuning the nonlinear optical properties by engineering donor-acceptor configurations in nitrochalcone derivatives
Undavalli, Gopi; Joseph, Mary; Arjun, K. K; Philip, Reji; Anand, Benoy; Rao, G. Nageswara
Optical Materials, 2021, Vol.115, p111024
80. Synthesis, growth and characterization of benzylideneaniline compounds: N-(4-bromobenzylidene)-4-fluoroaniline and N-(4-bromobenzylidene)-4-methoxyaniline
Subashini, A.; Veeramani, V.; Thamaraiselvi, K.; Crochet, Aurelien; Rose, Priya; Philip, Reji; Ramesh Babu, R.; K., Ramamurthi
Optical Materials, 2021, Vol.117, p111081
81. Enhanced optical nonlinearity in beta-MnO₂ nanowire network decorated with Ag nanoparticle
Kumar, Manish; Perumbilavil, Sreekanth; Goel, Alok; Philip, Reji
Optical Materials, 2021, Vol.118, p111226
82. Measurements and analysis of response function of cold atoms in optical molasses
Bhar, Subhajit; Swar, Maheswar; Satpathi, Urbashi; Sinha, Supurna; Sorkin, Rafael; Chaudhuri, Saptarishi; Roy, Sanjukta
Optics Continuum, 2022, Vol. 1, p.171-188

83. Microwave-driven generation and group delay control of optical pulses from an ultra-dilute atomic ensemble
Saaswath, J. K.; Pradosh, K. N.; Adwaith, K. V.; Sanders, Barry C.; Bretenaker, Fabien; Narayanan, Andal
Optics Express, 2021, Vol.29, p15940
84. Imaging through fog using quadrature lock-in discrimination
Kumar, Shashank; Debnath, Bapan; Meena, M.S.; Fade, Julien; Dhar, Sankar; Alouini, Mehdi; Bretenaker, Fabien; Ramachandran, Hema
OSA Continuum, 2021, Vol. 4, p1649-1657
85. Inhibition ability of Natural Compounds of Receptor-Binding Domain of SARA-CoV2: An In Silico Approach
Nedyalkova, Miroslava; Vasighi, Mahdi; Sappati, Subrahmanyam; Kumar, Anmol; Madurga, Sergio
Pharmaceuticals, 2021, Vol. 14, p1328
86. Influence of terminally attached branched alkyloxy chains on the mesophase behaviour of calamitic liquid crystals
Srinivasa H.T. and Mohammad Abdul Karim-Talaq
Phase Transitions, 2021, Vol.94, p.256
87. Joint mass-and-energy test of the equivalence principle at the 10⁻¹⁰ level using atoms with specified mass and internal energy
Lin Zhou, Chuan He, Si-Tong Yan, Xi Chen, Dong-Feng Gao, Wei-Tao Duan, Yu-Hang Ji, 1 Run-Dong Xu, Biao Tang, Chao Zhou, Sachin Barthwal, Qi Wang, Zhuo Hou, Zong-Yuan Xiong, Yuan-Zhong Zhang, Min Liu, Wei-Tou Ni, Jin Wang, and Ming-Sheng Zhan
Physical Review A, 2021, Vol. 104, p022822
88. Objectives of the Millimetron Space Observatory science program and technical capabilities of its realization
Novikov, I.D.; Likhachev, S.F.; Shchekinov, Yu A.; Andrianov, A.S.; Baryshev, A.M.; Vasyunin, A.I.; Wiebe, D.Z.; de Graauw, T.; Doroshkevich, A.G.; Zinchenko, I.I.; Kardashev, N.S.; Kostenko, V.I.; Larchenkova, T.I.; Likhacheva, L.N.; Lyakhovets, A.O.; Novikov, D.I.; Pilipenko, S.V.; Punanova, A.F.; Rudnitsky, A.G.; Smirnov, A.V.; Shematovich, V. I.
Physics Uspekhi, 2021, Vol. 64, p386-419
89. pinta: The uGMRT data processing pipeline for the Indian Pulsar Timing Array
Susobhanan, Abhimanyu; Maan, Yogesh; Joshi, Bhal Chandra; Prabu, T.; + 19 Co- Authors
Publications of the Astronomical Society of Australia, 2021, Vol. 38, e017, p11
90. A minimal space interferometer configuration for imaging at low radio frequencies
Jaini, Akhil; Deshpande, A.A.; Bitragunta, Sainath
Publications of the Astronomical Society of Australia, 2021, Vol.38, Article Number: e040
91. Device-independent bounds from Cabello's nonlocality argument
Rai, Ashutosh; Pivoluska, Matej; Plesch, Martin; Sasmal, Souradeep; Banik, Manik; Ghosh, Sibasish
Physical Review A, 2021, Vol.103, p062219
92. Structure and dynamics of the negative-ion resonance in H₂, D₂, and HD at 10 eV
Swain, Suvasis; Krishnakumar, E.; Prabhudesai, Vaibhav S.
Physical Review A, 2021, Vol.103, p062804
93. Transmission in a Fano-Anderson chain with a topological defect
Nehra, Ritu; Ramachandran, Ajith; Wuster, Sebastian; Sharma, Auditya
Physical Review B, 2021, Vol.103, p155111
94. Nonminimally coupled ultralight axions as cold dark matter,
Sankharva, Kishan; Sethi, Shiv,
Physical Review D. 2022, Vol.105, 3517

95. Invariants in copolar interferometry: An Abelian gauge theory
Thyagarajan, Nithyanandan; Nityananda, Rajaram; Samuel, Joseph
Physical Review D, 2022, Vol. 105, p043019
96. Active Brownian motion with directional reversals
Santra, Ion; Basu, Urna; Sabhapandit, Sanjib
Physical Review E, 2021, Vol 104, pL012601
97. Simple molecular model for ferroelectric nematic liquid crystals exhibited by small rodlike mesogens
Madhusudana, N.V.
Physical Review E, 2021, Vol. 104, p014704
98. Invariants in Polarimetric Interferometry: a non-Abelian Gauge Theory
Samuel, Joseph; Nityananda, Rajaram; Thyagarajan, Nithyanandan
Physical Review Letters 2022, Vol. 128, p091101
99. Detection of spin coherence in cold atoms via Faraday rotation fluctuations
Swar, Maheswar; Roy, Dibyendu; Bhar, Subhajit; Roy, Sanjukta; Chaudhuri, Saptarishi
Physical Review Research, 2021, Vol. 3, Article No. 043171
100. A spacetime calculation of the Calabrese-Cardy entanglement entropy
Mathur, Abhishek; Surya, Sumati; Nomaan, X
Physics Letters B, 2021, Vol. 820, p136567
101. Emergence of quantum phases for the interacting helical liquid of topological quantum matter
Kumar, Ranjith R.; Rahul, S.; Narayan, Surya; Sarkar, Sujit
Pramana - Journal of Physics, 2021, Vol. 95, p54
102. Quantum Langevin dynamics of a charged particle in a magnetic field: Response function, position–velocity and velocity autocorrelation functions
Bhattacharjee, Suraka; Satpathi, Urbashi; Sinha, Supurna
Pramana - Journal of Physics, 2022, Vol. 96, Article No. 53
103. Loophole-Free Interferometric Test of Macrorealism Using Heralded Single Photons
Joarder, Kaushik; Saha, Debashis; Home, Dipankar; Sinha, Urbasi
PRX Quantum, 2022, Vol. 3, p010307
104. An actively compensated 8 nT-level magnetic shielding system for 10-m atom interferometer
Yu-Hang Ji, Lin Zhou, Si-Tong Yan, Chuan He, Chao Zhou, Sachin Barthwal, Feng Yang, Wei-Tao Duan, Wen-Dong Zhang, Run-Dong Xu, Qi Wang, Dong-Xu Li, Jia-Hong Gao, Xi-Chen, Jin Wang, and Ming-Sheng Zhan.
Review of Scientific Instruments, 2021, Vol. 92, 083201
105. Actin filament alignment causes mechanical hysteresis in cross-linked networks
Scheff, Danielle R.; Redford, Steven A.; Lorpaiboon, Chatipat; Majumdar, Sayantan; Dinner, Aaron R.; Gardel, Margaret L.
Soft Matter, 2021, Vol. 17, p5499
106. Strain localization and yielding dynamics in disordered collagen networks
Swarnadeep Bakshi, Vaisakh V. M., Ritwick Sarkara and Sayantan Majumdar
Soft Matter, 2021, Vol. 17, p6435
107. Influence of medium structure on the physicochemical properties of aging colloidal dispersions investigated using the synthetic clay LAPONITE®
Misra, Chandeshwar Ranganathan, Venketesh T. Bandyopadhyay, Ranjini
Soft Matter, 2021, Vol. 17, p9387
108. Direction reversing active Brownian particle in a harmonic potential
Santra, Ion; Basu, Urna; Sabhapandit, Sanjib
Soft Matter, 2021, Vol. 17, p10108-10119

109. DC field coupled evaporation of a sessile gold nanofluid droplet
Zaibudeen, A.W.; Bandyopadhyay, Ranjini
Soft Matter, 2021, Vol. 17, p 10294-10300

Papers In Conference Proceedings

110. Wideband antenna for detecting global signal from the recombination epoch
K.Kavitha, Agaram Raghunathan;R.Somashekar, B.S.Girish, K.S.Srivani;Ravi Subrahmanyam; N.Udaya Shankar;Mayuri Sathyanarayana Rao;Saurabh Singh; Jishnu Nambissan
2021 IEEE Indian Conference on Antennas and Propagation (InCAP), 2021, pp. 367-370, doi: 10.1109/InCAP52216.2021.9726484.
111. A complete evolutionary cycle of HBL Component from end-phase to disappearance and Re-emergence
Kushwaha, P. Singh, K. P. Sinha, A. Pal, M. Dewangan, G. C. Agarwal, A.
in *AstroSat View of Blazar OJ 287*., 2022, ICRC, 644

Popular Articles

112. Sir C. V. Raman: Raman effect and beyond
Ketan, Rikame
Cosmic Vartha, February 2022
113. Assam connection
Nath B. B., Biswas, S.,
Frontline, February 25, 2022
114. Manmondir Nam-rohosyo (The origin of the Bengali word for 'Observatory')
Desh' literary magazine, 17 April, 2 November 2021.

Miscellaneous Articles

115. Norman Robert Pogson and observations of the total solar eclipse of 1868 from Masuliptam, India
Nath, B. B., W. Orchiston
Journal of Astronomical History & Heritage, 2021, Vol. 24, p 629

116. Dust in Clusters of Galaxies
Shchekinov, Y., Nath, B. B., Vasiliev, E.
Universe, 2022, Vol.8, 212

117. Letter of Interest Key Topics in Quantum Gravity,
Jan de Boer, Bianca Dittrich, Astrid Eichhorn, Steven B Giddings, Ste_en Gielen, Stefano Liberati, Etera R Livine, Dieter Lst, Daniele Oriti, Kyriakos Papadodimas, Antonio D Pereira, Mairi Sakellariadou, Sumati Surya, Herman L Verlinde,
SNOWMASS21-TF1TF9094

Books

118. Homi J. Bhabha: A Renaissance man among scientists
Nath, Biman B.
a monograph, published by Niyogi Books, February 2022.
119. Nokkhotrer sathe kotha koy prithibir pran
Nath Biman B.
A book on popular science in Bengali, published by Shishu Sahitya Samsad, Kolkata, January 2022

Papers in Press - In Journals

120. The Simons Observatory: Galactic Science Goals and Forecasts.
Brandon S Hensley, Susan E Clark, Valentina Fanfani, Nicoletta Krachmalnicoff, Mayuri Sathyanarayana Rao, Ningfeng Zhu, Andrea Zonca,
The Astrophysical Journal, 929, 2, 166, 2022
121. Characterizing the Optical Nature of the Blazar S5 1803+784 during Its 2020 Flare
Agarwal, Ashwani Pandey, Aykut Özdönmez, Ergün Ege, Avik Kumar Das, and Volkan Karakulak
The Astrophysical Journal, 2022, Volume 933, 42
122. ArXiv in the Open Access Era: its usage and impact on physics researchers
M.N., Nagaraj; M.K., Bhandi
Bulletin of the American Astronomical Society, 2022, Vol. 54, No. 2

123. Mobile Application Development Using MIT App Inventor: An Experiment at Raman Research Institute Library
Kaddipujar, Manjunath; Rajan, Jacob; Kumbar, B.D.
Bulletin of the American Astronomical Society, 2022, Vol. 54, No. 2
124. Rubicene, an Unusual Contorted Corefor Discotic Liquid Crystals
Sivakumar, Irla; Swamynathan, K.; Ram, Dinesh; Raghunathan, V.A.; Kumar, Sandeep
Chemistry: An Asian Journal, 2022, e202200073
125. Correlating the drying kinetics and dried morphologies of aqueous colloidal gold droplets of different particle concentrations
Zaibudeen, A.W.; Bandyopadhyay, Ranjini
Colloids and Surfaces A, 2022, Vol. 646, Article No. 128982
126. High surface wetting and conducting NiO/PANI nanocomposites as efficient electrode materials for supercapacitors.
Yashwanth V Naik, Mahadevappa YK; Srinivasa HT; Palakshamurthy BS.
Inorganic Chemistry Communications. 138, 109275, 2022.
127. Pattern selection in radial displacements of a confined aging viscoelastic fluid Palak; Parmar, Vaibhav Raj Singh; Saha, Debasish; Bandyopadhyay, Ranjini
JCIS Open, 2022, Vol. 6, Article No. 100047
128. 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.; Sajjan, D.; Vinitha, G.; Philip, Reji
Journal of Alloys and Compounds, 2022, Vol.907, Article No.164413
129. A broad-band X-ray study of the asynchronous polar CD Ind
Dutta, Anirban and Rana, Vikram
Monthly Notices of the Royal Astronomical Society, 2022, Vol. 511, p4981
130. Low-frequency wideband timing of InPTA pulsars observed with the uGMRT
Nobleson, K.; Agarwal, Nikita; Girgaonkar, Raghav; Pandian, Arul; Chandra Joshi, Bhal; Krishnakumar, M.A.; Susobhanan, Abhimanyu; Desai, Shantanu; Prabu, T.; Bathula, Adarsh; Pennucci, Timothy T.; Banik, Sarmistha; Bagchi, Manjari; Dhanda Batra, Neelam; Choudhary, Arpita; Dandapat, Subhajit; Dey, Lankeswar; Gupta, Yashwant; Hisano, Shinnosuke; Kato, Ryo; Kharbanda, Divyansh; Kikunaga, Tomonosuke; Kolhe, Neel; Maan, Yogesh; Marmat, Piyush; Arumugam, P.; Manoharan, P.K.; Pathak, Dhruv; Singha, Jaikhomba; Surnis, Mayuresh P.; Susarla, Sai Chaitanya; Takahashi, Keitaro
Monthly Notices of the Royal Astronomical Society, 2022, Vol. 512, p1234
131. Star-dust geometry main determinant of dust attenuation in galaxies
Sachdeva, S., Nath, B. B.
Accepted for publication in MNRAS, submitted in December 2021
132. Discovery of quasi-periodic oscillations in the persistent X-ray emission of accreting binary X-ray pulsar LMC X-4
Ketan Rikame, Biswajit Paul, Pragati Pradhan, K. T. Paul,
Monthly Notices of the Royal Astronomical Society, 512, 4792, 2022
133. On the detection of a cosmic dawn signal in the radio background
Saurabh Singh, Jishnu Nambissan T., Ravi Subrahmanyam, N. Udaya Shankar, B. S. Girish, A. Raghunathan, R. Somashekar, K. S. Srivani & Mayuri Sathyanarayana Rao
Nature Astronomy, 28 February, 2022

134. Bubbles and OB associations
Drozdov Sergey A., Vasiliev Evgenii O., Ryabova Marina V., Shchekinov Yuri A., and Nath Biman B.
Open Astronomy, 2022, Vol. 31, p154
135. Improved imaging through flame and smoke using blue LED and quadrature lock-in discrimination algorithm
Bapan Debnatha Jayashree; A.Dharmadhikari, Meena M.S; Hema Ramachandran; Aditya K.Dharmadhikari
Optics and Lasers in Engineering, Volume 154, July 2022, 107045
136. Topology of multipartite non-Hermitian one-dimensional systems
Ritu Nehra and Dibyendu Roy
Physical Review B 105, 195407, 2022
137. Observation of banded spherulite in a pure compound by rhythmic growth
Ghosh, Subhadip; Patra, Dipak and Roy, Arun Roy
Physical Review Materials, 2022, Vol. 6, Article No.053401
138. Testing quantum foundations with quantum computers
Sadana, Simanraj; Maccone, Lorenzo; Sinha, Urbasi
Physical Review Research, 2022, Vol. 34 Article No. L022001
139. Interplay of self-assembly and viscoelasticity in chiral liquid crystal gels;
Raj Kumar Khan, Sayantan Majumdar and Pratibha Ramarao
Physics of Fluids 34 (4), 047108, 2022
140. Customized low-cost high-throughput amplifier for electro-fluidic detection of cell volume changes in point-of-care applications
Kaushik, Saurabh; Selvanathan, Prabhakaran; Soni, G.V.
PLoS ONE, 2022, Vol. 17, e0267207
141. Galaxy rotation curve measurements with low cost 21 cm radio telescope
Pandian, Arul B.; Ganesh, L.; Inbanathan, S.S.R.; Ragavendra, K.B.; Somashekar, R.; Prabu, T.
Sadhana, 2022, Vol.4, Article No. 68
142. System design and calibration of SITARA—a global 21 cm short spacing interferometer prototype
Jishnu N. Thekkeppattu, Benjamin McKinley, Cathryn M. Trott, Jake Jones, and Daniel C. X. Ung
Publications of the Astronomical Society of Australia, 2022, Vol. 39, e018

Papers in Press – In Conference Proceedings

143. RaFiDe part 2: Signal anomaly detection and prediction of astronomical data for a radio astronomy observation planner
Bhat, Shashank Sanjay; Prabu T; Saha, Snehanshu
URSI GASS 2021, Rome, Italy, 28 August -4 September 2021

Conferences Attended & Institutions Visited

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
A Raghunathan	2021 IEEE Indian Conference on Antennas and Propagation (InCAP), Jaipur, 13 – 16 December 2021	Wideband antenna for detecting global signal from the recombination epoch (<i>Oral</i>)
Abhishek Ghadai	International Conference on Complex Fluids and Soft Matter – Virtual CompFlu (Online), IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021	Correlation between shear-band dynamics and elastic turbulence in an entangled wormlike micellar solution
Abhishek Mathur	Chennai Mathematical Institute, Chennai, 19 & 28 October 2021 Chennai Symposium on Gravitation and Cosmology, IIT Madras, Chennai, 2 - 5 February 2022, (<i>Online</i>)	Sorkin-Johnston formalism for QFT in curved spacetimes Spacetime entanglement entropy of quantum fields
Aditi Agarwal	National Workshop Astrophysical jets and observational facilities National perspective, 05-09 April, 2021 (<i>Online</i>)	
Agnibha De Sarkar	Fermi Summer School 2021, 07 June - 26 July 2021 37th International Cosmic Ray Conference (ICRC), Berlin, Germany, 12 - 23 July 2021	Galactic molecular clouds as sources of secondary positrons
Alakananda Patra	RSC-IISER Desktop Seminar with Cryst Eng Comm, 09 September 2021 28th National Conference on Liquid Crystals (NCLC-2021), Department of Chemistry, Assam University, Silchar, Assam, 21 - 23 December 2021	Synthesis and characterization of novel N-extended triphenylenes
Anirban Dutta	50 years Astronomical X-ray spectroscopy in the Netherlands (<i>Online</i>),	

Name	Conference Attended/ Institutes Visited, Date	
	<p>Harvard & Smithsonian Center for Astrophysics, 17 - 19 January 2022</p> <p>40th Astronomical Society of India Meet 2022 (Online), 25 - 29 March 2022</p>	
Anson Thambi	<p>International Conference on Complex Fluids and Soft Matter – Virtual CompFlu (Online), IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021</p> <p>APS Satellite Meeting, International Centre for Theoretical Sciences (ICTS), Bangalore, 15 - 18 March 2022</p>	Dynamics of Granular particles
Ashwin Devaraj	<p>BeXRB 2021, 26 - 30 July 2021</p> <p>40th Astronomical Society of India Meet 2022, IIT Roorkee, 25 - 29 March 2022(Online)</p>	Discovery of a cyclotron line GRO J1750-27 with NuSTAR
Biman Nath	<p>National Webinar, St. Xavier's College, Kolkata, 27 August 2021 (Online)</p> <p>Seminar, Scottish Church College, Kolkata, 04 December 2021</p>	<p>The story of the cosmic microwave background photons (Invited)</p> <p>'The dusty universe' (Invited)</p>
Biswajit Paul	<p>"Astrophysical jets and observational facilities: National perspective", 05 - 09 April 2021</p> <p>"Science with XSPECT onboard XPoSAT", 22 September 2021</p> <p>ICHEC WG meeting, 16 November 2021 (Online)</p> <p>National Space Science Symposium, IISER Kolkata, 31 January – 04 February 2022</p>	<p>X-ray Polarimetry Satellite (XPoSAT) and the Indian X-ray Polarimeter (POLIX)</p> <p>Prospect of study of extended objects with XSPECT (Invited)</p> <p>Indian X-ray Polarimeter (POLIX) Onboard X-ray Polarimetry Satellite (XPoSAT) (Invited)</p> <p>Exploring the X-ray Universe (Invited)</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	Exploring the Cosmos 22, North Bengal University, Siliguri, 15 March 2022	Neutron Stars in X-ray Binaries: Surprises every now and then <i>(Invited)</i>
Deepak Mehta	<p>International Centre for Theoretical Physics (ICTP) - International Centre for Theoretical Sciences (ICTS) Winter School on Quantitative Systems Biology, <i>(Online)</i>, 06 - 17 December 2021</p> <p>International Conference on Complex Fluids and Soft Matter – Virtual CompFlu <i>(Online)</i>, IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021</p> <p>APS Satellite Meeting, International Centre for Theoretical Sciences (ICTS), Bangalore, 15 - 18 March 2022</p>	Microfluidics Chamber for Live Cell Microscopy
Dibyendu Roy	<p>Institute for Theoretical Physics in Leuven, Belgium, 17 February 2022 <i>(Online)</i></p> <p>APS Satellite Meeting at International Centre for Theoretical Sciences (ICTS), Bangalore, 18 March 2022 <i>(Oral, Invited)</i></p>	<p>Nonequilibrium many-body dynamics of photons</p> <p>Spectral form factor in fermionic and bosonic models of many-body quantum chaos <i>(Invited)</i></p>
Girish B S	<p>Square Kilometre Array India Consortium – Hardware meeting, 17 May 2021 <i>(Online)</i></p> <p>Webinar, Organized by Xilinx, USA, 23 June 2021</p> <p>Square Kilometre Array India Consortium – Technical Group Meeting , 18 November 2021 <i>(Online)</i></p> <p>Webinar: Organized by Xilinx, USA, 03 February 2022</p> <p>The 40th Annual Meeting of the</p>	<p>Integrated Prototype board – Design concept and current status.</p> <p>Requirements for a good thermal design of RFSoc</p> <p>Integrated Prototype Architecture and Opportunities for Student Participation.</p> <p>Xilinx solutions for Space 2.0/New Space applications</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	Astronomical Society of India, IIT Roorkee, 25 - 29 March 2022 (<i>Online</i>)	
Gopalkrishna M R	Critical Design Review (CDR) of the POLIX Project for URSC, ISRO	POLIX Signal Processing FPGAs
Gunjan Tomar	37th International Cosmic Ray Conference (<i>Online</i>), 12 - 23 July 2021 ISAPP School Paris Saclay 2022 on 'Astrophysical Sources of Cosmic Rays', Université Paris Saclay, France, 28 March 2022	UHECRs from Low-Luminosity AGNs
Keerthipriya S	InCAP 2021, Talk in the IEEE Young professionals' session, 13 - 16 December 2021 (<i>Online</i>)	Reconfigurable multifunctional antennas for Cognitive Radio applications and Radiometers for Cosmology (<i>Invited</i>)
Makarand Diwe	International Centre for Theoretical Physics (ICTP) - International Centre for Theoretical Sciences (ICTS) Winter School on Quantitative Systems Biology (<i>Online</i>), 06 - 17 December 2021 APS Satellite Meeting International Centre for Theoretical Sciences (ICTS), Bangalore 15 - 18 March 2022	
Manjunath Kaddipujar	International Conference on 'Marching Libraries from Traditional to Hybrid: Connecting, Communicating and Cooperating (ICMLTH – 2021)'; Karnataka University, Dharwad, 30 September- 1 October 2021	
Manjunath M	Open Access on the Occasion of National Library Week, MPLA and TSLA International Webinar, 14 November 2021	

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
Mayuri S. Rao	<p>4th global 21-cm workshop, 11 - 14 October 2021</p> <p>Tata Institute of Fundamental Research (TIFR), Mumbai, 28 February - 01 March 2022</p> <p>National Centre for Radio Astronomy (NCRA), Pune, 03 - 05 March 2022 SAZERAC 21 cm 2022, 14 - 17 March 2022</p> <p>Astronomical Society of India (ASI) 2022, IIT Roorkee, 25 - 29 March 2022</p>	<p>PRATUSH: A proposed lunar orbiter to detect the global redshifted 21-cm signal from Cosmic Dawn and Epoch of Reionization (<i>Oral, Contributed</i>)</p> <p>Experimental radio astronomy for CMB studies</p> <p>Experimental radio astronomy for CMB studies PRATUSH: a proposed lunar orbiter experiment for studying the cosmic dawn (<i>Oral</i>)</p> <p>PRATUSH: a proposed Indian lunar orbiter experiment for studying the Cosmic Dawn (<i>Oral</i>)</p>
Nayantara Gupta	International Centre for Theoretical Sciences (ICTS), Bangalore, 11 August 2021	Multimessenger Astronomy: Progress and Problems
Palak	<p>IOP Advanced School in Soft Condensed Matter - Solutions in the Summer 2021, 05 - 09 July 2021</p> <p>APS Satellite Meeting International Centre for Theoretical Sciences (ICTS), Bangalore, 15 - 18 March 2022</p> <p>AERC-2022, 26 - 28 April 2022</p> <p>Institute of Light and Matter (iLM), France, 02 May 2022</p> <p>The École normale supérieure – ENS, France, 03 - 04 May 2022</p>	<p>Pattern selection in radial displacements of a confined aging viscoelastic fluid</p> <p>Emergent patterns and stable interfaces during radial displacement of a viscoelastic fluid</p> <p>Pattern selection in radial displacements of a confined aging viscoelastic fluid</p> <p>Pattern selection in radial displacements of a confined aging viscoelastic fluid</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
Pooja Joshi	<p>ICTP- International Centre for Theoretical Sciences (ICTS) Winter School on Quantitative Systems Biology, (<i>Online</i>), 06 - 17 December 2021</p> <p>International Conference on Complex Fluids and Soft Matter – Virtual CompFlu (<i>Online</i>), IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021</p> <p>APS Satellite Meeting, ICTS, Bangalore, 15 - 18 March 2022</p>	
Prabhu T	<p>International Pulsar Timing Array (IPTA), School/Workshop: 14 – 18 June 2021 (<i>Online</i>)</p> <p>International Pulsar Timing Array (IPTA), Science Meeting: 21 - 25 June 2021 (<i>Online</i>)</p> <p>Indian Institute of Science (IISc): Commemoration of the 75th Anniversary of ECE department, Talk Series, IISc, Bangalore, 29 October 2021</p> <p>ThoughtWorks e4r Symposium 2022, 19 - 20 February 2022 (<i>Online</i>)</p> <p>National Science Day Celebration, SJBIT, Bangalore, 23 February 2022</p> <p>Astronomical Society of India (ASI) 2022 - HPC Workshop on Radio Astronomy Data Analysis in the SKA Era, IIT Roorkee, (<i>Online</i>), 25 March 2022</p> <p>Astronomical Society of India (ASI) 39th Annual meeting, 25 - 28 March 2022 (<i>Online</i>)</p>	<p>We are building the world's largest and most sensitive radio telescope - The Square Kilometre Array</p> <p>How to build a Simple Radio Telescope</p> <p>Transient/ Pulsar Search Pipeline for the SKA</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
Rahul Sharma	Name of conference: 50 years Astronomical X-ray spectroscopy in the Netherlands, Online, 17-19 January 2022	
Ranjini Bandyopadhyay	<p>ICTS Journal Club, International Centre for Theoretical Sciences (ICTS), Bangalore, 01 April 2021 (<i>Online</i>).</p> <p>Soft and Living Matter Seminar series, Indian Institute of Technology, Hyderabad, 20 July 2021 (<i>Online</i>)</p> <p>Current Trends in Non-equilibrium Physics, Jawaharlal Nehru University, New Delhi, 24 November 2021</p> <p>Virtual Compflu 2021, IIT Gandhinagar, Gandhinagar, 14 December 2021</p>	<p>Settling dynamics and flow instabilities in glassy shear thinning suspensions</p> <p>Settling dynamics and flow instabilities in glassy shear thinning suspensions</p> <p>Selection of pattern morphologies at a fluid-fluid interface</p> <p>Emergent patterns and stable interfaces during radial displacement of a viscoelastic fluid</p>
Reji Philip	<p>LSUS-2021, MG University, Kottayam, 07 - 09 April 2021</p> <p>AICTE Training and Learning (ATAL), Faculty Development Programme, NIT Trichy, Thuvakudi, 07 - 11 June 2021, (<i>Online</i>)</p> <p>Nirmala College Muvattupuzha, Kerala, 28 June 2021 (<i>Online</i>)</p> <p>IITDM Kurnool, Kurnool, 10 - 14 July 2021 (<i>Online</i>)</p> <p>Marthoma College Perumbavoor, Kerala, 15 July 2021 (<i>Online</i>)</p> <p>Institute of Plasma Research (IPR) Ahmedabad, 18 October 2021 (<i>Online</i>)</p>	<p>Ultrafast laser-produced plasmas from metals in the film, nano and bulk forms (<i>Invited, Oral</i>)</p> <p>Nonlinear optical materials: Recent advances (<i>Invited</i>)</p> <p>Fundamentals of Nonlinear Optics</p> <p>Introduction to Laser-produced plasmas, under the Faculty development program in Energy trends in photonics</p> <p>Fundamentals of Nonlinear Optics, under the faculty refresher course</p> <p>Laser-produced plasmas (<i>Colloquium Talk</i>)</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	<p>UGC-HRDC Winter school in Physics and Chemistry, Kannur University, Kannur, 24 November - 07 December 2021 (<i>Online</i>)</p> <p>IIT Mandi, Suran, 18 February 2022 (<i>Online</i>)</p> <p>Payyannur College, Kerala, 26 February 2022 (<i>Online</i>)</p>	<p>Nonlinear Optics</p> <p>Introduction to Nonlinear Optics</p> <p>Raman: The Man and the Scientist</p>
Sachin Barthwal	<p>"Quantum Simulations and Computations with Cold Atoms-2022" during 26th-28th January 2022 organized by I-HUB Quantum Technology Foundation. (<i>Webinar</i>)</p> <p>Distinguished Lecture titled "Quantum Entangled and its Classical Cousin, where are We now" by Professor Joseph H. Eberly on 16th April 2021 organized by University of Hyderabad.</p>	
Sadiqali Rangwala	Molecules and Ions at International Centre for Theoretical Sciences (ICTS), Bangalore, 10 - 22 May 2021	Symmetry, Collision, Exchange and Diffusion in Ultra- Cold Ion-Atom Collisions
Sandeep Kumar Mondal	ISAPP School Paris Saclay 2022 on 'Astrophysical Sources of Cosmic Rays', Université Paris Saclay, France, 28 March 2022	Modelling of Blazars with Multiwavelength Data and Neutrino Astronomy
Sanjib Sabhapandit	<p>Statistical physics: Recent advances and future directions, 14 - 15 February 2022</p> <p>Tankhiwale lecture series, Physics Department, Nagpur University, Nagpur, 07 - 08 March 2022.</p>	<p>Freezing Transition in the Barrier Crossing Rate of a Diffusing Particle (<i>Invited</i>)</p> <p>Large Deviations in Nonequilibrium Systems (<i>Invited</i>)</p>
Saptarishi Chaudhuri	Talent Search Webinar Programme, Karnataka Science and Technology Academy [KSTA], 19 November 2021 (<i>Online</i>)	Quantum Mechanics & its Applications (<i>Invited talk, Oral presentation, Online platform</i>)

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
Saumya Behera	ITPAR (<i>Online</i>), 07 December 2021	Implementing Intra-particle Entanglement: Protocol & Experimental Progress
Saurabh Singh	<p>2021 XXXIVth General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS), 28 August - 04 September 2021, (<i>Online</i>)</p> <p>Global 21-cm Workshop, 11 - 14 October 2021 (<i>Online</i>)</p> <p>RRI, 07 Jan 2022</p> <p>Cambridge University, UK, 13 January 2022 (<i>Online</i>)</p> <p>Tata Institute of Fundamental Research, Mumbai, 21 January, 2022</p> <p>University of KwaZulu-Natal, Durban, South Africa, 09 March 2022 (<i>Online</i>)</p> <p>SAZERAC 21 cm 2022, <i>Online</i>, 14 - 17 March 2022</p> <p>Astronomical Society of India, IIT Roorkee, 25 - 29 March 2022</p>	<p>SARAS-3 Radiometer: Design and Performance of the Receiver, PRATUSH: Probing Reionization of the Universe using Signal from Hydrogen (<i>Oral</i>)</p> <p>SARAS 3: A precision radiometer for observations of cosmic dawn via 21-cm signal (<i>Invited, Oral</i>)</p> <p>On the detection of a cosmic dawn signal in the radio background</p> <p>SARAS 3 observations of cosmic dawn</p> <p>On the detection of a cosmic dawn signal in the radio background</p> <p>On the detection of a cosmic dawn signal in the radio background</p> <p>On the detection of a cosmic dawn signal in the radio background</p> <p>On the detection of a cosmic dawn signal in the radio background (<i>Invited, Oral</i>)</p> <p>On the detection of a cosmic dawn signal in the radio background</p>
Sayantan Majumdar	<p>International Conference on Complex Fluids and Soft Matter – Virtual CompFlu, IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021 (<i>Online</i>)</p> <p>Celebration of National Science Day 2022, Pt. Ravishankar Shukla University and CRSI, Raipur, 05 March 2022</p>	<p>Origin of two distinct stress relaxation regimes in shear jammed dense suspensions (<i>Invited, Oral</i>)</p> <p>Strain Localization and Yielding Dynamics in disordered Collagen Networks (<i>Invited, Oral</i>)</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
Sebanti Chattopadhyay	International Conference on Complex Fluids and Soft Matter – Virtual CompFlu, IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021 (<i>Online</i>)	Effects of adhesive interaction on memory formation in dense granular suspensions
Shiv Sethi	Epoch of Reionization, SKAIC, 14 - 25 June 2021 (<i>Online</i>) The Early Universe, International Centre for Theoretical Sciences (ICTS), 03 - 12 January 2022 (<i>Online</i>)	Cosmic Dawn Cosmological observables and early universe
Sonali Sachdeva	Astronomical Society of India Meeting 2022 ,IIT Roorkee, 25th to 29th March 2022, 21st National Space Science Symposium 2022, IISER Kolkata, 31st January to 4th February 2022 International Women’s Day Event talk on 8th March 2022, Raman Research Institute	Star-dust geometry main determinant of dust attenuation in galaxies (Oral) Star-dust geometry main determinant of dust attenuation in galaxies (Oral) My journey through space and time
Sourav Bhadra	40th Astronomical Society of India Meet 2022 (<i>Online</i>), 25 - 29 March 2022	Cosmic rays from massive star clusters: a close look at Westerlund 1
Srivani K S	Webinar on Thermal Management Solutions, 27 May 2021 (<i>Online</i>) Webinar on Requirements for Good Thermal Design, 23 June 2021 (<i>Online</i>) RFSoc Multi-Tile Synchronization (MTS) Characterization and Performance on the RFSoc Gen, 03 - 28 July 2021 Webinar on Xilinx Peta Linux on Zynq using Vivado, CoreEL and Xilinx, 08 October 2021 (<i>Online</i>)	

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	<p>Webinar on Solutions for New Space / Space 2.0, 03 Feb 2022 (Online)</p> <p>40th Annual Meeting of the Astronomical Society of India, 25 - 29 March 2022 (Online)</p>	
Sukanya Sadhu	<p>CECAM Nanopore Workshop, 08 - 10 September 2021</p> <p>International Conference on Complex Fluids and Soft Matter – Virtual CompFlu, IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021 (Online)</p>	Nanopore Translocation and Nanochannel Confined Biopolymers: bridging theory and experiments
Sukh Veer	<p>EMBO Workshop: Axon 2021: Structure and Function, 04 - 07 October 2021 (Online)</p> <p>APS Satellite Meeting, International Centre for Theoretical Sciences (ICTS), Bangalore 15 - 18 March 2022</p>	Actin-Spectrin molecular shock absorber may protect axon against stretch induced damage
Sumati Surya	<p>PSI Lecture, Perimeter Institute, Canada, 03 May 2021 (Online)</p> <p>Quantum Foundations, Gravity, and Causal Order, Banff International Research Station, Canada, 30 May – 04 June 2021</p> <p>Singularity Theorems, causality and all that, A tribute to Roger Penrose, 14 – 18 June 2021</p> <p>QASTM Talk, 05 July 2021 (Online Seminar)</p> <p>Pabna University of Science and Technology, Pabna, Bangladesh, 06 July 2021 (Online)</p>	<p>The Causal Set Approach to Quantum Gravity (lecture)</p> <p>Growing a Quantum Universe, Causally (Invited)</p> <p>Spacetime Geometry from Causal Order (Invited)</p> <p>Geometry from Order: The Causal Set Approach to Quantum Gravity</p> <p>Spacetime Discreteness: An Introduction to Causal Set Theory</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	<p>First ISQG Meeting, 05 – 07 October 2021</p> <p>Dublin Institute for Advanced Studies, Ireland, 27 October 2021 (<i>Online</i>)</p> <p>Future Trends in Gravitational Physics, S.N. Bose National Center for Basic Sciences, Kolkata, 08 - 10 February 2022</p> <p>Perimeter Institute, Canada, 11 February 2022</p>	<p>Status Report on Causal Set Theory (<i>Invited</i>)</p> <p>What is a Quantum Causal Set?</p> <p>Spacetime Entanglement Entropy: Discreteness and Covariance (<i>invited</i>)</p> <p>“Opening Academia: Perspectives on the Historical and Future Role of Women in Physics (<i>Panelist</i>)</p>
Supurna Sinha	<p>IISER Kolkata summer school on “Quantum Information and Quantum Technology’, QIQT 2021: 07 July 2021 (<i>Online</i>)</p> <p>Syracuse University, USA, 12 November 2021 (<i>Online</i>)</p> <p>Statistical and Nonlinear Physics, Buffalo University, USA, 20 November 2021 (<i>Online</i>)</p> <p>Women of RRI’ International Women’s Day Event talk, 08 March 2022.</p>	<p>Likelihood theory in a Quantum World (<i>Invited</i>)</p> <p>A Quantum Diffusion Law (<i>Invited</i>)</p> <p>A Quantum Diffusion Law (<i>Invited</i>)</p> <p>Life of a Scientist: Purnima Sinha</p>
Tanuman Gosh	40th Astronomical Society of India Meet 2022 (<i>Online</i>), 25 - 29 March 2022	A modern perspective on Ultraluminous X-ray sources
Urbasi Sinha	<p>Science Technology and Innovation Forum Side Event: The Era of Quantum Information Technology- Promises and Pitfalls, ITU and the UN Department of Economic and Social Affairs, 03 May 2021</p> <p>ASSOCHAM 2nd Annual international: India Quantum Technology Conclave</p>	<p>(<i>Invited</i>)</p> <p>(<i>Invited speaker at panel discussion</i>)</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	IQTC2021, Unlocking the Potential of Quantum for India, 25 May 2021	
	Tata Institute of Fundamental Research (TIFR), Vigyan Vidushi Programme, 14 June 2021	Photonic Quantum Science and Technologies <i>(Invited)</i>
	Plenary lecture, Summer school on Quantum Information and Quantum Technology QIQT 2021, IISER Kolkata, Kolkata, 05 July 2021	Photonic Quantum Science and Technologies
	IEEE Photonics Society Bombay Chapter, 17 July 2021	Quantum Communications <i>(Invited)</i>
	AICTE STTP Hands on training on "Quantum Computing and its Applications", MAKAUT, Kalyani, West Bengal, 23 July 2021	Quantum Communications
	Quantum Computing session at the CDAC Technology Conclave, 28 July 2021	Quantum Computing and Secure Quantum Communications: Two sides of the same coin
	National Quantum Science and Technology Symposium (NQSTS 2021), 30 July 2021	Quantum Science and Technologies using photons
	"Race for Quantum Rays (Q-Rays)", 28 August 2021	<i>(Invited)</i>
	Security in the Post Quantum World, TCS Global event Anvetion, 01 September 2021	<i>(Invited)</i>
	Vienna Quantum Foundations conference, Vienna, Austria, 07 September 2021	Revealing new facets of Superposition and Interference <i>(Invited)</i>
	Quantum Security Symposium, Data Security Council of India, 15 September 2021	<i>(Invited)</i>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	<p>Global Quantum Communication, 5th International Yanqi Lake meeting, 15 October 2021</p> <p>IEEE Quantum Week international conference, 20 October 2021(Online)</p> <p>National Student Symposium on Physics, Indian Association of Physics Teachers, Indian Academy Degree College, Bangalore, 12 November 2021</p> <p>National Laser Symposium, Bhabha Atomic Research Centre, 19 January 2022</p> <p>International Conference on Quantum Information and Foundations, ICQIF 2022, ISI/SNBNCBS/CU Kolkata, 18 February 2022.</p> <p>National Science Day celebrations, Laboratory for Electro-Optics systems, Indian Space Research Organization, 28 February 2022.</p> <p>School of Physical Sciences March meeting, Jawaharlal Nehru University (JNU), , New Delhi, 29 March 2022.</p>	<p>(Invited)</p> <p>Photonic Quantum Science and Technologies</p> <p>(Invited)</p> <p>(Invited)</p> <p>(Invited)</p> <p>Photonic Quantum Science and Technologies (<i>Chief guest of honour speech</i>)</p> <p>(Invited)</p>
Urna Basu	<p>University of Cambridge, UK, 27 April 2021 (Online)</p> <p>ICTP program, International Centre for Theoretical Physics (ICTP), Italy, 08 September 2021 (Online)</p> <p>Scottish Church College, Kolkata, 19 November 2021 (Online)</p> <p>Seminar at the Department of Physics, IISER-Kolkata, Kolkata, 22 February 2022</p>	<p>Active Brownian Motion with Directional Reversals</p> <p>Statistical Physics of Complex Systems (Invited)</p> <p>Going beyond equilibrium: Physics of active particles</p> <p>Active Brownian Motion with Directional Reversals</p>

Name	Conference Attended/ Institutes Visited, Date	Title of the Paper/Talk
	STATPHYS-Kolkata XI, Kolkata, 21 - 25 March 2022 (<i>Online</i>)	
Vaibhav Parmar	<p>IOP Advanced School in Soft Condensed Matter - Solutions in the Summer 2021, 05 - 09 July 2021</p> <p>Current Trends in Non-Equilibrium Physics, , School of Physical Sciences, Jawaharlal Nehru University, New Delhi, 22 - 26 November 2021</p> <p>International Conference on Complex Fluids and Soft Matter – Virtual CompFlu, IIT Gandhinagar, Gandhinagar, 13 - 15 December 2021 (<i>Online</i>)</p> <p>APS Satellite Meeting, International Centre for Theoretical Sciences, Bangalore 15 - 18 March 2022</p>	<p>Fingers, toes, branches and flowers: An experimental study of inter-facial patterns formed by the displacement of aging clay suspensions in a confined geometry</p>
Vanishree Bhat	28th National Conference on Liquid Crystals (NCLC-2021), Department of Chemistry, Assam University, Silchar, Assam, 21 - 23 December 2021	Synthesis and mesomorphic characterization of some novel steroidal mesogens: A structure property correlation
Vinutha C	FPGA and OpenCL Performances for SKA, 02 March 2022	
Yogesh Arya	International Conference on Complex Fluids and Soft Matter – Virtual CompFlu, IIT Gandhinagar, Gandhinagar 13 - 15 December 2021 (<i>Online</i>)	Behaviour of Laponite nanoplatelets in ion exchange resin mixture

Colloquia and Seminars

Appendix - III

Name	Title	Date
Prof. Shri Kulkarni California Institute of Technology, USA	FRBs at the bottom (Special Online RRI Seminar)	01 April 2021
Nikolai Sinitsyn Los Alamos National Laboratory, USA	Time travels with quantum computer	05 April 2021
Charles H. Bennett BM Research, USA	Quantum Information	14 April 2021
Ofer Firstenberg Weizmann Institute of Science, Israel	Bringing noble-gas spins into the light	22 April 2021
Ebrahim Karimi University of Ottawa, Canada	Structured Photons – Their Application in Quantum Photonics	28 April 2021
Prof. Jean-Philippe Bouchaud Capital Fund Management and French Academy of Sciences	Marginally stable economies?	29 April 2021
Jay M Gambetta IBM Research, USA	Quantum circuits, and the future of quantum technology in the cloud	13 May 2021
Prof Julia Yeomans The Rudolf Peierls Centre for Theoretical Physics, UK	Self-propelled Topological Defects	27 May 2021
Prof Stefano Liberati Scuola Internazionale Superiore di Studi Avanzati (SISSA), Italy	From Analogue to Emergent Gravity: three small lessons	15 June 2021
Dr. Sucheta Chatterjee Presidency University, Kolkata	Cosmological Evolution of Supermassive Black Holes	29 June 2021
Prof. Itai Cohen Cornell University Ithaca, USA	The rapidly expanding thickening universe: critical points, dethickening, superthickening, and meta material liquids	29 July 2021
Mark M. Wilde Louisiana State University, USA	Quantum Entanglement: Applications in Communication & Cryptography	04 August 2021
Prof Markus Arndt University of Vienna, Austria	Universal matter-wave interferometry: Experiments at the quantum-classical interface and on biomolecule metrology	12 August 2021
Syamsundar De Paderborn University, Germany	Photonic Platforms for Quantum Information Technologies: From Time-Multiplexing to Measurement-Based Methods	12 August 2021

Name	Title	Date
Sidney Nagel The University of Chicago, USA	Directed aging: using memory and nature's greed as a new principle for materials design	26 August 2021
Christopher Wilson University of Waterloo, Canada	Microwave quantum optics with artificial atoms	08 September 2021
Narendra Nath Patra Raman Research Institute, Bengaluru	Probing galaxy formation and evolution using observations of nearby galaxies	10 September 2021
Didier Barret French Research Council, France	The Athena Space X-ray Observatory	16 September 2021
Saurabh Singh Raman Research Institute, Bengaluru	Probing early Universe through 21-cm line	20 September 2021
Prof. Basudeb Dasgupta Tata Institute of Fundamental Research, Mumbai	Cracking the Supernova Neutrino Code	21 September 2021
Parameswaran Ajith International Centre for Theoretical Sciences (ICTS), Bengaluru	Gravitational lensing of gravitational waves: A new frontier	28 September 2021
Indranil Chattopadhyay Aryabhata Research Institute of Observational Sciences (ARIES), Nainital	'Seeing' the accretion discs around compact objects - A two temperature description	21 October 2021
Prof. Gulab Dewangan Inter-University Centre for Astronomy & Astrophysics (IUCAA), Pune	Interplay between the Accretion disk and Hot corona in Active Galactic Nuclei	26 October 2021
Mehran Kardar Massachusetts Institute of Technology, USA	Competitive growth on a rugged front	28 October 2021
Apoorva Patel Indian Institute of Science (IISc), Bengaluru	Software simulator for noisy quantum circuits	02 November 2021
Hajime Tanaka The University of Tokyo, Japan	Impact of structural ordering in supercooled liquids on vitrification and crystallization	11 November 2021
Sougato Bose University College London, UK	Quantum Information and Spin Chains	17 November 2021
Mayuri S. Rao Raman Research Institute, Bengaluru	Cosmic Microwave Background studies through the experimentalist's lens	18 November 2021

Name	Title	Date
Artur Ekert University of Oxford, UK	Privacy for the paranoid ones - the ultimate limits of secrecy	25 November 2021
Mike Cates University of Cambridge, UK	Informatic versus Thermodynamic Entropy Production in Active Systems	02 December 2021
Irmgard Bischofberger Massachusetts Institute of Technology, USA	Instabilities and flow-induced structures in lyotropic chromonic liquid crystals	16 December 2021
Nipanjana Patra Curtin University, Australia	Joining the frontier of experimental Radio Astronomy-Capacity building for New Telescopes in pursuit of New Science	06 January 2022
Saurabh Singh Raman Research Institute, Bengaluru	On the detection of a cosmic dawn signal in the radio background	07 January 2022
Shovan Dutta Max Planck Institute for the Physics of complex systems, Germany	Controllable long-range entanglement in a lossy qubit array	10 January 2022
Raj Prince Polish Academy of Sciences, Poland	Constraining the Cosmology with Quasars	27 January 2022
Debayan Chakraborty The University of Texas at Austin, USA	Surveying complex energy landscapes using different flavors of coarse graining	04 February 2022
Christopher J. Conselice University of Manchester, UK	New Results on Galaxy Mergers: Galaxy Formation, Cosmology, and Gravitational Waves	08 February 2022
Prof Béatrice Bonga Radboud University, Netherlands	Resonances in general relativity	21 February 2022
Jonathan Baugh University of Waterloo, Canada	Single-electron devices: applications in quantum information	23 February 2022
Jiarul Midya Forschungszentrum Jülich, Germany	Properties of hairy nanoparticle melts	04 March 2022
T.R.Vishnu Chennai Mathematical Institute, Chennai	Integrability and dynamics of the Rajeev-Ranken model	09 March 2022
Francesco Shankar University of Southampton, UK	Testing galaxy assembly histories via DREAM, a novel semi-empirical model	10 March 2022
Sudipta Sarkar Indian Institute of technology, Gandhinagar	Light rings of stationary spacetimes	11 March 2022

Name	Title	Date
Nishant Singh Inter-University Centre for Astronomy & Astrophysics (IUCAA), Pune	Magnetic fields of the Sun, active regions, and their interaction with the surface gravity mode	15 March 2022
Krishna Murari ELI-HU Non-Profit Ltd, Hungary	Few-cycle Mid-Infrared Pulse Generation for Attosecond Science	23 March 2022
Prof. Arjun Yodh University of Pennsylvania, USA	Phase-Transitions, Relaxation, and Shape Transformations in Soft Materials	31 March 2022

Visitors

Appendix - IV

Name	Date of Arrival & Departure
Nishant K.Singh Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune	14 August 2021 - 24 August 2021
Manish Verma- Undergraduate student Indian Institute of Science (IISc), Bangalore	14 July 2021 – 14 January 2022
Dr. Anoop K K – Assistant Professor Cochin University of Science and Technology (CUSAT), Cochin, Kerala	10 October 2021 – 24 October 2021
Rajiuddin S K - PhD Student Indian Institutes of Science Education and Research (IISER), Kolkata	03 November 2021 for one year
Tadasha Das – PhD Student Indian Institutes of Science Education and Research (IISER), Kolkata	24 November 2021 for one year
Dr. Smijesh N – Assistant Professor Mahatma Gandhi University, Kerala	26 December 2021 – 31 December 2021
Prof. Urna Basu S.N. Bose National Centre for Basic Sciences, Kolkata	28 December 2021 – 16 January 2022
Dr. Arpita Das – PDF Universitat Innsbruck, Innsbruck, Austria	03 January 2022 - 07 January 2022
Raj Prince Centre for Theoretical Physics, Warsaw, Poland	20 January 2022- 3 February 2022
Sudipta Sarkar Indian Institute of Technology, Gandhinagar	10 March 2022 - 12 March 2022
Aditi Vijayan Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune	11 February 2022 - 01 March 2022
Maximilian Ruetp University of York, Heslington England	21 March 2022 - 24 March 2022

Visiting Student's Programme

Appendix - V

Mentors	Students
Biswajit Paul	Shirisha Vissom
Gautam V. Soni	Divya M.
Mayuri S.	Sonia Ghosh Sanjay S. Aditya Krishna
Pramod Pullarkat	Jahnvi M. Zalki Abhijnan Chakraborty
Reji Philip	Cyril Benny Sharon Mary Tomson
Sadiq A. Rangwala	Bismay Swain
Sapatarishi Choudhury	Dighvijay Malavika Unni Venkat Ramana
Urbasi Sinha	Sreekuttan Shailja Kapoor Melvee George

A photograph of the Raman Research Institute building, a long, two-story structure with a series of columns and balconies, set against a clear blue sky. A large tree with green and yellowing leaves is in the foreground, partially obscuring the building. The building is surrounded by a green lawn and some bushes.

Raman Research Institute

Audited Statement of Accounts

2021-2022

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, Sadashivanagar, Bangalore 560080, which comprises of the balance sheet as at March 31st 2022, 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, 2022, 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 and 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 account 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 : 22029146AMFYGR9463**

**Place : Bangalore
Date : 5th July 2022**

RAMAN RESEARCH INSTITUTE, BENGALURU
BALANCE SHEET AS AT 31ST MARCH 2022
UDIN-22029146AMIFYGR9463

		(Amount in INR)		
CORPUS/CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year	
Corpus/Capital Fund	1	107,03,99,571	104,98,46,818	
Reserves & Surplus	2	-	-	
Earmarked & Endowment Funds	3	78,88,57,374	67,67,74,846	
Secured Loans & Borrowings	4	-	-	
Unsecured Loans & Borrowings	5	-	-	
Deferred Credit Liabilities	6	-	-	
Current Liabilities & Provisions	7	3,81,61,058	2,03,99,221	
TOTAL		189,74,18,003	174,70,20,885	
ASSETS				
Fixed Assets	8	86,81,99,897	84,94,75,308	
Investments- from earmarked & endowment funds	9	90,09,46,279	70,58,45,983	
Investments- Others	10	1,00,00,000	1,00,00,000	
Current Assets, Loans & Advances	11	11,82,71,827	18,16,99,594	
TOTAL		189,74,18,003	174,70,20,885	
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

Sd/-

(B. Anand)

Partner

M No. 029146

BENGALURU / 05-07-22

RAMAN RESEARCH INSTITUTE, BENGALURU
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2022
UDIN-22029146AMIFYGR9463

		(Amount in INR)		
INCOME	Schedule	Current Year	Previous Year	
Income from Sales/Services	12	-	-	
Grants/Subsidies	13	59,30,21,660	61,31,39,234	
Fee/Subscriptions	14	-	-	
Income from Investments for earmarked/endowment funds)	15	-	-	
Income from Royalty	16	-	-	
Interest Earned	17	35,76,374	58,82,798	
Other Income	18	1,09,90,429	1,51,45,694	
Increase/Decrease in stock of finished goods	19	-	-	
TOTAL (A)		60,75,88,463	63,41,67,726	
EXPENDITURE				
Establishment Expenses	20	40,82,99,075	43,56,52,202	
Other Administrative Expenses	21	14,26,78,883	11,33,48,305	
Expenditure on Grants/Subsidies	22	-	-	
Interest	23	-	-	
Depreciation (Net as per Schedule 8)		6,43,21,660	6,96,39,234	
TOTAL (B)		61,52,99,618	61,86,39,741	
INTEREST ON GRANT BALANCES TRF TO BHARATKOSH - Sch 7(A)(1b)		21,62,647	25,28,635	
BALANCE-SURPLUS/(DEFICIT) CARRIED TO CORPUS/CAPITAL FUND - Sch. 1(2b)		(98,73,802)	1,29,99,350	
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/-

(Narash V. S)

Administrative Officer (i/c)

Sd/-

(Tanu Souradeep Ghosh)

Director

Sd/-

(B. Anand)

Partner

M No. 029146

BENGALURU / 05-07-22

RAMAN RESEARCH INSTITUTE, BENGALURU
RECEIPTS AND PAYMENTS STATEMENT FOR THE YEAR ENDED 31ST MARCH 2022
UDIN-22029146AMFYGR9463

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year	(Amount in INR)
I. Opening Balances			I. Expenses			
a) Cash in hand	17	300	a) Establishment Exp	40,82,99,075	43,56,52,202	
b) Bank Balances	32,66,38,753	4,15,52,578	b) Admin Expenses	14,26,78,883	11,33,48,318	
c) Deposits	2,33,89,167	23,98,76,801	c) PF-Final Settlement	1,00,27,365	2,03,06,638	
d) Stamps (Franking MIC)	94	8,620	d) Pension Payout	1,25,04,258	-	
II. Grants Received			II. Payments made against projects	3,04,04,248	5,48,75,764	
a) From Govt. of India	62,80,00,000	61,28,00,000				
b) From State Govt.	-	-	III. Investment and deposits made			
c) From other sources	7,32,64,371	10,53,67,898	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	5,07,67,569	4,22,67,303	
b) Own Funds	-	-				
			V. Refund of surplus money / loans			
IV. Interest Received			a) To Govt. of India	-	-	
a) On Bank deposits	2,35,61,834	1,29,25,379	b) To State Govt	-	-	
b) on Loans, Advances etc.	59,360	83,754	c) To other fund providers	-	-	
V. Other Income (Specify)	1,10,40,556	1,52,19,526	VI. Finance charge (Interest)	-	-	
VI. Amount Borrowed	-	-	VII. Other Payments (Specify)	-	-	
VII. Any other Receipts (Specify)			a) TDS Receivable	9,53,794	6,67,719	
a) Advances	-	49,80,186	b) Advances	8,50,69,167	1,87,16,278	
b) Receivables	46,79,986	1,47,86,982	c) Investments (Nett)	28,99,399	8,44,347	
c) Accrued Interest	7,44,657	5,99,623	d) EMD, SD, CD (Deposits)	2,25,000	-	
d) Investments (Nett)	12,53,67,151	4,30,05,923	e) Bills Payable	56,26,016	2,17,12,502	
e) Overheads	-	-	f) Payroll Recoveries	-	4,56,78,849	

RAMAN RESEARCH INSTITUTE, BENGALURU
RECEIPTS AND PAYMENTS STATEMENT FOR THE YEAR ENDED 31ST MARCH 2022
UDIN-22029146AMFYGR9463

		(Amount in INR)			
RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
f) EMD, SD, CD (Deposits)	-	4,35,000	g) Deposits (for services)	-	-
g) Pension Corpus	-	7,23,718	h) Duties & Taxes	31,79,949	10,92,808
h) Employees's subscription	92,61,613	2,62,18,626	i) Provision	27,39,358	79,019
			j) PF-Withdrawals	-	1,33,15,136
			h) CPF (Emplyr Share)-Trf to Pension	-	-
			VIII. Closing Balances		
			a) Cash Balance	-	17
			b) Bank Balances		
			i) Deposit Accounts	46,39,04,469	32,66,38,753
			II) Current/Savings Account	67,03,484	2,33,89,167
			c) Postal franking machine	25,525	94
TOTAL	122,60,07,559	111,85,84,914		122,60,07,559	111,85,84,914

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

Sd/-
(B. Anand)
Partner
M No. 029146

BENGALURU / 05-07-22

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

	(Amount in INR)	
	Current Year	Previous Year
Schedule 1- Corpus/Capital Fund		
(1) CAPITAL FUND REPRESENTING ASSETS CREATED OUT OF GRANTS		
As per last account	101,21,44,810	103,95,16,741
Addition during the year	12,64,73,817	11,22,14,948
Less: Deductions during the year <i>(includes Capital Work-in-progress)</i>	8,02,58,033	6,99,47,645
Less: Depreciation chargeable transferred to Income and Expenditure A/c	6,43,21,660	6,96,39,234
BALANCE AS AT THE YEAR END	99,40,38,934	101,21,44,810
(2) GRANT BALANCES		
(a) NON-RECURRING GRANT		
Balance as at the beginning of the year		7,49,616
Add: Contributions during the year	2,77,82,313	
Less: Expenditure incurred during the year	9,93,00,000	6,93,00,000
	5,07,67,569	4,22,67,303
BALANCE AS AT THE YEAR END	7,63,14,744	2,77,82,313
(b) RECURRING GRANT		
Balance as at the beginning of the year		(30,79,655)
Transferred from Income & Expenditure- -Account for the year	99,19,695 (98,73,802)	1,29,99,350
BALANCE AS AT THE YEAR END	45,893	99,19,695
TOTAL (1+2)	107,03,99,571	104,98,46,818

	(Amount in INR)	
	Current Year	Previous Year
Schedule-2- Reserves & Surplus		
NOT APPLICABLE		
TOTAL	-	-

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

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 31/03/22
					Capital Expenditure	Recurring Expenditure		
Funded by Government Agencies								
1	DAE	Prof. Krishnakumar-RRF-DAE	(10,58,715)	13,50,000	-	2,91,285	2,91,285	-
2	DBT	Joint Project-Dr. Pramod	(3,97,102)	53,337	-	-	-	(3,43,765)
3		DST-BDTD Grant-Dr. Gautam	(1,07,260)	12,00,000	-	5,03,420	5,03,420	5,89,320
4		Ramanujan Fellowship- Dr Pramod	2,06,447	-	-	-	-	2,06,447
5	DST	DST-QuST grant-Prof Urbasi	90,77,128	-	9,92,250	3,86,436	13,78,686	76,98,442
6		DST-Indo-Russia-Prof. Sandeep	9,94,573	-	-	5,66,212	5,66,212	4,28,361
7		DST-WOS-A-Dr. Sanjukta	17,38,400	33,626	-	10,31,250	10,31,250	7,40,776
8		DST-IndoItaly-Dr. Urbasi	15,96,463	43,79,446	-	12,46,740	12,46,740	47,29,169
9		CEFIPRA Grant- Dr. Sadiq Rangwala	79,867	-	-	-	-	79,867
10		PRATUSH-Dr. Mayuri	13,70,257	-	-	6,10,288	6,10,288	7,59,969
11	ISRO	ISRO-Polix Payload-Prof Biswajit	36,21,829	1,70,00,000	-	56,21,780	69,62,633	1,36,59,196
12		ISRO-QKD-Project-Dr. Urbasi	5,86,68,156	74,901	24,53,785	45,20,477	69,74,262	5,17,68,795
13		Ramanujan Fellowship- Dr Sayantan	5,25,925	2,30,000	-	2,91,916	2,91,916	4,64,009
14		TARE Grant- Dr. Anoop. CUSAT	2,32,441	2,00,000	-	4,32,441	4,32,441	-
15		Ramanujan Fellowship- Dr Urna Basu	6,93,334	1,40,000	-	2,28,594	2,28,594	6,04,740
16	SERB	Vajra Fellowship-Prof Salya Majumdar	(15,883)	-	-	-	-	(15,883)
17		SERB Grant-Dr. Ranjini	3,92,382	2,50,000	-	2,19,182	2,19,182	4,23,200
18		Vajra Fellowship-Prof Sanders	(1,81,496)	-	-	-	-	(1,81,496)
19	MeITY	Joint Project-Dr. Urbasi	5,24,66,191	2,52,01,362	44,62,995	59,06,711	1,03,69,706	6,72,97,847
20	INSA	INSA-Fellowship-Prof. Raghunathan	(76,452)	-	-	3,68,754	3,68,754	(4,45,206)
21	WT-OBT	WT-OBT-IA-Team Sc. Grant (Dr Pramod)	-	2,12,75,742	-	-	1,08,75,986	1,03,99,756
22	TIFR	TIFR-Grant-Prof. Krishnakumar	48,212	-	-	48,212	48,212	-
		SUB TOTAL	12,98,74,697	7,13,88,414	79,09,030	2,24,73,698	1,20,16,639	15,88,63,544
Funded by other than Government Agencies								
1	IKP	GCE Grant-Dr. Gautam Soni	6,72,357	(3,53,433)	-	21,520	21,520	2,97,404
		SUB TOTAL	6,72,357	(3,53,433)	-	21,520	21,520	2,97,404
Retirement Funds								
1		Gratuity Fund	5,57,08,611	2,66,80,831	-	1,26,32,462	(1,81,30,696)	8,76,87,676

Schedule 3- Earmarked/Endowment Funds

(Amount in INR)

SI No	Funding Agency	Project Name	Opening Balance	Additions during the year	Utilisation			Total Utilisation	Balance as on 31/03/22
					Capital Expenditure	Recurring Expenditure	Advances/Receivables		
2		Leave Salary Fund	4,75,90,435	3,76,46,751	-	1,17,21,336	(1,53,79,955)	(36,58,619)	8,88,95,805
3		Pension Commutation Fund	23,44,55,055	(64,93,002)	-	1,07,82,875	(1,79,42,478)	(71,59,603)	23,51,21,656
4		RRI Pension Fund	10,44,92,197	1,77,03,663	-	1,25,04,258	-	1,25,04,258	10,96,91,602
5		RRI Provident Fund	10,39,81,494	1,03,39,638	-	62,21,445	-	62,21,445	10,80,99,687
		SUB TOTAL	54,62,27,792	8,58,77,881	-	5,38,62,376	(5,14,53,129)	24,09,247	62,96,96,426
		GRAND TOTAL	67,67,74,846	15,69,12,862	79,09,030	7,63,57,594	(3,94,36,290)	4,48,30,334	78,88,57,374

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

		(Amount in INR)	
	Current Year	Previous Year	
Schedule 4- Secured Loans & Borrowings			
NOT APPLICABLE	-	-	-
TOTAL	-	-	-
Schedule-5- Unsecured Loans & Borrowings			
NOT APPLICABLE	-	-	-
TOTAL	-	-	-
Schedule 6- Deferred Credit Liabilities			
NOT APPLICABLE	-	-	-
TOTAL	-	-	-
Schedule-7- Current Liabilities & Provisions			
A. CURRENT LIABILITIES			
1. Sundry Creditors			
a) for goods	-	14,586	27,09,670
b) Others	1,93,761	26,95,084	9,52,000
2. Earnest Money Deposit	6,63,000		1,00,00,000
3. Advances Received	1,00,00,000		
4. Statutory Liabilities			
a) Overdue	-	-	-
b) Others	-	-	-
5. Other Current Liabilities (Incl. Bharatkosh remittance pending)	34,64,016	14,59,928	14,59,928
TOTAL (A)	1,43,20,777		1,51,21,598
B. PROVISIONS			
1. Gratuity			
2. Superannuation / Pension	-	21,353	
3. Accumulated Leave Encashment	-	-	
4. Others (Specify)	2,38,40,281	52,56,270	
TOTAL (B)	2,38,40,281		52,77,623
TOTAL (A+B)	3,81,61,058		2,03,99,221

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

Schedule 8- Fixed Assets										(Amount in INR)		
Description	Rate	GROSS BLOCK					DEPRECIATION			NET BLOCK		
		Valuation as at the beginning of the year	Cost at the end of the year	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	3,78,735
RMV II Stage	-	31,19,436	-	-	-	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	8,00,63,261
2. Buildings												
a) On freehold land	1.63	19,65,31,504	24,64,102			19,89,95,606			4,84,44,117	15,05,51,489	15,13,14,894	15,13,14,894
3. Canteen Infrastructure	4.75	44,09,909	1,49,890			45,59,799			24,73,746	20,86,053	21,49,194	21,49,194
4. Plant Machinery, Equipment	4.75	108,20,66,917	7,96,00,613			116,16,67,530			62,81,35,163	53,35,32,367	50,74,70,378	50,74,70,378
5. Vehicles	9.50	74,51,930	25,73,337	44,04,884		56,20,383		55,02,519	20,71,645	35,48,738	1	1
6. Furniture & Fixtures	6.33	1,62,54,060	3,33,641			1,65,87,701		10,42,892	1,40,94,697	24,93,004	32,02,255	32,02,255
8. Computer Peripherals	16.21	18,78,18,813	72,22,552	1,46,901		19,48,94,464		7,79,692	16,19,75,431	3,29,19,033	2,65,07,978	2,65,07,978
9. Library Books	4.75	23,17,43,452	2,69,225			23,20,12,677		1,10,15,294	17,68,66,444	5,51,46,233	6,88,92,302	6,88,92,302
Total Fixed Assets		180,98,38,017	9,26,13,360	45,51,785		189,78,99,592		6,99,39,275	103,40,61,243	86,38,38,349	84,00,98,434	84,00,98,434
B. Work in Progress												
Capital Assets		93,76,874	3,67,70,617	4,17,85,943		43,61,548				43,61,548	93,76,874	93,76,874
Total Capital Work in Progress		93,76,874	3,67,70,617	4,17,85,943		43,61,548				43,61,548	93,76,874	93,76,874
Grand Total		181,92,14,891	12,93,83,977	4,63,37,728		190,22,61,140		6,99,39,275	103,40,61,243	86,81,99,897	84,94,75,308	84,94,75,308
Previous Year		168,86,01,051	10,50,29,852	3,77,58,417		175,58,72,466		6,51,86,568	83,27,36,613	92,31,35,873	92,10,51,006	92,10,51,006

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

(Amount in INR)

Schedule 9- Investments from Earmarked/Endowment Funds	Current Year	Previous Year
1. In Fixed Deposits		
RRI Pension Fund	10,42,64,861	10,71,64,250
RRI Provident Fund	10,30,59,608	8,43,74,503
Other Grants & Funds	24,65,80,000	12,51,00,000
2. Other Approved Securities	-	-
3. Shares	-	-
4. Debentures / Bonds	-	-
5. Retirement funds invested in Life Insurance Corporation of India	41,19,05,137	-
6. Retirement funds invested in SBI Life Insurance	-	33,77,54,101
Claim (to be submitted) pending towards settlements made during the year	3,51,36,673	5,14,53,129
TOTAL	90,09,46,279	70,58,45,983

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

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

	(Amount in INR)	
	Current Year	Previous Year
Schedule 11- Current Assets, Loans & Advances		
A. CURRENT ASSETS		
1. Inventories	5,70,820	5,95,537
2. Cash balances in hand (Including cash imprest)	-	17
3. Unused stamp value on Postal Franking Machine	25,525	94
4. Bank Balances		
Main Account	4,75,589	21,50,183
Pension Fund Account	26,47,666	64,44,950
Provident Fund Account	26,27,697	1,35,98,786
Extra Mural Grants	9,52,532	11,95,248
TOTAL (A)	72,99,829	2,39,84,815
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	16,41,625	3,84,72,091
Deposits	9,42,32,225	13,10,62,691
Others	34,81,976	35,53,990
Income Accrued	25,06,794	74,32,494
2. Income Accrued		
Main Account	9,95,542	5,91,204
Pension Fund Account	94,296	6,98,585
Provident Fund Account	4,12,822	37,87,586
Extra Mural Grants	20,84,566	14,21,612
3. Claims Receivable	35,87,226	64,98,987
Main Account	19,74,542	22,31,209
Pension Fund Account	17,84,780	15,80,902
Provident Fund Account	20,07,983	22,20,619
Extra Mural Grants	13,96,472	31,33,887
TOTAL (B)	11,09,71,998	15,77,14,779
TOTAL (A+B)	11,82,71,827	18,16,99,594

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2022

		(Amount in INR)	
		Current Year	Previous Year
Schedule 12- Income from Sales/Service			
NOT APPLICABLE			
Total		-	-
Schedule 13- Grants/Subsidies			
1. Central Government			
Grants-in-aid			
i) Non-Plan			
ii) Deferred Grant (To the extent of depreciation chargeable)		6,43,21,660	6,96,39,234
iii) Recurring		52,87,00,000	54,35,00,000
Total		59,30,21,660	61,31,39,234
Schedule 14- Fees/Subscriptions			
NOT APPLICABLE			
Total		-	-
Schedule 15- Income from Investments			
Interest on Investment from Earmarked / Endowment Fund			
		3,78,80,492	3,28,75,357
Less: Transferred to Earmarked / Endowment Fund		3,78,80,492	3,28,75,357
Total		-	-
Schedule 16- Income from Royalty/Publication			
NOT APPLICABLE			
Total		-	-
Schedule 17- Interest Earned			
1) On Term Deposits			
a) With scheduled banks			
		-	-
2) On accounts with banks			
a) Attributable to Core grant funds (transferable to Bharatkosh)		21,62,647	25,28,635
b) Attributable to Own/other funds		13,54,367	32,70,409
3) On Loans/Advances			
a) Employees		59,360	83,754
Total		35,76,374	58,82,798

RAMAN RESEARCH INSTITUTE, BENGALURU
SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2022

(Amount in INR)

	Current Year	Previous Year
Schedule 18- Other Income		
1) Profit on sale/disposal of assets	-	-
a) Own Assets	-	-
b) Assets acquired out of grants	-	-
2) Miscellaneous Income	1,09,90,429	1,51,45,694
Total	1,09,90,429	1,51,45,694

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

	Current Year	Previous Year
Schedule 20- Establishment Expenses		
a) Salaries & Wages	21,49,78,253	23,55,60,318
b) Allowances & Bonus	46,46,547	4,72,87,858
c) Contribution to NPS	93,62,874	57,58,442
d) Staff welfare expenditure	1,49,73,575	2,34,38,474
e) Retirement/Terminal benefits	16,43,37,826	12,36,07,110
Total	40,82,99,075	43,56,52,202

	Current Year	Previous Year
Schedule 21- Other administrative expenses		
1) Advertisement	7,48,847	7,55,000
2) Amenities	9,39,591	7,90,058
3) Audit Fee	55,755	53,100
4) Bank Charges	55,613	1,23,417
5) Campus Maintenance	4,45,71,637	2,45,92,671
6) Conveyance	1,99,996	4,45,238
7) Corporation Taxes	2,74,867	2,87,367
8) Creche	-	3,60,000
9) Electricity Charges	1,29,88,315	1,27,08,423

Continued on the next page

Schedule 21- Other administrative expenses (Continued)		Current Year	Previous Year
10) Entertainment & Hospitality		6,104	17,158
11) Freight		2,04,657	4,24,110
12) Honorarium & Professional Fee		74,53,231	74,97,836
13) Journal Subscription		57,63,176	33,51,326
14) Lease Rent (Gauribidanur)		5,92,970	5,57,510
15) Miscellaneous Expenses		8,32,904	9,26,778
16) Outreach		4,66,100	1,13,671
17) Patent Fee		3,04,390	5,57,362
18) Payroll Processing Charges		4,52,880	4,35,774
19) Ph.D Programme Expenditure		16,03,048	12,72,556
20) Postage & Courier Charges		28,102	64,596
21) Printing & Stationery		4,07,476	4,17,344
22) Repairs & Maintenance		1,25,59,746	1,18,72,312
23) Security Charges		1,06,21,017	80,11,108
24) Seminar/Conference		2,80,021	4,85,955
25) Stores & Consumables		3,52,23,381	3,12,51,594
26) Telephone & Communication		18,94,642	16,11,984
27) Travel Expenditure		1,21,667	10,66,573
28) Uniform & Livery		29,539	54,679
29) University Affiliation Fee		6,00,000	-
30) Vehicle Maintenance		21,21,432	19,41,686
31) Visiting Students Programme		8,59,842	5,39,206
32) Water Charges		4,17,937	7,62,913
	Total	14,26,78,883	11,33,48,305
Schedule 22- Expenditure on Grants / Subsidies			
	NOT APPLICABLE	Current Year	Previous Year
	Total	-	-
Schedule 23- Interest			
	NOT APPLICABLE	Current Year	Previous Year
	Total	-	-

RAMAN RESEARCH INSTITUTE, BANGALORE

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 net 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%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 net 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 net 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.

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
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 Pension funds managed by SBI Life Insurance Company Limited, 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. Evaluation of the adequacy of retirement funds is taken up once in 5 years and in that cycle, the evaluation will be carried out in the ensuing financial year. In view of this, no provision has been made during the year in respect of incremental liability, if any. 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 31-3-2021, 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 4/187-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
- 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. 21,62,647/-** has been apportioned on the basis of monthly outstanding unspent grant balances
5. Schedules 1 to 25 are annexed to and form an integral part of the Balance Sheet as at **31st March 2022** and the Income & Expenditure Account for the year ended on that date.
6. 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

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

Sd/-
(Tarun Souradeep Ghosh)
Director

Sd/-
(B. Anand)
Partner
M. No. 029146

BANGALORE / 05-07-2022





**FOR FURTHER INFORMATION, PLEASE WRITE TO
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