ANNUAL
REPORT
2022-23

Science and Engineering Research Board

विज्ञान और इंजीनियरी अनुसंधान बोर्ड

SCIENCE AND ENGINEERING RESEARCH BOARD

ANNUAL **REPORT** **2022-23**

From the Secretary's Desk

It is my pleasure to present the Annual progress and activities of the Science and Engineering Research Board (SERB), Department of Science and Technology during the financial year 2022-2023. The Board is continuously devising innovative schemes for R&D in frontier areas of Science and Engineering. Its interventions are primarily focused on expanding the country's research base without compromising the research quality. In a short span of time, SERB has developed a strong connection with the scientific community of the country. It supports all the research needs of its stakeholders across various disciplines in the form of grants and fellowships.

Science and Engineering Research Board's-State University Research Excellence (SERB-SURE) scheme was recently launched to increase the research capabilities in a structured way, to establish a powerful R&D ecosystem in the state as well as private universities & colleges. The scheme would also cater to self-financed institutions operational within these universities. It will help in bringing the university system into mainstream research and enable young faculty to participate in cutting-edge research. It would also extend support to data-driven social science research. Faculties of state universities (45% in rural areas) would get opportunities for research, as a part of this scheme. Research support under SERB-SURE is critical for strengthening the STI ecosystem in the country, which is the need of the hour.

While the number of female students in STEM has risen, their participation in the workforce remains low. India is striving towards bringing gender equity and inclusion in Science and Technology. The SERB POWER Mobility program aims to provide opportunities for Indian Women Scientists, Engineers, and Technologists to undertake collaborative research and gain exposure to excellent research facilities at the international level. There is a need for outreach initiatives for taking science to broader audiences and building a robust research ecosystem.

I wish to place on record my sincere gratitude to the SERB Board, Program Advisory/Expert Committees, and all partners for their support in strengthening the Indian research ecosystem and India's rise as a global scientific power.

(Dr. Akhilesh Gupta)

Dr. AKHILESH GUPTA

Secretary, SERB

CONTENTS _____

1

THE ORGANIZATION

The Science and Engineering Research Board (SERB), a statutory body of the Department of Science and Technology was operational in the year 2011 for planning, promoting and funding internationally competitive research in the emerging areas of Science and Engineering. SERB, since its inception, has been instrumental in building a sustainable research ecosystem in the country through its diverse programme portfolio that includes research grant funding, fostering young researchers, recognizing and rewarding research excellence, promoting scientific networks and partnerships, along with enhancing gender and social inclusiveness. Through its programmes, policies, procedures and practices, SERB strides ahead in its mission to advance scientific research in the country.
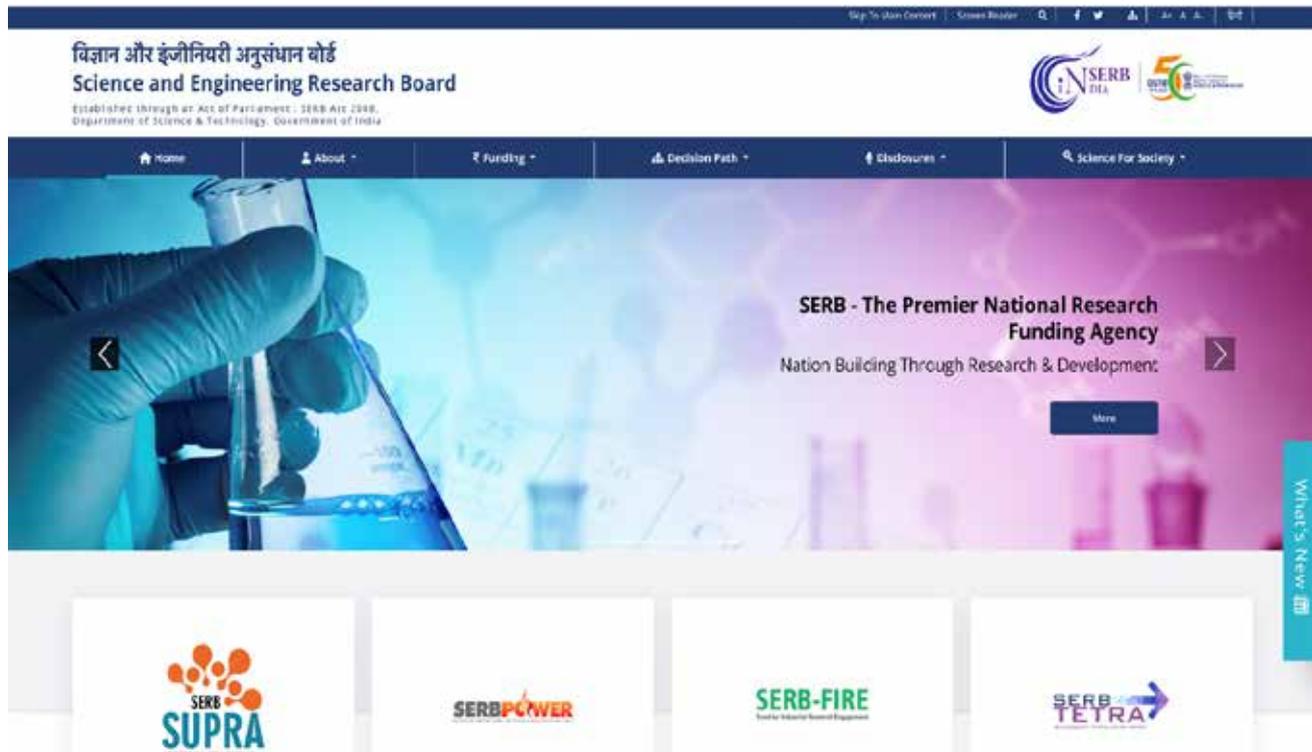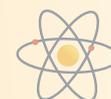
1.1 Vision, Mission & Goals

To better focus its energies and resources on the realization of its mandate, SERB defined its vision, mission, and goals as per the following.
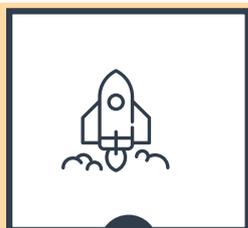
VISION

To position science and technology as the fulcrum for social and economic change by supporting competitive, relevant, and quality scientific research and development.

GOALS

I. Stimulating the search for new knowledge and encouraging invention, discovery, innovation, and development by supporting bottom-up research competitively and at all levels of our research eco-system.

II. Support conceptually new directions, even when risky, but having the potential for non-incremental and transformative success. Strengthen deep-expertise in specific domains and link them through inter-disciplinary and multi-institutional 'top-down' programmes that address challenging national problems.

III. Develop funding programmes which connect with needs of our society and identify key scientific questions, both basic-science and application that have concrete societal values.

IV. Launch and strengthen programmes to bring in researchers from under represented regions, weaker and marginalized segments of the society.

V. Realizing the importance of gender parity, ensure that all programmes proactively have mechanisms to encourage enhanced and equitable representation of women scientists.

VI. Initiate and strengthen schemes that link teachers in colleges and resource-poor universities with opportunities in active research, thereby aiding in expanding the footprint of quality science.

VII. Through global bilateral and multilateral partnerships support collaborative top-quality research in cutting-edge areas to ensure the rapid growth of quality science in India.

VIII. Scout, mentor, incentivize and reward exceptional performers, teams and institutions.

IX. Show unstinted commitment towards science by constantly improving our methods and swiftness for research support, while ensuring the highest adherence to financial processes.

X. Recognizing that all research support has at its base the development of quality, well-trained researchers; initiate and strengthen programmes of identifying research potential, mentoring, training and hands-on workshops, on a broad-based national scale.

XI. Make SERB the vehicle of choice for all R&D funding agencies for their core programmes by developing inclusive processes and proactively synergizing with them for the requisite integration and consolidation of the research effort in Science and Engineering in the country.

MISSION

As the premier national research funding agency, raise the quality and footprint of Indian Science and Engineering to the highest global levels in an accelerated mode, through calibrated, competitive support of research and development.

1.2 Organization Chart

The organisation structure of SERB is given in Figure 1.1
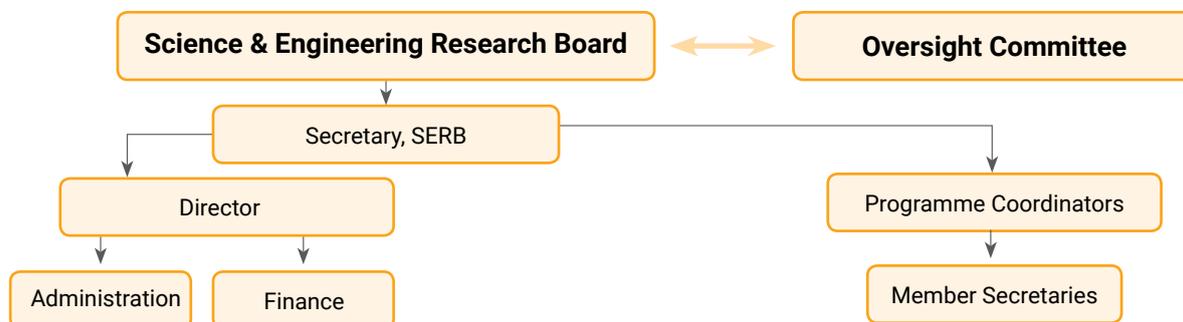
Fig 1.1: Broad Working Organization Chart of SERB

1.3 Programme Chart

The various scientific programmes and schemes handled by SERB are given below (Figure 1.2)
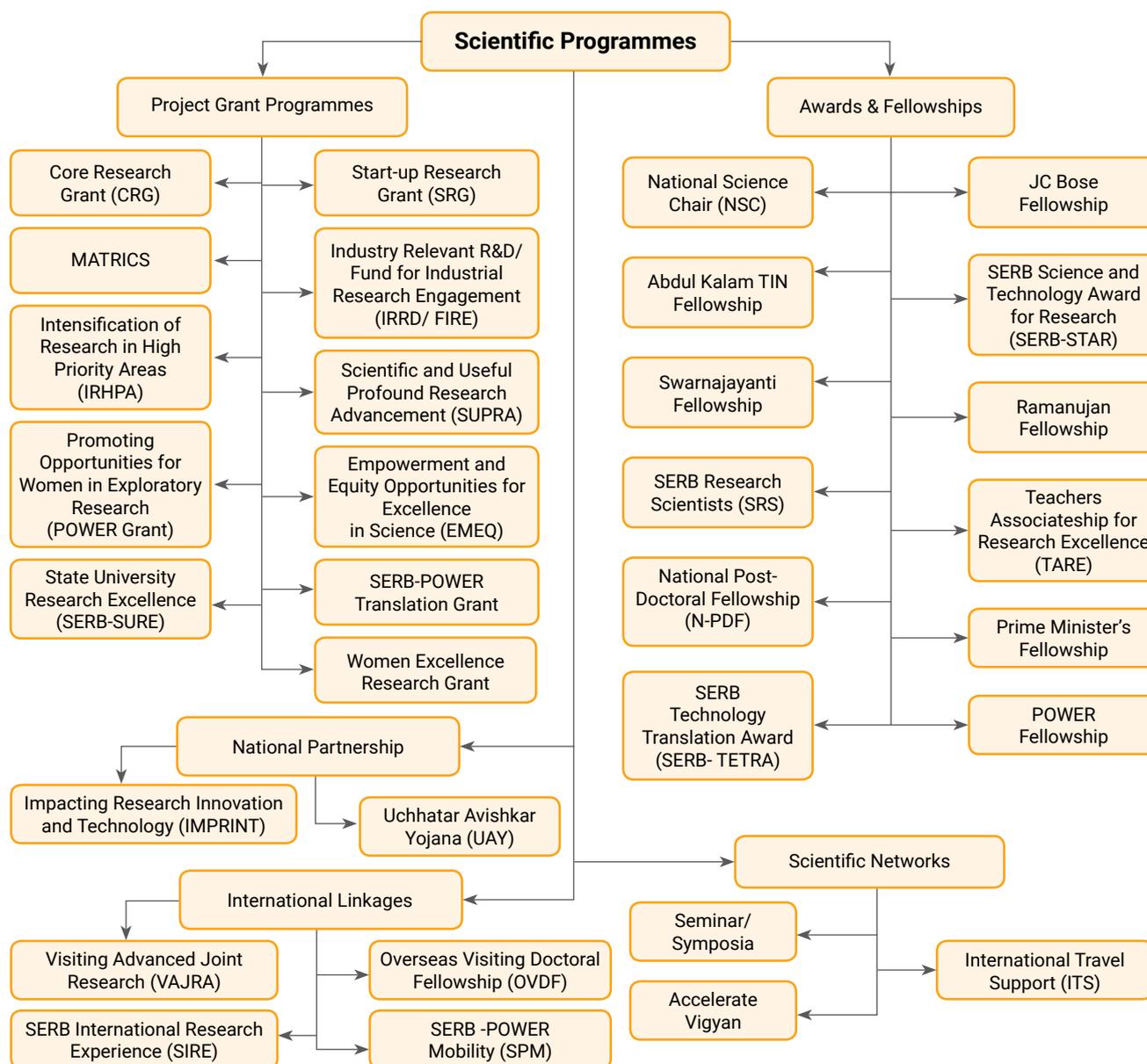
Fig 1.2: Flowchart depicting programmes handled by SERB
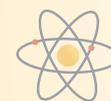
1.4 Board & Oversight Commitee

a) The Board

The Board, chaired by the Secretary of, the Department of Science and Technology (DST), is comprised of 17 members including a few eminent Indian Scientists and six Secretaries to the Government of India. Following are the Members of the Board as depicted in the Flowchart (Figure 1.3).

```
Science and Engineering Research Board  ⟷  Oversight Committee
```

Chairperson

Dr. Srivari Chandrasekhar
Secretary
Dept of Science & Technology

Chairperson

Dr. K Radhakrishnan
Former Secretary
Department of Space

Members of the Board

Members of the Committee

Shri B.V.R Subrahmanyam CEO NITI Aayog	**Dr. Rajesh S Gokhale** Secretary DBT	**Dr. N Kalaiselvi** Secretary DSIR	**Dr. M. Ravichandran** Secretary MoES	**Dr. Srivari Chandrasekhar** Secretary DST	**Dr. Akhilesh Gupta** Secretary SERB
Dr. T.V. Somanathan Secretary Dept. of Expenditure MoF	**Dr. Rajiv Bahl** Secretary Dept. of Health Research MoHFW	**Dr. Vijay Bhatkar** Former, Chancellor Nalanda University Bihar	**Prof.Indranil Manna** Vice Chancellor BIT-Mesra Ranchi	**Prof. Ashutosh Sharma** President, INSA	**Prof. Umesh Waghmare** President Indian Academy of Science
Dr. Virendra M. Tiwari Director CSIR-NGRI	**Prof. Annapurni Subramaniam** Director IIA-Bengaluru	**Prof. T.G. Sitharam** Chairman AICTE	**Prof. S.K. Barik** Professor NEHU, Shillong	**Prof. Indranil Manna** President Indian National Academy of Engineering	**Dr. Tessy Thomas** Director General Aeronautics Systems-DRDO
Prof. M.V. Padma Srivastava Chief Neurosciences Center AIIMS-Delhi	**Prof.V.K. Vijay** Centre for rural development & technology IIT-Delhi	**Shri J. Chaddah** Country Manager Intel India		**Prof. Devang V. Khakhar** Former Director IIT Bombay	**Prof. Talat Ahmad** Former Vice Chancellor University of Kashmir

Fig 1.3: Members of the Board and Oversight Committee

b) The Oversight Committee

The SERB Act provides for the constitution of an Oversight Committee to advise and assist the Board. A scientist of eminence and international repute chairs the Oversight Committee with the Secretary to the Government of India in DST as Vice Chairperson and a few distinguished experts, Secretary to the Board and Presidents of the Indian National Science Academy, Indian Academy of Sciences, and Indian National Academy of Engineering as members. The members of the Oversight Committee are depicted in Figure 1.3.

1.5 The Peer Review Committees

The Board has a robust peer review mechanism for taking funding decisions. The proposals received under various schemes and programmes follow a peer review process, which involves two levels of appraisals. In the first stage, the proposals are sent to domain experts for their comments and the decision is taken by a preliminary screening committee.

In the second stage, the proposals are generally evaluated for funding by specific committees after peer review. A number of Committees have been constituted to evaluate R&D proposals and other applications for seeking support under various schemes and programmes. Major Committees are listed below:

1.5.1 Empowered Committee

An empowered committee is constituted under the Chairmanship of the Secretary, SERB. If the recommended cost of the proposal is greater than Rs.80 Lakh, it is referred to an Empowered Committee.

This committee is empowered to approve projects upto Rs. 5 crores, whereas for proposals costing more than Rs. 5 crores the same committee will serve as an appraisal body to the Board.

1.5.2 Expert Committees/Task Force/ Search cum Selection Committees

Five Expert Committees in broad areas are to help the Board in taking decisions on Start-up Research Grant (SRG) and National Postdoctoral Fellowship (NPDF) proposals. A Task Force constituted under the Board takes decisions on proposals received under EMEQ Scheme. These Committees take funding decisions on proposals received under the said schemes. Two expert committees help SERB in the evaluation of proposals for the SERB Research Scientist (SRS) Scheme and Teachers Associateship for Research Excellence (TARE). Two Expert Committees are to help in the selection of SERB-Power Mobility (SPM) & SERB-Power Translation (SPT). Two search cum selection committees help SERB in the selection of SERB-Power Fellows, J.C Bose Fellows & Ramanujan Fellows. Specific task force committees help SERB in taking decision of the proposals recieved under SIRE, STAR, Women Excellence Reasearch Grants and Special Calls.

1.5.3 Programme Advisory Committee (PAC)

Programme Advisory Committee (PAC) is the first-level peer review committee in the system. Sixteen PACs in various disciplines, each with a composition of 7 - 10 core members and a cohort of experts who can be co-opted in the committees whenever required, were constituted. PACs role is critical in taking decisions on R&D proposals submitted under the schemes.
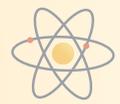
1.6 Growth Profile

The Board has brought forth several innovative programmes and schemes to identify potential scientists and support them in undertaking R&D in frontier areas of Science and Engineering. The Board interventions were primarily focused to expand the research base in the country without compromising the quality of research.

1.6.1 Milestones

The Board has come a long way in its journey from the erstwhile SERC to its current profile and some of the major milestones over the years are shown in Figure 1.4.

Transition from SERC to SERB — 2011

2013-14 — **Online submission of proposals, review and decision making process**

Adoption of "Code of Conduct" and "Conflict of Interest" policy — 2015

2016 — **Global Research Council (GRC) Annual Meeting in India**

Adoption of SERB Scientific Social Responsibility (SSR) policy — 2018

2020 — **Launch of Power Programme, empowerment of Women researcher**

Launch of SERB-PRISM, the real-time information portal of SERB — 2021

2022 — **Strengthen R&D in State Universities/Colleges**

Fig 1.4: Key Milestones of SERB since inception

1.6.2 Adaptability

The Board, since its inception, had introduced several schemes and programme to cater to various segments of the scientific community. Its adaptability to suit the changing S&T needs of the country is depicted in Figure 1.5.
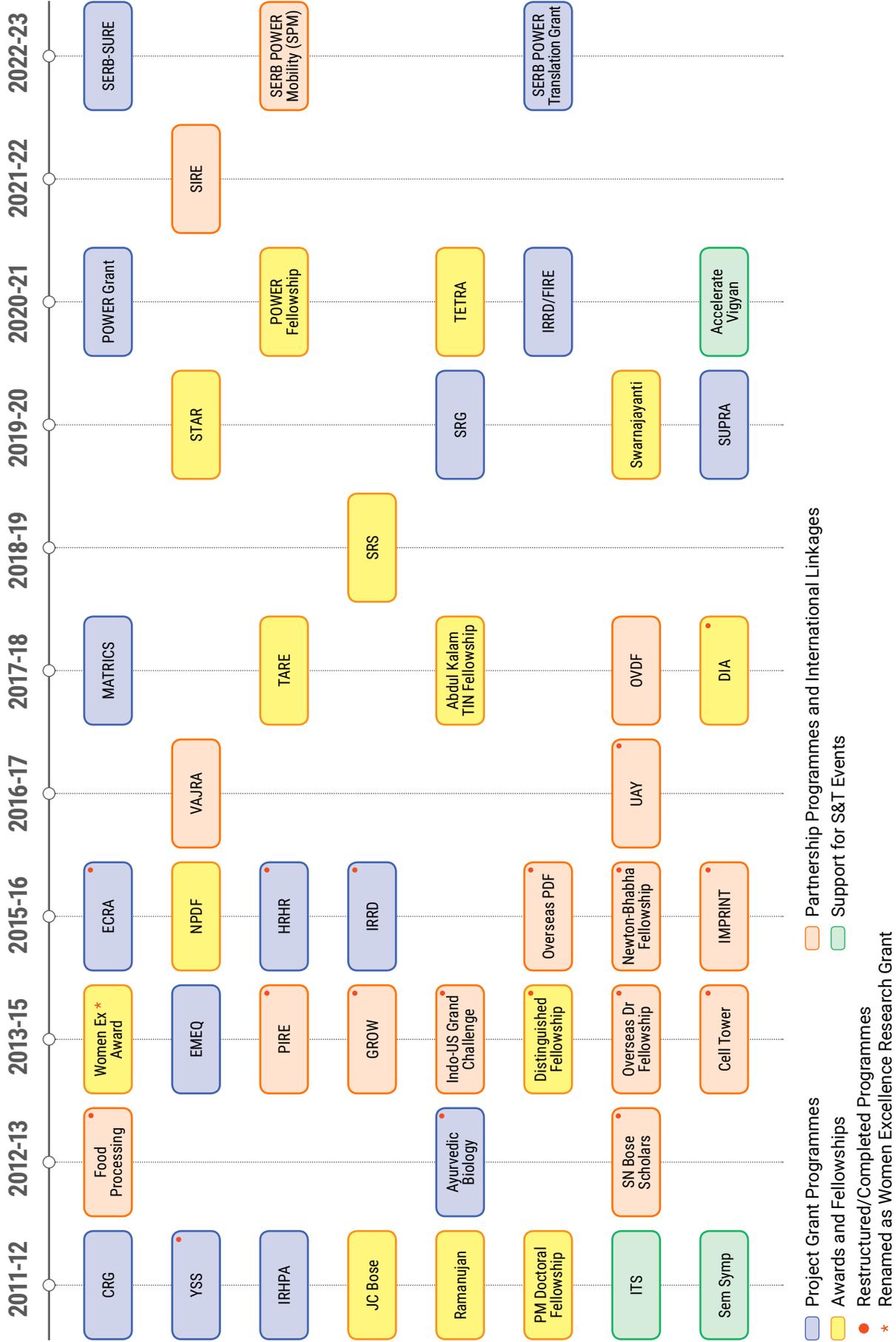
Fig 1.5: The growth profile of SERB programmes since inception

Timeline columns: 2011-12, 2012-13, 2013-15, 2015-16, 2016-17, 2017-18, 2018-19, 2019-20, 2020-21, 2021-22, 2022-23

2022-23: SERB-SURE, SERB POWER Mobility (SPM), SERB POWER Translation Grant

2021-22: SIRE

2020-21: POWER Grant, POWER Fellowship, TETRA, IRRD/FIRE, Accelerate Vigyan

2019-20: STAR, SRG, Swarnajayanti, SUPRA

2018-19: SRS

2017-18: MATRICS, TARE, Abdul Kalam TIN Fellowship, OVDF, DIA

2016-17: VAJRA, UAY

2015-16: ECRA, NPDF, HRHR, IRRD, Overseas PDF, Newton-Bhabha Fellowship, IMPRINT

2013-15: Women Ex Award *, EMEQ, PIRE, GROW, Indo-US Grand Challenge, Distinguished Fellowship, Overseas Dr Fellowship, Cell Tower

2012-13: Food Processing, Ayurvedic Biology, SN Bose Scholars

2011-12: CRG, YSS, IRHPA, JC Bose, Ramanujan, PM Doctoral Fellowship, ITS, Sem Symp

Legend:
- Project Grant Programmes
- Awards and Fellowships
- Restructured/Completed Programmes
- ● Renamed as Women Excellence Research Grant
- *
- Partnership Programmes and International Linkages
- Support for S&T Events

1.6.3 Budget

A Steady growth in terms of budgetary allocation for SERB was observed over the past many years. The allocation for SERB since inception is shown in Figure 1.6.

Allocation(in Crore)

Year	Allocation
2011-12	200
2012-13	400
2013-14	530
2014-15	535
2015-16	660
2016-17	767
2017-18	800
2018-19	1000
2019-20	956.57
2020-21	742
2021-22	911.46
2022-23	813.07

Fig 1.6: Budget Allocation
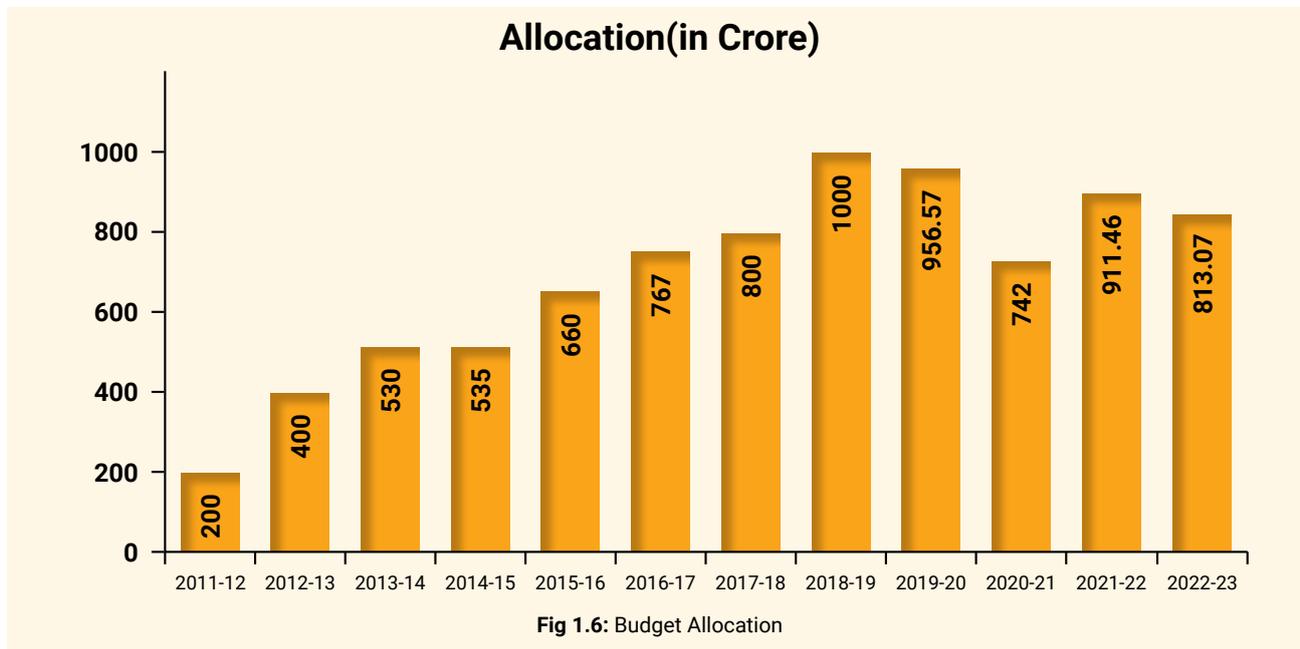
2

OVERVIEW

SERB serves as a premier national funding agency and the mandate is to promote R&D activities through appropriate policy interventions and to provide extramural funding to the researchers associated with various academic institutions, research laboratories and other R&D organizations for carrying out competitive basic or fundamental research in all frontier areas of Science and Engineering. SERB strives to serve the needs of the researchers by making timely funding decisions and responding to their responses. To achieve this, the Board has established a necessary policy and administrative framework that overrides conflicts of interest of grant-seeking applicants, reviewers, committee members and SERB officers elevating its functioning to the levels of leading global R&D funding agencies. The overall aim is to ensure transparency and accountability in order to assure the general public that the mechanisms in place are fair and non-discriminatory.

SERB continued the R&D support for the COVID-19-related projects that were initiated in response to the pandemic in the areas of affordable diagnostics, new or repurposed antivirals, vaccine development and as well as projects supported to catalyze R&D on critical components and innovations relating to make-in-India oxygen concentrators. In addition to the above R&D activities, SERB also implemented wastewater-based epidemiological monitoring for the SARS-CoV-2 virus across the country to monitor the viral load in the open drain systems in major cities.

In the said financial year, SERB continued to fund the ongoing research projects that are supported under various programmes and schemes. The new proposals received under various programmes and schemes were evaluated and funding decisions were made in the said financial year. The evaluation and monitoring meetings were organized to review the progress of ongoing and completed projects. In order to advance innovation and discoveries beyond the frontiers of current R&D activities SERB launched new programmes. In light of the pandemic situation, the ongoing projects were given no-cost extensions for the successful completion of the committed work. While a detailed account of activities and initiatives of SERB in the year 2022-23 are presented in the following chapters, the highlights are briefly indicated in this overview.

2.1 Ongoing Programmes / Schemes

SERB continued its research support through its ongoing programmes and schemes, the salient aspects of which are described below.

Core Research Grant (CRG) is the flagship programme of SERB. It provides individual-centric research support to researchers from academic institutions, research laboratories and other R&D institutions for undertaking research in the frontier areas of science and engineering. The support is provided for three years with no budget caps. One call for proposals was solicited and 8898 applications were received. A total
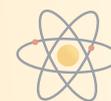
of 950 projects were sanctioned under the 16 research verticals. It includes special calls.

Start-up Research Grant (SRG) programme aims to aid researchers to initiate research careers in a new institution. It is meant to enable researchers to establish themselves and move on to mainstream research grants. The support comprises a flexibly structured research grant of Rs. 30 lakhs plus overheads for a period of two years. One call for proposals was solicited and 2711 grant applications were received. A total of 488 projects were sanctioned under SRG in the year 2022-23. The ongoing projects under the erstwhile Early Career Research Award (ECRA) continued to be supported and the completed Young Scientist Scheme (YSS) projects were processed for settlement and closure.

MATRICS is to provide fixed grant support to active researchers with good credentials in Mathematical, Theoretical and Quantitative, Social Sciences. The main feature of the scheme is the submission of a simple proposal and a flexible grant to cater to the specific needs of Mathematical, Theoretical and Quantitative Sciences research. One call for proposals was solicited and 1563 proposals were received. A total of 185 grants were sanctioned in the reporting period.

Scientific and Useful Profound Research Advancement (SUPRA) is formulated to explore new scientific breakthroughs, challenging the existing hypothesis and offering disruptive technologies in cutting-edge research areas. The proposed research is expected to contain significant risk elements but promises high rewards if the difficulties could be circumvented. The funding is provided normally for a period of three years. In the reporting period, a total of 367 proposals were received and 24 proposals were sanctioned under the SERB-SUPRA scheme.

Empowerment and Equity Opportunities for Excellence in Science (EMEQ) scheme is aimed to provide research support to researchers belonging to the Scheduled Caste and Scheduled Tribe to undertake research in frontier areas of science and engineering. Support consists of a project grant up to Rs. 50 lakh excluding overhead charges. One call for proposals was solicited in which 1065 proposals were received. 266 new projects were sanctioned in the reporting period.

National Science Chair (NSC) intends to recognise distinguished Indian superannuated scientists for their outstanding contributions in the areas of Science, Technology, Engineering and Mathematics (STEM) to promote excellence and growth in R&D. The NSC is provided in two modes, Mode 1: Scientific Excellence, the objective of which is to extend continuance of support for excellence in R&D activities and Mode 2:

Science Leadership which is more to do with recognition for thought leadership made by the awardee in his professional career. For the reporting period, 6 National Science Chair were sanctioned under Mode -1 and the search cum selection committee did not recommend any applicants for the Mode 2 category.

JC Bose Fellowship is awarded to active scientists as a recognition for their outstanding performance in the field of Science and Engineering. The fellowship is scientist-specific and highly competitive. 25 fellowships were sanctioned under the J C Bose Fellowship scheme in the reporting period.

Abdul Kalam Technology Innovation (AKTIN) Fellowship is awarded to outstanding engineers to recognize, encourage and support translational research of excellence in the fields of engineering, innovation and technology development. 10 AKTIN fellowships were recommended in the reporting period.

SERB Science and Technology Award for Research (SERB-STAR) is a prestigious award instituted by SERB to recognize and reward the outstanding performance of Principle Investigators (PIs) of SERB Projects. The award consists of a fellowship of Rs. 15,000 per month, a research grant of Rs. 10 lakh per annum and Rs. 1 lakh per annum as overhead charges for a period of three years. The fourth call for nominations was made in the year 2022- 23 in which 49 nominations were received out of which 22 nominations were recommended for STAR award.

SERB-Technology Translation Award (SERB-TETRA) is to catalyze technology translation in an academic setting. SERB-TETRA will challenge scientists executing SERB grants to establish an effective, functional, and synergistic working collaboration with an industry partner to elevate their breakthrough results and technologies to TRL-5 and beyond. The awardees are supported with an unstructured research grant of Rs. 15 lakh per year including overhead for a period of two years. In the reporting period, 1 project was sanctioned.

Swarnajayanti Fellowship was instituted by the Government of India, to commemorate India's fiftieth year of independence. The aim of this scheme is to incentivize young scientists with excellent research track records, by supporting their innovative projects in frontier areas of science and technology. The award is scientist-specific and very selective. The award consists of a fellowship of Rs. 25,000 per month, in addition to a salary drawn from the parent institute, for a period of five years. SERB supports the project component of the award through research grants. The award entails a flexible funding module to tailor support suited for individual research needs, which helps to diversify and broaden the scope of research. For the reporting period, the ongoing projects supported under

the Swarnajyanthi fellowship got continuing support and 1 fellowship was sanctioned during the financial year 2022-2023.

Ramanujan Fellowship offers support to brilliant Indian scientists and engineers returning from all over the world to pursue their research careers in India. This fellowship supports young researchers below the age of 40 years with a proven outstanding track record. The Ramanujan Fellows can work in any of the scientific institutions and universities across the country. The amount of fellowship offered under the scheme is Rs. 1,35,000 per month with a research grant of Rs. 7 lakh per annum and overhead charges of Rs.60,000 per annum for a period of five years. In the reporting period, 19 Ramanujan Fellowships were sanctioned.

SERB Research Scientists (SRS) scheme was initiated in 2018-19 to provide a platform for the sustainment of research careers of INSPIRE Faculty and Ramanujan Fellows for an additional period of two years. The amount of fellowship is Rs.1,25,000 per month and in addition, a research grant of Rs. 7 lakh per annum and overhead charges are provided. In the reporting period, 18 Fellowships were sanctioned.

Teachers Associateship for Research Excellence (TARE) scheme intends to facilitate mobility of faculty members working in state universities, colleges and private academic institutions to carry out research in an established public funded institutions such as IITs, IISc, IISERs, NITs, national institutions and central universities, preferably closer to the institution where the faculty member is working. The support consists of a research fellowship of Rs. 60,000 per annum subject to completion of a minimum of 90 days of research work per year in the host institution and a research grant of Rs. 5 lakh per annum and overheads. One call for applications was solicited and 475 applications were received. A total of 102 TARE associateships were sanctioned in the reporting period.

SERB National Postdoctoral Fellowship (NPDF) programme is designed to support and foster highly potential young researchers in leading research labs with accomplished mentors. The support consists of a fellowship of Rs. 55,000 per month plus HRA, a research grant of Rs. 2 lakh per annum and overhead for a period of two years. One call for proposals was solicited and received 3846 applications. In the reporting period, 235 SERB NPDF fellowships were sanctioned.

SERB Women Excellence Research Grant is a prestigious grant instituted to recognize and reward outstanding research achievements of young women scientists in frontier areas of Science and Engineering. The grant strives to serve as a source of inspiration to women scientists who have the potential to become world-class leaders in their fields of research. Women

scientists below 40 years of age who have received recognition from one or more of the National Science and Engineering Academies are considered for this grant. The PIs are supported with a research grant of Rs. 5 lakh per annum for a period of three years. In the reporting period, 3 SERB Women Excellence Research Grants were sanctioned.

SERB-POWER (Promoting Opportunities for Women in Exploratory Research) is to mitigate the gender disparity in science and engineering research funding in various S&T programmes in Indian academic institutions and R&D laboratories. SERB-POWER is specially designed to provide structured support towards enhancing diversity in research and to ensure equal access and weighted opportunities for Indian women scientists engaged in R&D activities. The funding framework consists of two categories: SERB – POWER Fellowship and SERB – POWER Research Grants.

The one call for proposals under SERB–POWER scheme was solicited, and 2685 proposals were received under SERB–POWER Grants and 231 projects were sanctioned. For SERB POWER fellowships 163 nominations were considered out of which 22 were recommended and 9 were sanctioned in the reporting period.

IMPRINT-II (Impacting Research Innovation and Technology) is a program piloted by the Ministry of Education (MoE) (previously, the Ministry of Human Resource and Development) and the Department of Science and Technology (DST). The programme aims to address and provide solutions to the most relevant engineering challenges faced by our nation by translating knowledge into viable technology (products and processes) in selected domains. IMPRINT-IIC.2, a consortium-based approach initiated under this programme, includes strong and complementary expertise from different disciplines in order to address major technological breakthroughs in designated areas towards addressing societal/industrial importance. SERB has been entrusted for the implementation of this programme. Out of the 08 approved projects, 03 were supported under IMPRINT-II C.2 while the ongoing projects of IMPRINT-II received continued support in the reporting period.

Visiting Advanced Joint Research (VAJRA) Faculty Scheme aims to tap the expertise of overseas faculty/ scientists including non-resident Indians (NRIs) and OCIs to undertake high-quality collaborative research in publicly funded academic and research institutions in India. In the reporting period 19 Visiting Advanced Joint Research facultyship were sanctioned.

SERB-International Research Exposure (SIRE) program is to impart high-end research training to young scientists in the frontier areas of science and
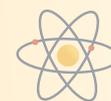
technology. The candidates selected under this program will be supported for a period of 02-06 months to visit top institutions around the globe, preferably the institutions where internationally acclaimed scientists are working. A total of 194 young scientists were recommended under various disciplines to impart high-end research training in frontier areas of science, technology, engineering, mathematics and quantitative social sciences out of which 148 scientists have been benefited under this programme.

International Travel Support Scheme (ITS) scheme provides financial assistance to Indian researchers for presenting an original research paper or chairing a session or delivering a keynote address at an International scientific event held abroad. In addition, support is also provided to young scientists (less than 35 yrs) for attending training programs, short-term schools and workshops. SERB supports round-the-trip economy class air fare by the shortest route and visa fees for attending the specific event. Registration fee is also provided to young scientists in addition to the above support. A total of 1644 researchers were recommended for attending the various international events.

Assistance to Professional bodies & Seminars/ Symposia is to support events having a strong orientation towards scientific research in the areas of basic sciences, engineering, technology, agriculture and medicine. SERB, extends partial support for organizing seminars/symposia/training programs/workshops/ conferences at national as well international levels in the above-mentioned research areas. The support is provided to Research institutes/ Universities/ Medical and Engineering Colleges and other Academic Institutions/ Professional bodies who organize such events for the scientific community to keep them abreast of the latest development in their specific areas. A total of 592 events were recommended in the reporting period.

Accelerate Vigyan is an inter-ministerial initiative scheme conceptualized and steered by SERB. The aim of the scheme is to expand the research base, with three broad goals – consolidation and aggregation of all national scientific training programs, initiating High end Orientation Workshops and creating opportunities for Research Internships. During the reporting period, 886 applications were received for High End Workshop (Karyashala-613 Applications) and Training & Skill Internship (Vritika-273 Applications). A total of 281 and 152 applications were supported for High End Workshop and Training & Skill Internship, respectively.

SERB-Conclave on thematic areas: SERB organized the following conclaves/workshops to disseminate the knowledge, ideas, information and future plans among various stakeholders on the following thematic areas.

(i). Professional Advancement Program for Indian Women Researchers in STEM: Two-day event was organized at Doon University, Dehradun in the month of June 2022, to enhance the skills and competence of women scientists and academicians in the field of STEM. In addition, the program also focused to sensitize women researchers in STEM for translational research and enable them to acquire competence for ensuring equal access and weighted opportunities in government funding schemes and programs. Nearly 200 women researchers and faculty members from various states of the country attended the program.

(ii). R&D funding opportunities and awareness workshop for researchers from North-East Institutions: The two-day conclave cum workshop was organized on R&D funding opportunities provided by DST-SERB to create awareness for researchers from North-East institutions in the month of July 2022 at the Indian Institute of Technology, Guwahati, Assam. The aim of the awareness workshop was to disseminate information on the different schemes and programs offered by DST-SERB for various stakeholders. Participants from Assam, Nagaland, Manipur, Meghalaya, Sikkim and Tripura attended the workshop. The themes of the workshop were Biodiversity & Environment Conservation, Translation and Entrepreneurship, Natural Principles for Healthcare, Empowering Women in Research and Leadership and Proposals. Funding opportunities and Ethics were discussed.

(iii). SERB Digital Gaming Research Initiative: SERB-INAE jointly organized a conclave to discuss the available technologies and the research potential in the field of gaming in India. The one-day conclave was organized in the month of July 2022 at JW Marriot, New Delhi to deliberate the need for research initiatives in the field of gaming and how digital gaming can make a difference in learning patterns in education and also the efforts for making indigenous leisure gaming platforms. The experts from Academia, Startups, and Industry actively participated in the said event. The notable speakers were Prof. Santanu Choudhury, Director, IIT-Jodhpur, Dr Shailja Vaidya, Scientific Advisor, DBT, Shri. Vipin Sondhi, Chairman, CII National Committee and Mission on Technology, Innovation and Research and Ms Anju Bobby George, VP, of the Athletics Federation of India as Special Guests.

(iv). Women driving Science and Technology in India: Two-day national event on "Women driving science and technology in India was organized by the Centre of Biomedical Research (CBMR), Lucknow under the aegis of SERB in the month of August 2022. The aim of the event was to provide a platform for doctoral students and early career faculty from the state of Uttar Pradesh to get familiar with the existing and /

or potential S&T opportunities for women in both the academic and corporate sectors of India. Nearly 200 participants from various institutes spanned across the Uttar Pradesh state participated in the said program.

(v). Energy Conclave at Institute of Nano Science and Technology (INST), Mohali: The energy conclave under SERB Centre for Energy Transformation and Storage was organized for two days in the month of September 2022 at INST, Mohali to discuss the ideas, information and future plans in the area of energy, transformation and storage. For the said event nearly 200 participants from various institutes across the country benefitted

(vi). Women in Science and Technology- Fostering innovation: The conclave was organized at the Indian Institute of Technology (IIT), Gandhinagar in the month of September 2022. The aim of the event was to encourage women researchers, scientists and engineers to translate their innovative ideas into technology and also provide a platform for women researchers to interact with industry experts. The notable speakers were Dr Archana Sharma, Sr. Advisor for relations with international organizations, CERN,

Geneva, Switzerland, the keynote speaker, Dr Ravinder Kaur from Siemens Health care Pvt, Ltd, Bengaluru, Dr Kamala Rai from Novartis, Hyderabad, etc. For this event, nearly 150 women researchers participated in the said program.

SERB- Vision Oriented Thought Exchange (VORTEX) program is to strengthen national S&T activities by interconnecting the active researchers to exchange the emergence of newer ideas in the field of science and engineering disciplines. SERB conducted a one-day VORTEX program on the present status and future prospects on the preparedness of the utilization of SERB National Cyro-Electron Microscopy facilities held at the Indian Institute of Technology, Bombay, on 5th May 2022. Experts in the field of Cryo-EM and structural biology were invited to deliver a talk on various aspects of structural biology focussing on expanding the capabilities and infrastructure for cryo-EM, Structural and functional insights into infectious disease biology using cryo-EM, understanding the structures of the newly synthesized compounds, etc. In this event post-graduate, doctoral students, young investigators and eminent scientists participated in the program.

2.2 New Initiatives

State University Research Excellence (SERB-SURE) is initiated to augment the research capabilities in a structured way to create a robust R&D ecosystem in state universities and colleges. The scheme provides research support to active researchers belonging to state universities and colleges including private universities and colleges across the country to undertake research and development in frontier areas of science, engineering and quantitative social sciences. The first call for proposals under the SERB-SURE scheme was solicited and received 5592 proposals.

SERB-POWER Mobility (SPM) is exclusively formulated to impart high-end research training in all frontier areas of science and technology for selected women scientists. Under this scheme the selected women scientists will be supported for a period of 01-03 months to visit top institutions around the globe, preferably to the institutions where internationally acclaimed scientists are working. The first call for proposals was announced and received 74 proposals in the reporting period.

SERB-POWER Translation Grant (SPT) In addition to grants and fellowships, SERB-POWER Translational verticals are initiated to encourage women researchers to translate their innovative ideas,

discoveries and inventions. This will catalyze the spirit of entrepreneurship among women researchers from tier I and II institutions. This program will challenge women scientists executing SERB grants such as CRG, SERB-POWER, etc to establish an effective, functional and synergistic working collaboration with an industry partner to elevate their breakthrough results and technologies to TRL level 5 and beyond. One call for proposals was solicited and received 38 proposals.

Special call for proposals- SERB-FIRE (Funds for Industrial Research Engagement) scheme. Under the FIRE scheme, SERB in collaboration with Industries (Applied Materials (AMAT), General Electricals (GE) and Intel, India) the following special call for R&D proposals were solicited from scientists on specific themes under the following thrust areas:

(i). Health care technologies

(ii). Aviation and Renewable Technologies

(iii). Next-generation Artificial Intelligence and Machine learning.

Three separate calls for proposals were solicited, wherein 13 projects were recommended, and 2 projects were sanctioned during the reporting period from 182 proposals received under this initiative.
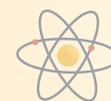
2.3 COVID-19 related R&D Initiatives

SERB continued the R&D support for the COVID-19-related projects that were initiated in response to the pandemic in the areas of affordable diagnostics, new or repurposed antivirals, vaccine development and as well as projects supported under critical components and innovations relating to make-in-India oxygen concentrators.

In addition to the above ongoing COVID-19 R&D activities, SERB also implemented wastewater-based epidemiological monitoring for the SARS-CoV-2 virus in the open drain systems and supported 15 proposals to cover all major cities across the country. SERB also conducted interim monitoring meetings to evaluate the work progress accomplished for the ongoing and completed COVID-19 projects supported during the first and second pandemics.

2.4 Total Expenditure for The Year 2022-23

The below chart depicts the total expenditure of Rs 813.07 crores in the year 2022-23 under different schemes and administrative heads.

SUPPORT FOR SCHEDULE CASTE
52.00

SUPPORT FOR SCHEDULE TRIBE
15.00

YSS+ECRA
5.69

ADMIN & ESTABLISHMENT
19.52

OTHERS
80.23

SERB-POWER
49.18

FELLOWSHIP
99.09

SRG
109.42

NPDF
37.92

SALARIES
6.63

IRHPA
13.08

SUPRA
15.07

IRRD
0.43

CRG/EMR
309.81
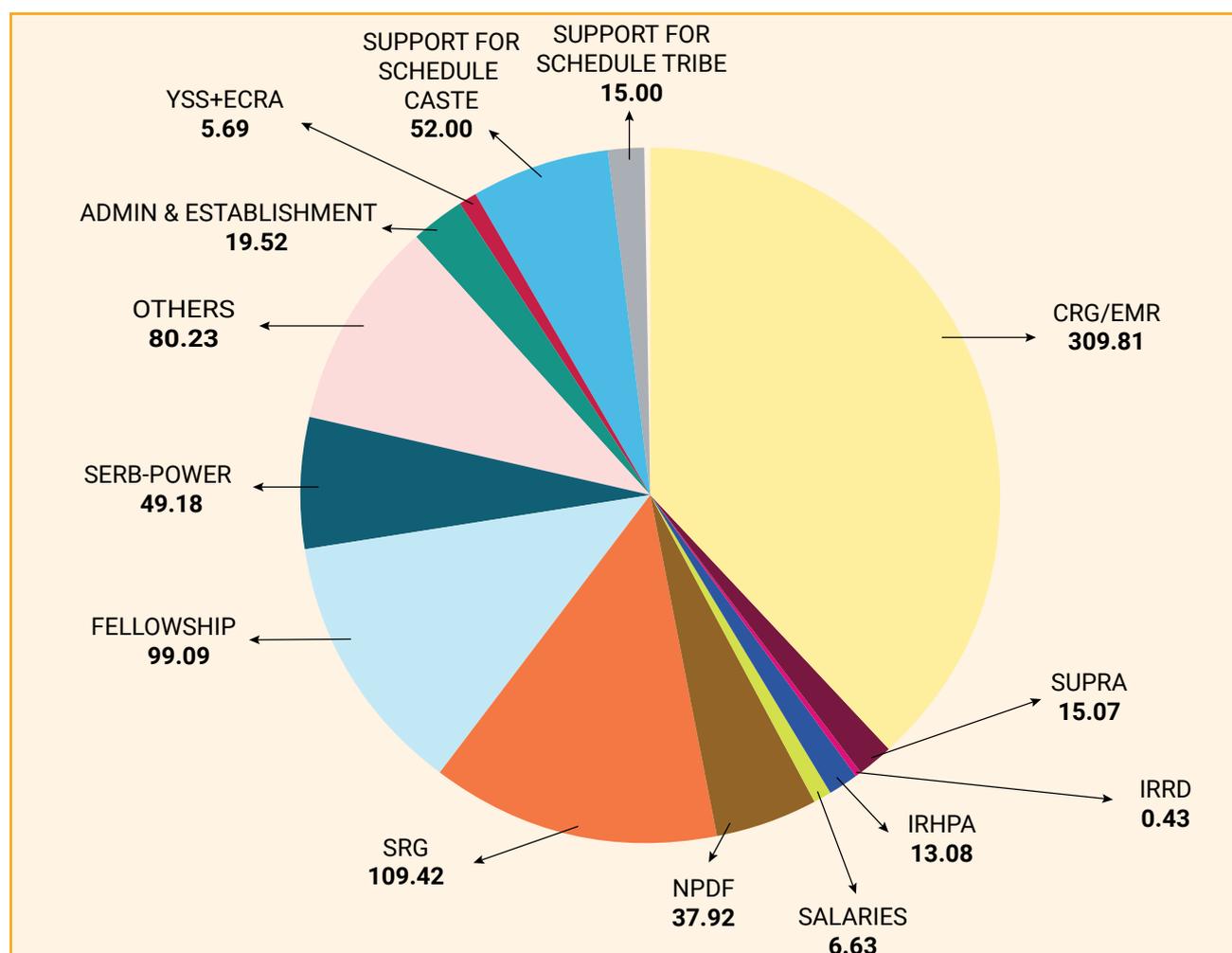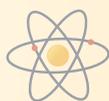
2.5 New Proposals Sanctioned During the Year 2022-23

The number of new proposals sanctioned in the year 2022-23 under the CRG scheme distributed sub-discipline-wise is given below:
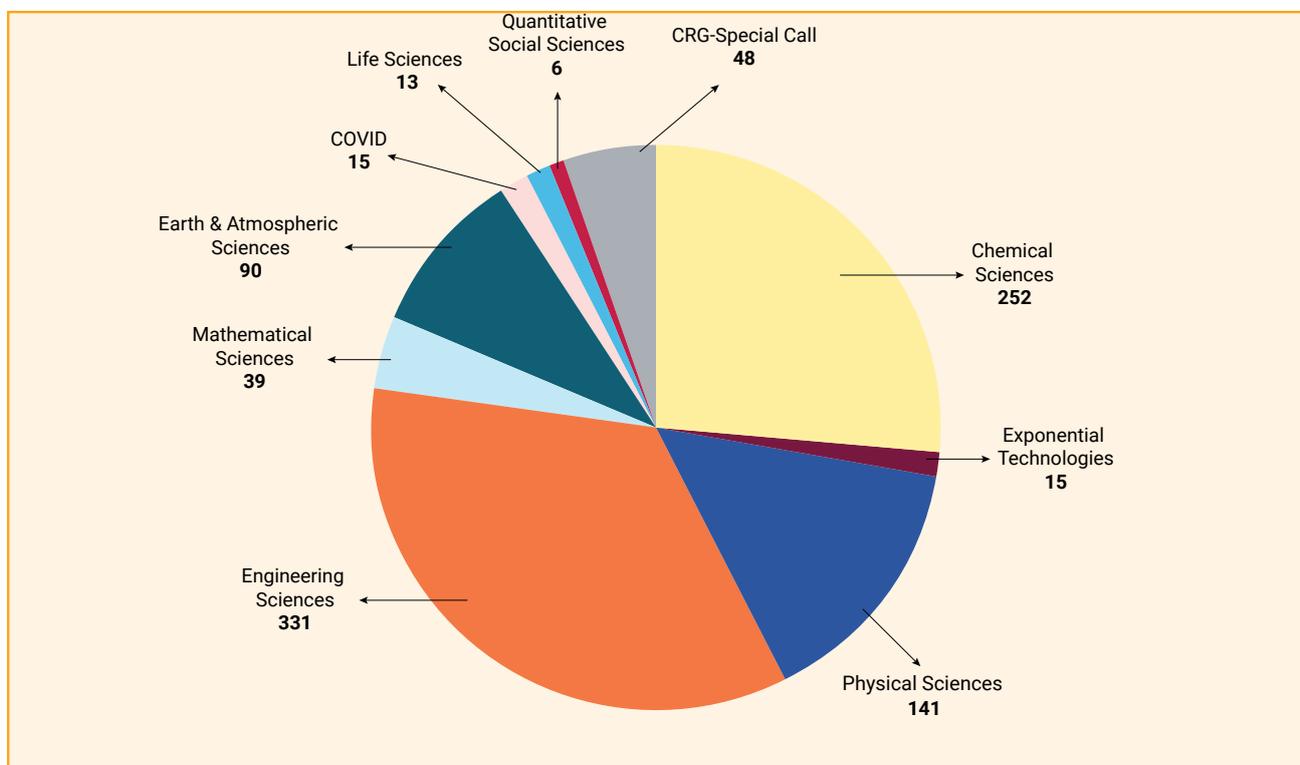
The number of new proposals sanctioned in the year 2022-23 under SRG and NPDF scheme distributed sub-discipline-wise are given below:

NPDF

- Engineering Sciences **57**
- Chemical Sciences **48**
- Physical & Mathematical Sciences **52**
- Life Sciences **60**
- Earth & Atmospheric Sciences **18**
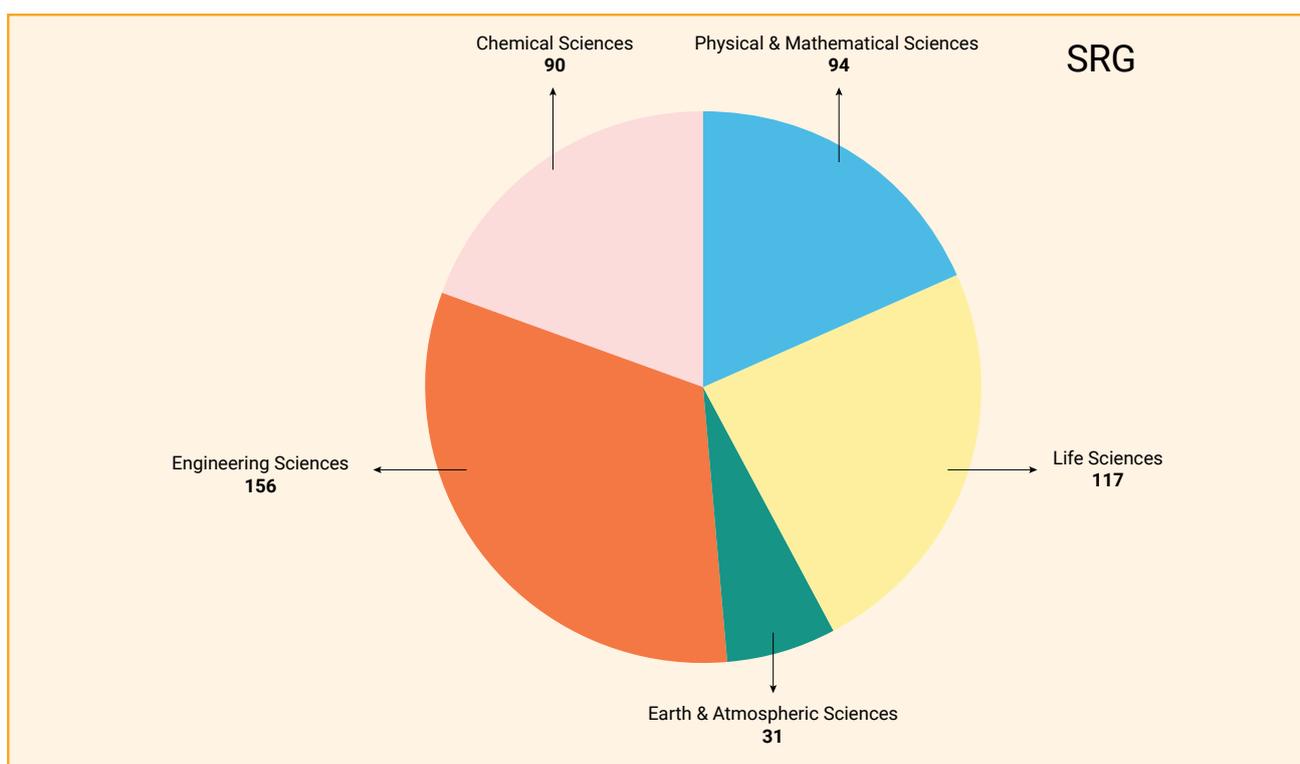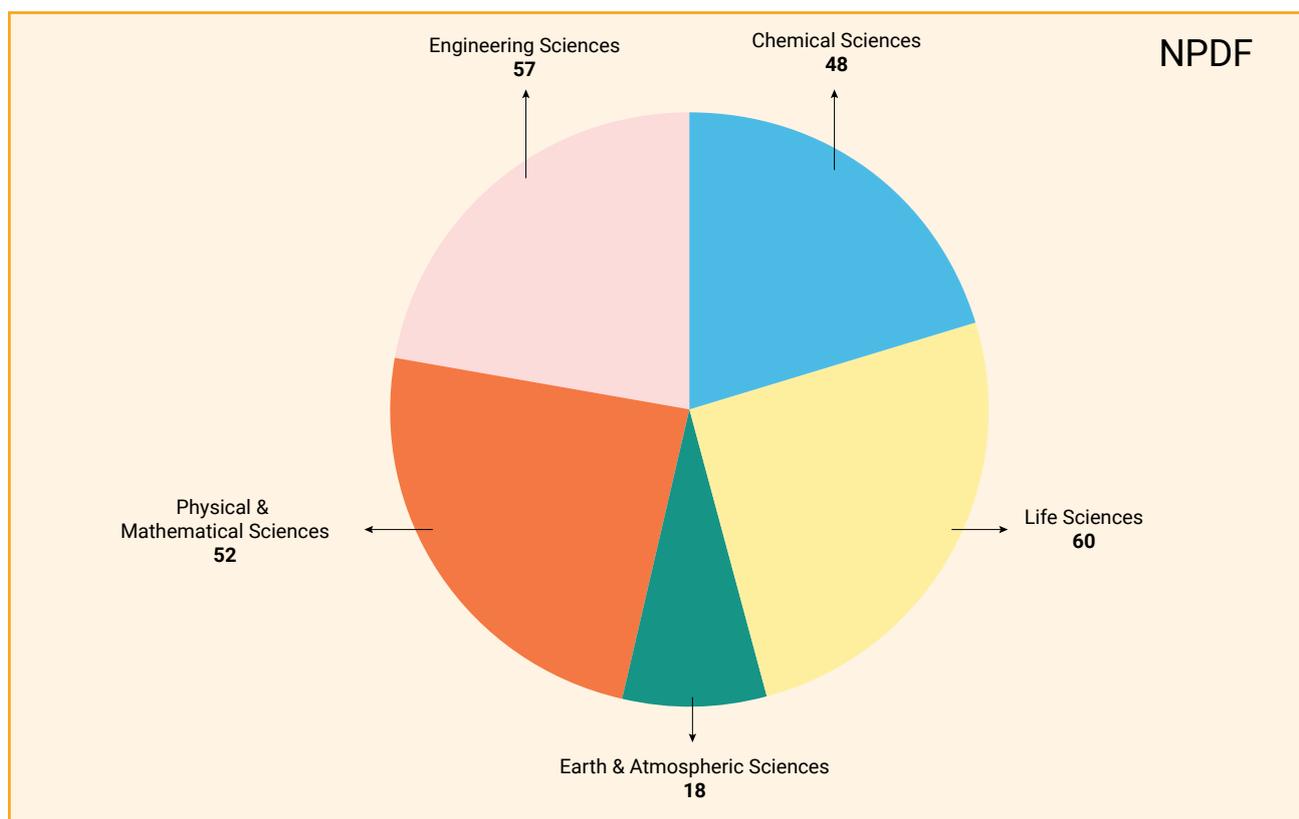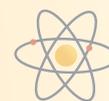
The number of new proposals sanctioned to women candidates in the year 2022-23 under different schemes are given below:

- TARE **48**
- SUPRA **3**
- CRG **88**
- SRG **84**
- EMEQ **47**
- MATRICS **20**
- NPDF **91**
- SERB-POWER **240**
- SIRE **31**
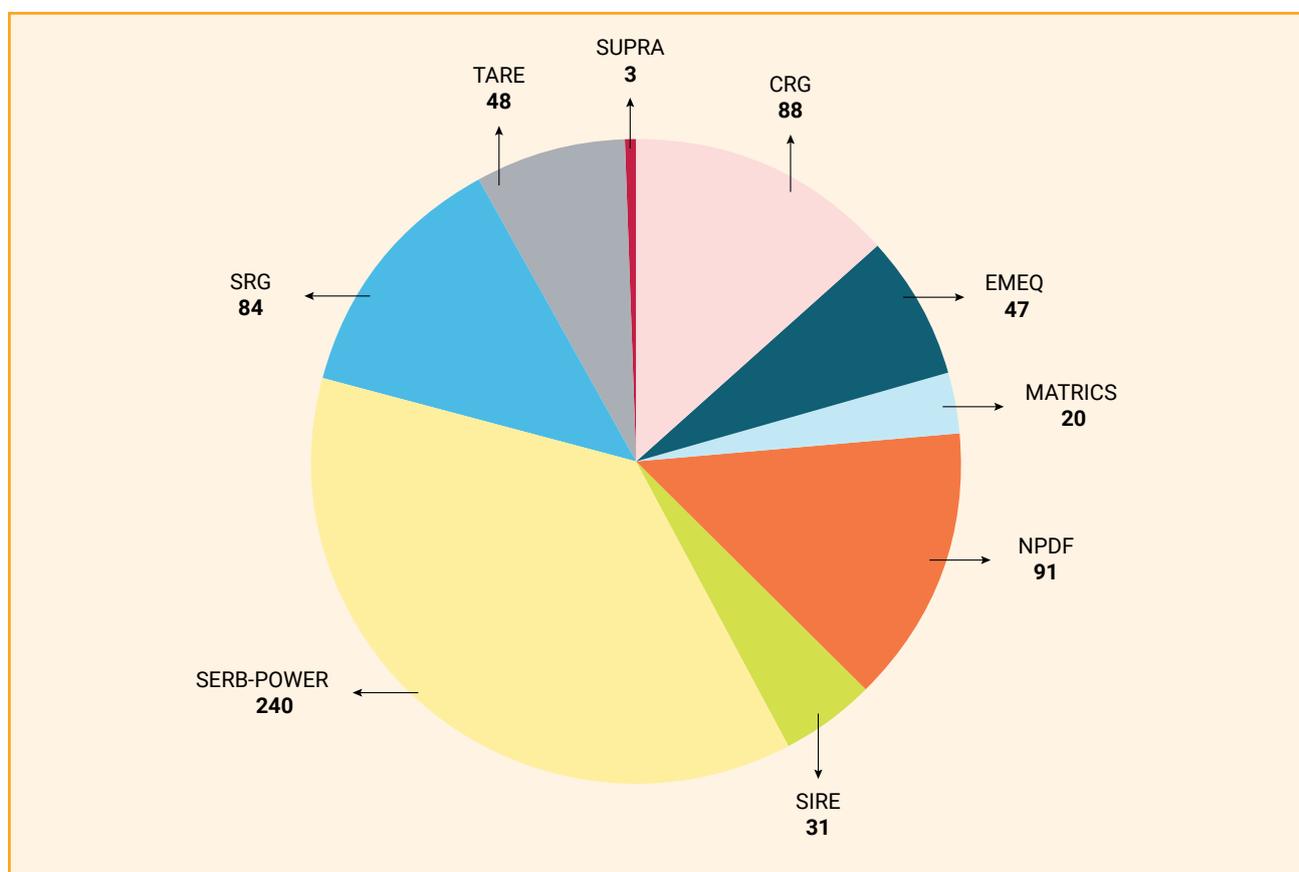
3

PROJECT GRANT PROGRAMMES

SERB was established by an act of parliament in 2009 to serve the country as a premier funding agency for promoting basic research and providing financial assistance to the scientific community. With a mission to support innovation and technological advancement, SERB provides critical support to the whole scientific community of India helping to drive progress and to impact society in a positive manner. Several programmes like Core Research Grant, Young Scientist Scheme, Intensification of Research in High Priority Areas, Start-up Research Grant etc. have been launched by SERB at different times. Recently, SERB has initiated several other new programmes with definite goals and characteristics with a focus to address specific requirements and maintaining synergy between academic institutions, research laboratories and industry. Further, some of the programmes have been re-formatted and replaced depending on changing needs and evolving research scenarios.

Core Research Grant (CRG), earlier known as Extramural Research (EMR) programme is a robust programme of SERB, serving the research community without any restrictions on the age of the Investigator or limitation in budget. Start-up Research Grant (SRG) is for helping young scientists in the country to initiate their scientific careers in a new place. As the requirements of Mathematical and Theoretical research are distinct in comparison to experimental research, a specially designed programme named MATRICS was introduced to offer fixed grant support to active researchers in Mathematical, Theoretical and Quantitative Social Sciences areas. The IRHPA programme follows a structured approach where important scientific areas have been explored with immediate needs and researchers are invited to submit proposals addressing those cutting-edge topics. Scientific and Useful Profound Research Advancement (SUPRA) is an exclusive programme for soliciting proposals of superior quality with out-of-box ideas and disruptive thinking.

SERB has made its mark on promoting research excellence with inclusiveness and the most egalitarian approach. Special schemes have been introduced to facilitate enhanced participation of weaker sections of society. Empowerment and Equity Opportunities for Excellence in Science (EMEQ) is to provide project support to researchers belonging to the SC and ST communities. POWER (Promoting Opportunities For Women in Exploratory Research) Grant is conceptualized to mitigate the problem of gender disparity in science.

Recently SERB has launched a new programme SERB-State University Research Excellence (SERB-SURE) to strengthen R&D ecosystem in State/Private University & Colleges.

In this chapter, the activities of programmes offering project-mode funding are articulated along with research highlights of some of the projects supported under these programmes.
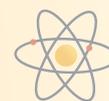
CRG-PROGRAMME ADVISORY COMMITTEES

CHEMICAL SCIENCES

- Inorganic & Physical Chemistry
- Organic Chemistry
- Earth & Atmospheric Sciences

ENGINEERING SCIENCES

- Chemical & Environmental Engineering
- Civil, Infrastructure & Transportation Engineering
- Electrical, Electronics & Computer Engineering
- Materials, Mining & Minerals Engineering
- Mechanical, Manufacturing, Aerospace Engineering & Robotics
- Exponential Technologies

LIFE SCIENCES

- Biomedical & Health Sciences
- Interdisciplinary Biological Sciences
- Organismal & Evolutionary Biology

- Mathematical Sciences

PHYSICAL SCIENCES

- Physical Sciences - I (CMP & MS)
- Physical Sciences - II (PHENNA-LOAMP)

- Quantitative Social Sciences

3.1 Supporting Core Research

3.1.1 Core Research Grant (CRG)

The flagship programme of SERB–Core Research Grant has always been in prominence since the inception of the Science and Engineering Research Council (SERC) four decades ago. It provides competitive-mode projects to individual researchers belonging to academic institutions, research laboratories and other R&D organisations to carry out basic research in all frontier areas of Science and Engineering. The CRG programme has played a pivotal role in building research capability across the country and sustaining the research interests of scientists. CRG programme functions across 16 disciplines/theme-wise verticals with individual Programme Advisory Committees and programme officers.

FEATURES

Highly competitive bottom-up project support

For researchers holding a regular academic/research position in a recognized academic institution or national laboratory or any other recognized R & D institution in India

The normal duration of the project is three years with no upper limit of budget

Website link: https://serb.gov.in/page/english/research_grants#Core%20Research%20Grant%20(CRG)

3.1.1.1 Inorganic and Physical Chemistry

In the reporting period, 144 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Inorganic and Physical Chemistry are shown in the following figure.

144 Projects Sanctioned

Expenditure (New and Ongoing)

53.52 cr

Areas Supported

Inorganic and Physical Chemistry

- Supramolecular & Coordination Chemistry
- Spectroscopy & Instrumentation
- Computational Chemistry
- Energy, Capacitor & related areas
- Polymer
- Bio-inorganic Chemistry
- Organometallics & Catalysis
- Interdisciplinary Areas
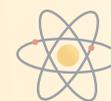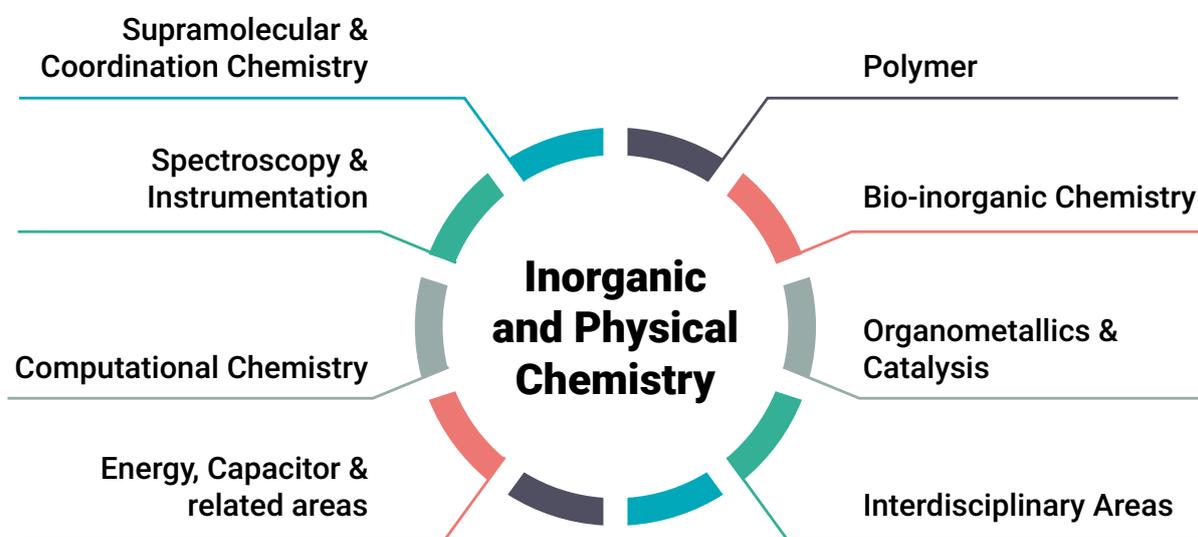
Research Highlight

Chemistry at Solid-Liquid Interface: Thin Films of Semiconducting 2D Coordination Polymers

Semiconducting 2D coordination polymers (CPs) are emerging as a new class of functional materials. Coupling the unique 2D structural features with physicochemical properties of CPs is intriguing. In this proposal, metal-ligand coordination at solid-liquid interface will be explored which could lead to capturing of interesting interfacial effects vis-à-vis generation of high-quality thin films of semiconducting 2D CPs by layer-by-layer (LbL) approach. In a project supported under Core Research Grant (Inorganic and Physical Chemistry), the group at IISER Pune aimed to perform an in-depth study of such semiconducting 2D CPs thin film systems upon looking at various semiconducting parameters such as carrier density, carrier mobilities, and types (n/p) of semiconductors and so on, employing Hall-effect measurements. Understanding these physical parameters is not only very much useful for rationally designing metal-organic systems with desirable properties but also important for device applications.

In the study, electrically conducting/semiconducting coordination polymers (CPs) thin films were fabricated by layer-by-layer (LbL) and/or electro-crystallization techniques for possible electronic and electrochemical device applications (Figure 3.1). Also, hetero-structured thin films of CPs were fabricated to study the emergence of novel properties at the interfaces. The high-quality thin film of a new 2D CP was fabricated by using $Cu(OAc)_2$ as the metal precursor and BPyDC (2,2'-bipyridene-4,4'-dicarboxylic acid) as the ligand. Thin films were fabricated via a layer-by-layer (LbL) approach already standardized in our lab and an unusual growth mechanism of Cu-BPyDC thin film at a solid-liquid interface was studied. Successful integration of 2D CP (Cu-BPyDC) into a hetero-structured thin film with 3D CP Cu-TCNQ (TCNQ = tetracyanoquinodimethane) by the LbL technique was further achieved. Variable temperature electrical transport measurements revealed the emergence of metallic conduction at the interface of Cu-BPyDC and Cu-TCNQ which is remarkable in the sense that Cu-BPyDC and Cu-TCNQ were realized to be band and Mott insulators. Strong interlayer hybridization and charge-transfer enabled an overlap of the conduction band and valence band in the Cu-TCNQ/Cu-BPyDC interface leading to metallic conduction as probed by density functional theory calculations. This work was carried out at the Indian Institute of Science Education and Research, Pune.
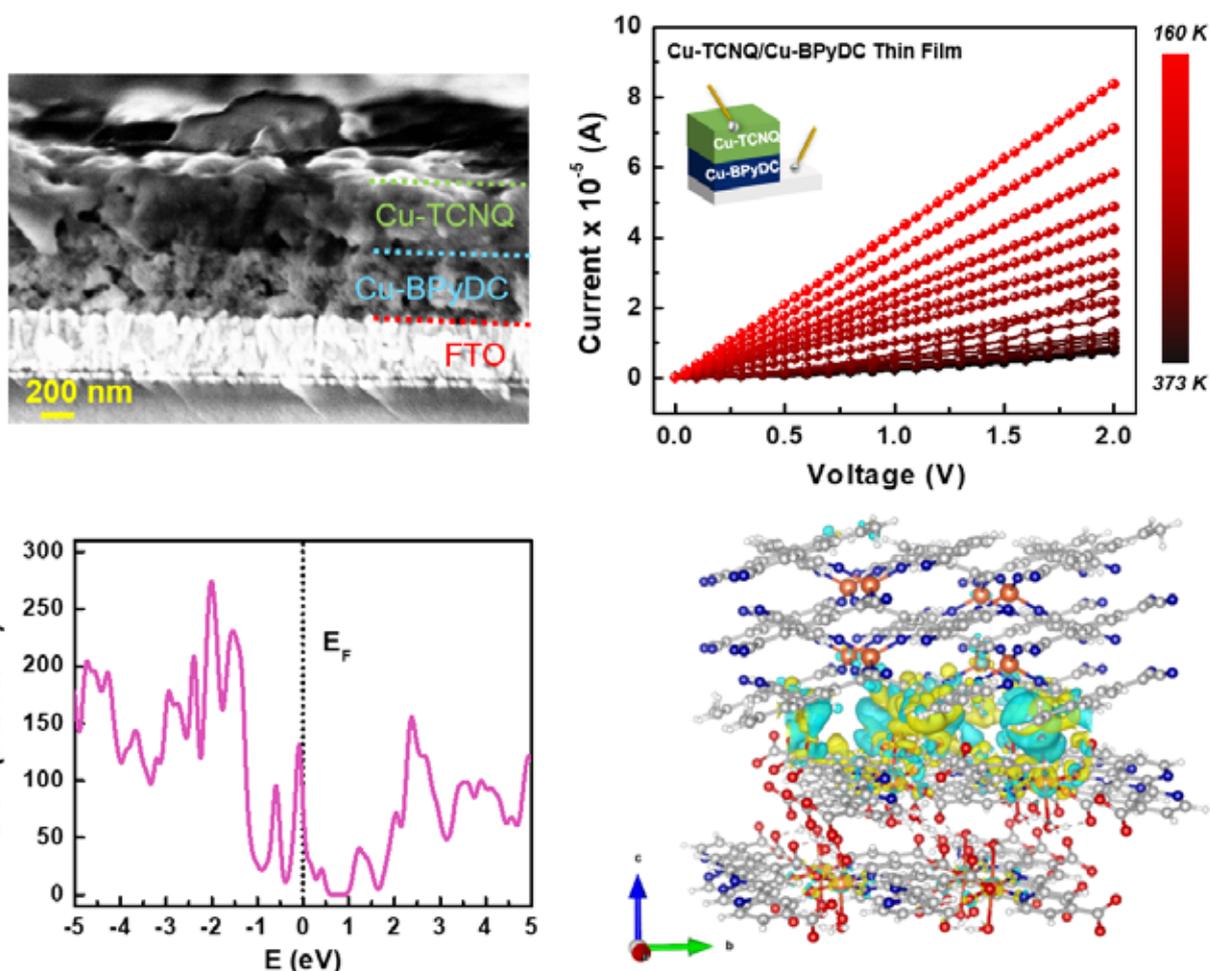
Fig 3.1: Hetero-structured Cu-TCNQ/Cu-BPyDC thin film exhibiting metallic conduction due to interfacial charge-transfer.

3.1.1.2 Organic Chemistry

In the reporting period, 108 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Organic Chemistry are shown in the following figure.

Areas Supported

Peptides, Bioconjugates & Drug Delivery

Organo-Catalysis & C-H Activation

Natural Products & Total Synthesis

Carbohydrate Chemistry

Organic Chemistry

Heterocyclic Synthesis

Polymer and Materials
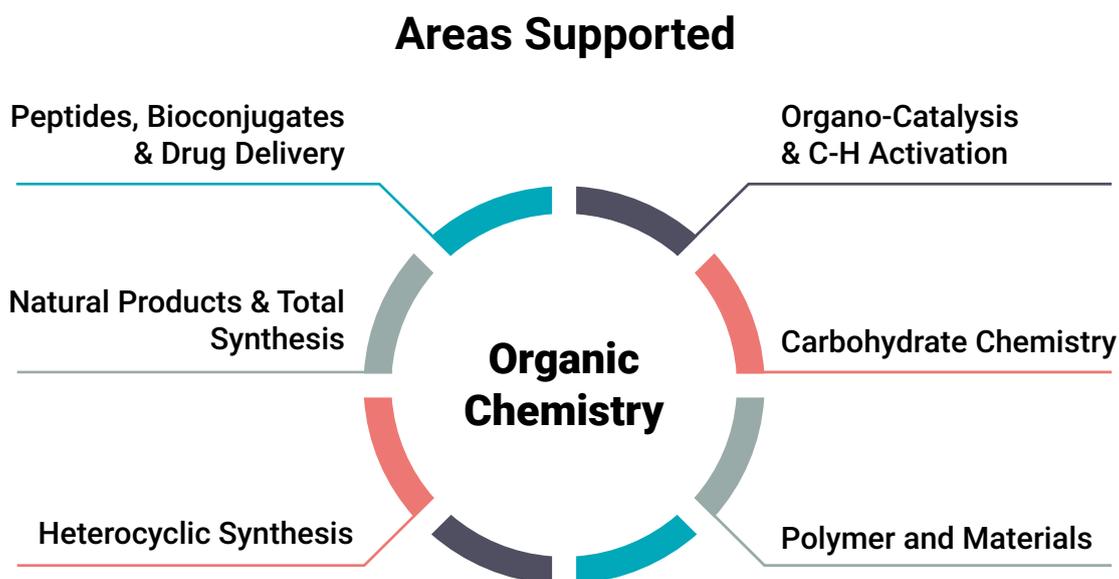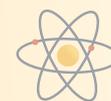
Research Highlight

Ir-Catalyzed C(sp²)−H Bond Activation and Borylation of Arenes via Noncovalent Interactions

Controlling the chemical reactivity of similar types of C−H bonds, direct C−H activation and functionalization's have attracted enormous attention as simple and ideal reactions. In this context, the C−H bond activation and borylation have demonstrated potential because of the practicality and synthetic versatility of the B−C bonds. A major challenge in C−H activation and borylations is how to control the site selectivity. In many instances, steric factors govern the site-selectivity of the arenes, which makes the C−H borylation complementary to the widely used directed ortho metalations (DoMs). Importantly, the inherent functional group restriction of the substrate limits the practical utility of the DoMs and thus has strengthened

efforts to discover an efficient method for the ortho C−H activation and borylations. The major issues of these methods are the long route synthesis of the specific directing groups, the installation and removal of the directing groups after C−H functionalization. Moreover, using the directing group strategies, remote C−H bond (meta & para) borylations are difficult to achieve.

In a project supported under Core Research Grant (Organic Chemistry), the group at CBMR, Lucknow explored a novel concept for the direct C−H bond activation and borylation (ortho, meta and para) of diverse aromatic molecules integrating noncovalent interactions and transition metal catalysts. The group
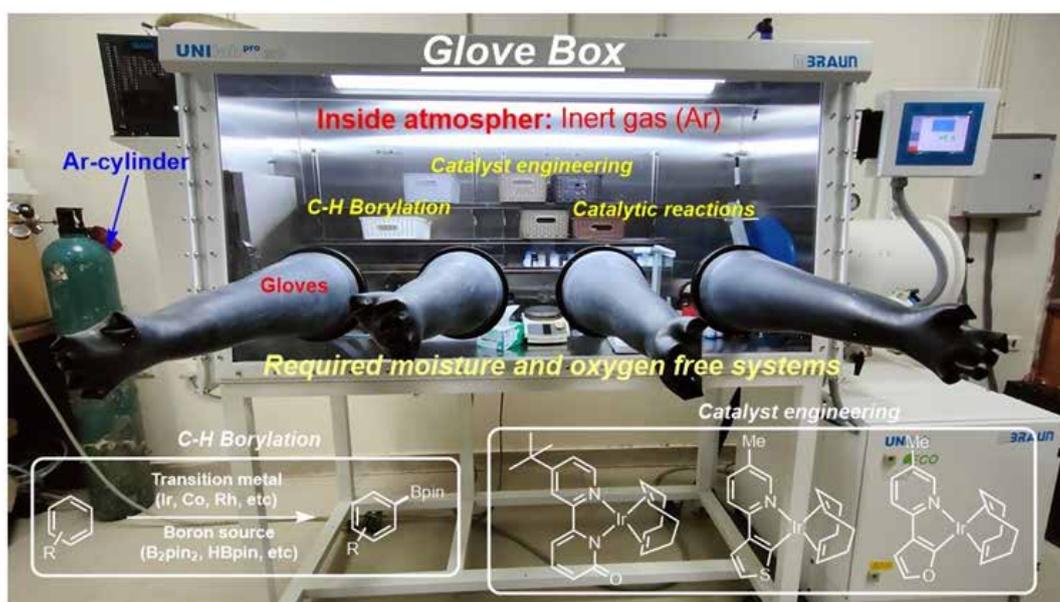
Fig 3.2: A schematic detailing the Ir-Catalyzed C(sp²)−H Bond Activation and Borylation of Arenes via Noncovalent Interactions

aimed to solve the long-standing problems associated with the site-selective C-H bond activation, which is presently performed with the help of big directing groups/templates. The aim was directed towards the generation of new concepts and hypothesis in C−H bond activation chemistry, which would be the complementary method for the aromatic electrophilic substitution chemistry and thus expected to modernize today's industry. In line with these proposed objectives, a series of new generation ligands and catalysts have been engineered and prepared. Several new generation ligands (such as PYT ligand, 1st generation defa ligand, 2nd generation defa ligand etc), catalysts (such as Ir-PYT catalysts, 1st generation & 2nd generations etc) were developed (Figure 3.2). These newly engineered ligands and catalysts exhibit excellent activity. They have demonstrated the minimization of the need to use complicated directing groups for achieving site-selectiveCH borylation reactions which are not beneficial for industrial deployment. This work was done at the Centre for Bio-Medical Research, Lucknow.

3.1.1.3 Earth and Atmospheric Sciences

In the reporting period, 90 new projects were sanctioned. The areas in new & ongoing projects supported under CRG − Earth and Atmospheric Sciences are shown in the following figure.

Areas Supported

Geophysics, Tectonics, Structural Geology

Hydrogeology, Waste disposal, etc.

Petrology, Geochemistry, Isotopes

Agrometeorology, Soil Sciences

Earth and Atmospheric Sciences

Weather forecasting, Climatology, Upper Atmosphere, Aerosols

Remote Sensing, GIS

Climate Change, Glaciology, Paleontology, Stratigraphy

Oceanography

90
Projects Sanctioned
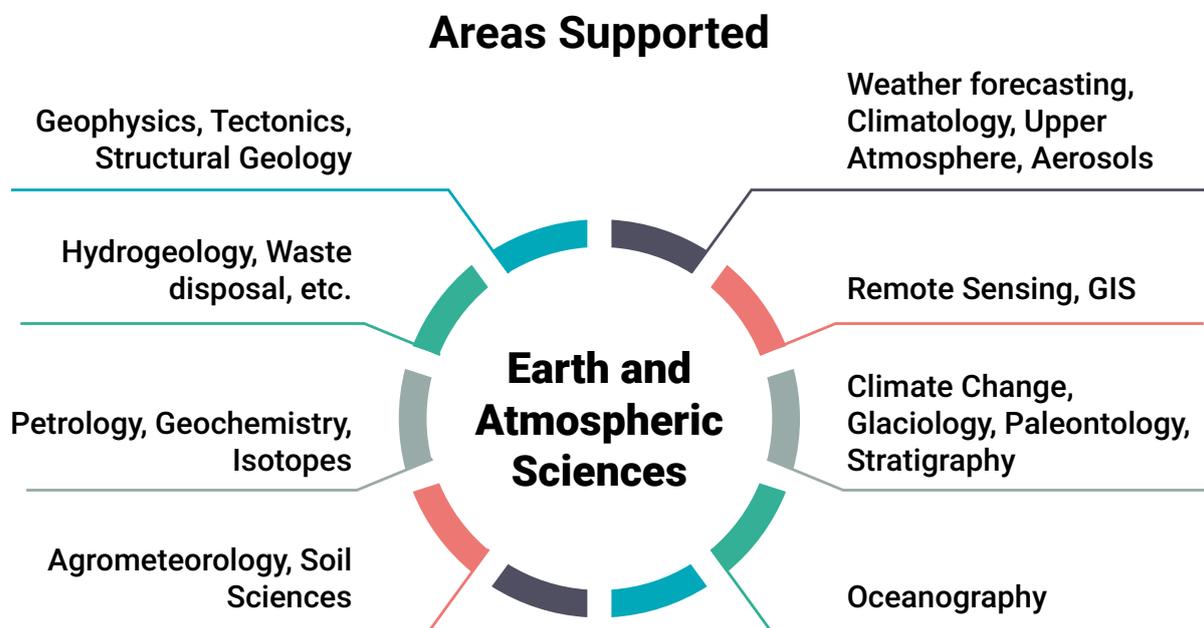
Expenditure
(New and Ongoing)

17.72 cr

Research Highlight

Mineralogy, geochemistry and geochronology of micro granular enclaves and host Ladakh granitoids, Trans-Himalaya, India: Implication on subduction-related magma chamber processes, sources and timing of plutonism and crustal growth

The Ladakh Batholith is an assembly of polychronous (ca. 70-45 Ma) composite plutons formed by multiple pulses of coeval mafic-felsic arc magmas, which have experienced multistage growth history of synchronous mixing, fractionation, mingling, and diffusion. Mafic to hybrid micro granular enclaves and synplutonic dykes are formed by injecting into the partially crystalline granitoid during their evolution from initial to waning stages at shallow crustal depths (Figure.3. 3(a), (b)). Positive whole rock εNd^t, zircon εHf^t values and young Hf model ages strongly suggest the involvement of juvenile sources and mixing between mafic-felsic magmas in their genesis (Figure. 3.3(c)). Zircon U-Pb-Hf isotopic data precisely mark one of the many India-Asia collisional ages at ca. 50-51 Ma. The Ladakh granitoid in the Karakoram fault zone melted to produce the Miocene leucogranites and pluton in eastern Ladakh. The micro granular enclaves and synplutonic dykes, which were earlier thought to be older and youngest magmatic bodies respectively than the host granitoids, are found to be coeval and solidified synchronously. This work was done at Kumaun University, Nainital.
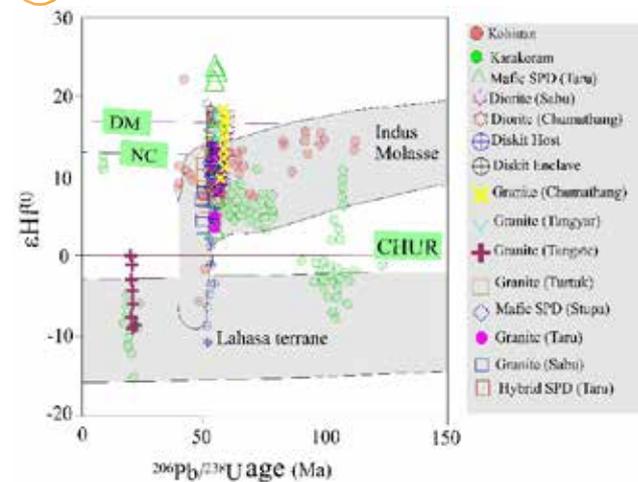
Fig 3.3: (a) Randomly oriented, fine grained, melanocratic to mesocratic microgranular enclaves of different sizes and shapes, coeval with Ladakh granitoids. (b) Disrupted mafic synplutonic dyke zone in the Ladakh granitoids. (c) Zircon εHf_t vs. U-Pb age from granitoids, diorite, enclaves, synplutonic dyke of Ladakh granitoids, showing mostly juvenile source, 51-52 Ma age of India-Asia collision, and Miocene granitoid formed from older continental crust. Data of Kohistan and Karakoram are from other sources.

3.1.1.4 Chemical and Environmental Engineering

In the reporting period, 38 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Chemical and Environmental Engineering are shown in the following figure.

Areas Supported

Molecular Simulation

System Biology

Environmental

Flow System & Microfluidics

Chemical Sensors

Chemical and Environmental Engineering

Catalysis

Refinery

Bio-energy/Bio-fuel

Macromolecules

Solar Desalination

38

Projects Sanctioned

Expenditure
(New and Ongoing)

10.28 cr
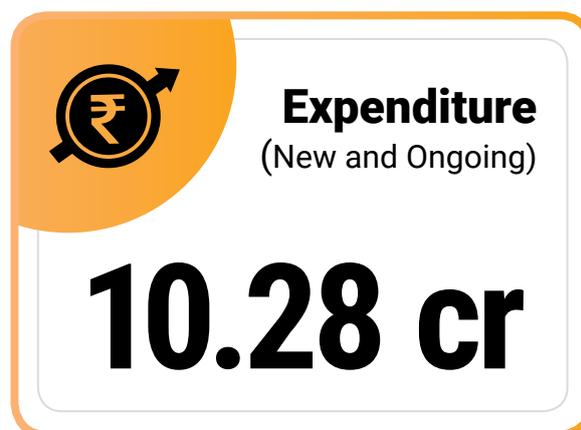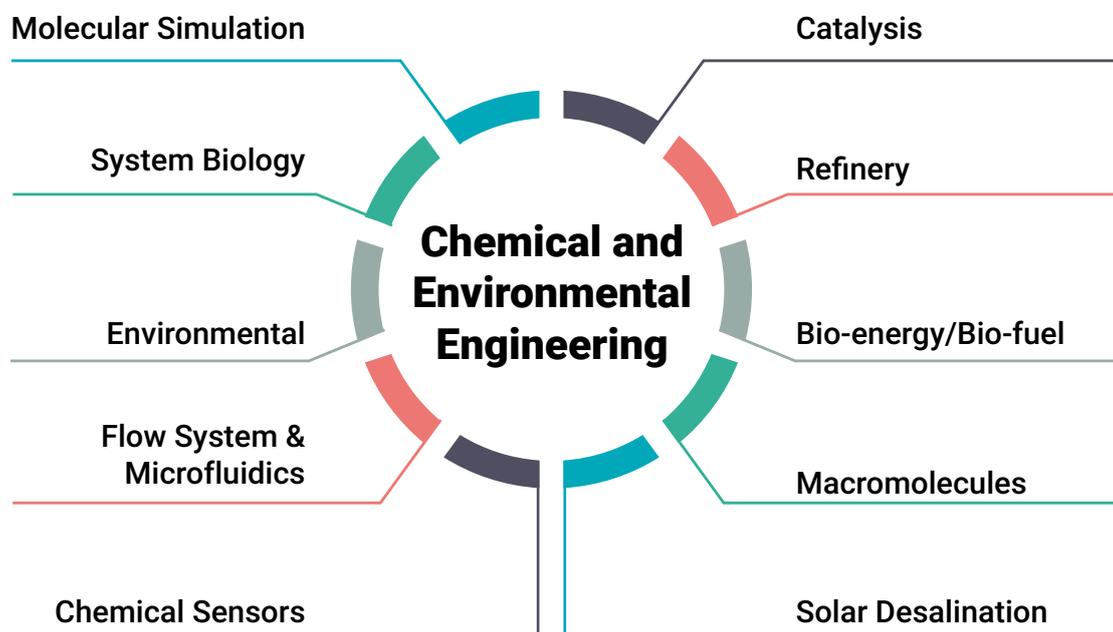
Research Highlight

Experimental and Theoretical Investigations of Complex Rheological Behaviors in Time Dependent (Aging) Soft Materials

Many thixo-viscoelastic materials have been reported to undergo enhancement in elastic modulus with time and decrease in the same under the application of the deformation field. Incorporation of this feature in a viscoelastic structural kinetic model has an apparent possibility of violating the second law of thermodynamics. Furthermore, in a related experimental observation, stress was reported to undergo a non-monotonic change as a function of time under the application of constant strain.

Interestingly, the proposed simple formalism predicts the experimental observation of the non-monotonic stress relaxation very well.

An aqueous dispersion of carbachol, which has a soft solid like consistency, has often been termed as non-thixotropic constant yield stress material. In this work, the team investigate signatures of physical aging in an aqueous dispersion of Carbopol that shows yield stress and weak enhancement in elastic modulus as a function of time. Through a variety of experiments that

involve creep, small amplitude oscillatory shear, and startup flows, this comprehensive work suggests not just the presence of physical aging and thixotropy but also the clear signatures of over aging in an aqueous dispersion of Carbopol.

As shown in (Figure 3.4), while undergoing sol-gel transition, both systems pass through a critical point. An approach to the critical point is characterized in terms of the divergence of zero-shear viscosity and the subsequent appearance of the low-frequency modulus.

In the vicinity of the critical gel state, both the viscosity and the modulus show a power-law dependence on the relative distance from the critical point. Interestingly, the longest relaxation time has been observed to diverge symmetrically on both sides of the critical point and also shows a power-law dependence on relative distance from the critical gel point. The critical (power-law) exponents of the zero-shear viscosity and modulus are observed to be related to the exponents of the longest relaxation time by the hyperscaling laws.
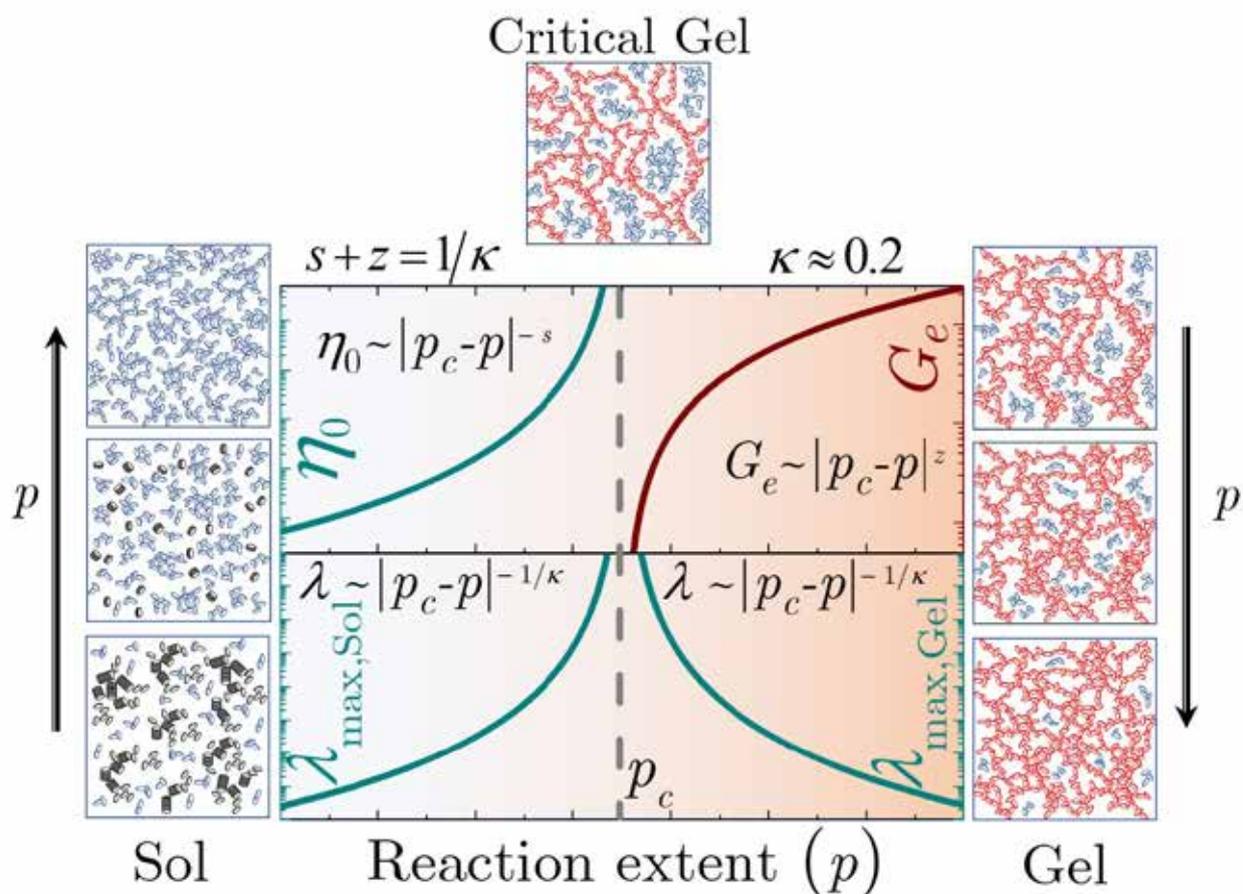
Fig 3.4: A material undergoing sol−gel transition evolves from the pre-gel (sol) state to the post-gel state through the critical gel state.

A phenomenological analytical expression for the relaxation modulus in the post-gel state is proposed by invoking the symmetry associated with the evolution of the relaxation time on either side of the critical gel state and by accounting for natural constraints. This expression, which depends on the extent of cross-linking, can be suitably transformed to obtain analytical expressions for the dynamic moduli and the continuous relaxation time spectrum. Thus, the proposed model facilitates a comprehensive description of viscoelastic evolution from the pre-gel to the post-gel states. Such a well-calibrated phenomenological model can be used to determine any linear viscoelastic response over a wide range of frequencies and extents of cross-linking encompassing the entire sol−gel transition. The work was carried out at the Indian Institute of Technology, Kanpur.

3.1.1.5 Civil, Infrastructure and Transportation Engineering

In the reporting period, 32 new projects were sanctioned. The areas in new & ongoing projects supported under CRG - Civil, Infrastructure and Transportation Engineering are shown in the following figure.

Areas Supported

Civil, Infr. and Trans. Engg.
- Structural Engineering
- Water Resources Engineering
- Hydrology
- Transportation Engineering
- Geotechnical Engineering
- GIS
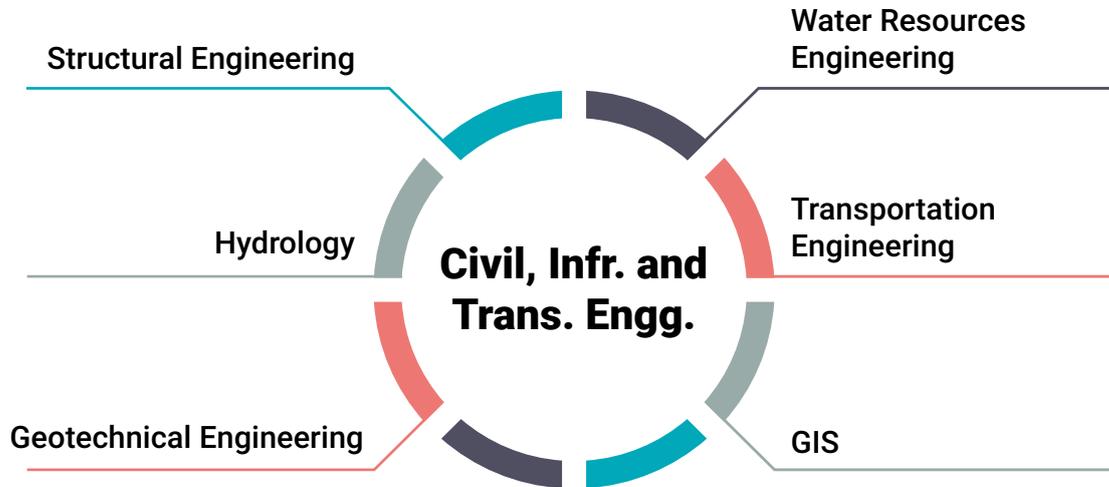
32 Projects Sanctioned

Expenditure (New and Ongoing) **7.16 cr**

Research Highlight

Form-Finding and Load Analysis of Tensile Membrane Structures by Stochastic Optimisation.

The goal of this research project was to develop new, computationally efficient optimization algorithms for the form-finding and load analysis of tensile membrane structures (TMS). Current research on TMS is limited, with the traditional form-finding and analysis tools showing large variations in their overall results. The researcher aimed to understand the physics of the TMS analysis, review existing algorithms, and identify the most suitable methods for the development of new techniques.

As a result of the project, several new form-finding techniques of frame supported TMS was developed using heuristic solvers like an ant colony, particle swarm optimization and artificial neural networks. A novel mesh-based method called the 'Updated Weight Method' (UWM) was also developed for TMS of all types (Figure 3.5). Mesh based-form finding methods, however have several issues such as mesh distortion, hyperparameter and initial shape selection etc. Due to this, several mesh-less form-finding methods were also proposed. A physics-informed neural network (PINN) based algorithm was developed to directly solve the governing Euler-Lagrange equation for minimal shape TMS and a derived modified Laplace equation and the Generalized Laplace for non-minimal frame-supported shapes. These meshless methods were shown to take care of the aforementioned issues with meshed solutions (Figure 3.6). A more generalized mesh-less framework based on gradient enhanced PINN
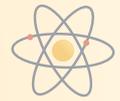
for the form-finding of frame and cable supported TMS was proposed by the direct minimization of potential energy. The developed methods provided an extensive set of both mesh-based and meshless novel solutions for TMS form-finding. In addition, several new load analysis methods were developed, including optimisation-based load analysis and a load analysis framework for ABAQUS (Figure 3.7). The new form-finding and load algorithms were tested on different TMS classes and their validity was compared against standard software (like Rhinoceros 3D and ABAQUS). The new techniques were evaluated in terms of accuracy, clarity, and computational efficiency against the existing algorithms. Overall, the developed methods provide the user with a robust and integrated solution for the analysis of TMS.

In conclusion, the research project has successfully proposed several new form-finding and load analysis techniques for TMS. The developed algorithms have shown promising results in terms of accuracy and efficiency. The research group has already started working on an Indian Standard code for the standardization of safe and easy design of TMS under a BIS working group (CED-38/WG-2). The study has also led to the publication and preparation of journal articles and magazines and conducting webinars. In the future, the group hopes to integrate the developed tools into software, which will help in the adoption of such structures in the country. This research was carried out at the Indian Institute of Technology, Bombay.
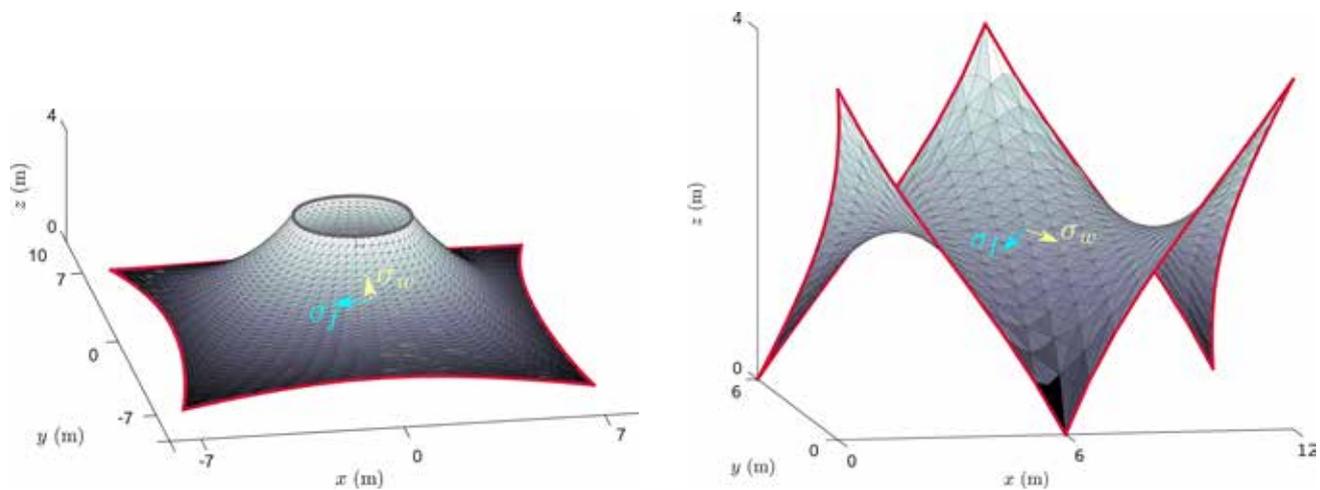
Fig 3.5: Form-finding of a conic and a twin hypar using updated weight method
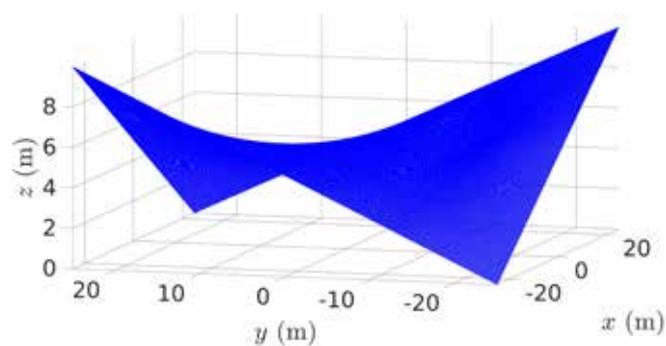
Fig 3.6: Form-finding of a hypar using physics-informed neural network.
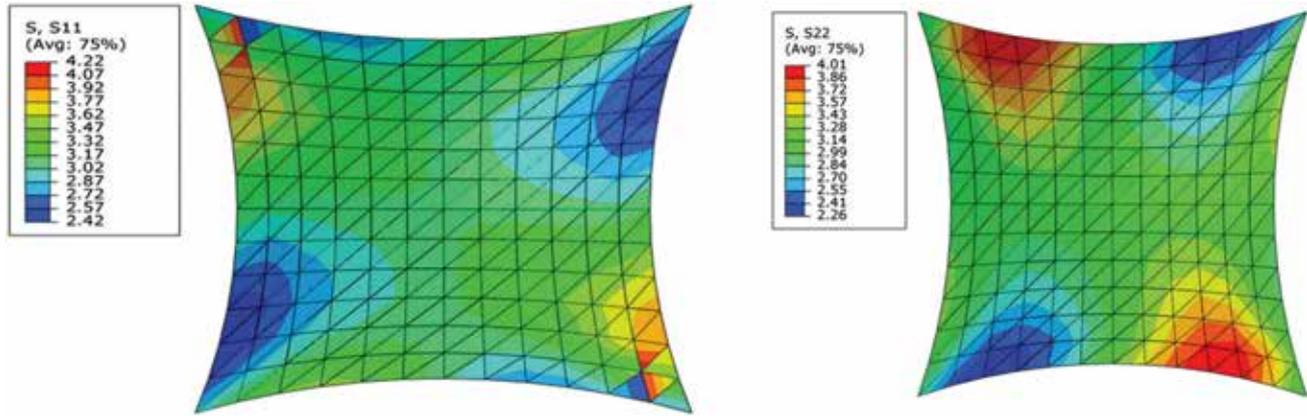
Fig 3.7: Load analysis of a hypar TMS

3.1.1.6 Electrical, Electronics and Computer Engineering

In the reporting period,136 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Electrical, Electronic and Computer Engineering are shown in the following figure.

Areas Supported

Computer Science

Electronic Devices

Power System

Electrical Devices, Systems & Drives

Electrical, Electronics and Computer Engineering

Communication System

Healthcare Devices & Assistance System

Cyber Physical System

Signal Processing
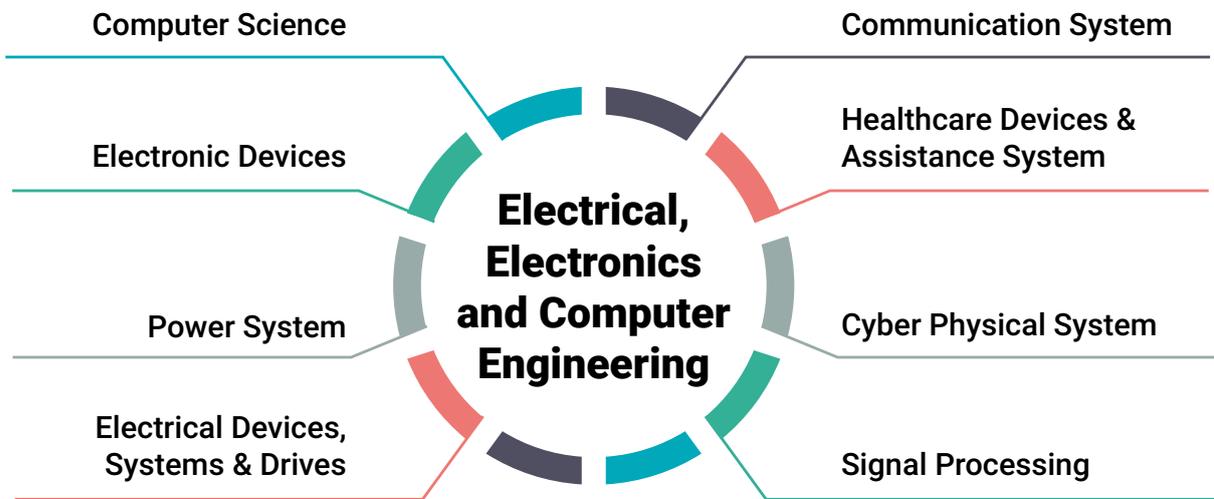
136
Projects Sanctioned

Expenditure
(New and Ongoing)

35.81 cr
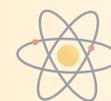
Research Highlight

Design of High Power CW Magnetrons and Investigations on Strategies for their Phase Control

This work aimed to develop new designs and techniques to improve the power handling capability of the magnetron, which is limited by its thermal management. One approach is to combine the output power of two magnetrons, but this requires phase locking each magnetron due to the lack of phase stability. To overcome this limitation, simulation studies were conducted on stacked magnetron configurations, and the importance of a binding rod in facilitating power combining was established. A novel stacked magnetron configuration called the isolated rod stacked magnetron (IRSM) was proposed, which improves the power rating of the magnetron to 45 kW at an efficiency of 49.3%. These studies were done at 2.45 GHz to compare with literature, and a 3.7 GHz conventional magnetron (Figure 3.8) was designed with an output power of 8.11 kW and an efficiency of 62.4%, which is state-of-the-art around this frequency range. Additionally, stacked magnetron designs were proposed (Figure 3.9), including a novel dual output stacked magnetron (Figure 3.10) that can provide over 95% combining efficiency. Other proposed designs include a novel strapping arrangement (Figure 3.11) for the magnetron to improve mode separation and new strapping techniques for improved thermal management (Figure 3.12). The proposed strapping structure improved the mode separation by almost 61% in 10 vanes anode case while the proposed design showed that the peak temperature was 110 °C lower than the conventional straps when operated at the same power. The work is being carried out at the Indian Institute of Technology, Bombay.
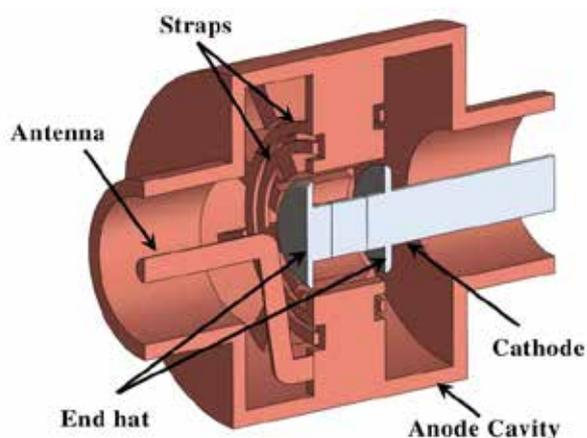
Fig 3. 8: Cut section of the ten vane single cavity magnetron.
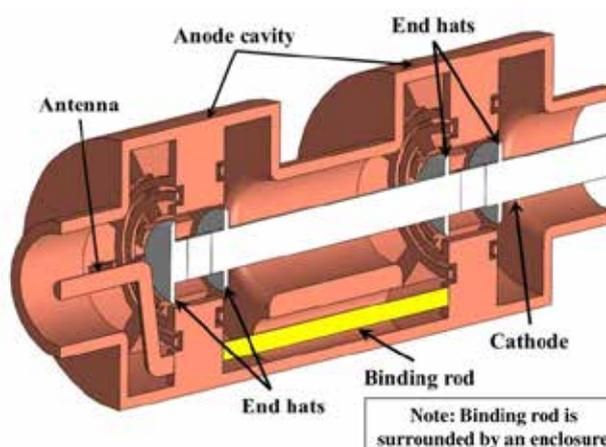
Fig 3. 9: Cut section view of the proposed IRSM design
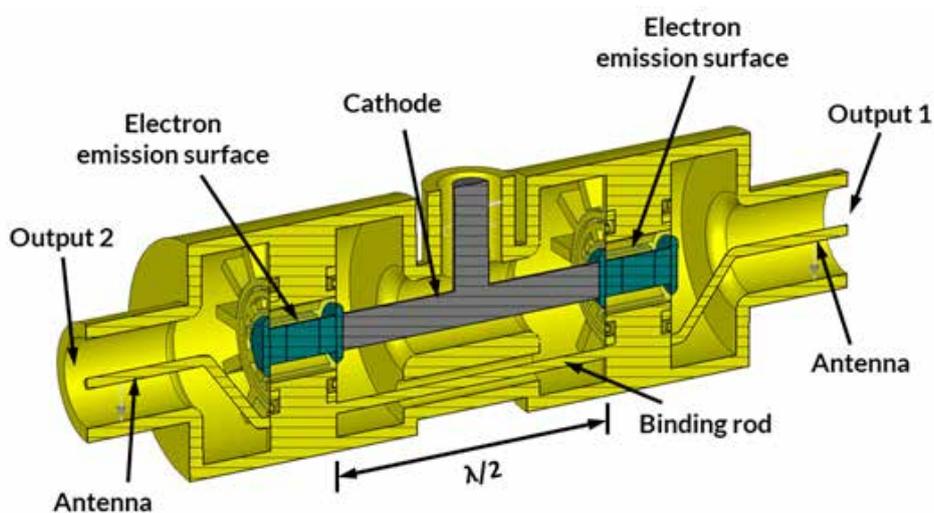
Fig 3. 10: Cut-section view of proposed Dual output stacked magnetron (DOSM)
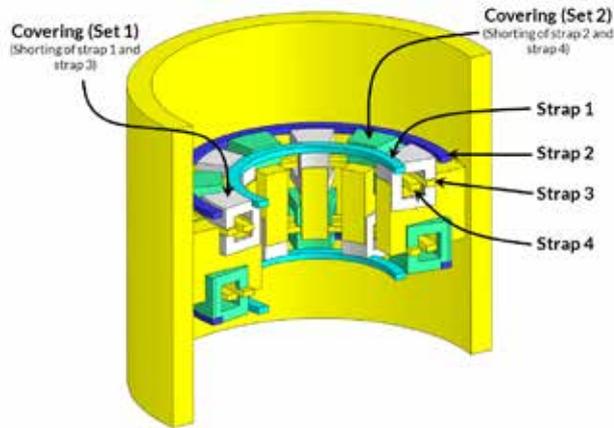
Fig 3. 11: Cut section of the proposed design for higher mode separation
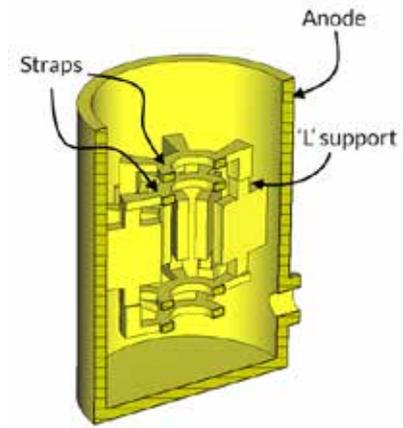
Fig 3. 12: Cut section of anode for better thermal performance

3.1.1.7 Materials, Mining and Minerals Engineering

In the reporting period, 53 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Materials, Mining, and Minerals Engineering are shown in the following figure.

Areas Supported

Metallurgy

Biomaterials

Mining Engineering

Materials, Mining and Minerals Engineering

Mineral Processing

Material synthesis & Development

Functional materials
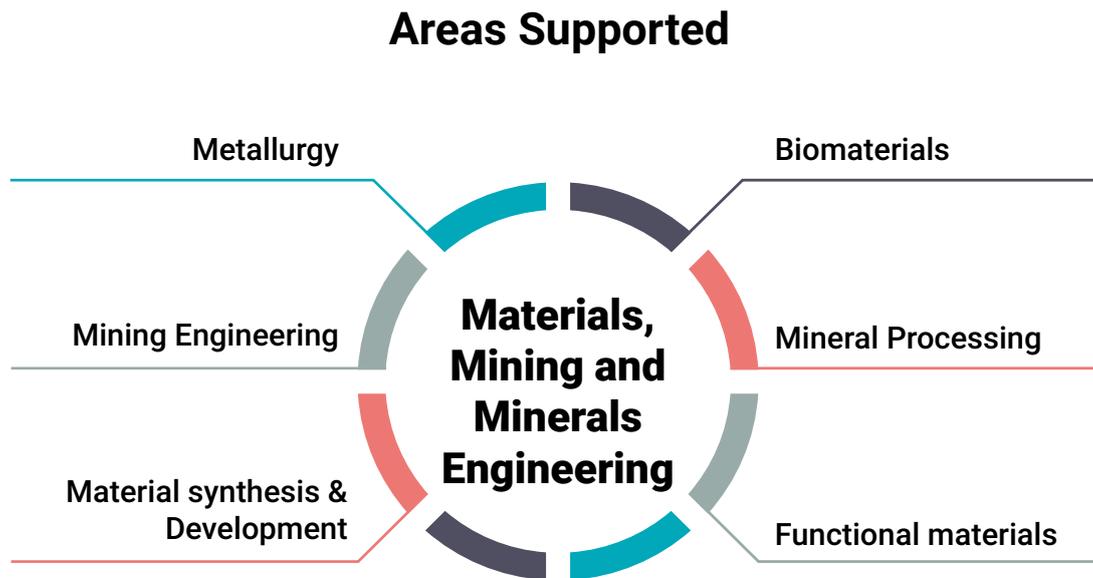
53
Projects Sanctioned

Expenditure
(New and Ongoing)

15.86 cr

Research Highlight

Bilayer functionalized scaffold for peripheral nerve and guided motor neuron regeneration

A damaged and poorly functional peripheral nervous system (PNS) negatively influences the quality of daily life heavily in terms of both money and the mind. Artificial regenerative grafts in clinical use have failed to set the gold standard for neural regeneration. These grafts promote fascicular regeneration. However, they are not equipped to guide axonal regeneration. Thus, more precise treatment technologies are urgently required. The team designed a scaffold that promotes fascicular and axonal regeneration in damaged peripheral nerves to achieve this aim. Additive manufacturing technology is used to prepare a novel axonic regeneration approach-based scaffold with specific functionalization for guiding motor neurons toward skeletal muscles. A three-dimensional polycaprolactone polymer-based scaffold supports directional regeneration of the axons through morphological and electrical cues. It is tailored to direct individual branches of motor axons from the neural conduit toward muscle, ensuring good signal transmittance (Figure 3.13). The structural integrity of the polymeric scaffold, provided by its mechanical property, is essential for cell adhesion, proliferation,

differentiation, and its overall suitability for tissue engineering. The mechanical properties and surface morphology of the scaffold are ideal for soft tissue engineering. In-vitro evaluation revealed that the scaffold is biocompatible and biodegradable. Specific functionalization of the scaffold enhances the growth of neurites and is directed to the target direction. In this work, the team have developed an effective neural scaffold that promotes motor regeneration from neurons to muscles. It allows total regeneration of motor neurons with all its interfaces and does not need any further external stimulation to guide the regeneration of the motor axons. A combination of electrospinning and 3D printing technique, with a gradient of neurotropic factor was used for this purpose. In-vitro studies have proven the efficacy of this specially designed template in guiding the branches of the axon in the perpendicular direction to reach the muscular junction. Detailed in vitro studies and in vivo evaluation is pending. The work is being carried out at the Centre for Nanotechnology, Indian Institute of Technology Roorkee, Uttarakhand
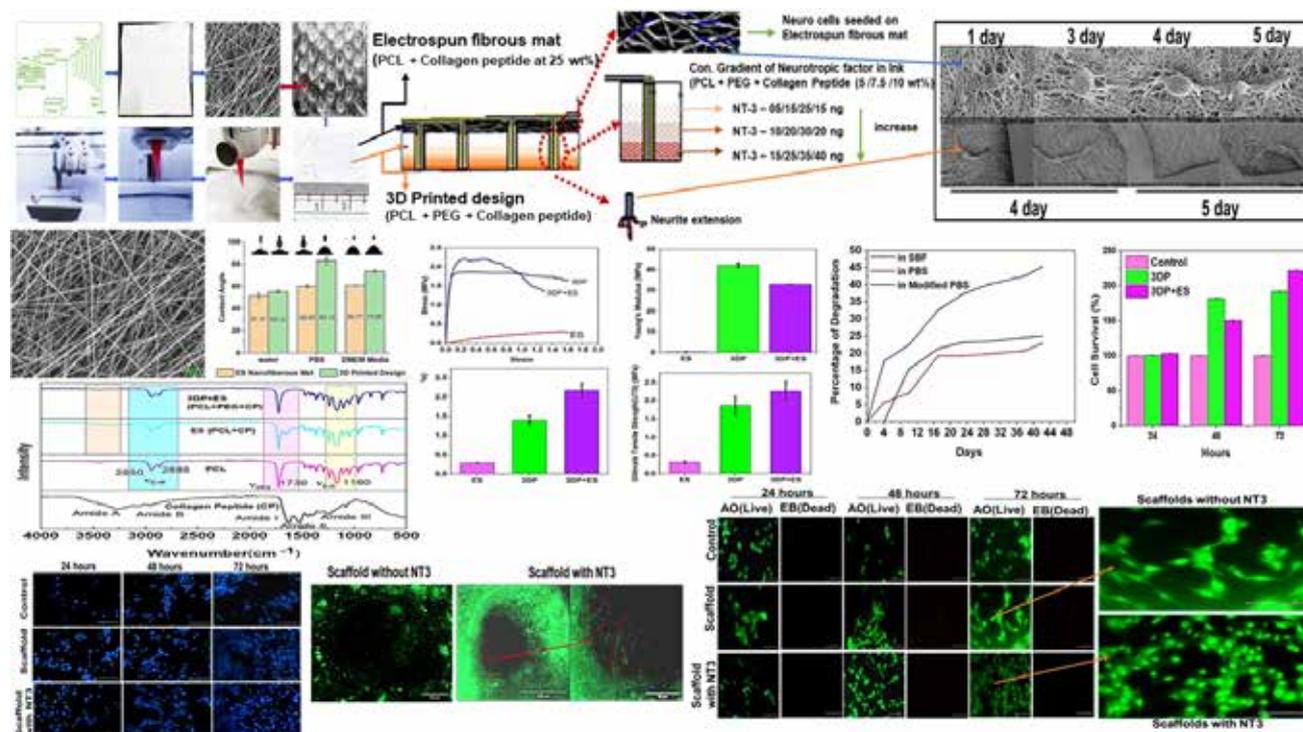
Fig 3.13: Pictorial representation of the methodology adopted and experimental results achieved.

3.1.1.8 Mechanical, Manufacturing, Aerospace Engineering and Robotics

In the reporting period, 72 new projects were sanctioned. The areas in new & ongoing projects supported under CRG–Mechanical, Manufacturing, Aerospace Engineering and Robotics are shown in the following figure.

Areas Supported

Aerodynamics

Manufacturing Engineering

Combustion

Machining

Mechanical, Manufacturing, Aerospace Engineering and Robotics

Design

Fluid Mechanics

Robotics

Thermal Engineering
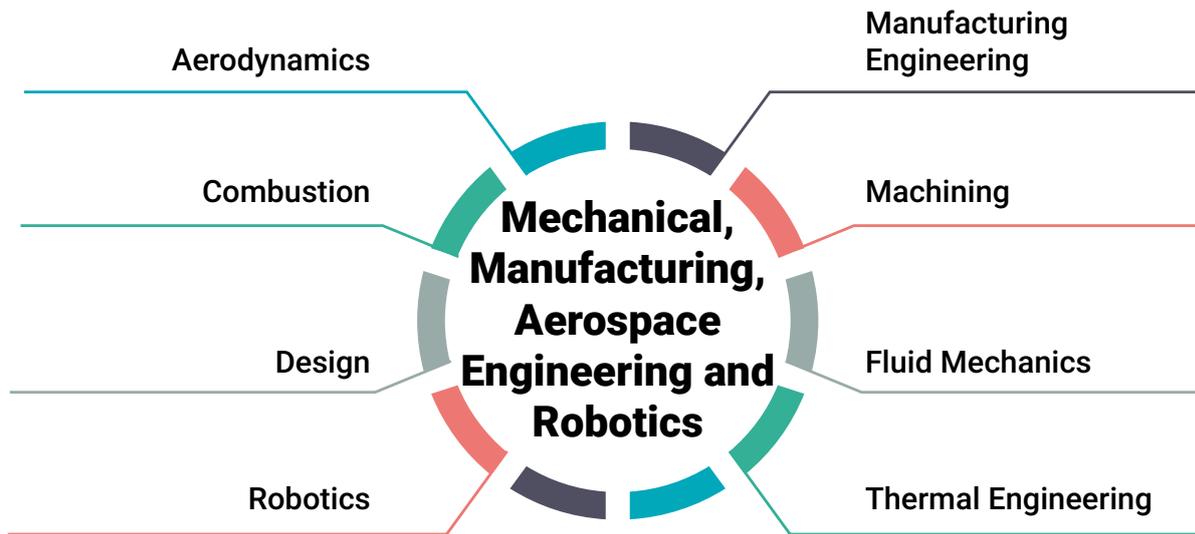
72 Projects Sanctioned

Expenditure (New and Ongoing)

16.45 cr

Research Highlight

Bone fracture analysis for type-2 Diabetic patients with osteoporosis based on experimentation and finite element modelling

This project investigated the effect of diabetes and osteoporosis on bone fracture behavior experimentally and numerically. Diabetes has become a global epidemic since it affects over 425 million adults worldwide and is projected to reach 629 million by 2045. Bone fracture in type 2 diabetes mellitus (T2D) patients occurs differently as compared to the normal population. Individuals with type 2 diabetes mellitus (T2D) have a three-fold greater hip fracture risk than those without diabetes, independent of dual-energy x-ray absorptiometry (DXA) determined bone mineral density (BMD). Previous large studies explain the BMD T-score inability, a quantitative measure, to accurately predict fracture risk in T2D. Mechanisms underlying the inferior bone quality and skeletal fragility in diabetes are not fully understood, making the clinical identification of individuals at risk for fractures difficult. The team aimed to investigate the
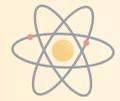
comprehensive multiscale bone quality parameters such as biomechanical, microstructural, material, and compositional bone properties in clinical populations with and without T2D. Our findings show that T2D causes accumulation of non-enzymatic cross links in organic matrix of bone which subsequently reduces the mechanical competence of bone. Further, a numerical model was developed to predict bone fracture risk in diabetic population (Figure 3.14). The developed model is helpful for clinicians to predict bone fracture risk in diabetic patients. This work was done at Indian Institutes of Technology, Ropar and Postgraduate Institute of Medical Education and Research, Chandigarh.
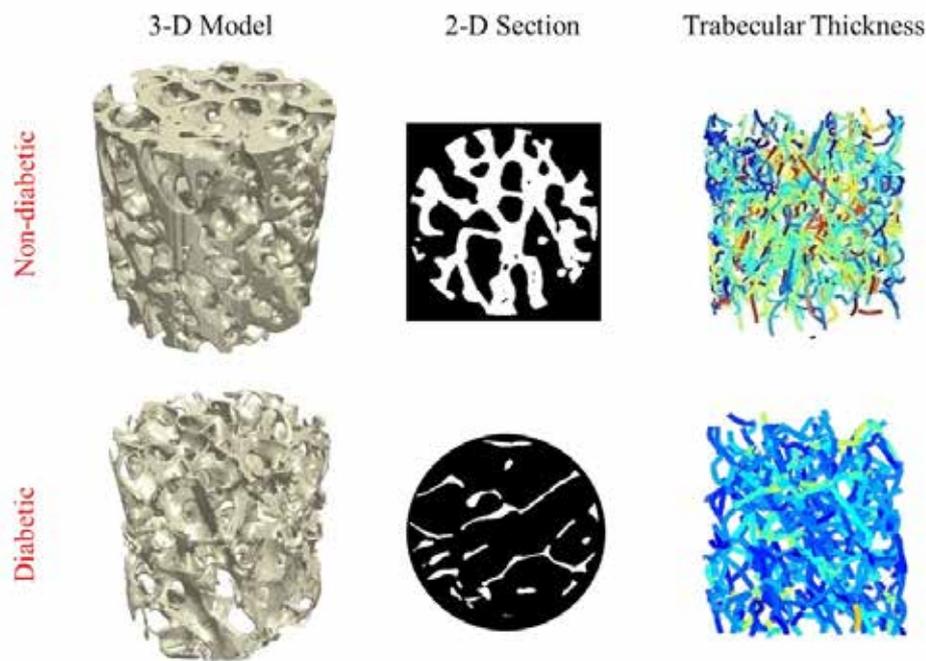
Fig 3.14: Micro-CT derived microstructure of trabecular bone obtained from non-diabetic and diabetic patients. A considerable degradation in microstructure of trabecular bone of diabetic patients can be observed.

3.1.1.9 Exponential Technologies

In the reporting period, 15 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Exponential Technologies are shown in the following figure.

Areas Supported

15
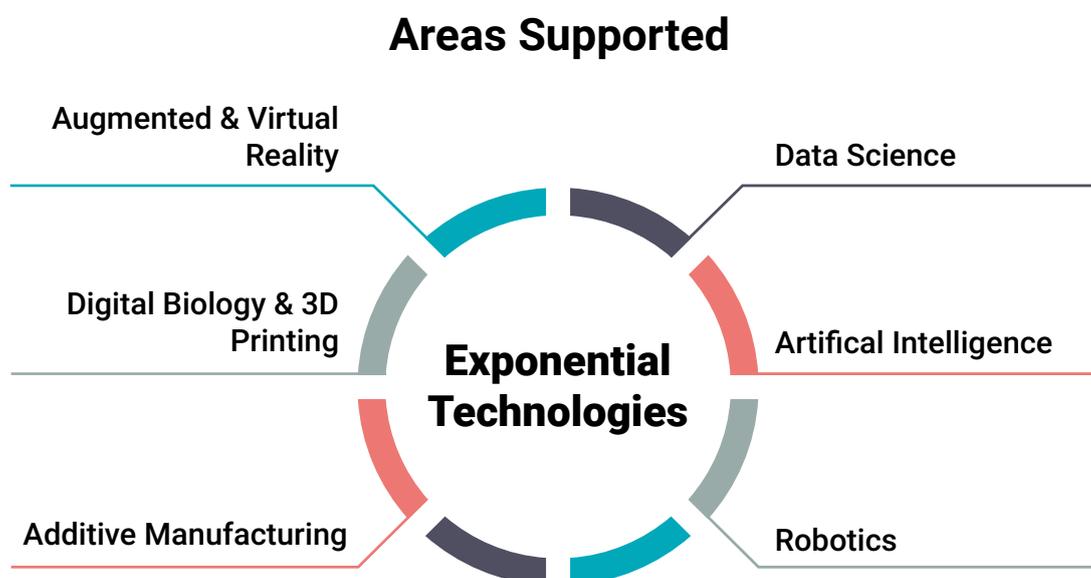
Projects Sanctioned

Expenditure
(New and Ongoing)

3.69 cr

Research highlight

Additive Manufacturing of Large Size Metal Components with Wire & Powder Hybrid Direct Energy Deposition (WP-DED) Process

This project plans to develop a Wire & Powder Hybrid Direct Energy Deposition (WP-DED) process bringing together the advantages of a high deposition rate with high accuracy for large components (greater than 1m size in X,Y,Z directions). Apart from the system setup and integration, the project also includes studies on (a) addressing the distortion and residual stress concerns in the fabrication of large components and (b) addressing possible property irregularity arising out of using energy sources with different energy densities. The project will also result in spin-off benefits in the form of multi-process, multi-material capabilities in addition to modelling and characterization knowledge.

Numerical modelling of the LDED process was carried out using the commercial finite element software package ANSYS. Computational modelling work has focused on simulating the evolution of temperature and residual stress during the deposition of thin-wall geometries out of Inconel 625 alloy using the LDED process. Understanding the residual stress evolution in this simple structure (thin-wall geometries) commonly fabricated using metal AM processes will pave the way

for understanding the residual stress evolution in more complex shaped structures. A representative finite element mesh for a 5-layer thin-wall geometry with the substrate is shown in (Figure 3.15). A convection boundary condition ((h) = 15 W/m^2 K) was applied to all free surfaces. A fixed temperature boundary condition (T = 25 ºC) was applied to the base of the substrate. The laser was modelled as a heat source with a Gaussian distribution.

As the process involves the hybrid deposition of wire and powder-based systems, the first step involves the stabilization and optimization of the individual processes. While the wire-DED is already in place, the powder-DED is recently installed. Hence, initial trials on stabilizing the powder feed and aligning the powder focus with the laser focus were carried out. (Figure 3.16) shows the powder-DED process with Inconel powder being carried out. The finite element modelling is being carried out using the commercial software package ANSYS. This work is being done at the Indian Institute of Technology, Hyderabad.
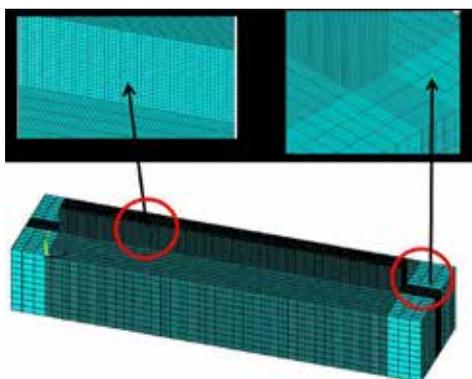
Fig 3. 15: Representative finite element mesh of a 5-layer thin-wall geometry along with substrate
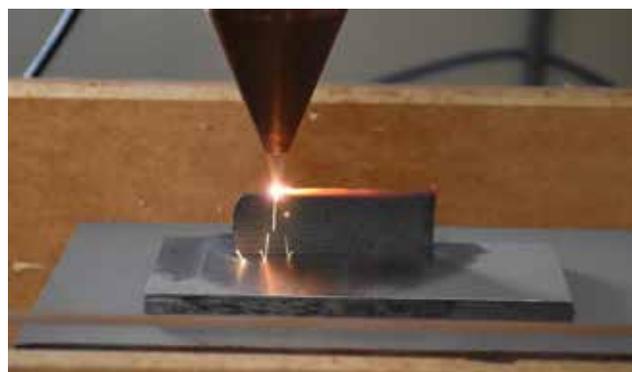
Fig 3.16: Powder-DED in process
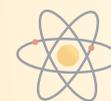
3.1.1.10 Biomedical and Health Sciences

In the reporting period, 1 new project was sanctioned. The areas in new & ongoing projects supported under CRG – Biomedical and Health Sciences are shown in the following figure.

Areas Supported

Cancer Biology

Cell/Molecular biology

Neurosciences

Drug Design/Target

Biomedical and Health Sciences

Metabolic Syndromes

Communicable Disease

Virology

Tissue/ Biomedical Engineering
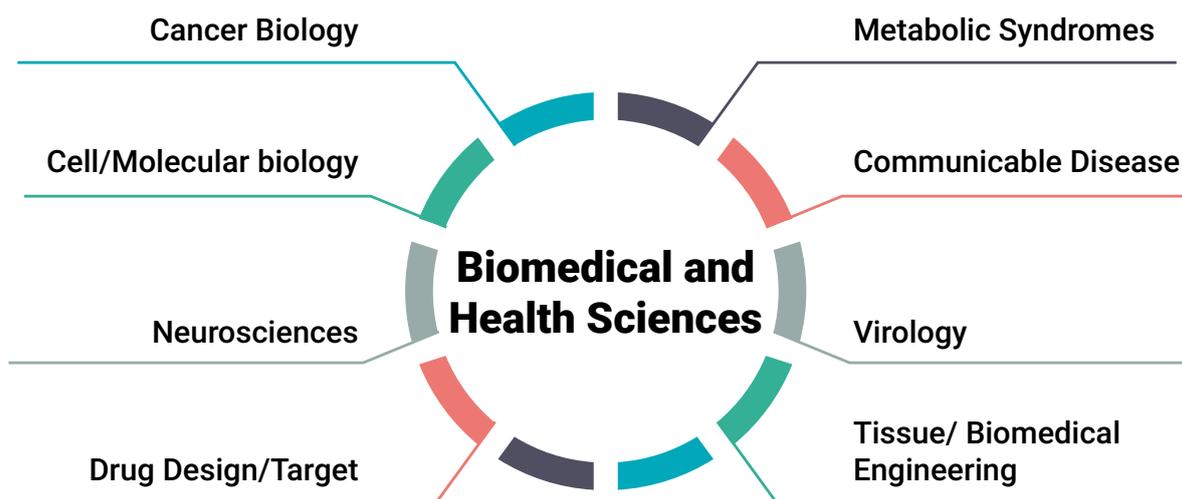
1 Project Sanctioned

Expenditure (New and Ongoing)

21.26 cr

Research Highlight

Deciphering the role of Serine/Threonine phosphorylation in Bacillus anthracis for developing novel anthrax spore vaccine

Bacillus anthracis (BA), a spore-forming bacterial pathogen is the causative agent of anthrax that majorly affects livestock, farm animals and sometimes humans. The spores of BA are naturally found in soil and infect the host via three different routes: inhalational, gastrointestinal or cutaneous, which is the common mode of infection and comprises 95% of anthrax cases worldwide. Two events, sporulation and germination are vital in the life cycle and the survival of

BA. Keeping in view of safety and efficacy of the current vaccination regimens, novel vaccines and vaccination strategies are thus required to protect humans from this disease.

The project has been supported to understand the role of serine/threonine protein phosphatase PrpN in the life cycle of BA strains and any additional modifications in the regulatory pathways can be able to overcome the limitations of residual toxicity and can be used
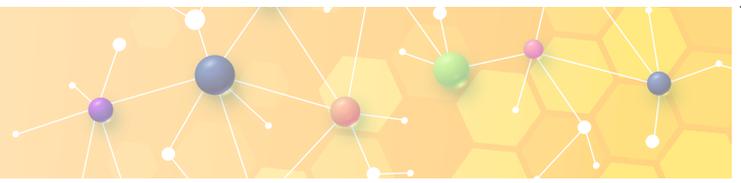
as a potential therapeutic option. Investigators using a bioinformatic approach and phosphatase assay characterized a putative second serine/threonine phosphatase PrpN.
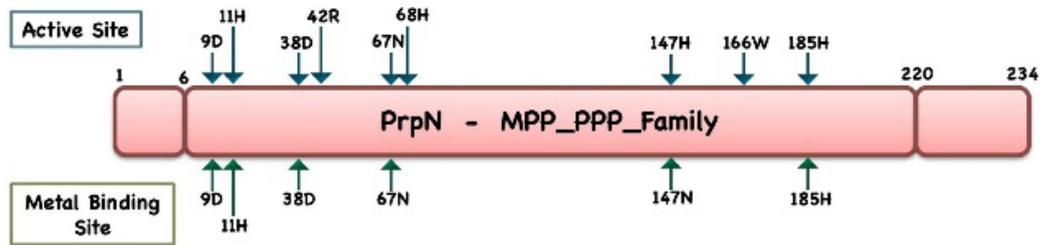
Fig 3.17: Schematic description of PrpN phosphatase domain

To study the function of the PrpN ser/thr protein phosphatase (Figure 3.17). in the physiology of BA, investigators generated a null mutant of *prpN* (BAS Δ *prpN*) in the background of *B. anthracis* Sterne strain and found the plausible role of *PrpN* in *Bacillus* growth in normal as well as stress conditions (Figure 3.18)
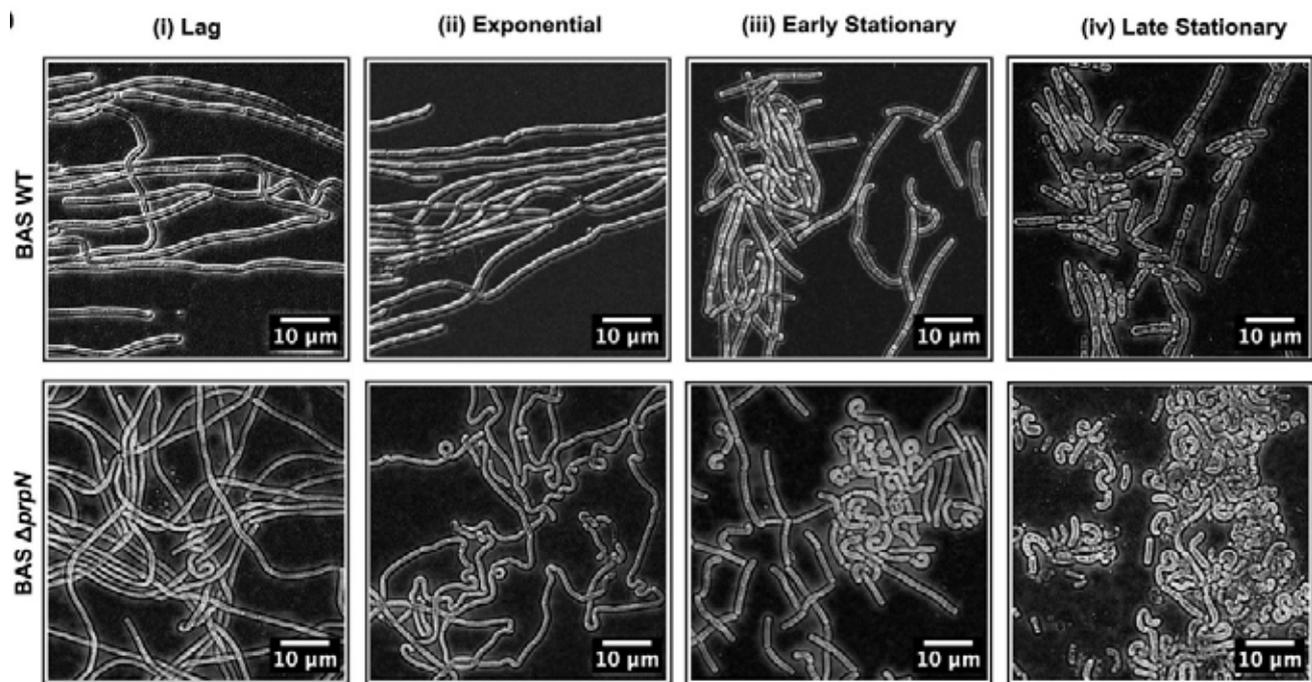
Fig 3.18: Representative phase contrast microscopy images of BAS WT and BAS *ΔprpN* strains at different time points.

The absence of PrpN causes structural abnormalities in vegetative bacterial cells. Using phase contrast (Figure 3.19(A)) and a scanning electron microscope (Figure 3.19(B)) investigator clearly showed the heterogeneous population of bacterial cells with structural aberrations such as coiled-coil structures and bent cells in deleted prpN strain. Investigators checked for cell septation (Figure 3.19(C)), which is crucial for bacterial growth and cell division. They found a high population of multi-septa cells in BAS Δ *prpN* strain compared to the BAS WT and BAS Δ *prpN::prpN* strain.
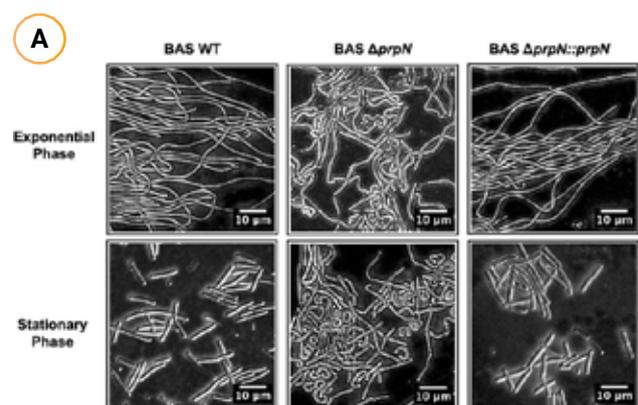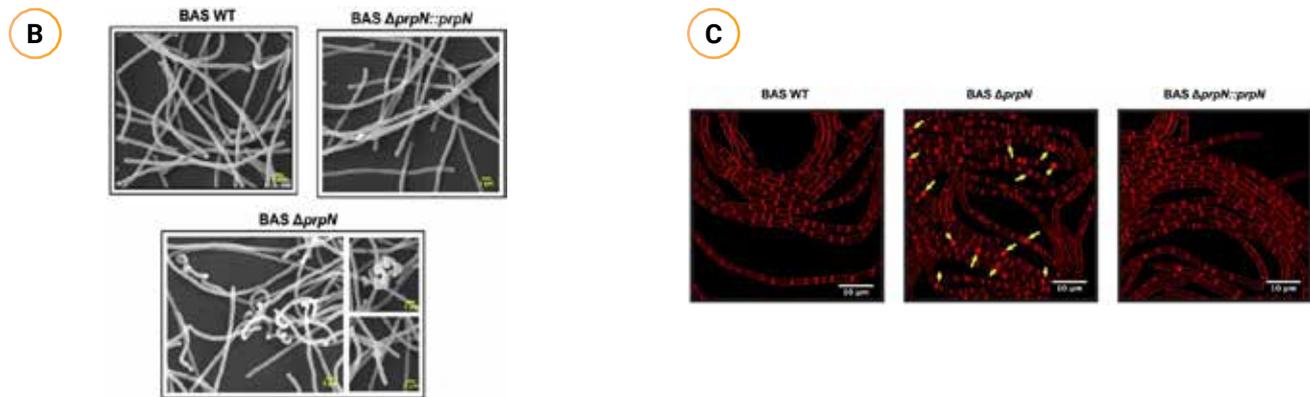
Fig 3.19: (A) Representative phase contrast images of bacterial cells at exponential and stationary growth phase. **(B)** Representative scanning electron microscope images of indicated vegetative bacterial cells. **(C)** Cell septation process of BAS WT, BAS *Δ prpN* and BAS *Δ prpN::prpN*.

Sporulation is a highly regulated process that involves asymmetric septation of the vegetative cells resulting in the generation of two distinct compartments- mother cells and forespore, forespore engulfment by mother cell, spore maturation and finally the release of mature spore following mother cell lysis. Using transmission electron microscopy TEM) investigator clearly showed that BAS WT and BAS *Δ prpN::prpN* spore images (showed intact spores having multiple protective layers (Figure 3.20(A)), while undeveloped spores and vegetative cells with asymmetric septation were seen in the BAS *Δ prpN* strain (Figure 3.20(B)). This clearly shows the indispensable role of PrpN during the sporulation process in BA.
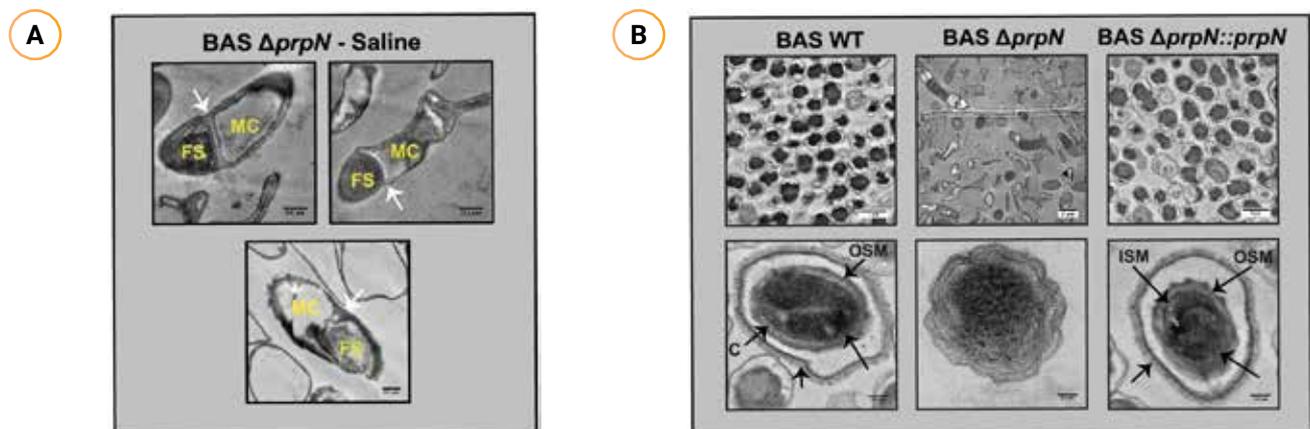
Fig 3.20: **(A)** Representative Transmission electron micrographs of indicated strain spores. Spore layers are depicted in the images with arrows- ES-exosporium, OSM-outer spore members, ISM-inner spore membrane, C-cortex. **(B)** Representative Transmission electron micrographs of BAS *Δ prpN* sporulating cells. FS denotes forespore and MC denotes mother cell. White arrow indicates asymmetric septation.

In order to test whether PrpN is required for efficient toxin production, which is crucial for the pathogenic cycle of BA, investigators made a whole cell lysate (Figure 3.21(A&B)) or supernates (Figure 3.21(C&D)) and protein obtained from the cells culture grown in NBY medium containing 1% NaHCO$_3$ and probed for PA and LF specific antibodies to examine the synthesis and secretion of toxin proteins. Interestingly they found a drastic reduction in both protein levels during toxin synthesis and as well as in the secretion stage in the BAS *Δ prpN* strain, compared to the BAS WT and BAS *Δ prpN::prpN* strain. These results clearly indicate the vital role of *PrpN* in BA toxin protein synthesis. The outcome of the work was published in a reputed peer-reviewed journal. This work was done at the University of Delhi, Delhi.
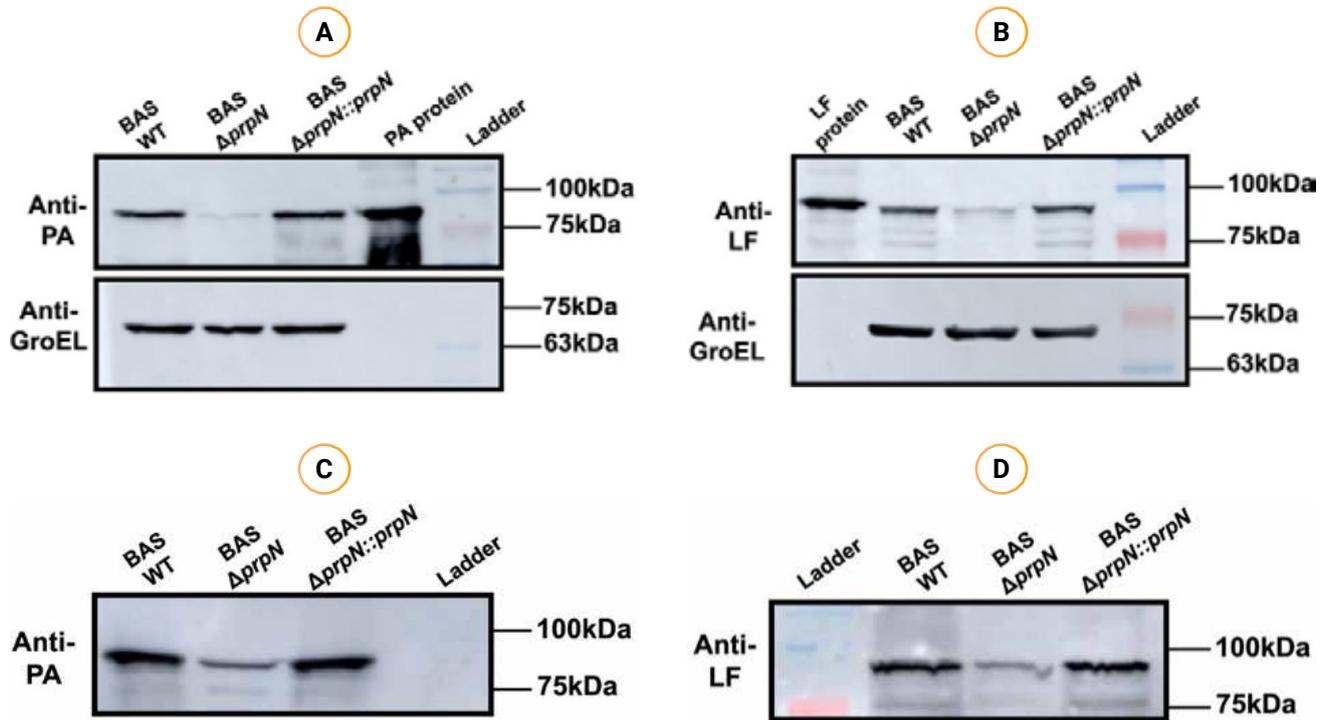
Fig 3.21: (A&B) Representative immunoblots showing PA, LF and AtxA synthesis in indicated strains in whole cell lysates and **(C&D)** Supernates.

3.1.1.11 Interdisciplinary Biological Sciences

In the reporting period, 3 new projects were sanctioned. The areas in new & ongoing projects supported under CRG–Interdisciplinary Biological Sciences are shown in the following figure.

Areas Supported

Cell Biology, Microbiology

Biochemistry, Molecular

Parasitology, Virology

Inter-disciplinary Biological Sciences

Computational and Structural Biology

Health Sciences

Plant and Agricultural Sciences
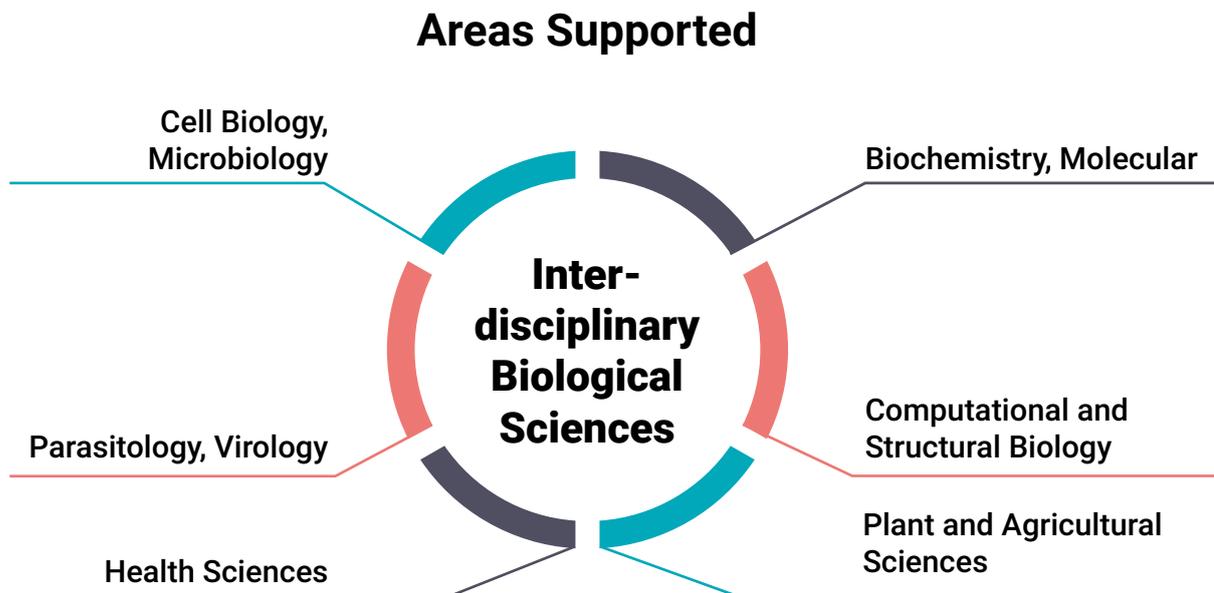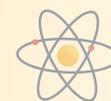
3 Projects Sanctioned

Expenditure (New and Ongoing)

17.37 cr

Research Highlight

Piezo-KLF2 axis in endothelial dysfunction and venous wall remodelling in varicose veins Samples were collected from 39 patients (29 men and 10 women) with chronic venous diseases who underwent vein stripping at Kempegowda Institute of Medical Sciences, Bangalore with their consent. The median age of patients was 39 years (range 21–68). Healthy saphenous veins were collected from 44 subjects who underwent coronary artery bypass grafting (38 men and 6 women) at Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bangalore. Varicose veins had a larger neointimal area compared to control saphenous veins (Figure 3.22). Tunica media was thickened, and bundles of SMCs were seen in varicose veins.
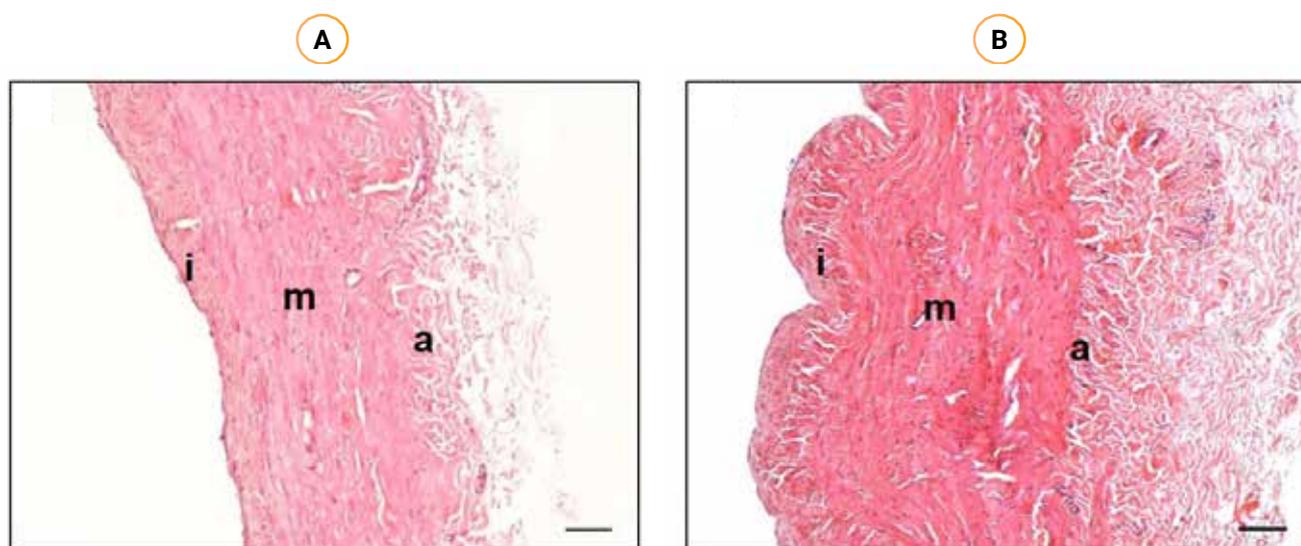
Fig 3.22: Microscopic photos showing the histological structure of vein (H&E staining). **(A)** Control saphenous vein shows the regularity of vein wall with normal thickness of three layers (tunica intima (i), tunica media (m) and tunica adventitia (a). Medial longitudinal bundles of SMCs are visible. **(B)** Section of varicose vein shows the irregular pattern of the wall with thickened neointima (i), VSMC proliferation in media (m) and adventitia (a). Magnification- 10X, Scale bar- 100μm

The expression levels of Piezo1 and KLF2 genes were assessed in 39 human varicose veins and 44 control saphenous veins by qRT-PCR. There was a marked reduction in Piezo1 and KLF2 mRNA expression in varicose veins compared to control veins (Figure 3.23).
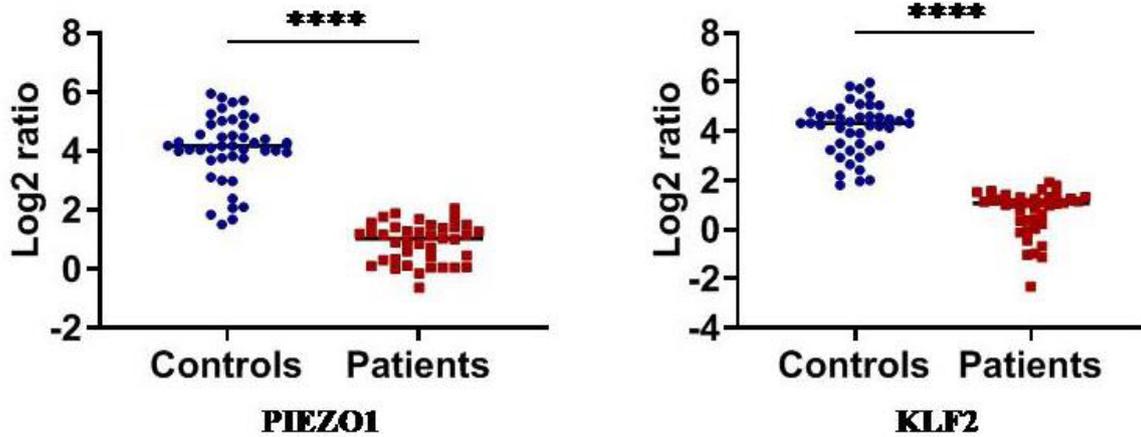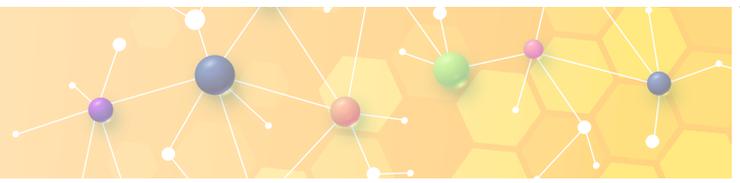
Fig 3.23: Scatter plots represent the mRNA changes of atheroprotective gene KLF2 in human varicose veins and control saphenous veins. GAPDH was used as the endogenous control. Horizontal lines in scatter plots indicate median values. Values are means ± SD (standard deviation) **** $p < 0.0001$.

The study found that mechanosensor Piezo1 expression is downregulated in varicose veins compared to healthy veins, unlike several cancers and atherosclerosis where Piezo1 overexpression was reported. Similarly, mechanotransducer KLF2 was found downregulated in varicose vein tissue samples compared to control veins. It also demonstrated that the occurrence of endothelial to mesenchymal transition in human varicose veins. This is by far the first study in which a mechanosensor was studied in the context of venous diseases, especially varicose veins. The intricate connection between Piezo1-KLF2 and EndMT signalling will be dissected in future in vitro flow-based experiments. The study is being carried out at Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram.

3.1.1.12 Organismal and Evolutionary Biology

In the reporting period, 9 new projects were sanctioned. The areas in new & ongoing projects supported under CRG −Organismal and Evolutionary Biology are shown in the following figure.

Areas Supported
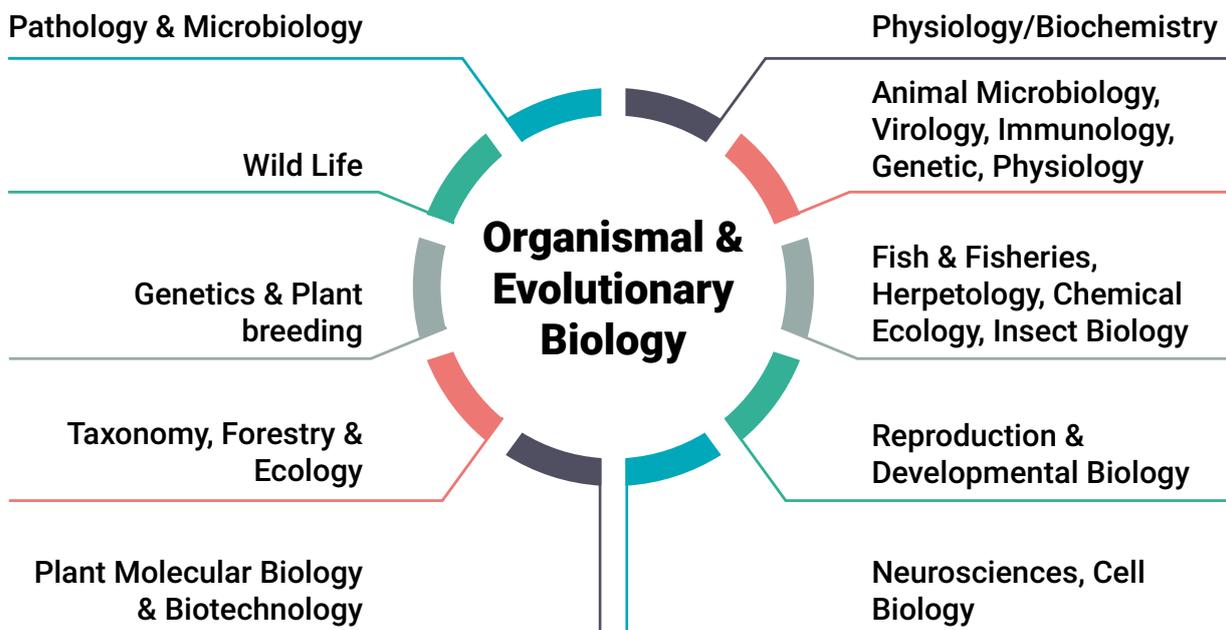
Projects Sanctioned
9

Expenditure
(New and Ongoing)

15.39 cr

Research Highlights

Study the role of tomato metacaspases during oxidative stress

The role of some tomato metacaspases (SolycMCs) during stress responses more specifically in oxidative stresses were characterised. In the tomato genome, eight Metacaspases (SolycMCs) were identified. The tomato MCs were named SolycMC1, SolycMC1-like1, SolycMC1-like2, SolycMC3, SolycMC3-like1 and SolycMC3-like2, SolycMC4 and SolycMC9 based on the homology with *Arabidopsis thaliana* Metacaspases. Expression of these SolycMCs was analyzed in tomato tissues exposed to various stresses. qRT-PCR analysis shows that Type II, SolycMC4 was highly upregulated in heat, wounding, hypoxia, osmotic stress, RB, MV, H_2O_2, ER and mitochondrial stress. SolycMC1 was upregulated in cold, heat, wounding, RB, MV, JA and SA treatments. Type II SolycMC4 was the most significantly upregulated in the hypoxia, osmotic stress, H_2O_2, ER and mitochondrial stress. SolycMC1 also showed upregulation in some of these stresses. Other SolycMC genes showed either downregulation or no change in expression in these stresses. Also, a relatively large number of stress responsive cis-regulatory elements were identified in the promoters of SolycMCs, indicating their possible roles in stress mitigation or stress responses. The expression of SolycMC4 was also analyzed by a GUS reporter assay. SolyMC4Prom::GUS lines showed GUS expression in various tissues including the vascular tissues of developing leaves, petioles, stem, primary and lateral roots. It was also observed that GUS expression was induced by wounding and H_2O_2, showing SolycMC4 roles in oxidative stress.

To characterize the roles in stress responses, 35S::amiRNA-SolycMC4 and 35::amiRNA-SolycMC1 expressing lines were generated for silencing of SolycMC4 and SolycMC1 in tomato, respectively. Biochemical characterization showed that silencing of SolycMC4 leads to less H_2O_2 content and higher activity of ROS scavenging enzymes in plants. It appears that ROS levels were altered to protect against oxidative damage and for signalling purposes. Further characterization of these lines showed a strong drought tolerance phenotype. Expression analysis of various known marker proteases (SBT3, RCR3, MLO1, PR1a) and nucleases (TBN1 and PRN1) was also altered in the plants indicating that drought tolerance phenotype was due to altered cell death concomitant in the SolycMC4 silencing lines. It was also observed a greater number of necrotic spots on leaves of 35S::amiRNA-SolycMC4 lines after ABA, H_2O_2 and MV (methyl viologen) treatments than the control plants. Characterization of 35::amiRNA-SolycMC1 lines also showed reduced height of plants and some other developmental alterations including increased chlorophyll and anthocyanin contents (Figure 3.24). Histochemical analysis showed reduced ROS levels and increased activity and expression of antioxidant enzymes indicating cellular ROS imbalances in 35S::amiRNA-SolycMC4 lines. It was observed an upregulated expression of chloroplast biogenesis marker gene rbcL and decreased expression of the petB gene which encodes the cytochrome b6 subunit of the cytochrome b6f complex and ndh1 gene of mitochondrial complex-1(Figure 3.25). The decreased activity of mitochondrial complex-I was observed indicating that the function of mitochondria and chloroplast was altered. Differential expression analysis using RNA-seq data showed that the Dehydrin gene which is expressed during drought stress and upregulated by ABA was upregulated in SolycMC4 gene silencing lines. In addition, Cpn10/ chaperonin 21, involved in protein folding, Superoxide dismutase Mn-Fe SOD and pathogenesis related protein, PR1b1 were also upregulated in these lines. All these results clearly showed that SolycMC4 is involved in regulating ROS, cell death programs and plant defence responses during oxidative stress. This work was done at The Maharaja Sayajirao University of Baroda, Gujarat.
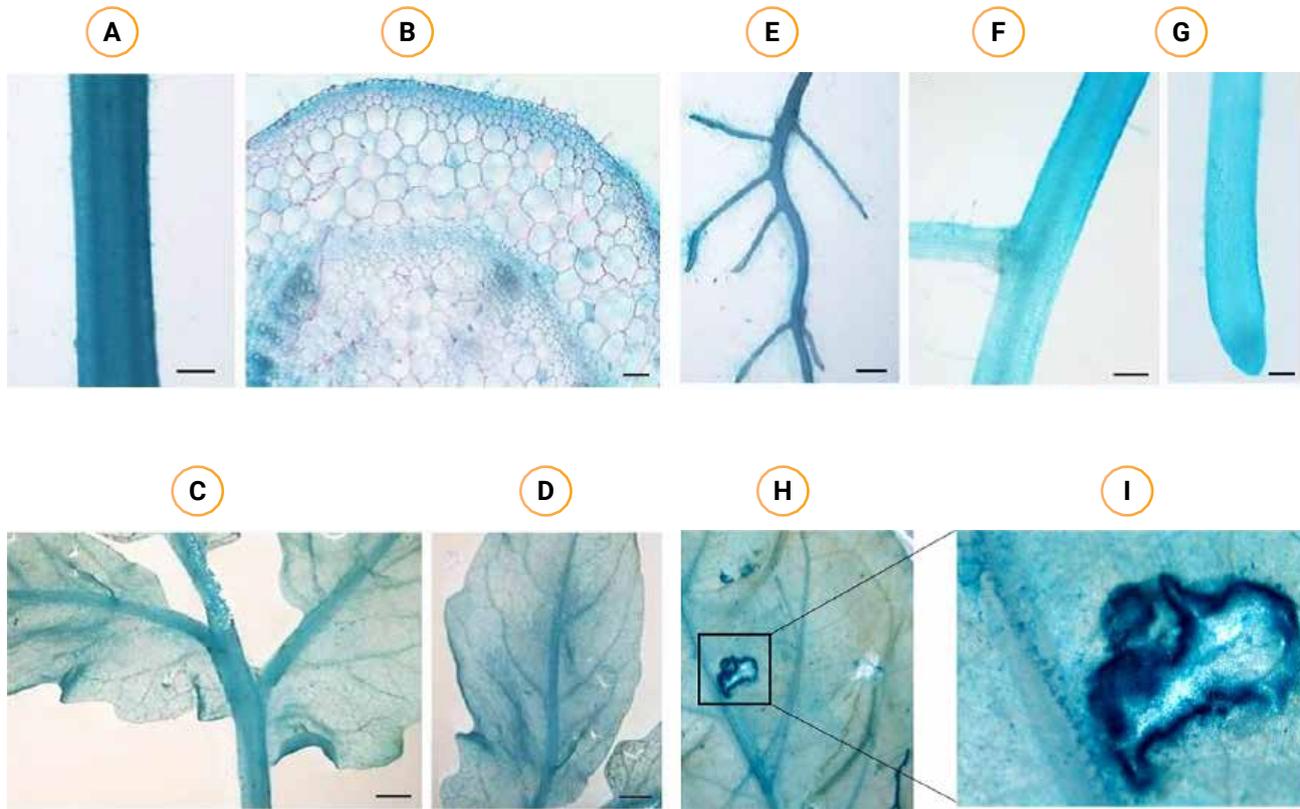
Fig 3.24: GUS expression pattern in 3-week-old SolycMC4Prom::GUS line in tomato: Expression in stem (A), in different cell layers of stem (B), in petiole and leaf (C; D) and in roots (E-G). GUS expression was also induced by wounding (H; I)
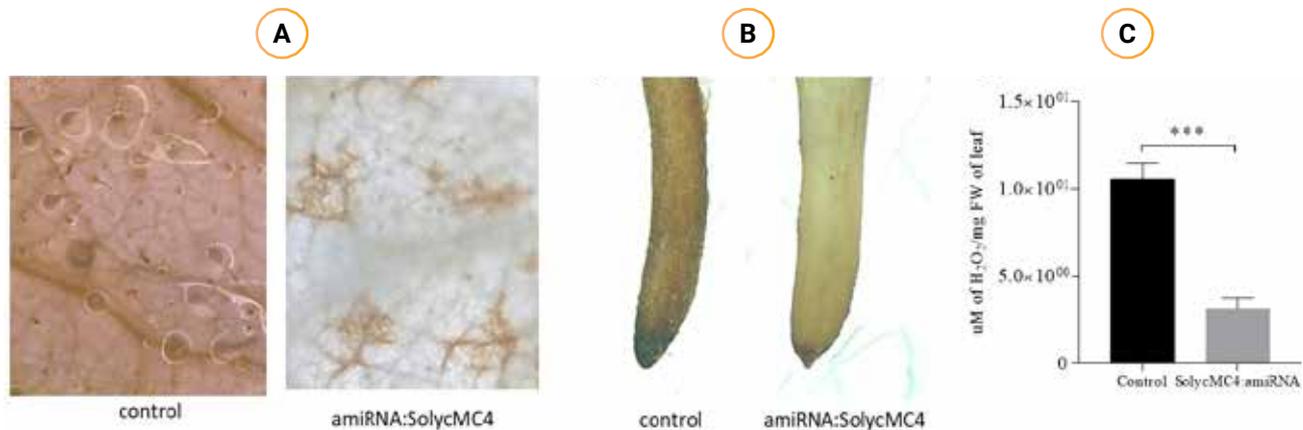
Fig 3.25: DAB staining for ROS (H_2O_2) detection in leaf (A) and primary root tip (B) of control and 35S::amiRNA-SolycMC4 line in tomato. Biochemical analysis also shows reduced ROS level in35S::amiRNA-SolycMC4 silencing line than the control (C).

Sex determination in the garden lizard, Calotes versicolor: Search for Regulators and Modifiers

The present project emanates from a vast diversity of the mechanism(s) of sex determination in lower vertebrates where, unlike mammals, the genomic mode of sex determination is not ubiquitous, and the process remains labile through embryonic development, adjusting to the diverse environment, hormonal and genomic signals. The Indian Garden lizard, *Calotes versicolor,* lacks a genomic mode of sex determination, nor does incubation temperature affect sex determination. Nevertheless, treatment of eggs with androgens or an inhibitor of the enzyme, Aromatase, show sex reversal towards male. Also, a number of autosomal (present in both sexes) genes express sex-specifically in the developing gonads.
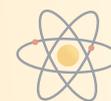
Curiously, in certain breeding seasons the sex ratio of the hatchlings is drastically skewed towards one or the other sex, regardless of the rearing conditions. In light of these observations, it was asked whether epigenetic factors, viz., the yolk constituents in the unfertilized egg and/or genomic modifications (e.g. DNA methylation) regulating differential gene expression have a causal role in the determination of sex in *C. versicolor*.

Calotes. versicolor eggs were reared in the lab at different temperatures (28^0C, 25^0C, 31^0C, 33^0C, 34^0C) or after a one-time application of testosterone (male hormone)/estradiol (female hormone) or Fadrozole (aromatase inhibitor) during early development at 28^0C (pivotal temperature) (Figure 3.26). Except for those treated with fadrozole and testosterone, all of which developed as males, >90% of the other embryos were females in 2020 and males in 2021. There is indeed a high but variable concentration of all the 3 reagents in the yolk of the mature day '0' eggs suggesting that they could influence the sex differentiation. Testosterone level was much higher in the embryos of 2021 than those of 2020 and '22 which indicates its role in male sex determination which needs to be confirmed by further studies. It has also been unveiled the whole genome of *C. versicolor* using hybrid NGS technology of Nanopore and Illumina which shows a 1.6 GB genome of C. versicolor which is now being analyzed and annotated. Curiously, *C. versicolor,* gene sequences are quite different from the American lizard, *Anolis caroliensis,* the only other well worked out lizard genome. The NGS data will enable to study the dynamics of differential methylation of genes in the testis and ovary as a function of development and differentiation which will be then compared with their transcriptome. This work is being carried out at Banaras Hindu University, Varanasi.

Fig 3.26: A brief description of the sex identification of the lizard, increasing size of the eggs as they grow, their maintenance in wet sand in an earthen pot, hatching from an egg, and a male and a female individual and the hemipenis in adult male. (Clock-wise)

3.1.1.13 Mathematical Sciences

In the reporting period, 39 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Mathematical Sciences are shown in the following figure.

Areas Supported
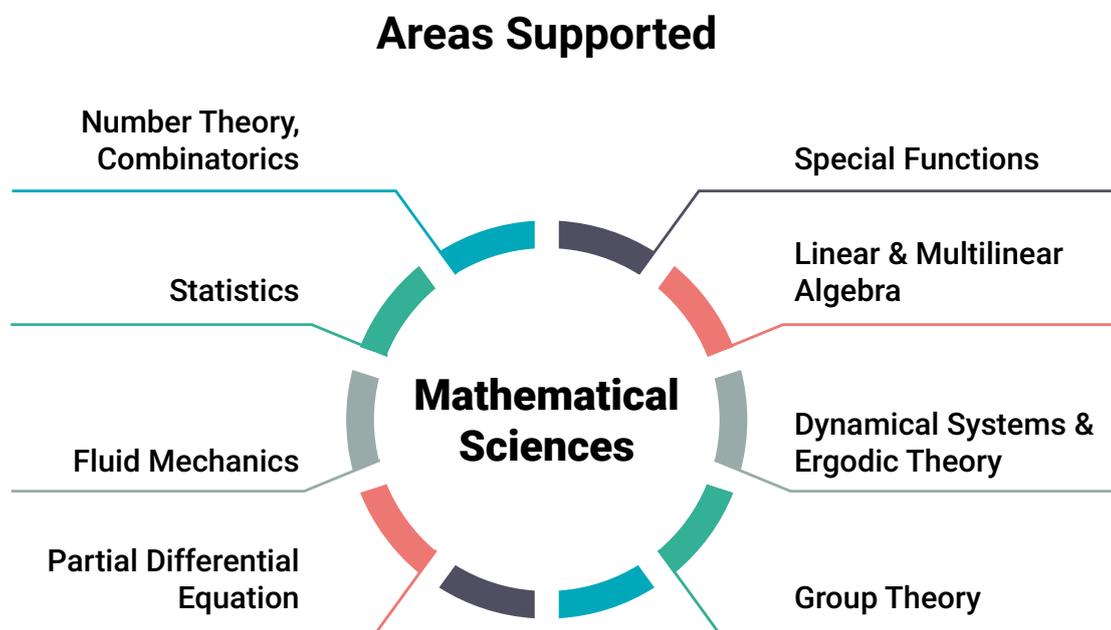
39 Projects Sanctioned

Expenditure (New and Ongoing)

5.56 cr

Research Highlight

High order entropy stable schemes and automatic mesh adaptation techniques: their design, analysis and applications

The TECNO framework which is low dissipative and demands sign stability of scaled entropy variable only across locally significant jumps was modified and therefore can work with other high order reconstructions (Figure 3.27). In fact, it is also proved that third order WENO and high order TVD reconstructions are signed stable at LSJ.
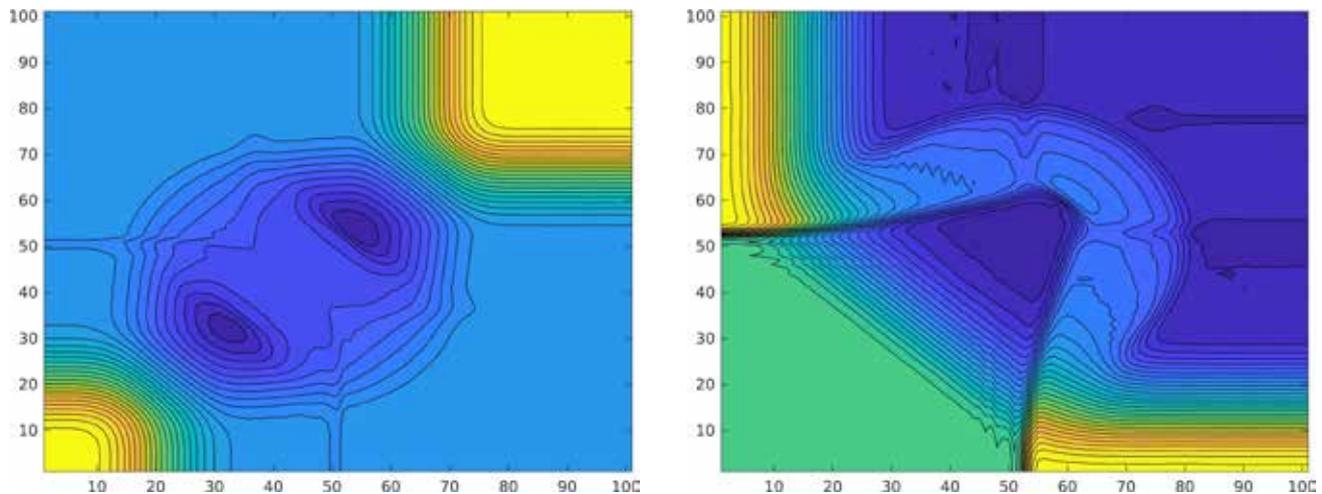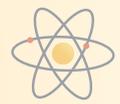
Fig 3.27: Representative contour plot of solution of 2D Riemann problems using algorithm proposed.

A total variation diminishing condition in terms of entropy variable was deducted and applied to design a diffusion matrix such that the resulting entropy stable flux ensures the complete removal of spurious oscillations (Figure 3.28).
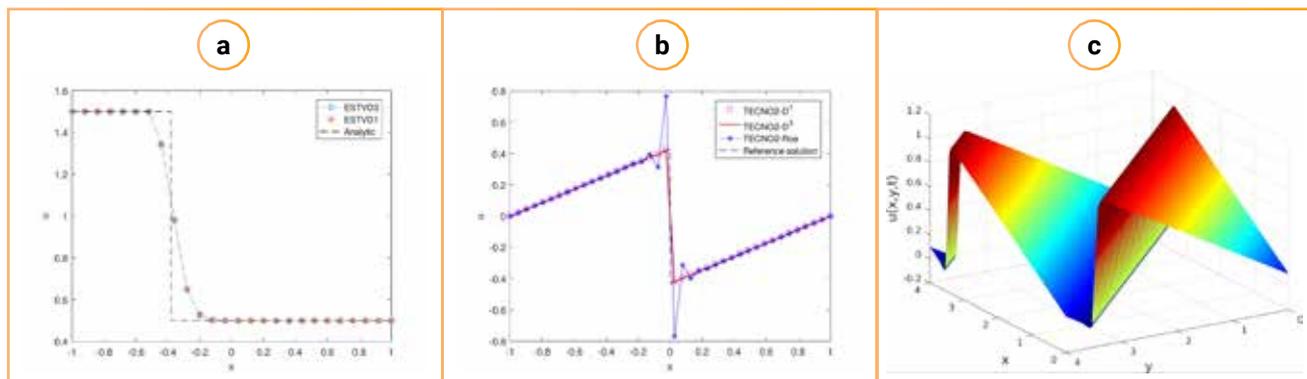
Fig 3.28: Non-oscillatory shock capturing by proposed entropy stable schemes in case (a) Linear transport equation, (b) 2D Burgers equation (c) Comparison of effect on solution approximation using proposed diffusion matrices for 1D Burgers equation.

It is not possible to have an initial data independent, 'uniformly' non-oscillatory three point fixed stencil scheme irrespective of its accuracy. In the light of data dependent stability conditions on three point second order upwind and centred schemes, necessary conditions on third order nonlinear WENO weights are imposed to get non-oscillatory WENO schemes. These conditions give further insight into the required structure of non-linear weights to design third order WENO schemes. Representative images are shown in (Figure 3.29).
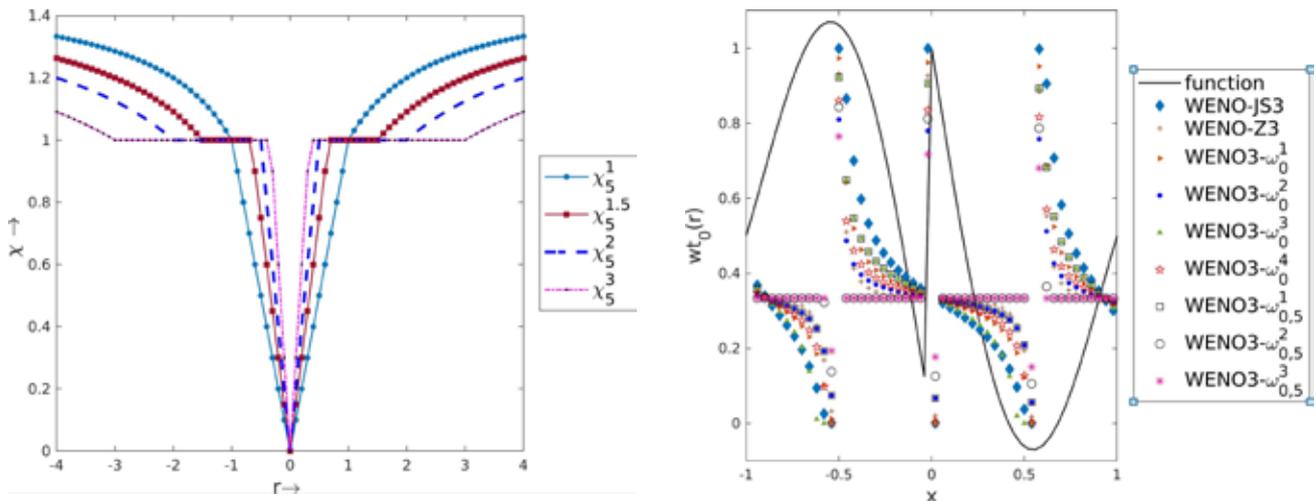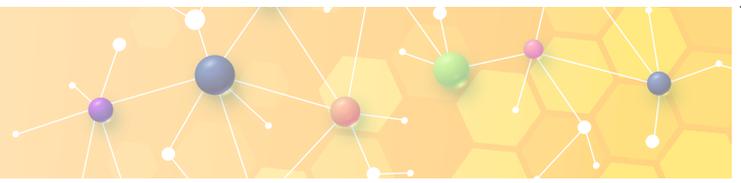
Fig 3.29: Distribution of different WENO3 weights with respect to the underlying function.

A new robust and automatic mesh adaptation algorithm was proposed for numerical solutions of singularly perturbed boundary and interior layer problems. The main salient features of the proposed heuristic mesh generation algorithm are: it does not require a prior knowledge about the nature or location of the layer region, it is independent of the problem under consideration and the numerical discretization scheme. A representative image is given in (Figure 3.30).

A parameter-uniform fitted mesh finite difference scheme was constructed and analyzed for a class of singularly perturbed interior turning point problems. The solution to this class of turning point problem possesses two outflow exponential boundary layers. Parameter-explicit theoretical bounds on the analytical solution derivatives are given, which are used in the error analysis of the proposed scheme. A hybrid finite difference scheme discretizes the problem comprising of midpoint-upwind and central difference operators on an appropriate piecewise-uniform fitted mesh.
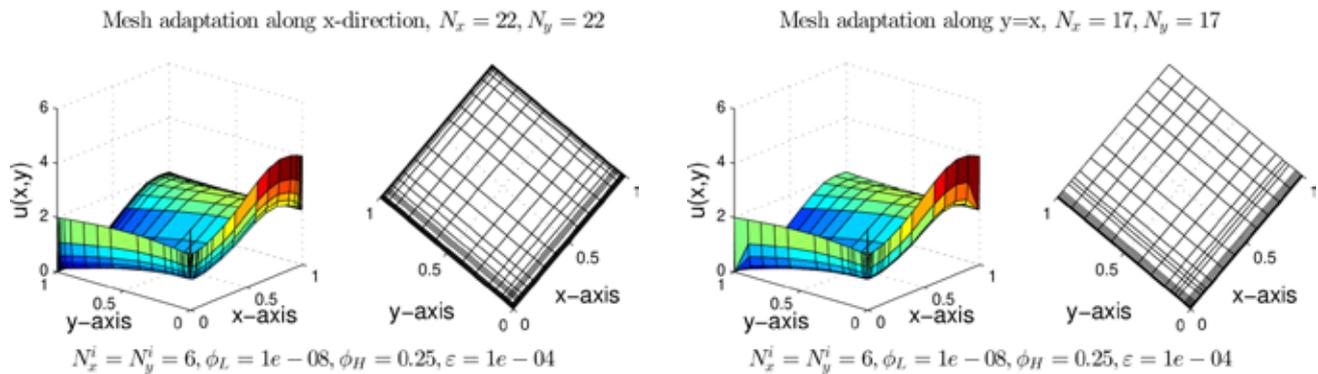
Fig 3.30: Simulation results for 2D problem using proposed mesh adaptation algorithm.

Application of developed techniques for haemodynamic and river model for accurate simulation of blood flow in human arteries and transport of contamination in rivers: The developed method is applied to 1D and 2D river flow problems which are modelled by Shallow water equations. The problem of partial Dam break is simulated (Figure 3.31). This work was done at SRM Institute of Science and Technology, Chennai.
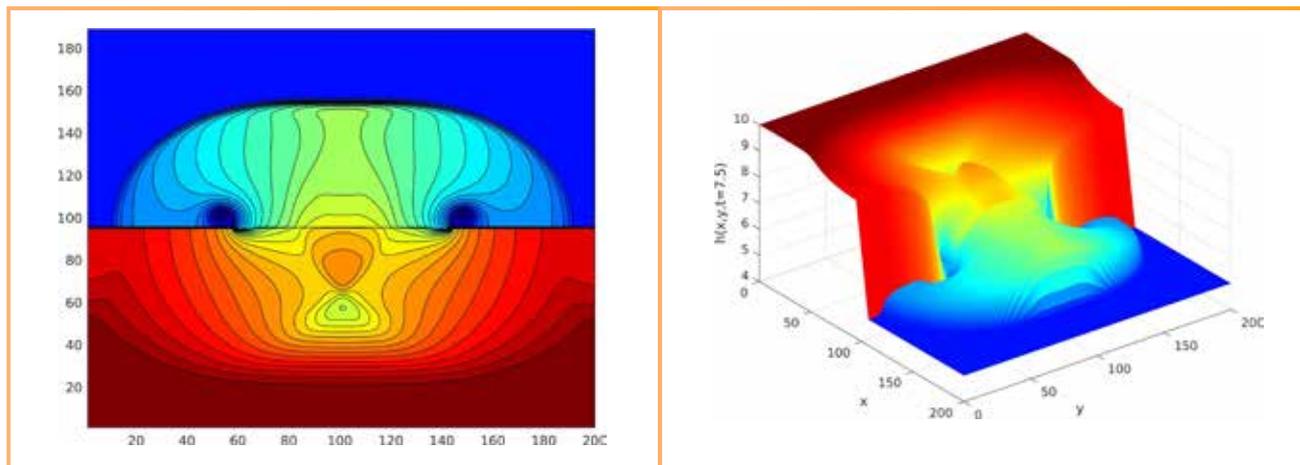
Fig 3.31: Simulation results water height in case of partial dam problem. Contour plot (left), 3D surface plot (right).

3.1.1.14 Physical Sciences I – (CMP & MS)

In the reporting period, 101 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Physical Sciences I – (CMP & MS) are shown in the following figure.

Areas Supported

Quantum Materials

Nanomaterials

Magnetism & Superconductivity

Physical Sciences I – (CMP & MS)

Crystal Growth

Semiconductor Physics

Solar Cells & Photovoltaics

Soft Condensed Matter
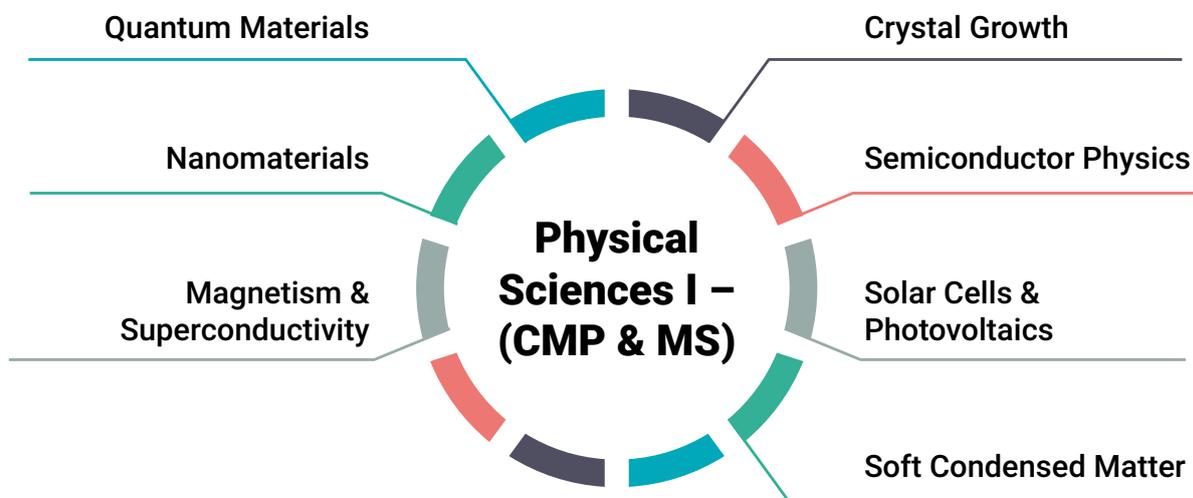
101 Projects Sanctioned

Expenditure (New and Ongoing)

27.68 cr

Research Highlight

Realization of Topological Phases Using Van-der Waals Heterostructures

For decades, physicists have been captivated by strongly correlated electronic systems, and the discovery of graphene and graphene-based Van-der Waals heterostructures such as twisted bilayer graphene has provided a platform for studying emerging quantum phases like superconductivity, correlated insulators, topological phases, and magnetic orders. Conventional resistance measurements are not sufficient to understand these intriguing quantum phases. Instead, heat transport measurements such as thermopower or thermal conductance, which are sensitive to the particle-hole asymmetry of the electronic structure and can detect charge-neutral excitations, can more effectively identify the emergent phases and their properties (Figure 3.32). Although thermal transport measurements are challenging to perform, this project, titled "Realization of Topological Phases Using Van-der Waals Heterostructures," uses high-accuracy noise thermometry to study the topological phases of the fractional quantum Hall in graphene and the strongly correlated phases of magic-angle twisted bilayer graphene at the integer fillings of the Moiré band (Figure 3.33). The major findings include detecting interaction-driven quantum phase transitions in twisted bilayer graphene (Nature Physics 18, 691-698), the detection of neutral modes (Nature Communications 13, 213), and the determination of the topological quantum numbers of fractional quantum Hall states in graphene (Nature Communications 13, 5185). This work was done at Indian Institute of Science, Bengaluru.
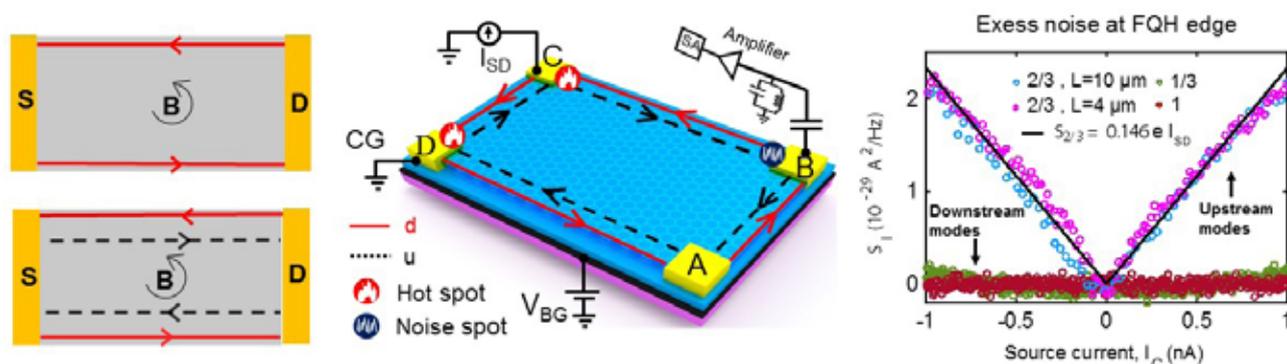
Fig 3.32: Left panel: Downstream (red lines) and upstream (dashed black lines). Middle panel: the schematic for noise measurement for "upstream" mode detection. Right panel: The noise is detected for fractional quantum Hall states with "upstream" modes whereas it remains zero for only downstream modes.
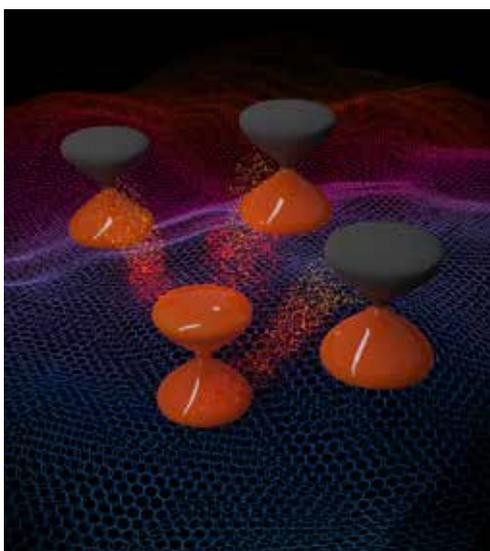
Fig 3.33: The interaction driven cascaded phase transition whenever the moiré super lattice is filled with one electron, and suddenly one of the flavours of the four Dirac cones become completely filled with electron and others becomes completely empty.
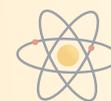
3.1.1.15 Physical Sciences II - (PHENNA-LOAMP)

In the reporting period, 40 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Physical Sciences II - (PHENNA-LOAMP) are shown in the following figure.

Areas Supported

Lasers & Optics

Plasma, High Energy

Nuclear Physics

Physical Sciences II - (PHENNA-LOAMP)

Astronomy & Astrophysics

Atomic & Molecular Physics

Nonlinear dynamics
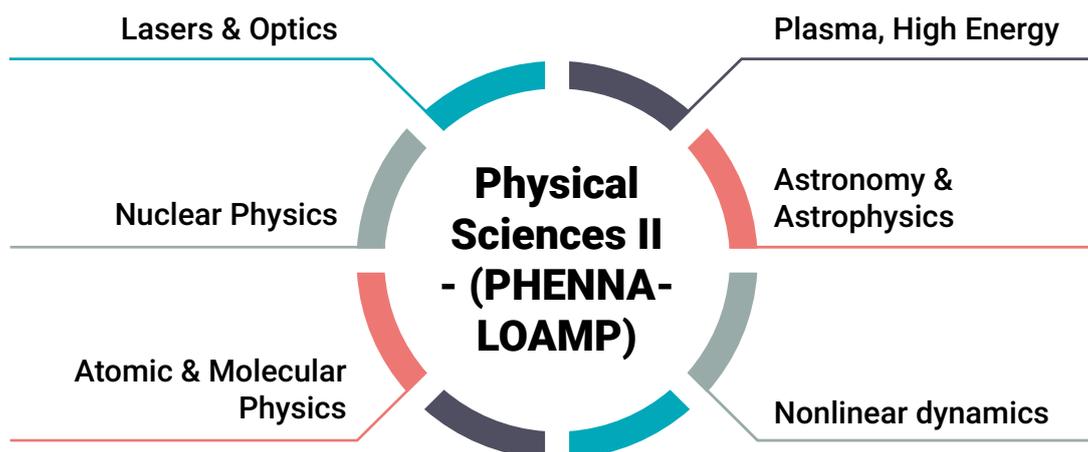
40 Projects Sanctioned

Expenditure (New and Ongoing)

10.10cr

Research Highlight

Experiments on the collective dynamics of interacting chemo-mechanical oscillators

- **Periodic oscillations in a string of camphor infused disks**

An experimental study on a filament made of camphor infused paper disks, stitched together adjacent to each other using nylon thread. The filament displays spontaneous translatory motion when it is placed on the surface of water due to the surface tension gradients created by camphor molecules on the water's surface.

The oscillations are analogous to ciliary and flagellar beating in biological organisms, which are actuated by the active forces due to molecular motors. Numerical model qualitatively reproduces different oscillatory modes of the filament (Figure 3.34).
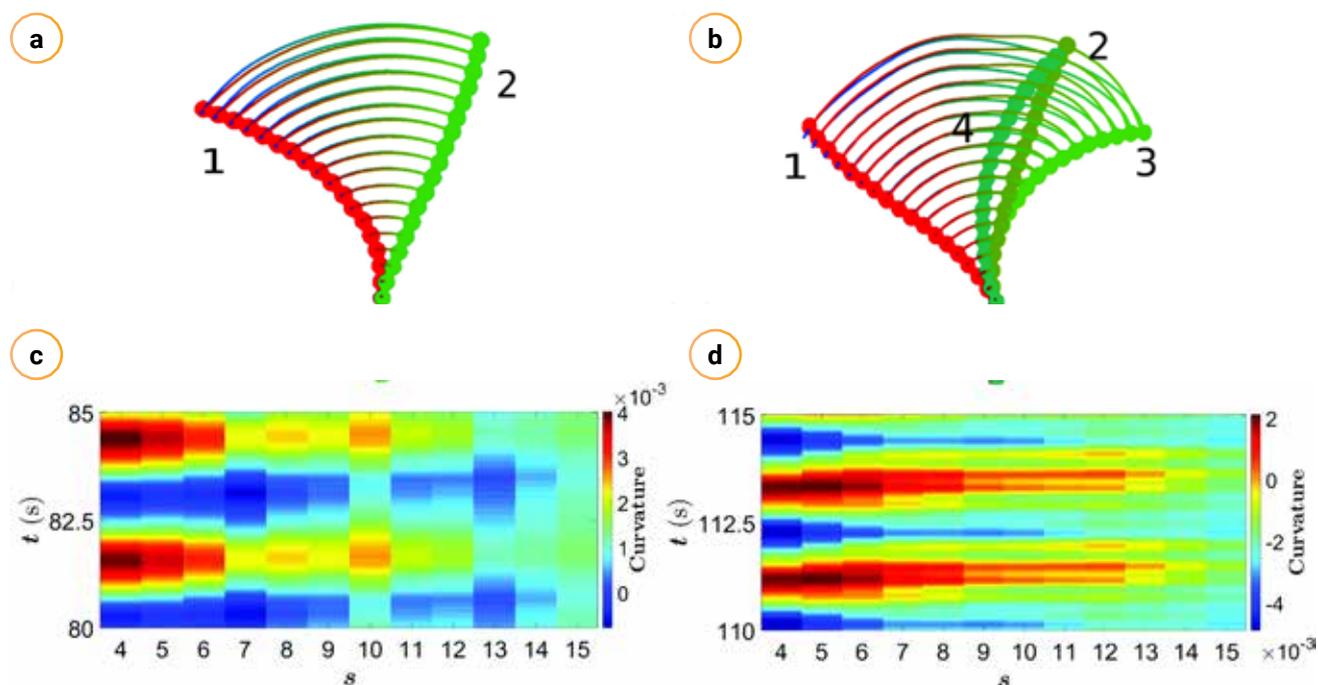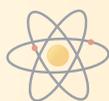
Fig 3.34: (a) Oscillations of active camphor-ribbon analogous ciliary and flagellar beating. **(b)** Oscillations with fluttering. **(c)** and **(d)** show curvature of ribbon as a function of time and distance from the pin for **(a)** and **(b)**.

- **Rotational synchronization of camphor ribbons in different geometries**

Experiments on multiple pinned self-propelled camphor ribbons, which is a rectangular piece of paper with camphor infused in its matrix. Experiments were performed on three, four, and five ribbons placed in linear and polygonal geometries. In different geometries, the ribbons have been observed to rotationally synchronize in all the possible configurations. A numerical model, emulating the interactions between the ribbons as Yukawa interaction was studied, which was qualitatively able to reproduce the experimental findings (Figure 3.35).
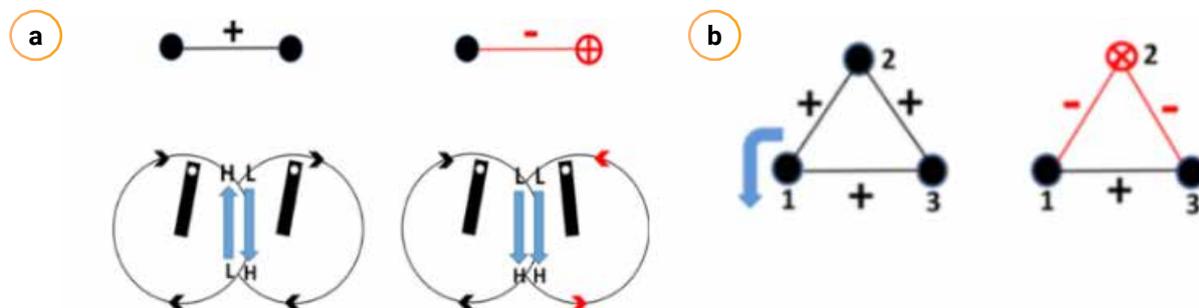
Fig 3.35: (a) Two ribbons: Co- and counter-rotating mode **(b)** Three ribbons: (i) All co-rotating (ii) One pair co-ratating and other two pairs are counter-rotating

- **Chimeralike states in a minimal network of active camphor ribbons**

In the minimal network of globally coupled camphor ribbons, chimeralike states are characterized by the coexistence of two synchronized and one unsynchronized ribbon. (x_1, x_2) and (y_1, y_2) are synchronized (coherent), while the other two pairs are unsynchronized (incoherent). This shows the emergence of chimeralike states in the network (Figure 3.36). This work was done at the Indian Institute of Technology, Bombay.
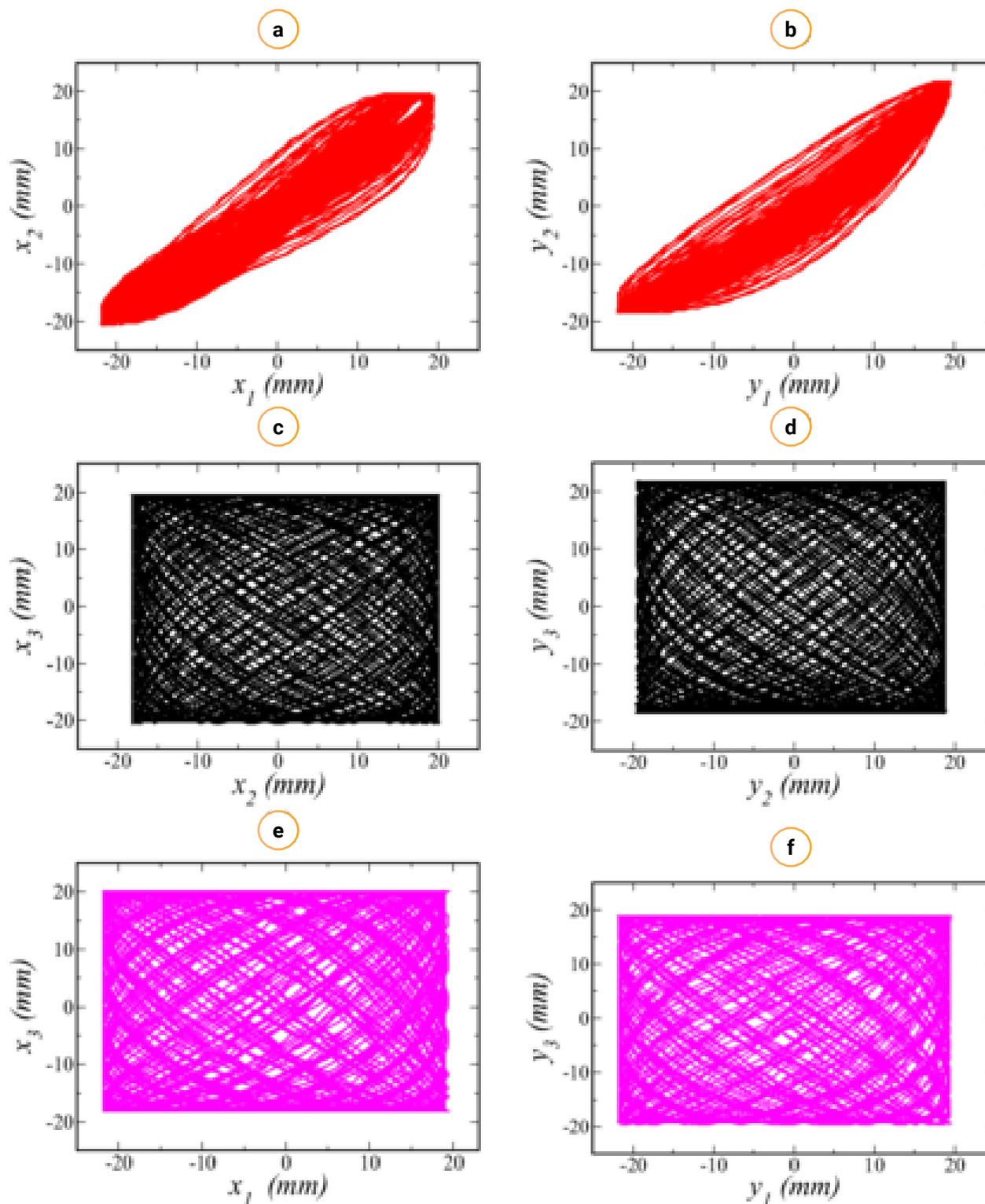
Fig 3.36: Chimeralike states: (a)-(b) show the synchronized pair 1-2. (c) -(f) show the remaining two unsynchronized pairs.

3.1.1.16 Quantitative Social Sciences

In the reporting period, 6 new projects were sanctioned. The areas in new & ongoing projects supported under CRG – Quantitative Social Sciences are shown in the following figure.

Areas Supported

- Mathematical
- Statistical
- Computational

Quantitative Social Sciences

6 Projects Sanctioned

Expenditure (New) **1.05 cr**
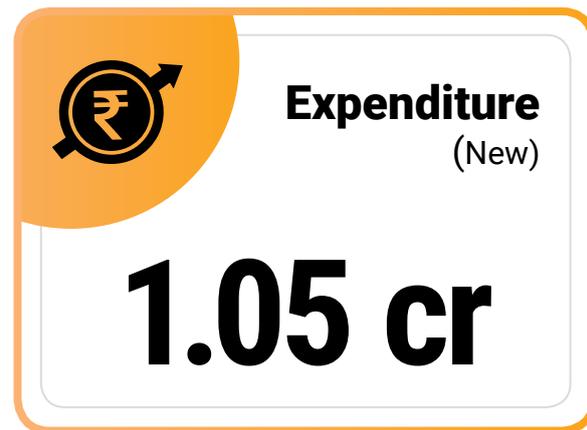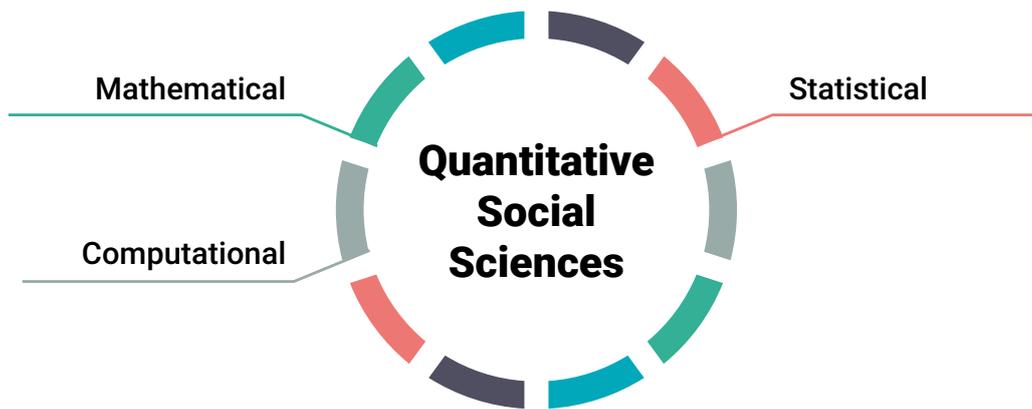
Research Highlight

Value Chain Analysis of Walnut in Jammu and Kashmir

All the Walnut growing districts are selected for the study purpose. A schedule was prepared for the survey purpose and a pilot survey was conducted. A list of villages with the highest area and production of walnut as well as walnut growers has been identified and a preliminary list has been prepared in consultation with the Department of Horticulture, Jammu. Training cum Awareness programme organised in Udhampur District for dissemination of production practices and marketing opportunities for walnut. Patangarh and Latti areas of Udhampur district were visited to collect primary data about the cultivation practices adopted by the walnut growers. First-hand information about the walnut area and production was collected from the walnut growers/ key informants. On spot, field visit was made to farmer's field for redressing their problems.

Meetings were held with the walnut exporters/ traders of Jammu and the following problems were listed by them:

- Premature harvest
- Post-harvest management
- Extraction of kernels
- Hygienic environment
- No single variety
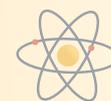
Table 1: Import Penetration Ratio of Walnut in India from 2011 to 2020

Years	Walnut Import (India) (000'tonnes)	Walnut Export (India) (000'tonnes)	Production (000'tonnes)	Import Penetration Ratio (IPR)
2011	0.17	5.58	284.40	0.001
2012	0.15	6.86	233.11	0.001
2013	0.30	41.50	240.63	0.001
2014	0.52	5.48	238.25	0.002
2015	4.45	6.48	228.60	0.020
2016	7.16	3.22	287.33	0.025
2017	21.77	2.92	299.71	0.068
2018	15.68	2.68	299.00	0.050
2019	17.36	1.59	296.00	0.056
2020	28.15	1.31	296.00	0.087
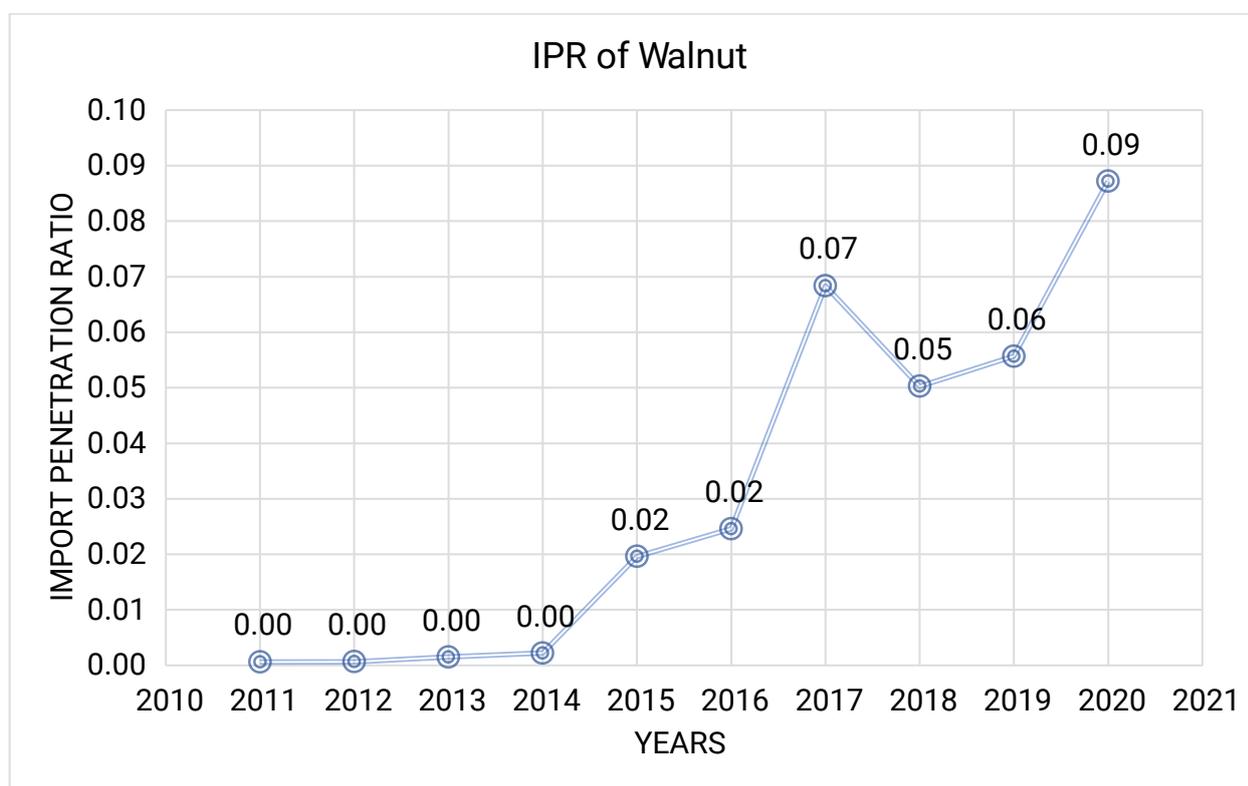
Fig 3.37: Import Penetration Ratio of Walnut
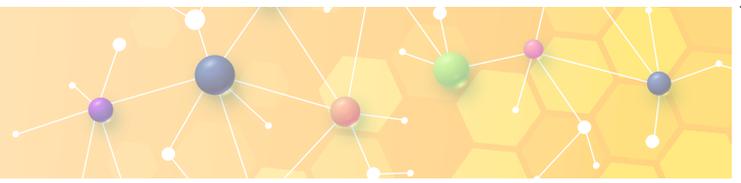
From (Figure 3.37) and Table 1, it could be inferred that from the year 2011 to 2014, the Indian walnut market was neutral to the global market as IPR was close to zero with increasing exports and decreasing imports. Thus, the government did not have to enforce such restrictions in the trade policy. But in 2015, the IPR index rose from 0.02 to 0.087 in 2020. This could preferably be because of the introduction of the new foreign trade policy of 2015 which diluted many trade barriers, reduced tariffs and brought about ease in exchange as our increased interior demand for walnut couldn't be met by the domestic production and reduced tariffs would help in managing domestic prices as well as attract global exporters (Figure 3.38-3.41). This work is being carried out at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar.

Fig 3.38: Glimpses of Training cum awareness programme(s)

Fig 3.39: Interaction with Walnut Growers (Village: Patangarh; Distt: Udhampur)
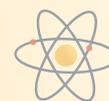
Fig 3.40: Visit to Walnut Orchards of the Farmer

Fig 3.41: Collection of Primary Data from the Key Informants/ Farmers from Latti Block of Udhampur District
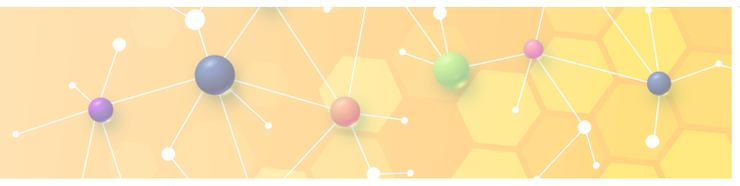
3.1.2 Core Research Grant (CRG) - Special Call

SERB has been promoting and supporting new ventures under its flagship programs such as CRG, IRHPA, SUPRA etc. in the areas of Science and Technology ecosystem growth. Additionally, to support areas which require immediate scientific intervention & attention (e.g., COVID-related R&D) and thrust fields of scientific research which are meant to address the key scientific gaps in the specific discipline or to provide a better technological solution to a particular problem, proposals are invited through the special calls time to time.

3.1.2.1 Wearable Electronics for Biomedical Applications

SERB announced a special call on "Wearable Electronics for Biomedical Applications". The focus of proposals under this call is to develop portable, wearable & implantable electronic devices that are essential for medical purposes such as diagnosis, examination, treatment, care, assistance, and research. Against this call, a total of 29 projects were recommended by the Expert Committee and a total of 27 projects were sanctioned during the reporting time.

27
Projects Sanctioned

Expenditure (New)
4.25 cr
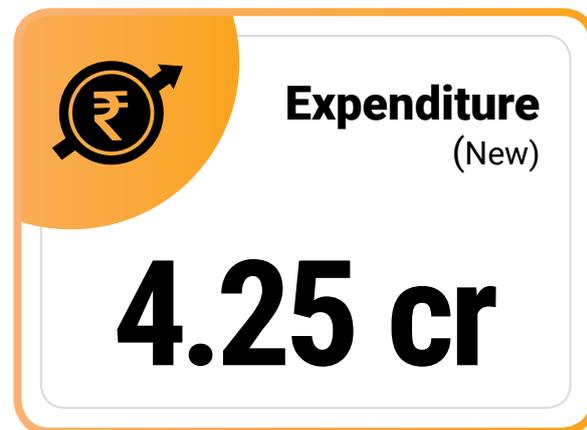
Development of an Intelligent Internet of Things (IIoT)-enabled Portable Device for Early Diagnosis of Foot and Mouth Disease of Dairy Cows

As per the latest research conducted by the Indian Council of Agricultural Research (ICAR) on livestock, India is losing Rs.18,000 crore per annum due to Foot and Mouth Disease (FMD) of animals including cattle, sheep, goats, and pigs. The losses are because of less milk production, and the death of the animals due to foot and mouth disease. Foot and mouth disease is a highly contagious disease of cloven-footed animals. Most of the time, animals are died from FMD due to a lack of diagnosis. However, If FMD will detect in the early stages then animals can be saved, and losses can be minimized. In this project, we will develop an Intelligent Internet of Things (IIoT)-based portable device that will effectively detect foot and mouth disease of dairy cows in the early stage and automatically inform the farmer as well as the veterinary doctor. Therefore, the proposed project will save animals from foot and mouth disease, and minimize the loss. Animal behaviour monitoring represents a class of Internet of Things (IoT) applications with enormous potential benefits for profitable dairy farming. Information on general health and FMD status can be monitored by measuring relevant physiological and behavioural parameters. Such remote information is potentially useful as a vital input in managing the health and reproduction of a large number of spread out and distantly located dairy animals centrally with limited manpower involvement. Furthermore, IoT represents a significant advancement over traditional management practices of dairy cattle involving large human involvement. Such practice is not much effective for round-the-clock monitoring which is more critically required for these two aspects of dairy cattle management. The computing and networking capabilities allow IoT networks to be reprogrammed or re-tasked after deployment in the field. Monitoring an animal's vital parameters using IoT-based wireless sensor networks (WSNs) appears to provide a flexible and robust monitoring system capable of remotely registering the parameters which are of interest. In this work, an IoT-based WSNs will be established in which Zig Bee (IEEE 802.15.4) will be implemented as the wireless communication protocol.
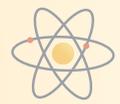
Each node in the network will be equipped with a body sensor to measure the vital physiological parameters related to the FMD of the cow. The nodes will be programmed to measure received signal strength allowing the distance between wireless sensors and a gateway to be estimated. To fuse the measured parameters and consequently classify the animal(s) into healthy/unhealthy. Comparing the advantages and disadvantages of decision trees compared to fuzzy logic and neural network classifiers, decision trees are the best candidate in terms of simplicity and accuracy to evaluate the animal's responses. The proposed project will design an automated system that will continuously and remotely monitor a large number of cows health status with minimum human involvement. This work is being undertaken at the Indian Institute of Technology (BHU) Varanasi.

A Hybrid Brain-Computer Interface Technology Using Wearable fNIRS & EEG

The research project aims to develop a hybrid wearable brain-computer-interface (BCI) system by integrating Electroencephalography (EEG) & functional near-infrared spectroscopy (fNIRS) for recording neurophysiological signals. EEG has been popular for brain-computer interfaces due to its simplicity and non-invasive recording. However, the poor spatial resolution of the EEG recording limits their applications. Functional near-infrared spectroscopy (fNIRS) has been explored recently for the brain-computer interface & brain imaging applications. The relative transparency of the biological tissue to the infrared wavelength made it possible to record brain activity with better spatial resolution than the EEG. The complementary properties of EEG (high temporal resolution) and fNIRS (high spectral resolution) systems provide the opportunity to record the brain signal effectively. Most of the already developed wearable hybrid BCI system uses continuous wave signal for excitation of the emitter in fNIRS. The continuous wave technology only measures the attenuation in the received signal and therefore provides limited information about the brain. Recently, researchers have shown that it is possible to extract additional information about brain activity by measuring the phase of photon propagation that reflects the average time taken for light to travel from a source to a given detector. The frequency of the emitter signal must be modulated at a frequency up to 100 MHz to detect such a minute phase change. Despite the potential, due to the complexity of the electronic circuit in the frequency-modulation (FM) approach, no wearable FM-fNIRS system is reported for BCI. This project aims to develop a hybrid BCI system using EEG and FM-fNIRS technologies. The followings are the key features of the proposed system: 1) Wearable and portable: Wearable BCI devices are more preferred as compared to the devices implanted via surgery. The proposed BCI device used EEG and fNIRS – both are wearable and scalp located devices. 2) High-resolution measurement: Both the technologies are complementary in their functionalities, i.e., the EEG provides excellent temporal resolution of the neural signals, whereas the fNIRS provides better spatial resolution. 3) FM-fNIRS System: Integration of the frequency modulation-based fNIRS system, which provides information about the phase change due to brain activity. 4) Low-voltage & low-power system: Voltage level and power consumption are crucial considering that the proposed system is wearable and battery operated. Therefore, the objective is to develop a BCI system with low voltage (3.3 V) and low power (less than ten mW for electronics) by using commercial-off-the-shelf components. This work is being undertaken at the Indian Institute of Technology, Delhi.

3.1.2.2 Biology of Plants under Extreme Environments

Plant life covers much of Earth land's surface, providing structure to the ecosystem, habitat for consumers, and regulating the exchange of energy and chemicals with the atmosphere. Climate-related extremes such as high and low temperatures, light, abiotic and biotic factors, are becoming more dangerous. The special call for proposals under plant sciences and climate is invited under this area to understand the wide range of effects of climate change both in terms of geographical location and productivity on plants in terms of physiology, biochemistry, and gene regulation pathway. During the year a total of 22 proposals were recommended out of which 6 projects were sanctioned.

6
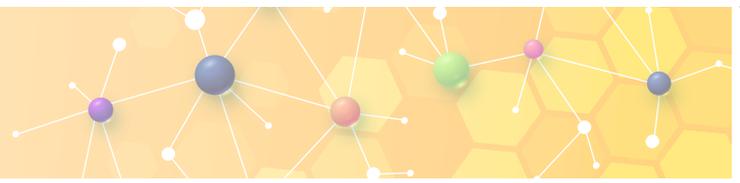
Projects Sanctioned

Expenditure (New)

0.58 cr

Research Highlight

Allele Mining for High-temperature Tolerance in Buckwheat — a Cold Desert Pseudocereal from The Himalayas

Buckwheat (Fagopyrum spp.) is a multi-purpose and nutritionally rich pseudocereal crop growing in the cold desert of the Himalayas. It can grow grown to an elevation of 4500 m, tolerate harsh cold and drought episodes, and flourish in nutritionally poor soils. It has become one of the vital food crops of the tribes living in high-altitude cold deserts. Buckwheat has gained special attention because of its stupendous agronomic, nutritional, and nutraceutical potential. It is a gluten-free substitute for major cereal like rice and wheat. Buckwheat has huge medicinal properties such as lowering serum cholesterol, cancer-fighting properties, boosting immunity, etc. Climate change poses a serious threat to agricultural productivity and food security. The human population relying only on a few cereal crops like wheat, rice and maize have made the agriculture sector extremely vulnerable to climate change. Artificial breeding involves bringing beneficial traits in one population from diverse genotypes. This results in narrowing the genetic base and shrinking agricultural diversity. However, diversification of the agriculture system is needed wherein crops naturally adapted to harsh environments and nutritionally rich must be incorporated. Underutilized pseudocereals have emerged as future crops. Despite its superiority over traditional cereal crops, statistics show that the area of buckwheat cultivation decreased by 46% in 2016-17 compared to 1970-71 (Report of Directorate of Economics and Statistics, Department of Agriculture and Cooperation, India). The downfall in buckwheat area cultivation and production emphasizes its sensitivity to temperature rise and the lack of crop improvement efforts and selection of improved varieties. The adverse effects of high-temperature stress are investigated in detail in several cereal and horticultural crops. However, buckwheat is less explored, and genetic diversity for high-temperature tolerance remains untapped. Allele mining offers tremendous opportunities to capture genetic diversity, which can be utilized to develop buckwheat adapted to wider geographic range. In view of the importance of this pseudocereal the following objectives will be taken up:

1) The effects of high temperature on nutritional potential and yield of buckwheat will be investigated.

2) Identification of genomic regions associated with high-temperature tolerance in buckwheat.

3) Identification of potential alleles and genotypes for breeding of high-temperature tolerant buckwheat varieties.

Overall, the project will provide unprecedented opportunities to increase our fundamental knowledge on high-temperature stress responses in underutilized pseudocereal buckwheat and the development of its genomic resources, which in the long run can be used to develop high-temperature resilient varieties.
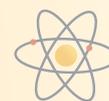
3.1.2.3 Reagentless Organic Synthesis and Selective Fluorination Strategies

Reagentless Organic Synthesis

SERB initiated a special call under the Core Research Grant (CRG) on reagent-less organic synthesis, with an aim to fund projects that explores to achieve maximum atom economy through 'clean' chemical reactions, with minimal waste generation to avoid adverse environmental impact. One of the approaches for reducing unwanted and wasteful materials emerging from a reaction or chemical technology process would be where the reactions could be achieved by the application of heat, light, sound or using electrolysis, leading to the development of sustainable technologies. The special call explored ideas with disruptive developments in reagentless, enabling strategies for synthetic applications both at the lab and kilo-scale reactors. The focus of the supported research was inextricably intertwined with potential applications in frontier areas of synthetic chemistry. The call entailed the submission of 142 proposals, with 4 projects being selected for support.

15

Projects Sanctioned

Expenditure
(New)

4.49 cr
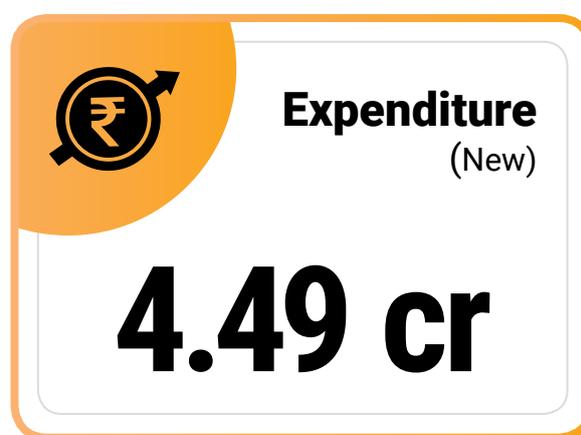
Selective Fluorination Strategies

Many commercially successful chemicals ascribe their biological activity and metabolic stability to the presence of strategically placed fluorine atoms in their structures. Despite the advances, the preparation of many fluorinated pharmaceutical building blocks and active agrochemical intermediates remains a significant challenge. SERB initiated a special call under the Core Research Grant (CRG) on Selective Fluorination Strategies to support the development of benign strategies for diverse organic substrates and amides, including late-stage fluorination. The call entailed the submission of 55 proposals, with 11 projects being selected for support.

Research Highlight

Study of Metallaphotoredox Catalysis for Tandem C-H Functionalization and Annulation

The merger of transition metal and photocatalysis, metallaphotoredox catalysis, provides an effective and straightforward approach for the construction of diverse carbo and heterocycles. Serving as a highly sustainable approach, this strategy continues to revolutionize synthetic techniques towards the construction of complex organic entities from simple building blocks. In addition, metallaphotoredox catalysis affords the exceptional reactive capacity of transition-metal-catalysis with photoinduced radical or energy transfer processes, thereby, making it conceivable to access discrete activation modes. In a project supported under Special Call (Reagentless Organic Synthesis), the group at IIT Guwahati aim to explore metallophotoredox catalysts for C-H functionalization and annulations. Mechanistically, photoredox catalysts, upon excitation in presence of light, can oxidize or reduce an organic or organometallic substrate via single electron transfer (SET) process. This SET process delivers highly reactive radical species or open-shell intermediates, which take part in low energy reaction pathway. Broadly, two types of photosensitizers are known to enable photoredox catalysis viz., a) metal based and b) organic dyes. The

more usual metal based photocatalysts, owing to their longer excited-state lifetimes and higher chemical stability of oxidized and reduced forms, have become the "go to" chromophores for chemists in the recent past, although organic dyes are cheaper, readily available and environmentally benign. Interestingly, these molecules also possess a unique ability to harvest light from house hold light sources or easily accessible LEDs. Thus, use of the approach for the site-selective C-H functionalization and subsequent annulation can lead to sustainable construction of diverse carbo- and heterocycles that would valuable in synthetic, medicinal and biological sciences.

3.1.3 Start-up Research Grant (SRG)

Providing opportunities for young researchers for pursuing exciting and innovative research in frontier areas of science and technology has always been given prime importance. Start-up Research Grant (SRG) has been launched by SERB for creating R&D platforms for young researchers to build their research careers. Through this two-year grant scheme, young scholars get an opportunity to boost their careers in their areas of specialization in a new institution or university. This grant helped in establishing the researchers and then moving on to the mainstream core research grant (CRG). The track record and the proposed research plan are the criteria for selection in this scheme. There are five discipline-wise verticals that are guided by individual Expert Committees. Initially, this scheme was launched as Young Scientist Scheme (YSS). Later it was reconstructed into two schemes Early Career Research Award (ECRA) and National Postdoctoral Fellowship (NPDF). The ECRA used to offer project grants for young researchers and later it was reconstructed as SRG. The ongoing projects awarded under ECRA and YSS continue to be supported. The research highlights of some of the projects under ECRA, YSS and SRG programmes under various disciplines are provided below.

FEATURES

SRG is a one-time career grant to young researchers.

Research grant of Rs. 30 lakhs plus Overheads for a period of two years

Flexibility in proposing budget under various heads as per requirement.

Website link: https://serb.gov.in/page/english/research_grants#Startup%20 Research%20Grant%20(SRG)
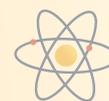
3.1.3.1 Chemical Sciences

In the reporting period, 90 new projects were sanctioned. The areas supported under SRG – Chemical Sciences are shown in the following figure.

Areas Supported

Inorganic Chemistry

Physical Chemistry & Spectroscopy

Organic Chemistry & Medicinal Chemistry

Chemical Sciences

Solid State Chemistry

Bio-physical & bio- chemistry

Energy, Materials & Nanotechnology

90
Projects Sanctioned

Expenditure
(New and Ongoing)

21.69cr
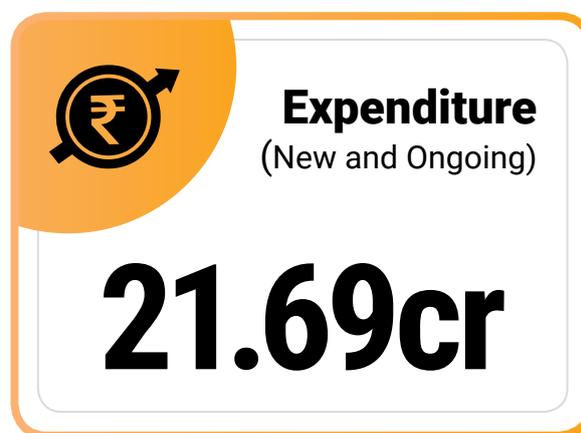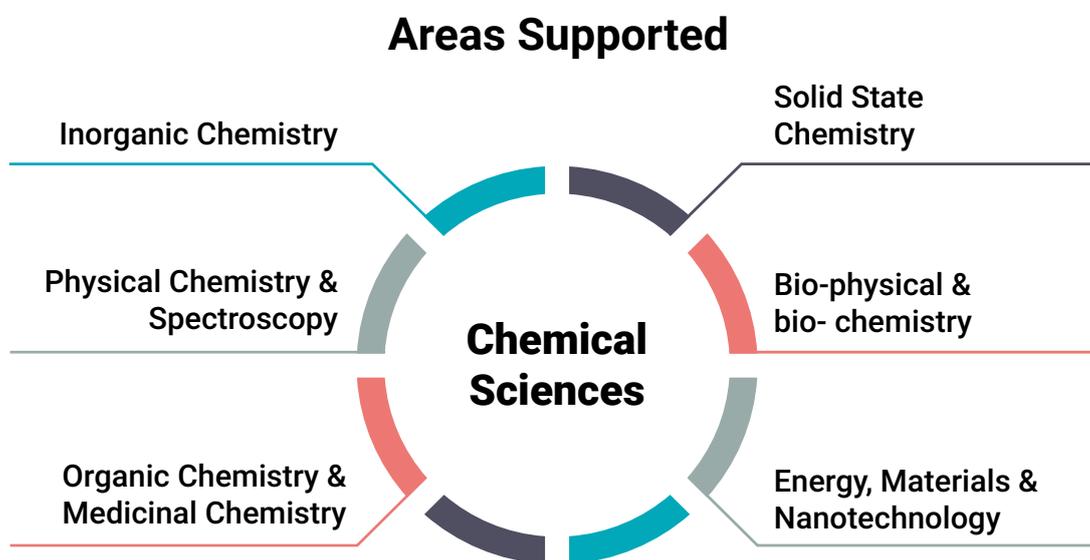
Research Highlights

Efficient Spin Polarized Capabilities and Ultrafast Carrier Dynamics of Chiral Quantum Dot Doped Biopolymer: Application towards the Spintronic Optoelectronic Device

Chirality was ubiquitous in Nature, and this was so despite the formidable challenges and energy costs associated with the perpetual selection of enantiomers and the building of helical-oriented biopolymers shaping the protein asymmetry. Chirality and chiral-induced spin selectivity (CISS) is the fundamental phenomenon not only in the naturally occurring processes, but recently received massive attention towards the technology developments. The chiral properties of nanoscale materials and their preferable interactions with the helicity of freestanding protein-based biopolymers generate a new platform for developing a biopolymer-based spintronic application which has hardly been investigated. In a project supported under the Start-up Research Grant scheme of SERB, researchers from the Institute of Chemical Technology, have developed a chiral quantum dot doped biopolymer with efficient spin polarized

capabilities and ultrafast dynamics (Figure 3.42). The innovations of the project are synthesis of chiral carbon dots (C-Dots) and incorporation in freestanding bovine serum albumin (BSA) biopolymer to build a helical-oriented biopolymers. The team has developed a chiral photoanode for photoelectrochemical measurements by exploring the chiral selective election transfer process. The outcomes of the studies include aspects of stereoselective interaction, that favor the electron transfer process and subsequently enhance the axial conductivity (out of plane) of the BSA biopolymer. The results obtained from the underlying mechanism of spin selectivity in C-Dot-doped BSA biopolymer may create a path toward advancements in fabricating the new chiral-sensitized bioelectronic devices. The work was done at the Institute of Chemical Technology, Mumbai.
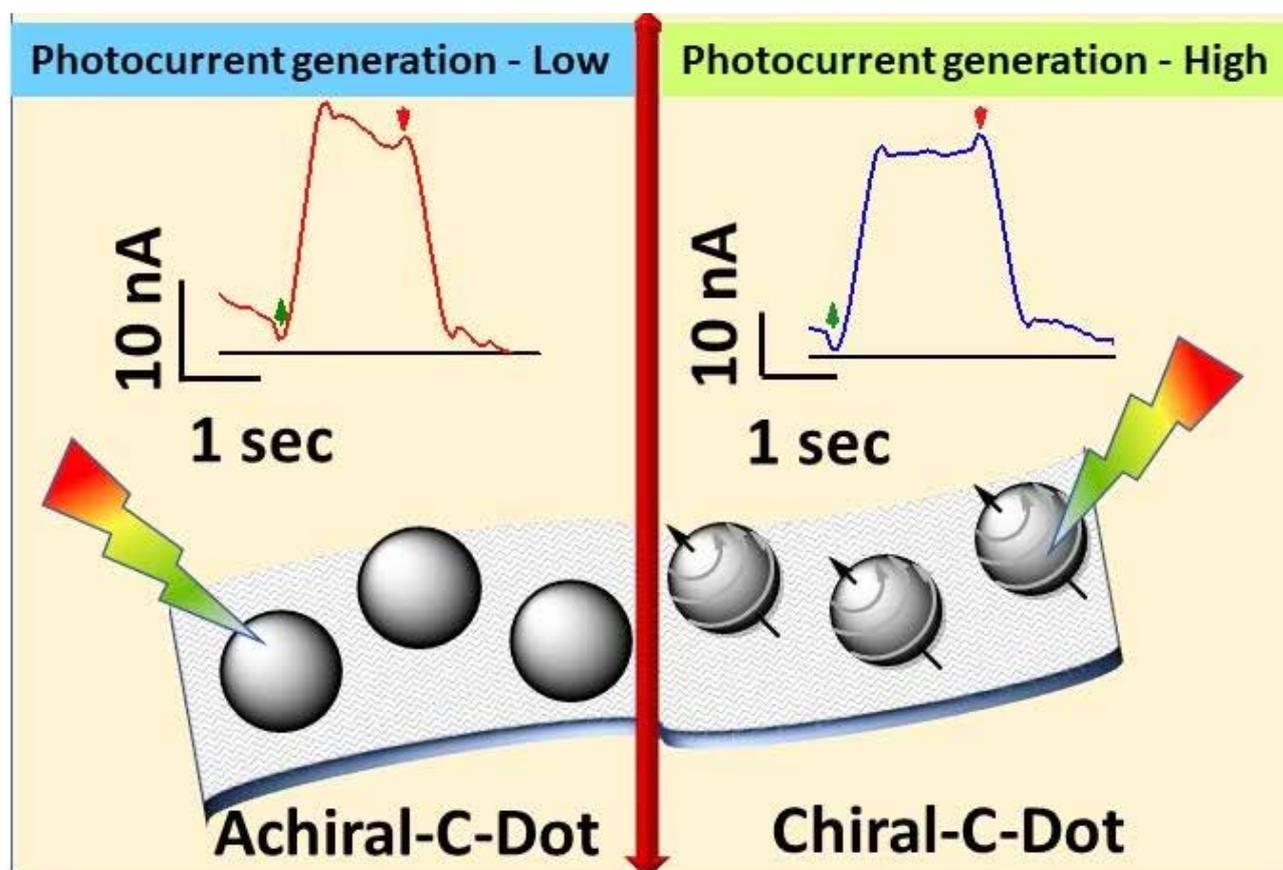
Fig 3.42: A higher photocurrent generation in chiral C-Dot-doped BSA biopolymer due spin selectivity
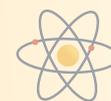
Synthesis of Nitrogen-rich Compounds for Gas Generator, Airbag, and Propellant Applications

Energetic materials are a chemical or mixture of chemicals that, when suitably initiated, can react so rapidly and with such liberation of energy that there can be damage to the surroundings in a very short time. These materials extended their use beyond primary applications and widely used in mines, safety equipment, construction/demolition field, space investigation, and many more. The insensitivity, performance, cost of synthesis, and environmental beingness of energetic materials will be the deciding parameters for practical application. Most of materials in use today, suffer from environmental toxicity, harmful detonation products and unintended initiation during their handling. In a project supported under SRG scheme, researchers at IIT Kanpur focused on the development of energetic materials with high density, energy content, safety, detonation performance, mechanical qualities, and environmental adaptability. The research has enabled development of many energetic materials in different classes. The team have

developed indigenous material which is zo-bridged 1,3,4-oxadiazole nitramine and its energetic salts from the commercially available cheap starting material. As compared to the benchmark traditional explosive, the said compound has a less complicated, straightforward synthetic route, and cheaper in comparison while providing required impact. The neutral compound and its energetic salts show good thermal stability, high density, excellent detonation properties, and better sensitivity that exceed those of RDX and comparable with HMX suggesting its potential in high-performance secondary energetic materials (Figure 3.43). The additional non-toxic nature of these unique energetic materials along with high thermal stability and low sensitivity makes these compounds a potential alternative for traditional nitramine explosives RDX, HMX, and ε-CL-20, and adds new dimensions towards development of gas generators, air bags and propellant applications. The work was done at the Indian Institute of Technology, Kanpur.
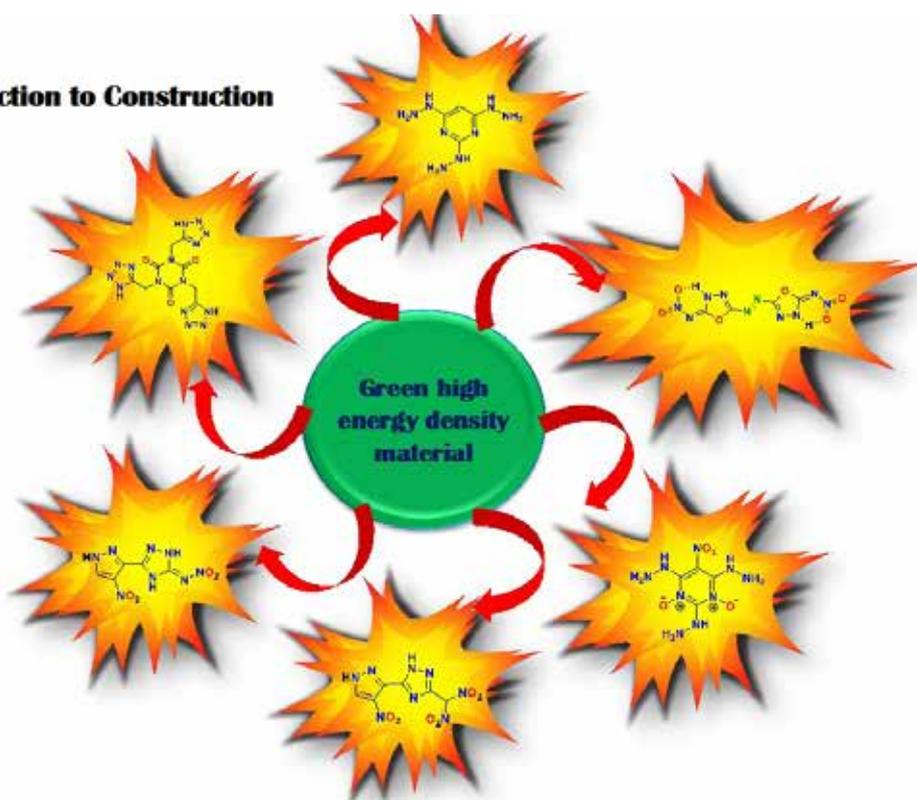
Fig 3.43: Nitrogen-rich compounds for gas generators, air bags and propellant applications.

3.1.3.2 Earth and Atmospheric Sciences

In the reporting period, 31 new projects were sanctioned. The areas supported under SRG – Earth and Atmospheric Sciences are shown in the following figure.

Areas Supported

Earth and Atmospheric Sciences

- Remote Sensing, GIS
- Petrology, Geochemistry, Isotopes
- Geophysics, Tectonics, Structural Geology
- Hydrogeology, Waste disposal, etc.
- Climate Change, Glaciology, Paleonto- logy, Stratigraphy
- Agrometeorology, Soil Sciences
- Weather forecasting, Climatology, Upper Atmosphere, Aerosols
- Oceanography
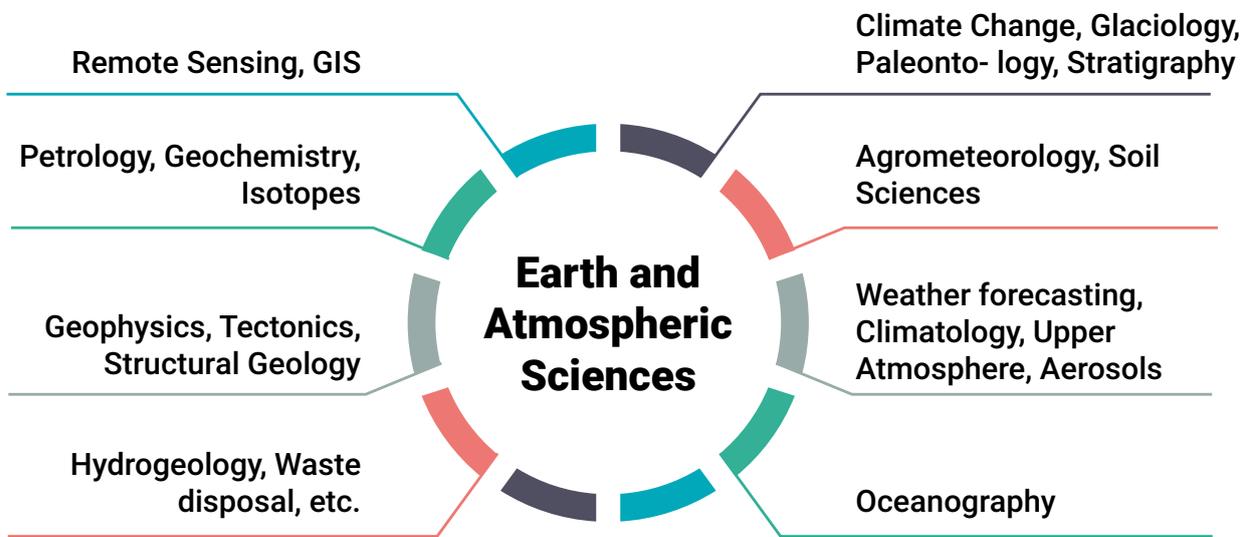
31
Projects Sanctioned

Expenditure
(New and Ongoing)

6.37cr

Research Highlight

Tracing the impact of Late Cenozoic climatic transitions on the erosion rates of Himalaya

This research project aims at contributing to the understanding of the impacts of climate change on erosion and landscape evolution of the Himalayas. This research established the first long-term record of Himalayan erosion rates at an unprecedented temporal scale that will elucidate the geomorphic impacts of climate variability.

A 6-Myr-long record of Himalayan erosion rates is measured based on ^{10}Be concentrations in Cenozoic foreland basin sediments (Figure 3.44). Himalayan erosion rates increased gradually towards the present with a periodicity of ~1 Myr (Figure 3.45). It is recommended that the ~1-Myr cyclicity evident in our dataset results not from a climate driver but from an emergent phenomenon related to the tectonic underplating of crustal material to the Himalayas.

This work was done at the Indian Institute of Science Education and Research, Kolkata.
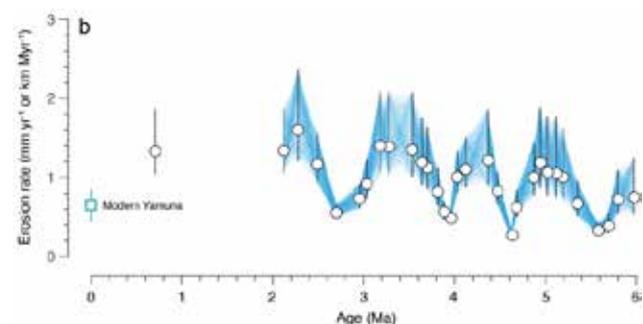
Fig 3.44: ^{10}Be-derived Himalayan erosion rates as a function of the depositional age.
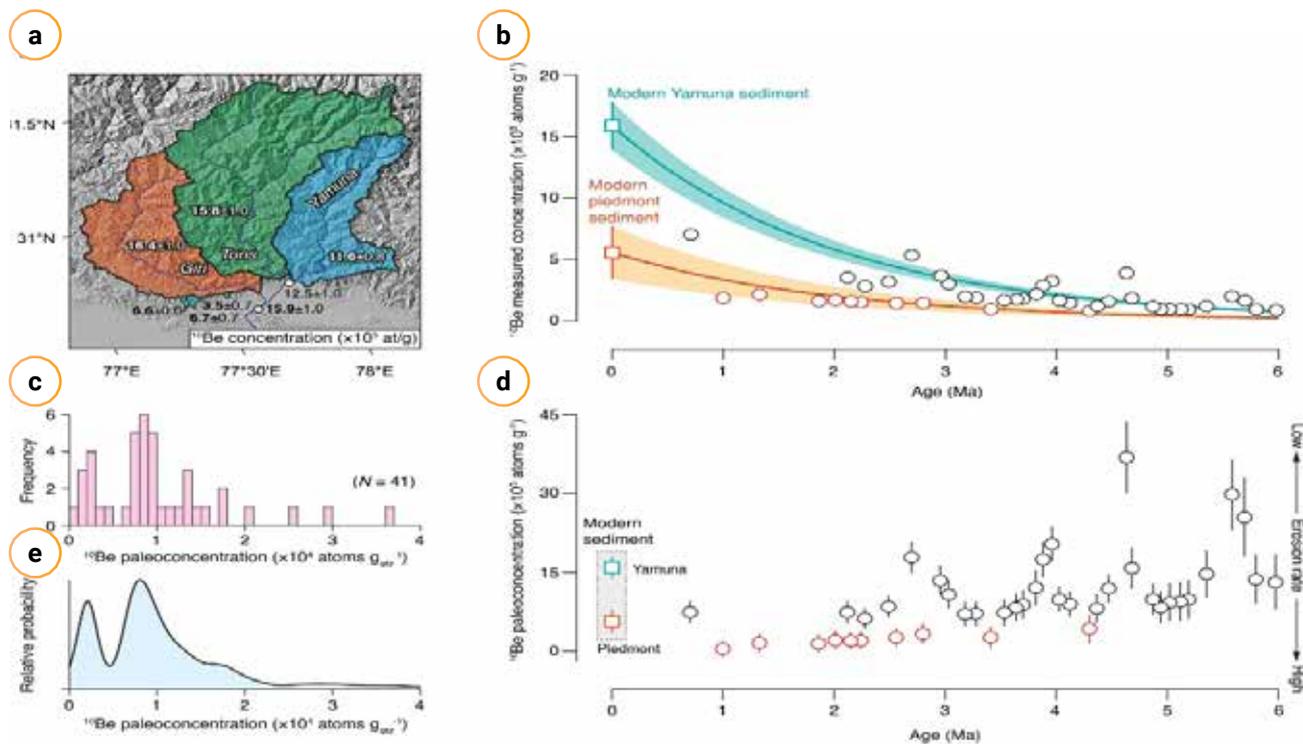
Fig 3.45: Cosmogenic ^{10}Be record of the northwestern Himalaya. **(a)** Map of the Yamuna catchment and ^{10}Be concentrations of modern river sediments. (b) Measured ^{10}Be concentration in the modern and paleo-sediments, respectively**. (c, d)** Histogram and probability density plot of reconstructed paleo-10Be concentration. **(e)** Reconstructed ^{10}Be concentrations in paleo-Yamuna and paleo-piedmont sediments prior to the burial in the foreland basin.

3.1.3.3 Engineering Sciences

In the reporting period, 156 new projects were sanctioned. The areas supported under SRG −Engineering Sciences are shown in the following figure.

Areas Supported
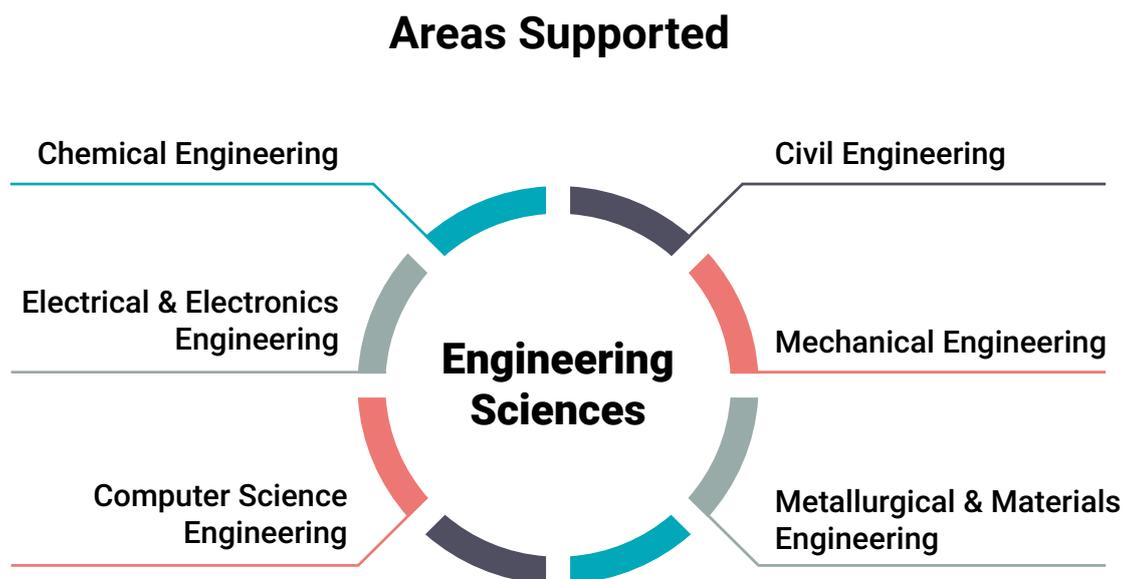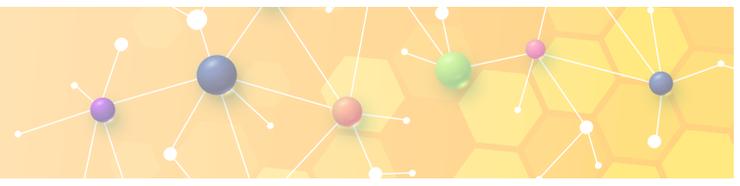
Research Highlights

A study on fatigue damage in additively manufactured IN718 alloy

In this project work, the research group contributed to the understanding of fatigue damage in additively manufactured materials and the role of different microstructural phases and manufacturing defects.

Room temperature tensile tests were performed on as-built, heat-treated, machined samples produced with 30μm layer thicknesses. As per (Figure 3.46(a)) the samples have been broken from the gauge length area. Performed three tests for each type of fabricated sample and have taken an average of that results. Tensile testing results are shown in (Figure 3.46(b)) Compared with heat treated, as-built, as-built machined and heat-treated IN718 has higher YS and UTS but lower elongation. Heat treatment has significantly increased the YS and UTS of the material. These tensile data will be used for further high cycle and low cycle fatigue tests.
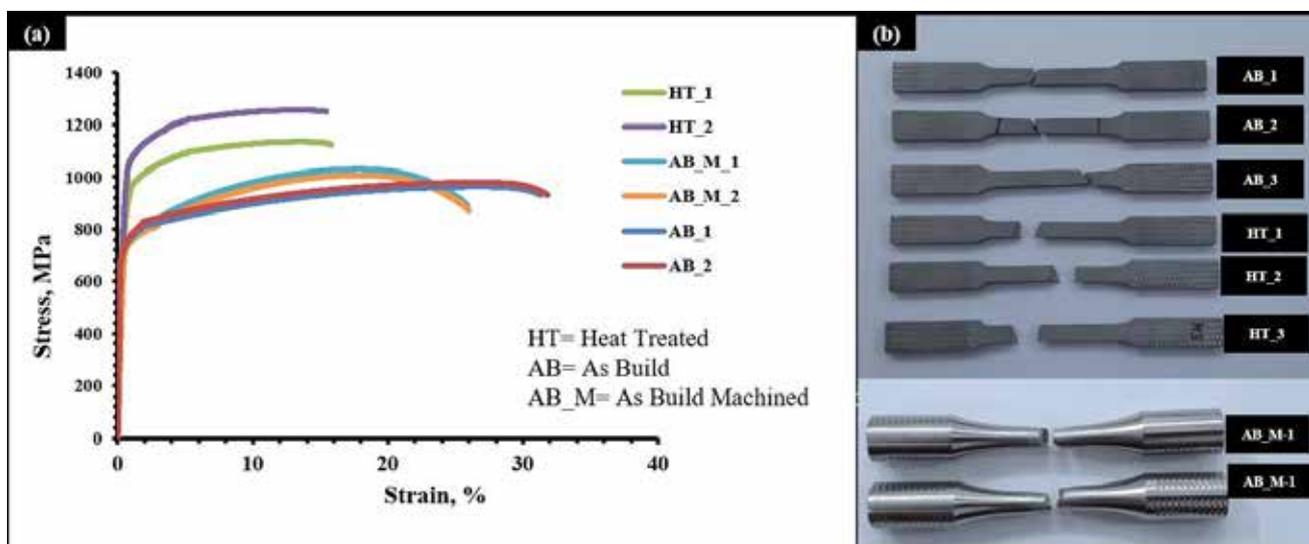
Fig 3.46: Showing the tensile test results along with broken samples (a) stress-strain curve, and (b) broken samples after tensile testing.

In the present work, selective laser melted superalloy IN718 specimens have been fabricated and investigated. The microstructure of SLM IN718 is characterized by columnar grains in the pile-up direction and the chessboard equiaxed grains in the horizontal plane. Such microstructure leads to anisotropic mechanical properties. Tensile strength of heat-treated SLM IN718 sample was slightly higher than that of as built and machined sample. Basically, they are following a trend of Heat-treated > Machined > As-built, and for elongation, they follow the reverse trend. At room temperature, the high cycle fatigue test (107) at three different R-ratios of heat-treated Inconel 718 alloy has been investigated. From the measured

S-N curve is clearly seen that the fatigue life increases with decreasing stress amplitude and the S-N curve appears to continuously decline as the life extends. LCF behaviour of SLM IN718 alloy was studied at room temperature and based on the results, the material exhibits cyclic softening at all strain amplitudes studied. A higher amount of softening is shown at higher strain amplitudes. Fractography of three different R-ratio HCF broken samples has been taken from FE-SEM to study fracture surface to determine the relationship between microstructure and mechanism of crack initiation and propagation and eventually the root cause of fracture. After heat-treating the as-built specimens, a noticeable improvement in microhardness (27%), tensile (23.20%), and fatigue strength was observed; a nearly two-fold improvement in fatigue strength. It was a result of the melt pool borders dissolving and the columnar dendritic microstructure almost completely disappearing after heat treatment. This work was done at the Indian Institute of Technology Roorkee.

Lab-on-Paper for Inexpensive Point-of-Care Diagnostics

In this project, inexpensive routes were explored to develop biosensors. A User-friendly detection mechanism is developed with this work. An App is developed for finding out the qualitative and quantitative presence of target analyte. Paper in general is made up of cellulose fibres, but the mechanical properties of each paper-type differ from each other due to the differences in the material compositions and manufacturing processes. It is hard to generalize a set of properties for paper, as the constituents of paper vary among different types of paper. Each type of paper serves a different specific function based on its structure and composition. Figure 3.47 shows a systematic representation of the treatment of A4 paper, Figure 3.48 shows for the complete removal of calcium as a filer material from A4 paper it required approx. 5 minutes of treatment time. After treatment, it was found that absorption time decreases.
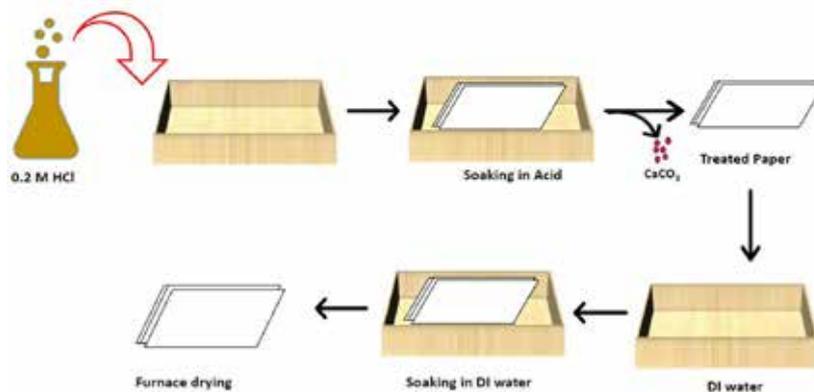
Fig. 3.47: Chematic representation of treatment of A4 paper.
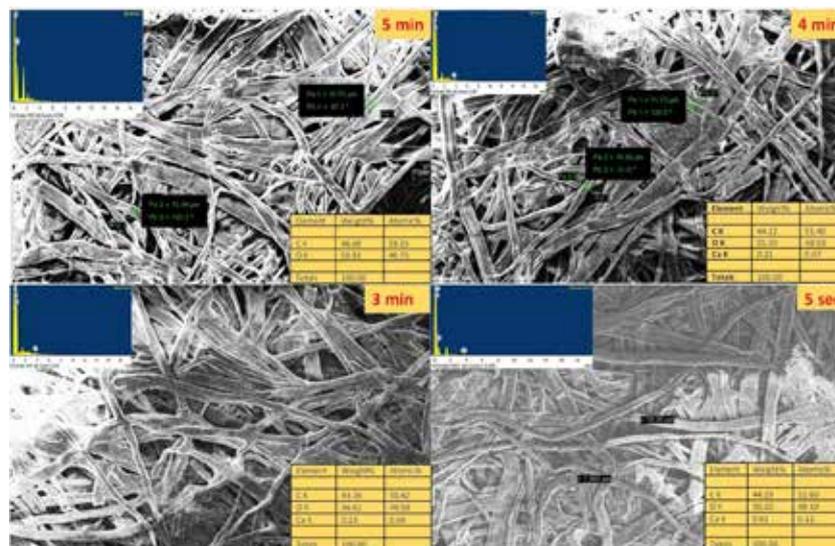
Fig 3.48: Comparative SEM images with EDX data for different time for treatment.

A proof of concept for the utilization of A4 paper, as well as the Whatman paper as a biosensor substrate has been successfully developed. A unique trident shape design has been developed for the multiplexed detection of three different analytes. A computational approach for the safe and secure working of the design has been ensured to optimize the design of microfluidics analytical devices. An android-based application has also been developed for the determination of analyte concentration. A new approach has been developed to avoid ambient light and camera phone hindrance by utilizing machine learning approaches In a nutshell, proof of concept on biosensors for multiplexed detection has been successfully developed. This work was done at the Indian Institute of Technology, Jodhpur.

3.1.3.4 Life Sciences

In the reporting period, 117 new projects were sanctioned. The areas supported under SRG – Life Sciences are shown in the following figure.

Areas Supported

Health Sciences

Plant Sciences

Life Sciences

Animal Sciences

Biochemistry, Microbiology and Molecular Biology

117
Projects Sanctioned

Expenditure
(New and Ongoing)

27.30cr
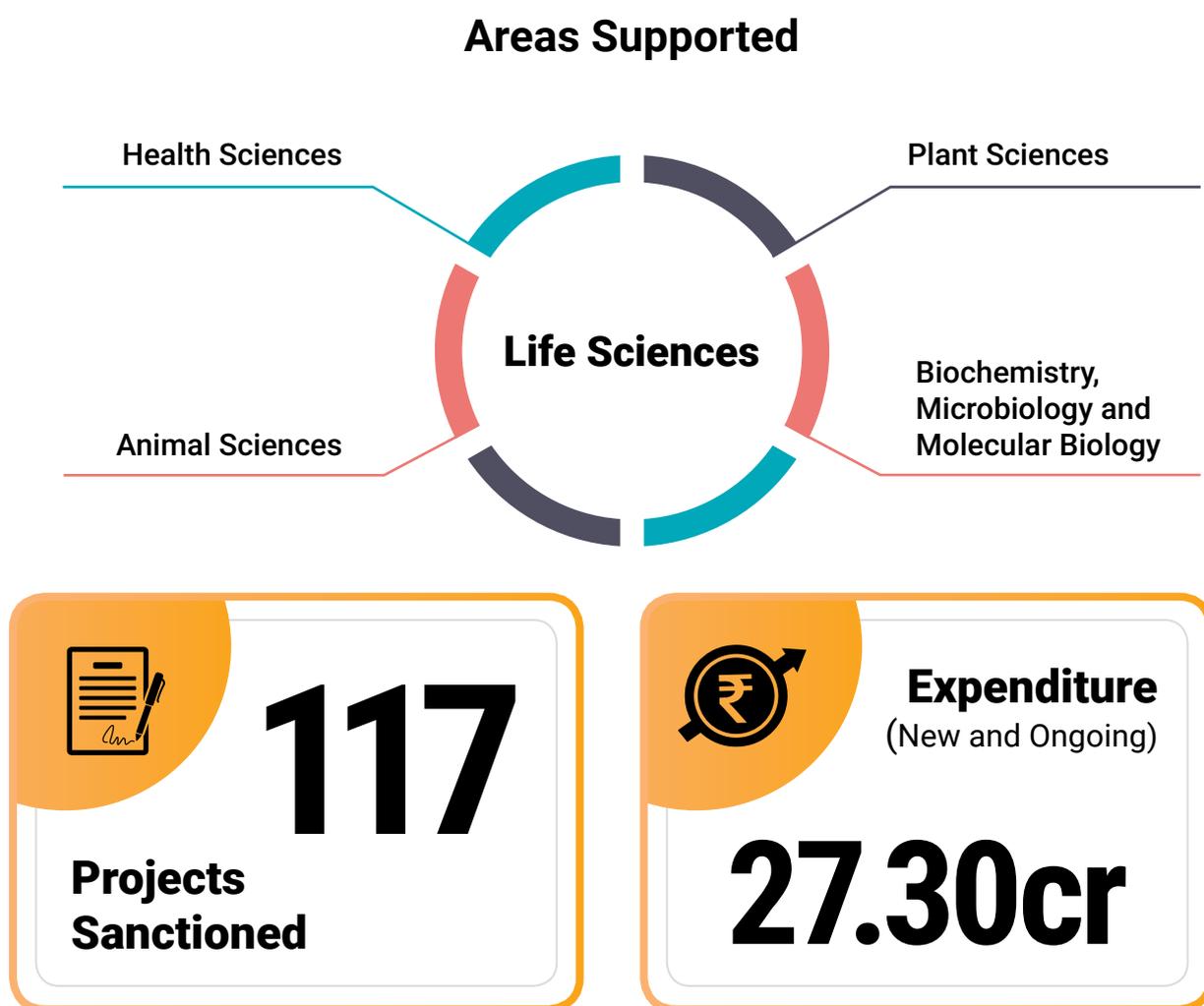
Research Highlights

Understanding the role of nodule-specific PIN-LIKES (PILS) protein in peanut root nodule development

Peanut is an important oil seed that doesn't need nitrogenous fertilizer due to its symbiotic relationship with *Bradyrhizobium spp.* Peanut's unique root nodule development involves rhizobial entry through epidermal cracks, unlike the root hair infection thread mechanism in model legumes (Figure 3.49). Investigators worked
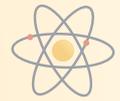
on the molecular mechanisms of peanut nodule symbiosis and found that the transcription factor Nodule Inception (NIN) regulates pericycle/cortical nodule organogenesis but not epidermal crack entry. It is also discovered that Nodule-enhanced Glycosyl Hydrolases (AhNGHs) play a crucial role in cell wall modification during crack entry (Figure 3.50). Our findings reveal a minimal, conserved, core signalling axis that could be used to engineer nitrogen-fixing root nodules for sustainable agriculture. This work was done at the National Institute of Plant Genome Research, New Delhi.

Fig 3.49: Cortical expression of *NIN* and the phenotype of *RNAi* knockdown of *AhNGH.*

Fig 3:50: Proposed model of nodule development in Peanut.

Calcium homeostasis modulator-1 (CALHM1) as a therapeutic target for the neurological disorder

Among the large family of G protein−coupled receptors (GPCRs) are many orphans, so-called because their signalling reactions remain poorly understood. Among these is GPR158 which is highly expressed in the nervous system and implicated in processes from cognition to memory to mood. However, the structural organization and signalling mechanisms of GPR158 are largely unknown. The group used single-particle cryo-electron microscopy (cryo-EM) to determine the structures of human GPR158 alone and bound to an RGS signalling complex (Figure 3.51). GPR158 has an unusual dimerization mode stabilized by a pair of phospholipids and the presence of an extracellular Cache domain, an unusual ligand-binding domain in GPCRs. The extensive set interaction at the dimeric interface locks GPR158 in a conformation that likely prevents G protein activation. RGS binds to the homodimer at a site that substantially overlaps the surface that binds G proteins, again preventing canonical G protein signalling. The binding of a ligand to the extracellular domain may regulate signalling through the RGS complex. Our structural and functional study on orphan GPR158 provide insights into the unusual biology of orphan receptors and the formation of GPCR-RGS complexes, where instead of heterotrimeric G-proteins or arrestins, RGS is coupled to GPR158 to bring in a paradigm shift in signalling pathways. The group proposed a model that conformational change triggered by GPR158 association with its ligand in the extracellular ectodomain is transmitted into the rearrangement of the cytoplasmic domains that engage RGS thereby altering its activity. As a catalytic entity, changes in RGS function would send a signal in the cell by selectively deactivating the G proteins, an effect that would alter the activity of effector enzymes that they regulate. Given that RGS binding precludes GPR158 from canonical activation of G proteins, one can describe it as an RGS-coupled receptor. The concept of functional coupling to RGS may be more broadly applicable across the GPCR family as means of transducing the signals. This work was done at the Indian Institute of Technology, Kanpur.

Fig 3.51: Overall structure of human orphan receptor, GPR158. (a) cryo-EM density map of GPR158, (b) the de-novo build atomic model of GPR158, where the extracellular cache domain was discovered, (c) cryo-EM density map of GPR158 coupled to RGS7-Gβ5, (d) atomic model of GPR158 coupled to GPR158 receptor, (e) atomic model of single subunit of GPR158, where different domain are colored

3.1.3.5 Physical and Mathematical Sciences

In the reporting period, 94 new projects were sanctioned. The areas supported under SRG – Physical and Mathematical Sciences are shown in the following figure.

Areas Supported

Lasers Optics, Atomic & Molecular Physics

High Energy Nuclear Physics, Astronomy & Astrophysics

Physical and Mathematical Sciences

Condensed Matter Physics, Materials Science

Mathematical Sciences

94
Projects Sanctioned

Expenditure
(New and Ongoing)

15.19cr

Research Highlights

Scandium Nitride (ScN) Schottky and *pn* Junction Diodes

The study aims to achieve the growth of epitaxial ScN thin films on (001) MgO substrates, characterization of the thin films, and demonstration of ScN-based Schottky and *pn*-junction diodes. It has been shown that the epitaxial single-crystalline ScN thin films have been deposited on (001) MgO substrates with molecular beam epitaxy and magnetron sputtering methods (Figure 3.52(a&b)). The effect of adatom mobility and the Ehrlich-Schwoebel barrier on ScN's growth mode has been evaluated to determine the growth conditions for achieving smooth films without extended defects. As the deposited ScN thin films exhibit a high *n*-type carrier concentration ($\sim 2\times10^{20}$ cm^{-3}) due to the presence of oxygen as an impurity, Mg-hole doping is successfully used to reduce the carrier concentration and eventually p-type ScN thin films are achieved. Schottky diodes are fabricated utilizing lithographically patterned metals such as Au, Ag, Pt, Ti, etc., on ScN films. Current-vs-voltage (IV) measurements show that the Ag/ScN and Au/ScN contacts exhibited rectifying diode behaviour with a Schottky barrier height of 0.55 ±0.05 eV and 0.59±0.06 eV, respectively (Figure 3.52(c)). *pn*-junction diodes are fabricated further, and their device performance is evaluated. The study has shown that the ScN-based high-quality Schottky and *pn*-junction diodes will enable ScN's application in electronic devices. This work was done at Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru.
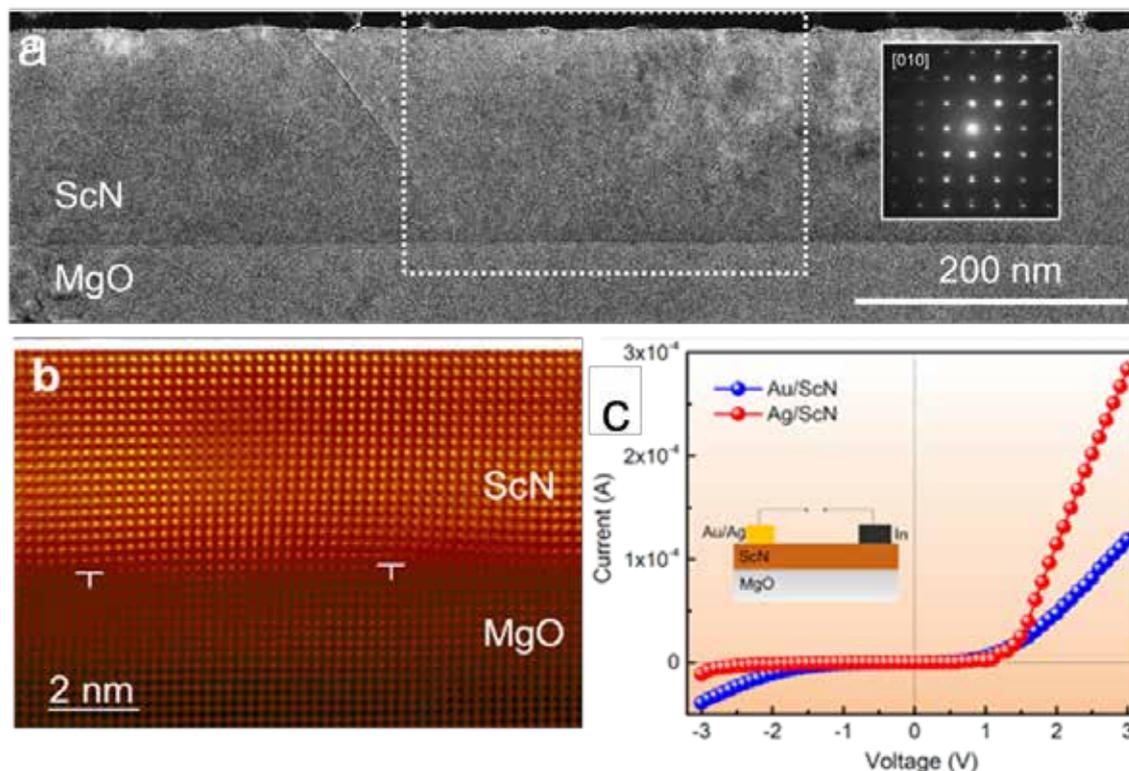
Fig 3.52: (a) High-resolution transmission electron microscopy (HRTEM) image of ScN film deposited on (001) MgO substrate at 800°C is presented that confirms the epitaxial growth without many extended defects. **(b)** High-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) image of the ScN/MgO interface showing cube-on-cube epitaxy. Due to the lattice-mismatch between ScN and MgO, some misfit dislocations are observed in the image. **(c)** Current-vs.-voltage (I-V) characteristic of Au/ScN and Ag/ScN Schottky device exhibit rectifying behavior. Ag/ScN and Au/ScN Schottky diodes exhibit Schottky barrier heights of 0.55 eV± 0.05 eV and 0.59 eV ± 0.06 eV, respectively.

Adaptive and efficient method of fundamental solutions for the numerical reconstruction of boundary data in two-phase inverse Stefan problems

The study aims at the efficient numerical solution of the two-phase nonlinear inverse Stefan problem. At first, an adaptive algorithm that estimates the optimal parameters in the MFS (Method of fundamental solutions) approximation using some apriori information in the one-dimensional boundary identification problem has been developed. Then heuristic a posteriori error estimators for the two-dimensional variant have been derived using the stability results and the denseness properties of the MFS approximations. The ideas are then extended to the classical one-phase inverse Stefan and Cauchy-Stefan problems in two dimensions that are essential in view of the sub-problem on the liquid phase.

Understanding the boundary identification problem enables one to construct heuristic posteriori error estimators in the liquid phase. Mean-driven adaptive algorithms are developed to filter out the undesired MFS parameter values. More importantly, the effectiveness of the proposed methodology has been demonstrated for a practical problem with an unknown solution. Subsequently, the findings from the boundary identification and the one-phase inverse Stefan problems are used to solve the two-phase nonlinear inverse Stefan problem. The problem has been dealt with in one dimension using apriori data and the algorithms developed are independent of the existing computationally expensive nonlinear optimization techniques, advancing the state-of-the-art in the MFS and inverse Stefan problems. This work was done at Birla Institute of Technology & Science, Pilani, Hyderabad.

3.1.4 MATRICS

MATRICS Scheme is aimed to provide fixed grant support to active researchers with good credentials in Mathematical Sciences, Theoretical Sciences and Quantitative Social Sciences. The main attribute of this scheme would be a simple submission of a concept note. The funding provided would cater to the specific needs of Mathematical/Theoretical Sciences research. During the reporting year, a total of 1563 proposals had been received and 185 proposals were sanctioned.

FEATURES

Research grants to active researchers in the field of (i) Mathematical Sciences and allied areas; (ii) Theoretical Sciences and Engineering or (iii) Quantitative Social Sciences

Submission of a simple 1-2 page mathematical/ theoretical proposal

Research grant of Rs. 2.00 lakh p.a. for a period of three years

Website links: https://serb.gov.in/page/english/research_grants#Mathematical%20Research%20Impact%20Centric%20Support%20(MATRICS)

185 Projects Sanctioned

Expenditure (New and Ongoing)

7.74cr

Research Highlights

Aspects of Chern Simons Theories

The study of quantum field theory in d=2+1 (two spatial dimensions plus time) is a frontier of interdisciplinary research with potential applications ranging from material science to quantum computation. In this project, several contributions were made to study the quantum field theories in three-dimensions. Relativistic quantum field theories exhibit a crossing symmetry that relates amplitudes for particle scattering to

amplitudes for anti-particle scattering. It has been demonstrated that the rules for crossing symmetry must be modified in Chern-Simons theories with matter to take into account the topological effects and derived an expression of their form for SU(N) theories in terms of the level k and rank N of the Chern-Simons theory. The modified crossing rules invoke mathematics closely related to topological quantum computation. (Figure 3.53) illustrates a crucial step of the argument.

A new large N limits were applied to certain quantum field theories involving bosons in d=3, based on fields that are tensors of rank greater than 2. They have classified the maximally single-trace interactions in d=3, which include the prism interaction, shown in (Figure 3.54) below. These give rise to solvable large N limits, in which a summable set of Feynman diagrams contribute, as illustrated in (Figure 3.55). This work was done at Dayalbagh Educational Institute, Agra.
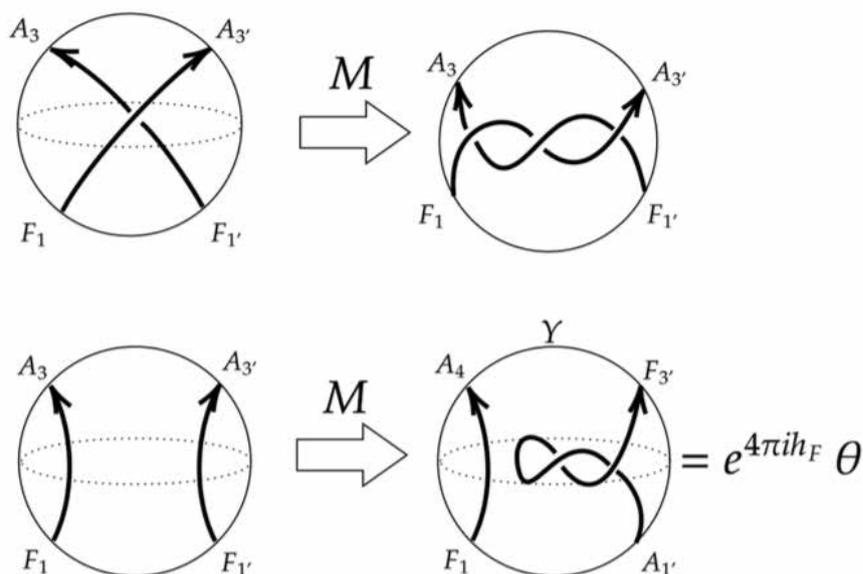
Fig. 3.53: This figure illustrates the action of the monodromy matrix on a basis of conformal blocks (represented as particle trajectories, or Wilson lines) for particle-anti-particle scattering in U(N) Chern Simons theory.
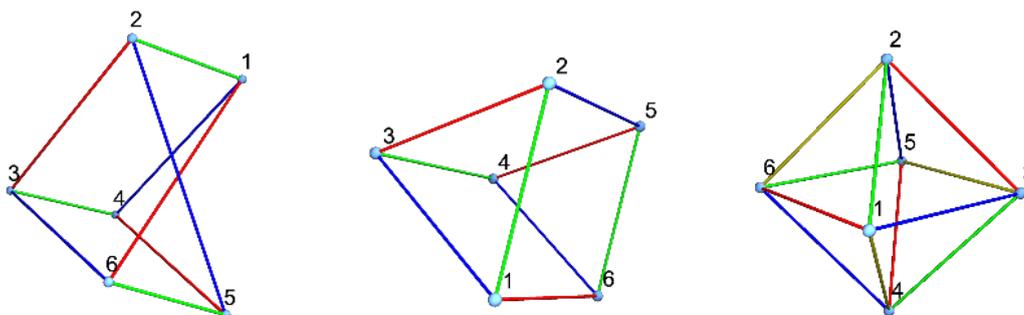
Fig. 3.54: Rank three and four maximally single-trace interactions for scalar fields in d=3. These graphs (from left to right) are the K3,3, the prism and the octahedron interactions
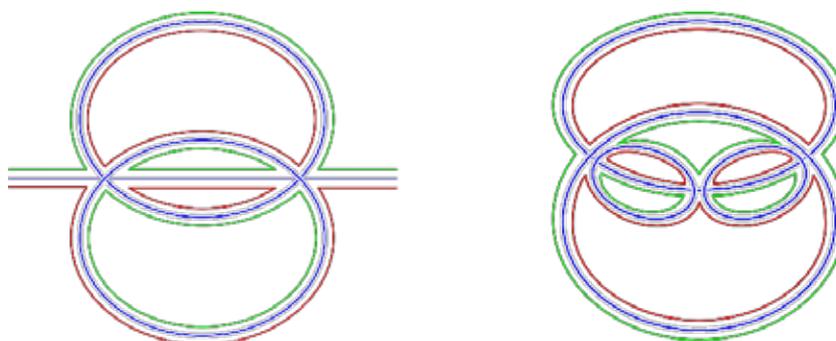
Fig. 3.55: Some Feynman diagrams in the large N limit of theories with the $K_{3,3}$ (left) and prism (right) interaction.
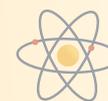
Modeling and simulation of a hydrodynamic instability with chemical reaction

The flows in porous media have been of profound interest to many researchers due to various economic and environmental processes viz., enhanced oil recovery, contaminant transport in aquifers, CO_2 sequestration, etc. In this direction, the researchers in the project have performed nonlinear simulations of reaction-induced radial viscous fingering (VF) and studied the effects of the chemical reaction on fingering instability in terms of two non-dimensional parameters, Damköhler number (Da) and the log-mobility ratio (Rc). Further, the existence of two critical mobility ratios for a given Da for the occurrence of VF has been investigated. Consequently, there exists a stable region in the Da-Rc parameter space separating two unstable regions (Figure 3.56(a)). The results improve the understanding of the effect of chemical reactions on miscible VF and thus pave the way to use chemical reactions to control miscible VF.

The stability of radial viscous fingering (VF) in miscible fluids has been investigated in this study. Using linear stability analysis and nonlinear simulations, the study demonstrates that this competition is a function of the radius r0 of the circular region initially occupied by the less-viscous fluid in the porous medium. For each r0, the stability is determined in terms of Péclet number (Pe) and log-mobility ratio (M) (Figure 3.56(b)). Thus, a natural control measure for miscible radial VF in terms of initial condition is established and compared with the experimental result obtained in the lab at IIT Ropar. Further, the effects of Neumann- and Dirichlet-type boundary conditions corresponding to reflective and absorbing cases on the viscous fingering instability are investigated through linear stability analysis and nonlinear simulations. It is found that the onset of VF is delayed in the absorbing boundary case as compared to the reflective one. This work was done at the Indian Institute of Technology, Ropar.
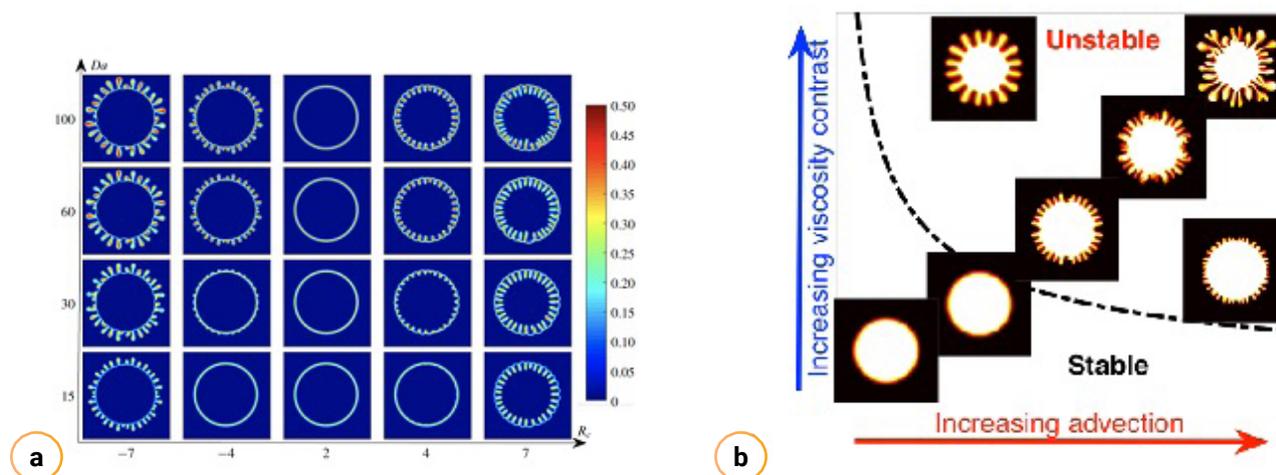
Fig 3.56: (a) Density plots of the concentration of product C in the A+B->C system. **(b)** Phase diagram of advection-diffusion effects in radial VF without reaction.

3.1.5 Industry Relevant R&D (IRRD)

Industry Relevant R&D (IRRD) scheme was launched in the year 2015 with the objective to utilize the expertise available in academic institutions and national laboratories to solve industry-specific problems for the larger benefit of society. IRRD supports the joint proposal by academic and industry partners.

1
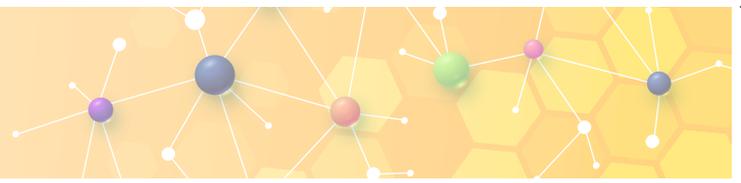
Project Sanctioned

Expenditure
(New and Ongoing)

0.43cr

Research Highlight

Development and validation of phyllosphere microbiome-based biostimulant for defense activation against blast disease and abiotic stress in rice

A total of 12 bacterial species of rice phyllosphere microbial communities was selected for the functional characterization leading to the development of a microbiome-based biostimulant for rice blast disease management.

A Phyllosphere microbiome-based bioinoculant product named EMPIRE (EMPIRE™) consisting of a mixture of diverse genera of bacterial communities was developed (Figure 3.57). EMPIRE™ showed biostimulant activity on rice crops by the production of phytohormones, antimicrobials, plant activators, and diffusible signalling factors. The product also showed mineral solubilization for contributing to plant nutrition. The product stimulated plant growth and suppressed rice blast disease and brown spots as well as enhanced rice yield (15-16%).
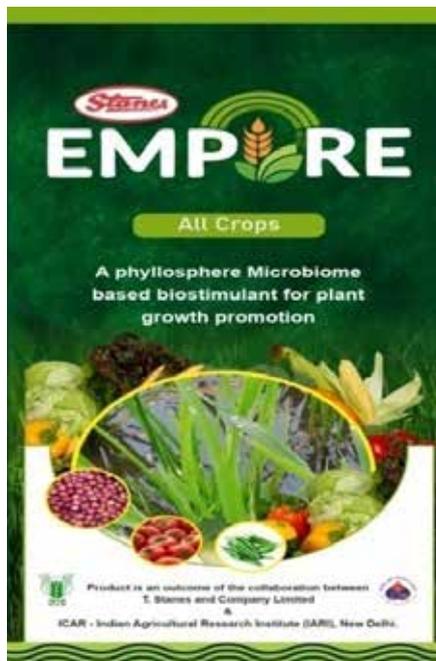
Fig. 3.57: Label and bottle design for microbiome formulation, EMPIRE
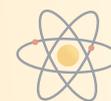
The product has reached the Technology Readiness Level (TRL)-8 during the project period which is nearing the final stages of product launch. Technology Readiness Level 9 is the last stage for commercialization for which regulatory clearances for market entry has to be obtained. At present scaling up to 1.0KL per day production is under progress at T- Stanes & Company Ltd, Coimbatore. This work was done at Indian Agricultural Research Institute (IARI), New Delhi.

3.1.5.1 Fund for Industrial Research Engagement (FIRE)

The Program "Fund for Industrial Research Engagement (SERB-FIRE)", led by Science and Engineering Research Board (SERB) under Industry Relevant R&D (IRRD) scheme, with support from industry members, intends to address the challenges in the research and innovation space in India, by creating an ecosystem that would accelerate the growth in the research work with national impact, and drive the R&D landscape efficiently and effectively. Through the SERB Industry-Academia Programs, the government and other industry partners create a pool of funding, resources and network that would enable strong research projects with breakthrough impacts on some of the major issues of the country. The program with an equal share co-funding mechanism between SERB and industry, entailed three calls for proposals, in collaboration with Applied Materials (AMAT), General electrics (GE) and Intel, India. The thrust areas in healthcare technologies, Aviation technologies, Renewable technologies and Next-generation Artificial Intelligence and Machine Learning were explored in the call for proposals. 13 projects are identified for probable support under the said initiative, in the year 2022-23 out of which 2 projects were sanctioned.

2 Projects Sanctioned

Expenditure (New) 0.32cr
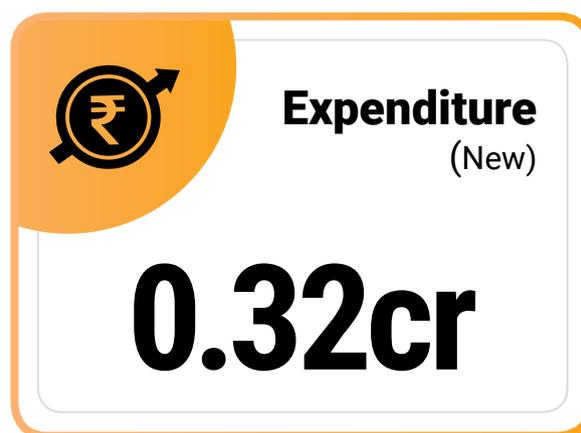
Research Highlight

Correlating Theoretical Insights Into Pre-Formation Dynamics With Post-Formation Experimental Characterisations Of Atomically Thin Coatings: Applications In Semiconductors And Life-Sciences

In a project, co-supported under SERB – AMAT partnership, the group at the Indian Institute of Technology, Bombay aim to develop molecular-level chemistry of interaction between active pharmaceutical ingredients and metal oxide formed during the atomic layer deposition processes. Particularly Acetaminophen and ibuprofen molecules are being explored, and their X-ray structures were analysed, including various isomorphic forms of the APIs (Figure 3.58). The mechanism of interaction between the surface and the API is being developed, and the Connolly surface for the solid-state structures will be looked into for various penetrative mechanisms of precursor on the API particles.
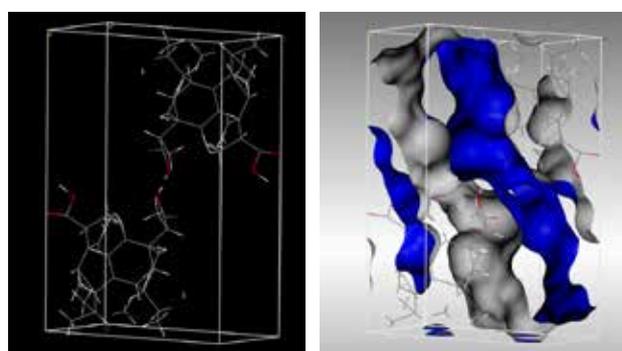
Fig. 3.58: The crystal structure of Iboprufan, along with the Connolly surface, indicates occupied and free volumes.

3.2 Promoting Innovation

3.2.1 Intensification of Research in High Priority Areas (IRHPA)

The scheme Intensification of Research in High Priority Areas (IRHPA) was launched to provide major funding support in high-priority areas where multidisciplinary, multi-institutional expertise may be required. The goal of the scheme is to strengthen the scientific footprints of our nation in the international scenario. For this purpose, SERB makes a national call for seeking proposals after identifying the priority areas. Various Core Groups, Centers of Excellence and National Facilities in frontline and emerging fields of Science and Engineering have been set up in academic institutions and national laboratories by significant contributions from this scheme. This scheme has thus helped in augmenting the R&D capabilities of the country in priority areas and several projects have been sanctioned under this scheme.

FEATURES

Top-down scheme supporting projects in priority areas

The amount of grant is usually higher than regular projects

Duration of the project is 5 years

Website links: https://serb.gov.in/page/english/research_grants#Intensification%20of%20Research%20in%20High%20Priority%20Areas%20(IRHPA)

2

Projects Sanctioned

Expenditure
(New and Ongoing)

11.38 cr
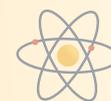
Research Highlights

IRHPA-Atmospheric studies in the Geophysically Sensitive Tropical to Sub-Tropical Transition Region with ST radar Facilities

A National ST Radar Facility has been established at Ionosphere Field Station, Haringhata, University of Calcutta (Figure 3.59). This is a unique facility around 50MHz set up in the country, being the first one in an Indian University and the third overall. The selection of the location of this radar has been determined keeping in view the severe weather conditions and cyclones which frequently develop over the northern Bay of Bengal and make this area extremely prone to damage. This being a major research facility in eastern and north-eastern India should be adequately utilized by the scientific community all over the country. Some of the initial scientific experiments conducted by the University of Calcutta using this radar show interesting features related to the Atmospheric Boundary Layer (ABL) as shown in Figure 3. 60. The tropical tropopause being a subject of considerable interest has also been investigated using the radar and the height variation is given in Figure 3.61. This work was done at the University of Calcutta, Kolkata.

Fig 3.59: Radar antenna array
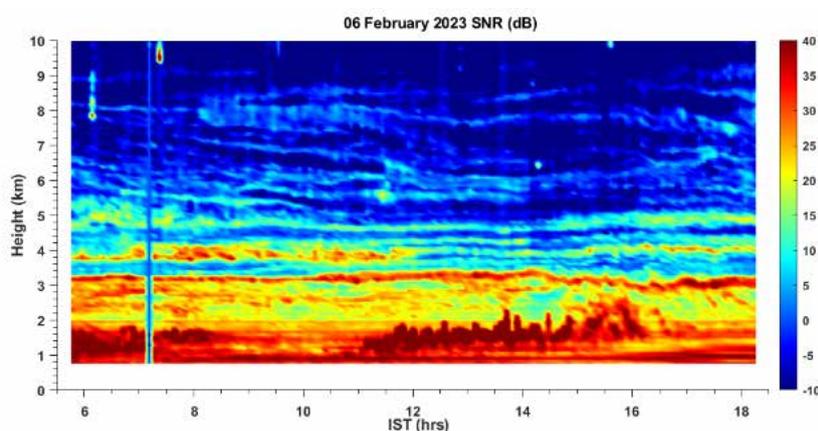
Fig 3.60: Height-Time SNR variation of atmospheric boundary layer observation

Figure: Detection of Radar tropopause Height using IMD -Kolkata Radiosonde balloon data
(a) Temperature profile (b) Relative Humidity profile
(c) Radar vertical SNR profile and (d) Radar Spectral width
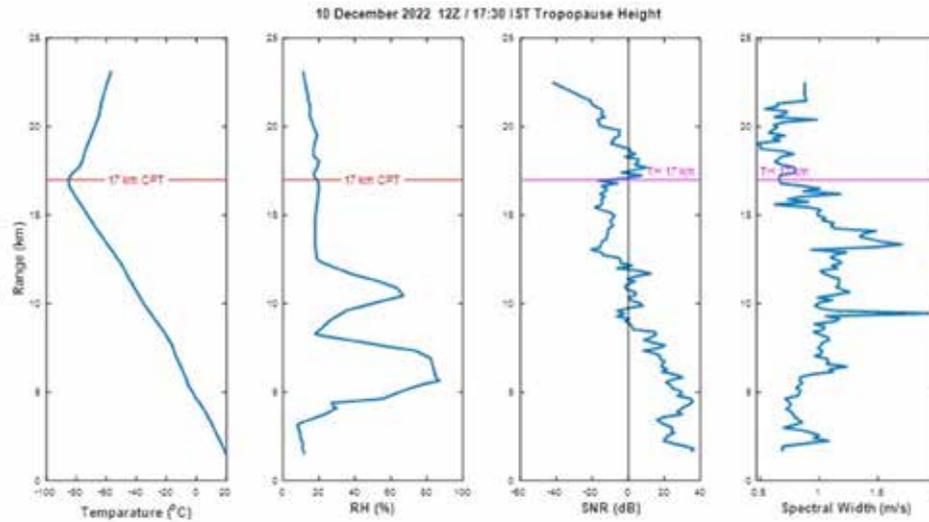
CPT- Cold Point Tropopause
TH- Tropopause Height

Fig 3.61: Tropical tropopause features

IRHPA-National Interdisciplinary Center for Cyber Security and Cyber Defense of Critical Infrastructures

C3i Malware Analysis Framework uses Artificial Intelligence/Machine Learning (AI/ML) algorithms to detect malware in Windows, Linux and Android executables, pdf, Microsoft Office documents, image files (jpeg, png etc.), php and javascript files. The framework is implemented in C3i MAF web-based tool where users can submit their files and obtain analysis results. An AI/ML-based detection tool has been developed to detect malicious web traffic to websites. The tool can detect XSS, CSRF, SQL Injection, and Command Injection attempts.

C3i Centre also developed India's first cyber security research test bed (Figure 3.62) with industry scale SCADA (Supervisory Control and Data Acquisition system) and OT (Operational Technology) for Power Generation, Transmission and Distribution, Water Treatment Plant, Industrial Discrete Automation with Robotic Arms. The test-bed has been used to detect vulnerabilities 15 of which are already listed with CVE numbers in the National Vulnerability Database. Also, further research on detecting cyber-attacks on SCADA/OT systems has been developed including algorithms for PLC False Data Injection detection, algorithms for cyber-physical system anomalies etc., and tested on these testbeds to validate the algorithms. Also developed tools to detect vulnerabilities and compliance with Modbus and DNP3 standards for PLC, SCADA and RTUs.

Fig 3.62: DCS testbed

Developed multiple honeypots to detect attacks on IT and OT infrastructure. The honeypots are systems that are designed to attract attackers to infiltrate the system by deceiving them into assuming that it is a critical system – and thereby becoming a subject of analysis of their modus operandi. C3i HAMMER – a Honeypot based Deception system provides intelligence on the tactics, techniques, and procedures used by external attackers on organizational assets as given in (Figure 3.63).

Fig 3. 63: Screen of the C3i Honeypot Dashboard Showing Collected Threat Intelligence

Also developed multiple tools for collecting and analysing threat intelligence which allows defenders to prepare their cyber defence based on tactics and techniques employed by cyber attackers and cyber criminals elsewhere. However, such threat intelligence often comes in the narrative form and mapping such information in a tactics, techniques, and procedures framework (TTPs) helps system defenders to use the information to mitigate attacks that employ the same TTPs. This work was done at the Indian Institute of Technology, Kanpur.

IRHPA-Virtual reality-based solution for effective neuroanatomy teaching

Virtual reality methods can be used to project the 3D images enabling a better understanding of the positions and relations of anatomical structures. Hence, this project aimed at developing a Virtual reality-based solution for teaching neuroanatomy to undergraduate medical students in a large classroom, which potentially will facilitate learning anatomy more easily than with 2D drawings/figures as the VR depicts the brain as a 3D object with substructures. The developed solution is to be deployed and validated in a medical college with students.

A well-framed neuroanatomy teaching module developed for utilizing the Virtual Reality aspects in neuroanatomy teaching. The three-dimensional and cross sectional (axial, sagittal and coronal planes) aspects of brain structures are well captured in this technique of teaching as a support to traditional teaching methods. A few images of the work progress are given in Figure 3.64.
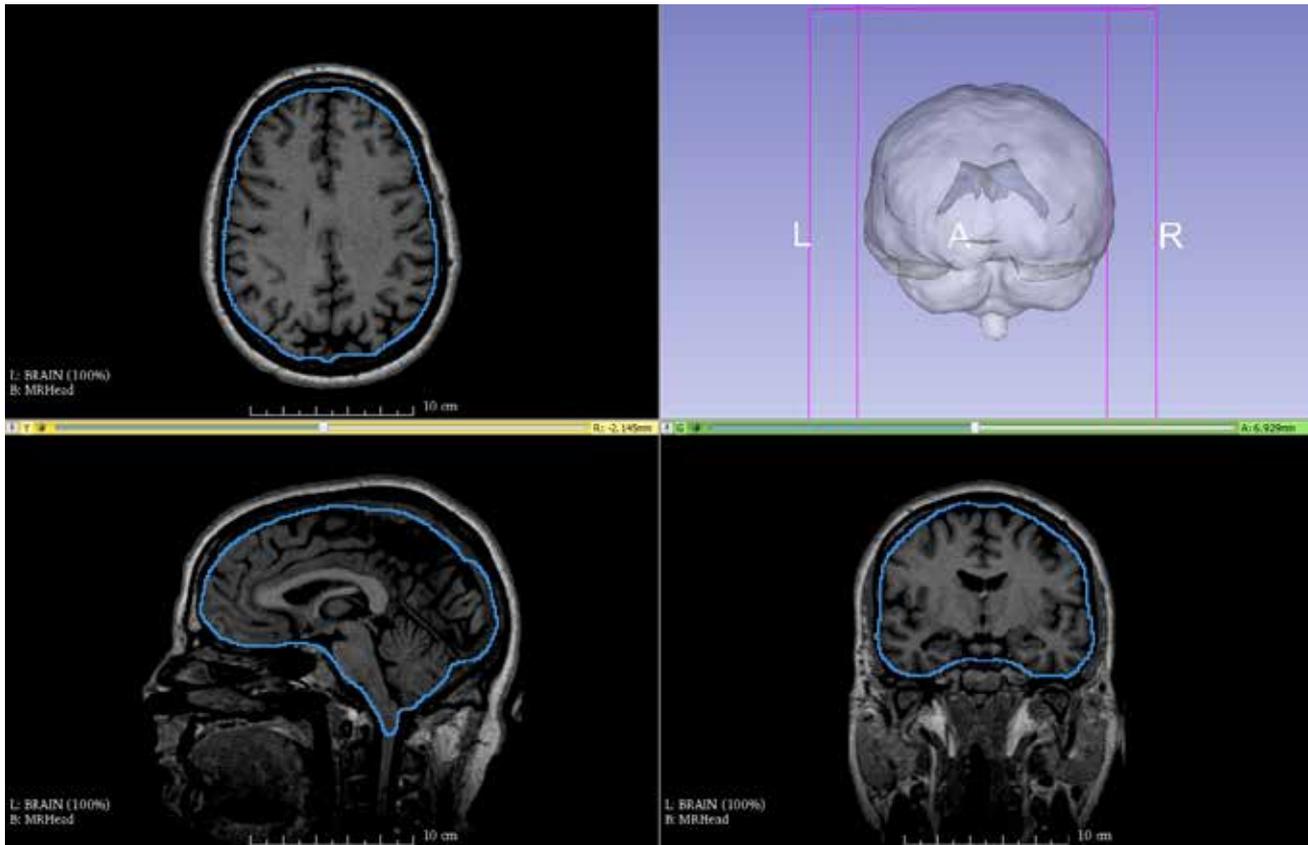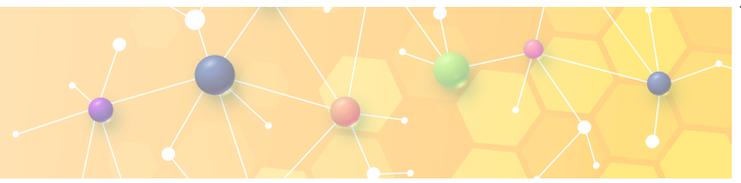
Fig 3.64: Segmented Ventricles using 3D Slicer

A solution for supporting the teaching of neuroanatomy based on virtual reality (VR) has been developed. This enables a 3D visualisation of anatomy which should facilitate learning of structures and their spatial configuration within the brain. The hardware setup uses the standard 3D visualisation design. It consists of 2 projectors, polarising lenses, a silver screen and passive spectacles with polarising lenses for the viewers. This is shown in (Figure 3.65).
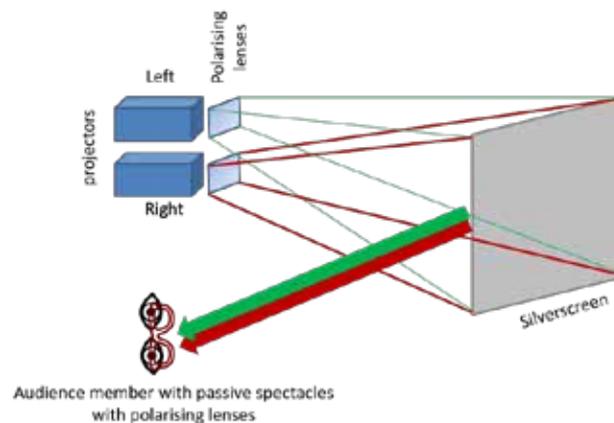
Fig 3.65: Hardware setup for 3D visualization

A 3-D model of the brain was developed using radiological images (MRI) and 3D projection with passive glasses was used to create the 3D visualization. A major redesign of the viewing tool was undertaken to incorporate several changes. Firstly, the viewer design now supports Windows OS, whereas the first version supported only a Linux-based application. Secondly, the UI has been designed to be more intuitive for an anatomy teacher who can do all manipulations using just a mouse. Thirdly, the application has both
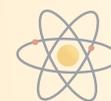
stereo and mono outputs. The mono output can be viewed with a single, normal projector. The teacher can manipulate the 3D models in the mono mode as well. This feature was incorporated to address the high cost of the stereo projection which may affect the adoption of the solution in resource-constrained settings. Finally, the backend was modified to enable ease of extension later to support advanced features such as dynamic fluid flow. This work was done at the International Institute of Information Technology, Hyderabad and Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum.

SERB Center for Advanced Processing Technology Development for Rare Earth Magnets for Automotive and EV Applications

The aim of the project is to set up pilot plant with all facilities required to manufacture near net shape Nd-Fe-B magnet adopting NPLP technique to produce magnets with energy product of 35 – 45 MGOe and coercivity of 10 – 15 kOe suitable for EV applications.

ARCI has taken up this project to establish a pilot plant production of Nd-Fe-B magnets by adopting a novel technology, known as New Press Less Process (NPLP) as given in (Figure 3.66).

Fig 3.66: A New Pressless Process equipment along with the near net shaped slab and arc magnets manufactured using the technology.

Initial R&D activity has been initiated under the project and efforts are on to develop heavy rare earth (Dy, Tb) free high coercive Nd-Fe-B magnets. The grain boundary diffusion technique has been adopted and the advantageous effect of using Nb as grain growth inhibitors for effective coercivity enhancement in melt spun Nd-Fe-Nb-B ribbons has been established.

The hysteresis loop measured for the as-recd and GBDP samples, respectively. (Figure 3.67(a)) The

GBDP sample exhibited a coercivity of 2.1 T, much higher than that of the as-recd sample which showed a coercivity of 1.2 T. The coercivity value of 1 T at 150oC critical for automotive applications could be achieved in the present study as shown in (Figure 3.67(b)) after the diffusion process and hence could prove to be a useful strategy adopted to develop magnets without Dy for EV applications.
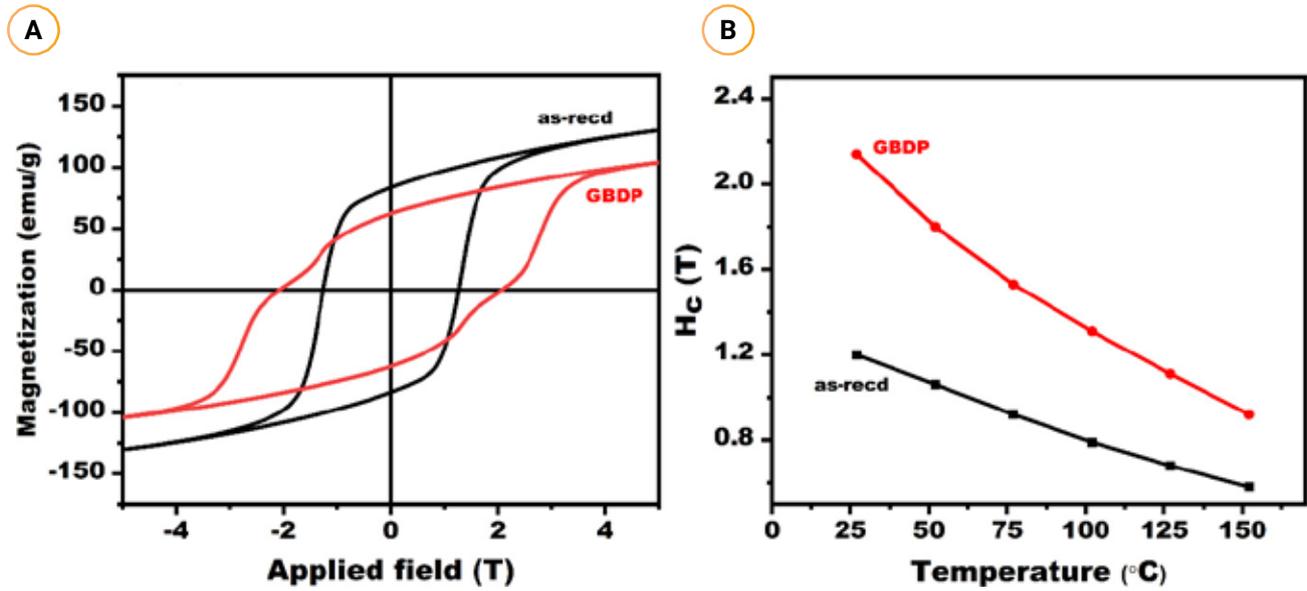
Fig 3.67: **(a)** Magnetic properties of the as-received (as-recd) and grain boundary diffused sample (20 wt.% Nd-Cu in Nd-Fe-B-Nb (GBDP)) with a) showing the enhancement in room temperature coercivity for GBDP and **(b)** temperature dependence of coercivity with GBDP exhibiting higher coercivity across the entire temperature range.

The initial magnetization curve of the diffused sample shows a kink (Figure 3.68(a)) corresponding to the pinning of the domain wall at the grain boundary caused by the enrichment of Nd and Cu. Transmission electron micrograph shows restricted grain growth due to the presence of Nb precipitates (indicated by arrows in the inset of Figure 3.68(b) and STEM-EDS mapping shows the enrichment of Nd and Cu along the grain boundary which aids the enhancement of coercivity. Sophisticated techniques like a 3-dimensional atom probe (3-DAP) were also employed to confirm the presence of Nb precipitates and the enrichment of Nd and Cu along the grain boundaries as shown in Figure 3.69. This work was done at International Advanced Research Centre for Powder Metallurgy & New Materials, Hyderabad and ARCI, Chennai.
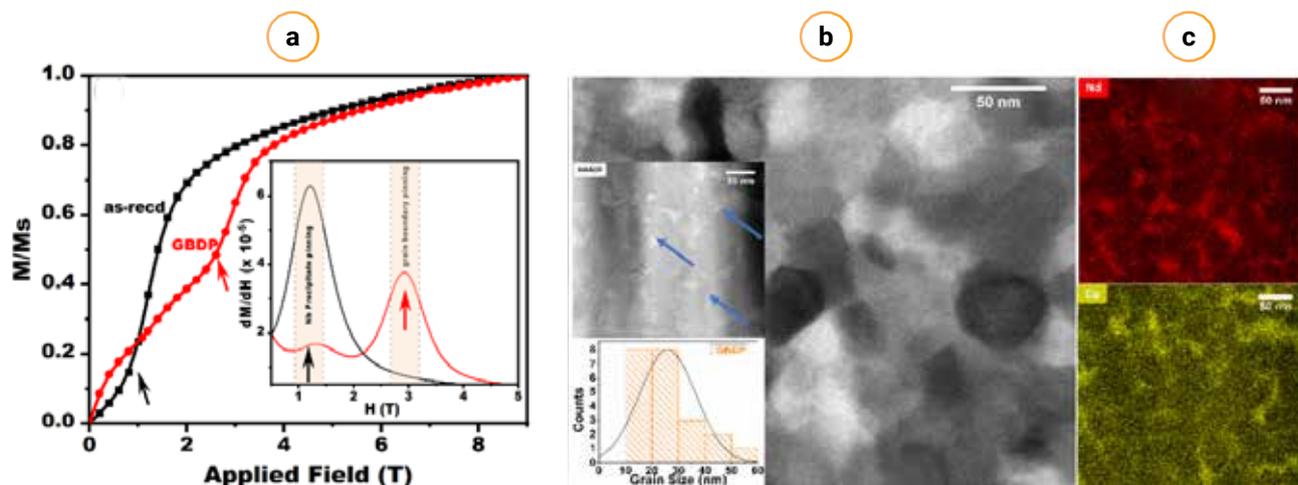
Fig 3.68: **(a)&(b)** Initial magnetization curve showing kink in the diffused sample and STEM-EDS showing the enrichment of Nd and Cu at the grain boundaries which aids pinning of domain walls enhancing the coercivity.
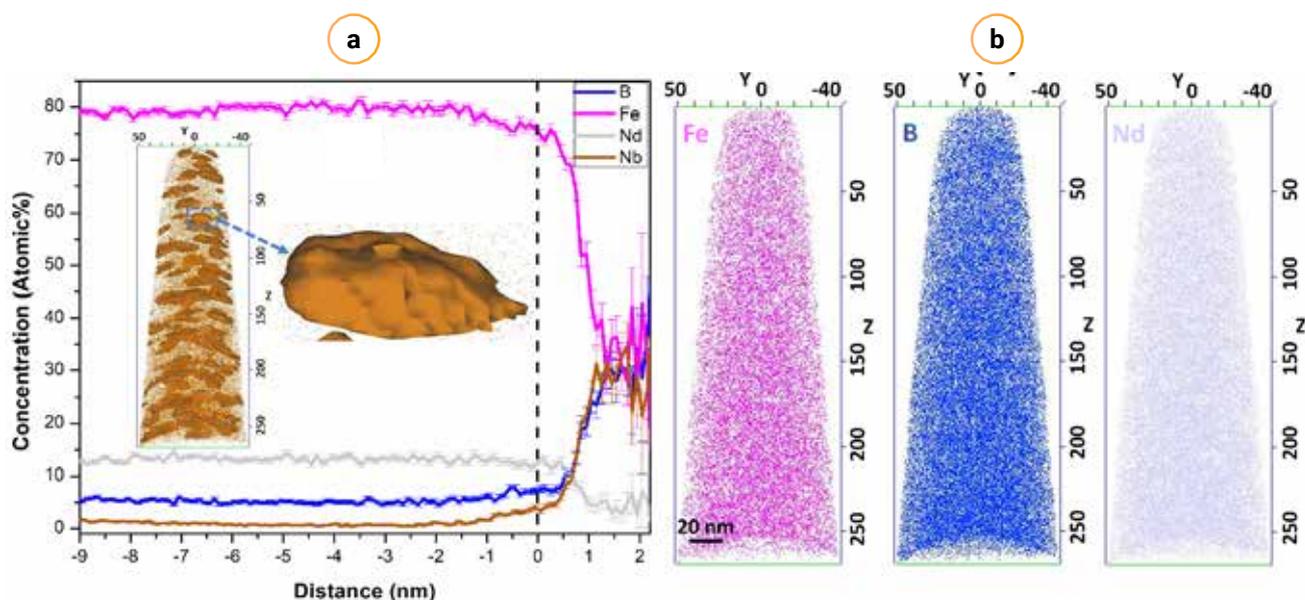
Fig 3.69: (a) 3DAP elemental distribution showing the presence of Nb precipitates and **(b)** 1-dimensional concentration profile across the grain boundary showing enrichment of Nd and Cu .

SERB - Centre(s) for Antibody Engineering

SERB has initiated efforts to advance research in antibody technology by establishing integrated antibody engineering platform(s) in India through R&D centres. The vision of these centres is to drive innovative and interdisciplinary collaborative research in recombinant antibody engineering and build critical infrastructures for technology-driven solutions.

Center for Immunotherapeutics/Immunodiagnostics Veneering Technologies (CiVET)

Center for Immunotherapeutics/Immunodiagnostics Veneering Technologies (CiVET) is a project supported under the SERB – Centre for Antibody Engineering, under the IRHPA program (Figure 3.70). The project implemented at the Indian Institute of Science Education and Research, Mohali and the University of Delhi, aims at discovering and developing novel antibodies for research, diagnosis and therapy for diseases of humans and animals. Diffused boundaries between habitats of humans and animals (including insects) result in frequent exposures to new and emerging pathogens several of which can jump species causing zoonosis or reverse zoonosis. Some pathogens can better adapt and establish commonly harmonious relations but some evolve into deadly agents with the potential to cause devastating pandemics thanks to our interconnected world. Numerous infectious agents endemic to subtropical countries such as those in the Indian subcontinent lack effective licences for vaccines despite extensive efforts made globally.

The new age therapeutics involving monoclonal or the single domain antibodies (sdAbs) are driving the field of biomedical research and biotechnology and are helping in the efficient management of communicable and non-communicable diseases. Early diagnosis of infection, developing cancer or autoimmune disease is critical for devising therapies for better prognosis and antibodies serve as one of the commonest recognition modules. Therefore, having access to affordable and robust antibodies is critical to improve human and animal health. The activities in the centre are intended to boost this avenue.

The group have generated neutralizing sdAbs against viruses such as SARS-CoV2 and DenV. Their antiviral activity has been demonstrated ex vivo in cell culture and in vivo in animal models. The sdAbs are devoid of Fc region and therefore could not cause antibody dependent enhancement of infection. The studies also selected sdAbs against some of the key host proteins such as galectin-3, an adhesion G protein coupled receptor (Gpr114), and a small GTPAse immunity associated proteins 7 (GIMAP7) and these sdAbs could have immunomodulatory properties acting on innate and/or adaptive immune cells during infection as well as developing cancers. Infect, anti-Gal-3 sdAb exhibited direct anti-viral functions against SARS-CoV2 due to the recognition of so called galecti-fold in the spike protein. Antibodies are not commercially available against Gpr114 and GIMAP7 and with their availability, cellular and molecular events driving the

differentiation and function of immune cells could better defined. The studies produced anti-DENV sdAbs in plants as a proof-of-principle demonstration and this endeavour could help scale up the production of clinically relevant antibodies.
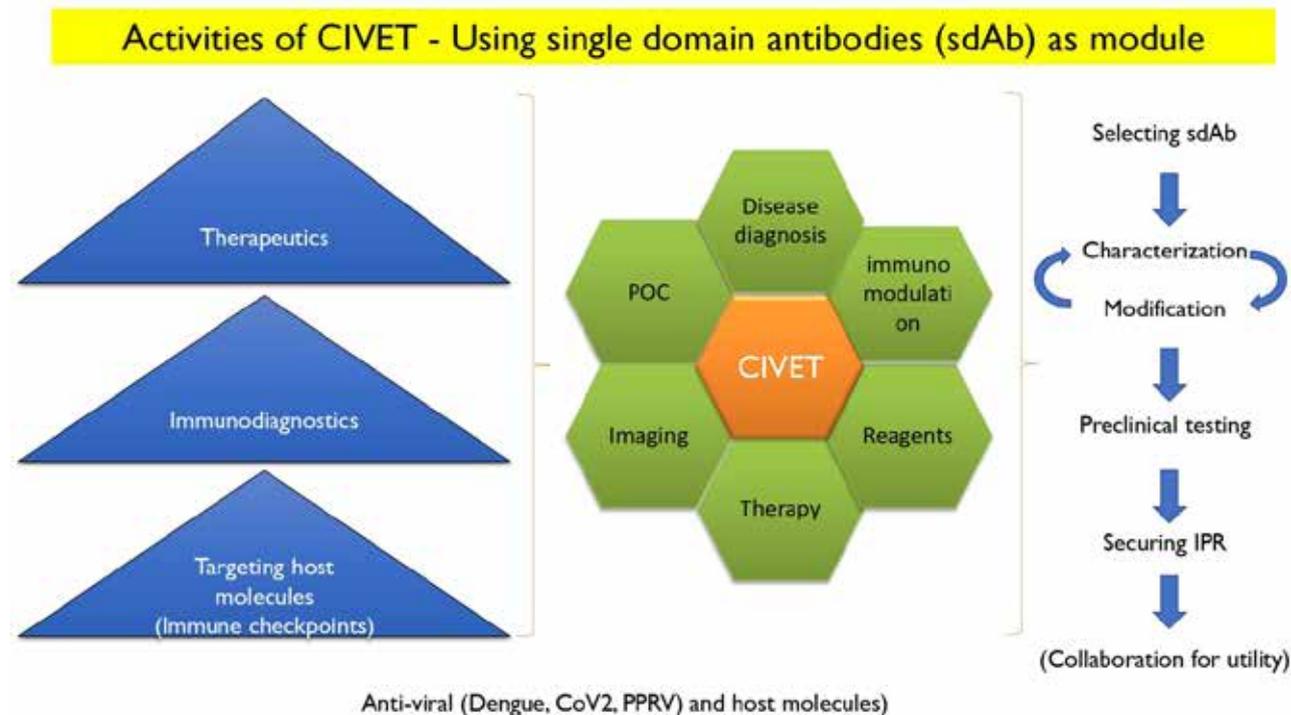
Fig 3.70: Schematic of proposed activities of Center for Immunotherapeutic/Immunodiagnostics Veneering Technologies (CiVET)

IRHPA- 3D-Bioprinting

3D Bio-Stereolithography for Engineering Functional Tissues

This project aims to develop 3D bioprinting technologies that enable the fabrication of 3D tissue scaffolds in a layer-by-layer format using 3D printers. The fabricated tissue constructs have two important applications:

- These scaffolds, when implanted in the human body, can be used to repair and regenerate tissues/organs of the human body that are damaged due to disease, trauma, or congenital defects.

- The tissue scaffolds can be used as organotypic in vitro models for probing the molecular basis of diseases and for screening of drug molecules, as better alternatives to animal testing.

Fabrication of the scaffolds by 3D bioprinting enables tissue-mimetic architecture and spatial organization of cells.

Digital light processing (DLP)-based 3D offers unique opportunities to prepare scaffolds that mimic the architecture and biomechanical properties of human tissues. However, the limited availability of biocompatible and biodegradable bio-inks amenable for DLP-bioprinting is an impediment in this field. To address this limitation, Investigators prepared two novel bio-inks for DLP-bioprinting, one each based on proteins and polysaccharides. They prepared a bio-ink from silk fibroin (SF) tailored for DLP bioprinting (Figure 3.71). Photocurable methacrylate-SF (SF-MA) was synthesized. Physical characterization of rheological and mechanical properties revealed that the 3D printed hydrogels of SF-MA (spanning from 10 to 25 wt%) exhibit bone tissue-like viscoelastic behaviour and compressive modulus ranging from ≈12 kPa to ≈96 kPa. The gels exhibited favourable degradation (≈48 to 91% in 21 days). This SF-MA bioink afforded the printing of complex structures, with high precision (Figure 3.72).
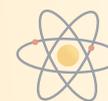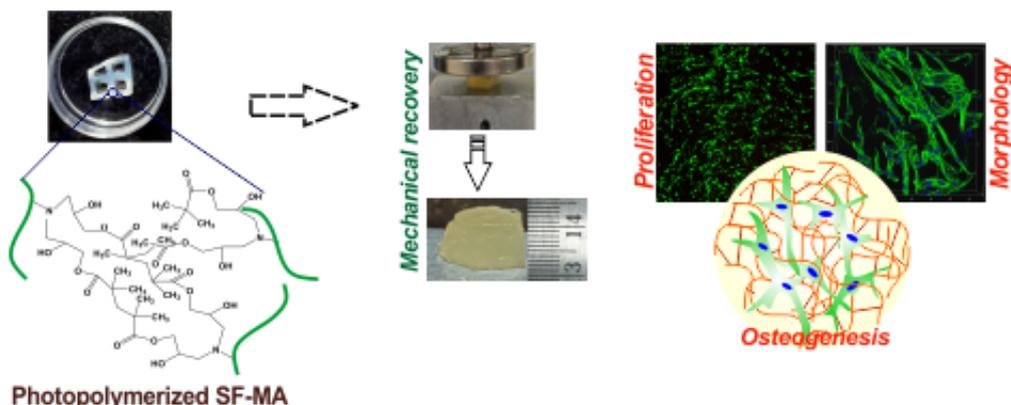
Fig 3.71: Summary of 3D DLP-bioprinting to prepare silk fibroin scaffolds.
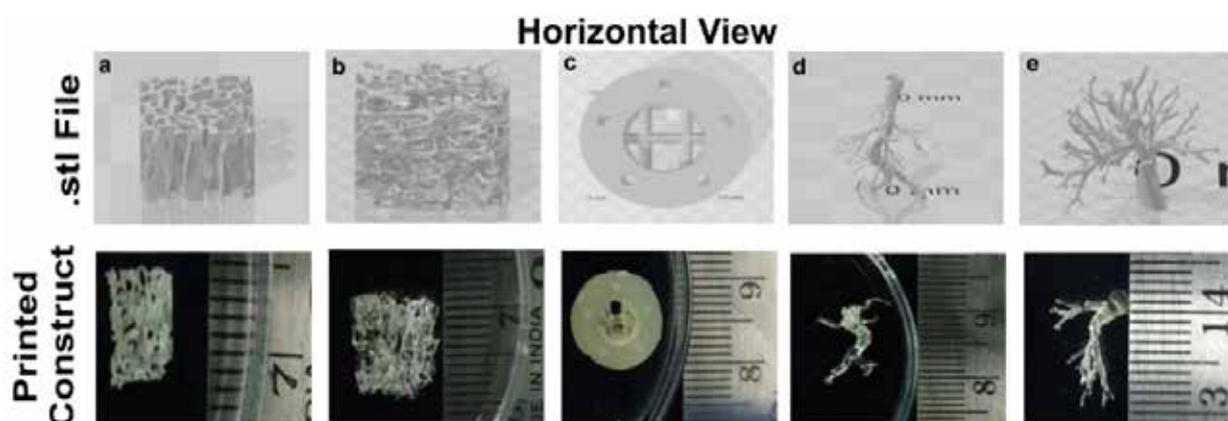
Fig 3.72: The design file and corresponding photographs of the 3D printed hydrogels demonstrating the printability of 15% SF-MA by DLP 3D bioprinter. (a, b) Trabecular bone, (c) Haversian bone, (d, e) vascular network

Pre-osteoblasts were successfully encapsulated in 3D bio printed SF-MA hydrogels with high viability. 15% SF-MA DLP bio printed hydrogels efficiently supported cell proliferation with favourable cell morphology and cytoskeletal organization (Figure 3.73). A progressive increase in cell-mediated calcium deposition up to 14 days confirmed the ability of the gels to drive osteogenesis, which was further augmented by soluble induction factors. This work demonstrates the potential of silk fibroin-derived bio inks for DLP-based 3D bioprinting of scaffolds for tissue engineering.
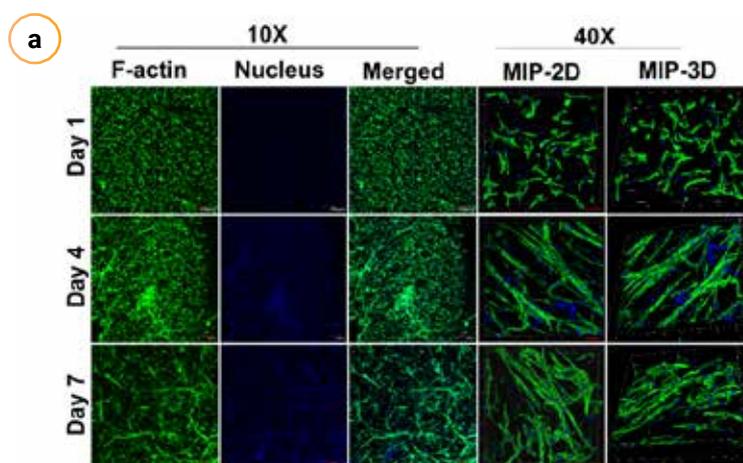
Fig 3.73: Maximum intensity projection (MIP) of fluorescently labeled F-actin organization in MC3T3-E1 pre-osteoblasts encapsulated in 15% SF-MA DLP bioprinted hydrogel; cells show elongated morphology, which changes from spindle to polygonal to multi-stellate morphology with time. (Magnification: 10× and 40×, Scale bar = 100 μm and 50 μm)
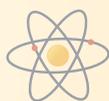
In addition, investigators demonstrated the outstanding printability of photocurable methacrylate-κ-carrageenan (MA-κ-CA) using DLP 3D printing (Figure 3.74).

3D printed hydrogels with varying concentrations (1–5% w/v) of MA-κ-CA were thoroughly characterized for their swelling, degradation, mechanical, and rheological properties, and suitability for bioprinting with living cells. The viscosity and shear thinning behaviour of MA-κ-CA faithfully recapitulate the biomechanical properties of soft human tissues.
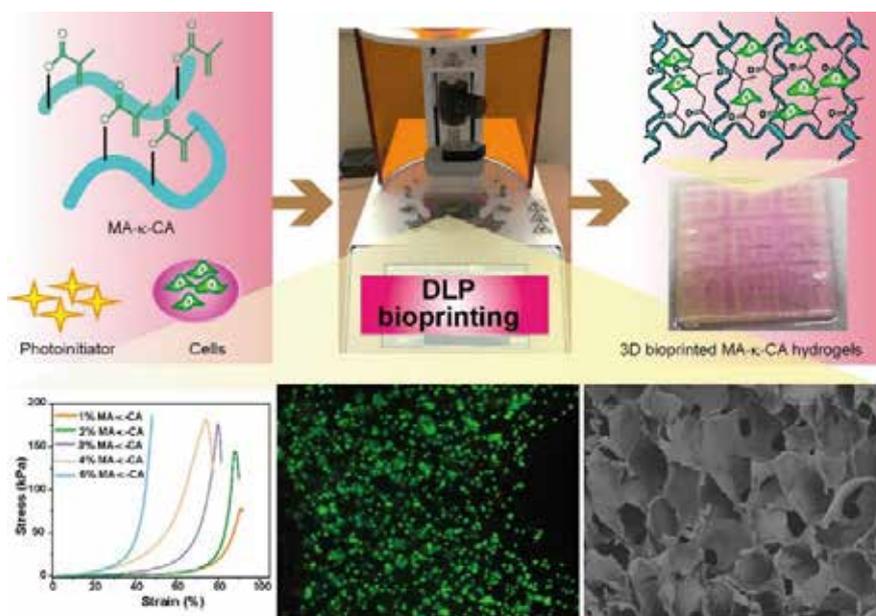
Fig 3.74: Summary of 3D DLP-bioprinting to prepare κ-carrageenan scaffolds.

Encapsulated NIH-3T3 fibroblasts show high viability and good proliferation over several days (Figure 3.75).

Furthermore, highly complex 3D hydrogel scaffolds of MA-κ-CA were printed to recapitulate the biological complexity of tissues and organs (Figure 3.76). This work presents a polysaccharide bio ink for preparing tissue scaffolds by DLP 3D bioprinting. This work was done at the Indian Institute of Science, Bangalore.
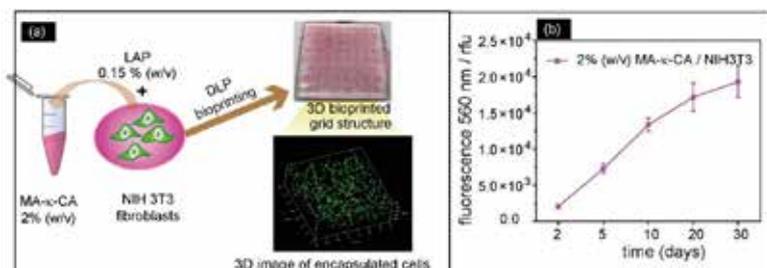
Fig 3.75: Schematic representation of 3D bioprinting of 2% w/v MA-κ-CA prepolymer solution mixed with NIH 3T3 cells and a digital photograph of DLP printed 3D tissue construct (a). Proliferation of NIH 3T3 cells was measured over 30 days using the Alamar blue (b).
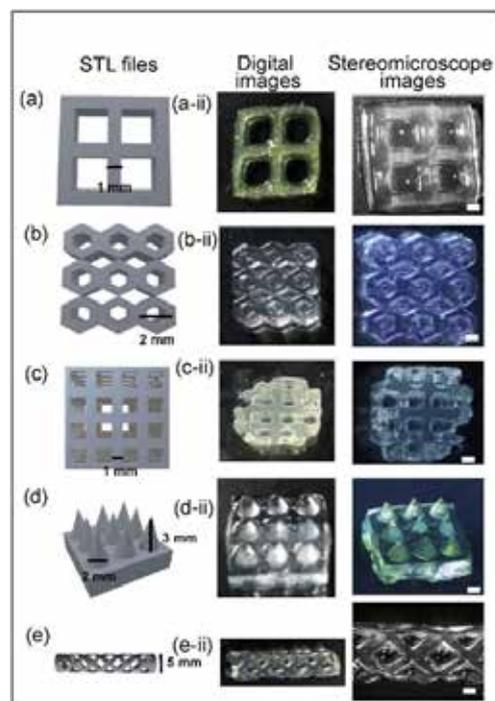
Fig 3.76: Printability of 3% (w/v) MA-κ-CA using DLP printer (a-e). Left side images are 3D printed constructs of different dimensions, which were fabricated according to the designed CAD models and were sliced to a layer file in the DLP system before printing, $8 \times 8 \times 2$ mm^3 grid (a), $8 \times 8 \times 2$ mm^3 honey comb (b), $8 \times 8 \times 8$ mm^3 cube with lumen (c), $2 \times 2 \times 3$ mm^3 fine needles on $8 \times 8 \times 2$ mm^3 square (d), and $5 \times 5 \times 10$ mm^3 BioStent
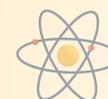
IRHPA Emergent property of Nanoscale matter

Nanostructured Materials for Hyperspectral Sensing

The PI's research group demonstrate solution-processed ultrafast self-powered photodetectors based on PM6:Y6 organic material. A detailed characterization of bulk-heterojunction PM6:Y6 photodiode reveals the influence that the thickness of photoactive material has on the dark current and electronic noise at low frequency. At room temperature, the photodetector exhibits -3 dB cut-off frequency of > 780 kHz, dark current density of ~14.9 x 10-11 A/cm^2 at zero bias and load resistance dependent response time ranging from 800-130 ns (Figure 3.77(a)), linear dynamic range over 140 dB, maximum responsivity of 0.57 AW^{-1}, detectivity ~ 1013 Jones. Also, explore the key response time limiting factors and compare our photodetector to current organic and standard Si

photodetectors (S1133), as shown in (Figure 3.77(b)). Considering various performance merits compared to traditional Si photodetector, the organic photodetector is found to rival low-noise. The PI's research group also investigated $CuFeSe_2$, $AgFeS_2$, Ag_2Te nanocrystals (NCs) as visible and IR photodetectors. The long emission lifetimes, as well as a strong overall tendency of carrier localization in these NCs, justifies the use of these materials as photosensitizers for chemical transformations as well as for photoelectrochemical light-harvesting devices. The lateral devices fabricated with $CuFeSe_2$ films show good responsivity of 0.4 mA/W (Figure 3.78). This work was done at the Indian Institute of Science, Bengaluru.

Merit Parameters	PM6:Y6 OPD	Hamamatsu Si PD S1133
A, Photo-active Area	4.5 mm^2	6.72 mm^2
λ, Wavelength (nm)	350 to 900 nm	320 to 730 nm
C_J, H = 0, V = 0 V, 1 MHz	5.76 nF	700 pF
I_D	~ 0.1 nA- 20 pA	10 pA
J_d (A/cm^2)	14.9 x 10^{-11}	14.88 x 10^{-11}
S_R, @ 400 nm	0.4 A/W	0.3 A/W
t_R/t_F, @ 1 kΩ Load V_R = 1 V, 830 nm	1- 2.4 µs, @ 405 nm	2.5 µs
@ 780 nm/ 405 nm, R_l=50 ohm	680 ns	450 ns
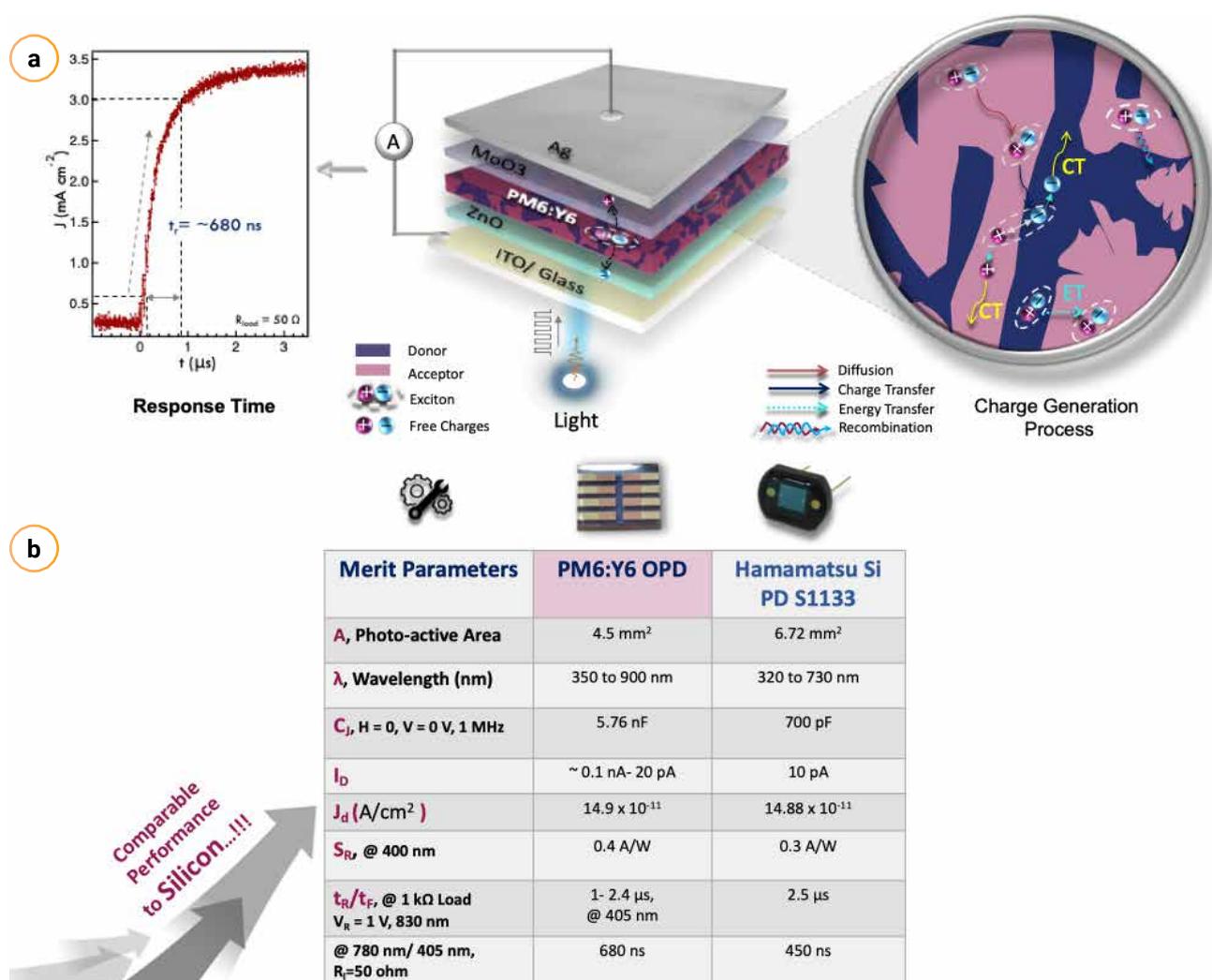
Fig 3.77: (a) Demonstrates the transient photoresponse of PM6:Y6 based BHJ photodiode at 10 to 90% rise response time, charge generation process, and **(b)** shows a comparison of the figure of merit of PM6:Y6 photodiode with standard Hamamatsu Si photodiode (PD S1133).
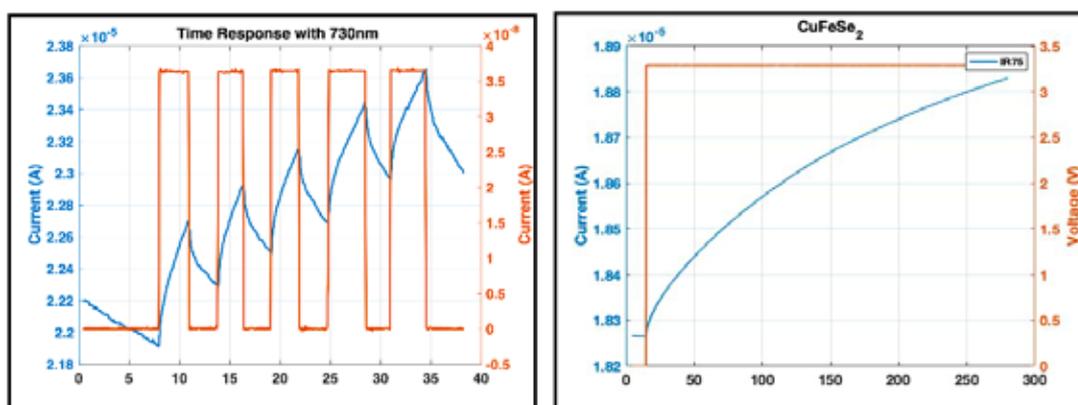
Fig 3.78: The response of CuFeSe$_2$ lateral devices to visible and IR light. The responsivity parameters for these devices were measured to be around 4 mA/W.

Cyro Electron Microscope

Establishing the North India Facility for Cryogenic-Electron Microscopy (cryo-EM)

As a part of the IRHPA program, the study on Elucidating the molecular basis of anaphylatoxin recognition and activation of the complement receptors was carried out at Indian Institutes of Technology, Kanpur. Key drugs targets for inflammatory disorders: Activation of the complement system is a critical part of the innate immune response and operates in a concerted fashion with antibodies and phagocytes towards the clearance of pathogens. Anaphylatoxins C3a and C5a are terminal products of the complement cascade acting as potent inflammatory peptides, and elevated levels of these molecules are implicated in multiple inflammatory disorders, including sepsis, asthma, cancer, and advanced stages of COVID-19 pathophysiology, while also playing critical roles in other physiological processes, such as neurogenesis and metabolism. The proximal step of C3a and C5a-mediated physiological responses is their interaction with two G protein-coupled receptors (GPCRs) namely, C3aR and C5aR1, respectively.

The molecular mechanisms underlying receptor selectivity, ligand recognition, receptor activation, and signalling bias have thus far remained elusive, representing a significant knowledge gap in our current understanding of the complement system. The study has determined seven cryo-EM structures of human C3aR, human C5aR1 and mouse C5aR1, activated by their respective natural agonists, and signalling-biased synthetic peptides (EP54 and C5apep), in complex with heterotrimeric G-proteins (Figure 3.79). These structures reveal novel binding pocket topologies compared to other peptide receptors, and intricate details of receptor activation and transducer-coupling mechanisms. Therefore, this study elucidates the molecular mechanisms of complement anaphylatoxin recognition by their respective receptors and offers a previously lacking framework to facilitate novel drug discovery targeting these receptors in multiple disease conditions including pathogenic infections.
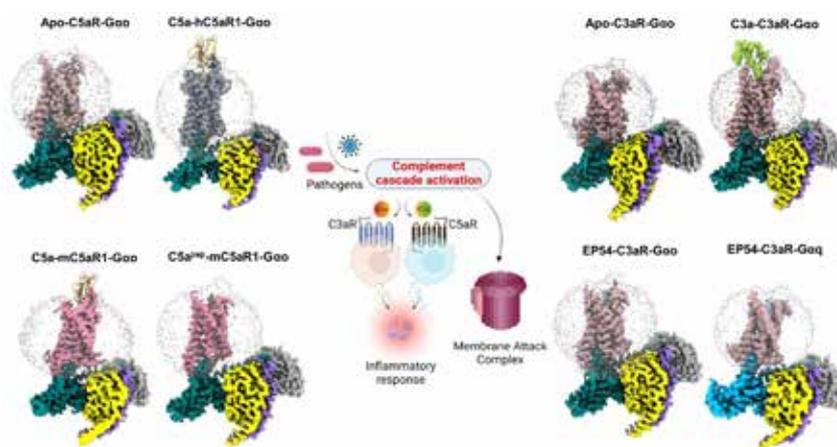
Fig 3.79: Structural basis of the anaphylatoxin by the complement receptors
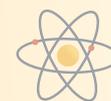
Complement activation is a key mechanism in our body's innate immune response to combat pathogenic organisms such as bacteria and viruses. The potent anaphylatoxins C3a and C5a exert their cellular and physiological effects through two different G protein-coupled receptors namely, C3aR and C5aR1. The present study has determined cryo-EM structures of C3aR and C5aR1 activated by C3a and C5a in complex with heterotrimeric G-proteins. These structural snapshots elucidates the molecular mechanisms of complement-recognition by their respective receptors, and offer a previously lacking framework to facilitate structure-based drug discovery to target these receptors in a spectrum of disease conditions.

SERB Centre for Energy Transformation and Storage

SERB has supported five SERB-centres for Clean Energy transformation to institutions placed at different geographical locations namely Indian Institute of Science, Bengaluru, Indian Institute of Technology at Bombay, Roorkee, Kanpur and Kharagpur. All the projects are multi-institutional in nature. The first instalment of funds has been released in 2022.

The PI's group in Indian Institutes of Technology, Bombay has plans to develop a new Sodium-ion battery and Sodium battery Capacitor and which is to be used in Microgrid operation. The battery prototype is made and is under electrochemical tests currently. This project also aims to test transparent PV panels, which can be used in corridors of buildings, office and mall peripherals present in the urban area. A 20 kWp microgrid system is supposed to be developed by the group, which will be generating around 80 to 100 units of energy in the day and will be reducing around 35 kilograms of CO_2 emission to the environment per installed system. This will be a significant step towards compensating for global warming in a significant way as the Indian Government is very serious towards environment preservation and global participation. The developed Microgrid by VNIT will be integrated with the developed battery and supercapacitors developed at the respective laboratories at Indian Institutes of Technology, Bombay & National Institute of Technology, Durgapur. Various control techniques like Droop Control and Modified Droop Control techniques have been developed and tested successfully along with various converters.

The project in Indian Institutes of Technology, Kharagpur has been approved about a year back and therefore is still in the setup stage in respect of manpower, equipment, etc. The following are the significant goals at the national and global scenarios that this project would target in future.

A. A significantly advanced energy system for large urban infrastructure delivering enhanced quality, reliability, resilience of power supply at lower costs and with adequate safety.

B. The above shall be realised by leveraging new technologies and methods for integrating solar PV panels into existing buildings, safe second-life diverse battery energy storage systems, intelligent optimised cooperation of multiple energy sources and load management.

Through this project the PI's group aims to build a team of unique R&D capacity to address problems of development and management of energy in Urban infrastructure, thus building capacity in the scientific ecosystem in order to participate in funding of research and development.

The broader aim of the centre at Indian Institutes of Technology, Kanpur is to become a hub for the development novel and low-cost battery chemistries beyond Li, their scale up and prototype development, cell fabrication at various scales, comprehensive testing of batteries and their assessment in real life applications and performance prediction. This centre is a multi-institute project having PIs from Indian Institutes of Technology, Roorkee, Indian Institutes of Technology, Jodhpur and CSIR-CECRI apart from Indian Institutes of Technology, Kanpur. Participating PIs have complementary expertise and will lead to the development of next-generation future battery technologies for not only surface transport but also for air mobility requiring much higher power and energy densities. Currently, the group focus on developing battery chemistries based on Na-ion and Al-ion and their electrochemical testing.

Significant progress has been achieved in developing rechargeable Mg- and Al- ion batteries by the PI's group in Indian Institute of Science, Bangalore. This is beyond Li- based batteries. In addition, progress has been made in alleviating thermal issues which will address the hot spots generated in batteries during operation. This is of great importance to address fire hazards in Lithium based batteries. The rechargeable battery technology (Zn / Mg / Al) is at prototype levels in the laboratory. They are expected to be scaled up to pouch cell level and taken further for large systems. This is being done with the help of ARCI, Hyderabad.

In the project at Indian Institutes of Technology, Roorkee, The PI's group has fabricated semi-transparent perovskite solar cells with the composition FA 0.9 Cs 0.1 PbI 2 Br. With this composition, they have reported a maximum efficiency of 11.5% and an AVT of 35% (LUE= AVT*Efficiency = 4.02%), which is the first report with this composition. LUE (Light Utilization Efficiency) refers to the ability of a photovoltaic cell to efficiently convert light into electrical energy while still

allowing a significant amount of visible light to pass through the cell. For semi-transparent perovskite solar cells, LUE is an important metric since these cells are designed to allow some visible light transmission while still generating electricity. Initially, semi-transparent films have been optimized by changing the thickness of active layer and compositional engineering.

Followed by semi-transparent devices (area ~ 01cm2) have been fabricated that resulted in transparency of around 35% and efficiency ~11.5%. The aim of the project is to demonstrate the proof of concept where a large area semi-transparent device will be fabricated to integrate with the window.

3.2.2 Scientific and Useful Profound Research Advancement (SUPRA)

The scheme Scientific and Useful Profound Research Advancement (SUPRA) is a new initiation of SERB which aims to explore new scientific breakthroughs, with long-term impact on our fundamental scientific understanding, and offer disruptive technologies at the cutting- edge research. Transformative and disruptive research concepts based on innovative and unproven hypotheses, possessing a high degree of uncertainty, yet having the conviction to produce a lasting impact across discipline boundaries qualify for support under this scheme. The proposals under this scheme are envisaged to obtain breakthrough solutions in identified areas. This will increase the knowledge base and at the same time will provide a wealth of deliverable outcomes. It is expected that these innovative proposals will have a considerable impact on global science and will also open up new opportunities in S&T.

F E A T U R E S

A scheme beyond normal core grants to support cutting edge research

Research support to an individual researcher or a group of researchers working in a recognized institution

Funding period is normally for three years, which could be extended to 2 years subject to performance evaluation

Website link: https://serb.gov.in/page/english/research_grants#Scientific%20and%20 Useful%20Profound%20Research%20Advancement%20(SUPRA)

24
Projects Sanctioned

Expenditure
(New and Ongoing)

15.07cr

Areas Supported

Mathematical Sciences

Life Sciences

Chemical Sciences

SUPRA

Engineering Sciences

Physical Sciences

Earth & Atmospheric Sciences
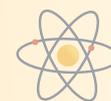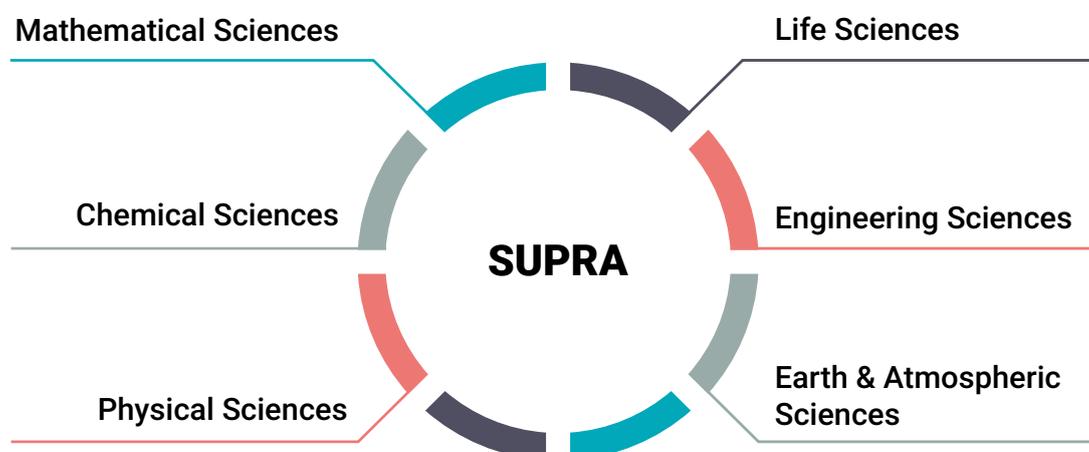
Research Highlight

Design and fabrication of microfluid based transparency switching Smart glasses suitable as windows

In this project, the PI made an effort to optimize "micro-abrasive blasting" parameters to achieve desired surface roughness. (Figure 3.80).

Optimized the device parameter for "tampered" glasses: Device fabrication parameters are optimized for tampered glass instead of standard soda lime glasses. The fabrication of switching glass by using tampered glasses will be very beneficial from the product point of view because Industries prefer tampered glasses instead of normal glass for smart windows applications.

Identification of suitable refractive indexed matched liquids: A set of liquids are identified based on experimental results, which have desired refractive index matching with optimized glass roughness, good wettability, stability, non-toxicity, non-flammability and environmentally benign (Figure 3.81).

Theoretical calculations and modelling: Efforts are made via theoretical modelling to gain insights into the design and functioning of microchannels and wetting aspects related to the drainage leading to an effective curtain effect.

Optimization of low-surface energy coating on the rough surface: Based on preliminary results, it is observed that the device performance (transmittance value in opaques state and switching speed) improves many folds by coating a low-surface energy material (i.e., hydroxyl-terminated siloxanes) on the rough surface of the glass.

Market research progress summary: The idea of "Smart Window Technology" got selected for "Gopalakrishnan Deshpande Centre for Innovation and Entrepreneurship (GDC) I-NCUBATE Programme at Indian Institute of Science, Madras Tech Park. This has helped to discover the potential customers of this project product idea in the actual consumer market. Further, Saint Gobain Research India (SGRI) has shown interest in this technology. Dialogues have been initiated for collaboration, and preliminary experiments are performed in collaboration with SGRI. In the initial phases, SGRI is willing to work collaboratively to understand the technology and assess the market feasibility of this technology to implement as Smart Glass Partition. This Work was done at Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru.
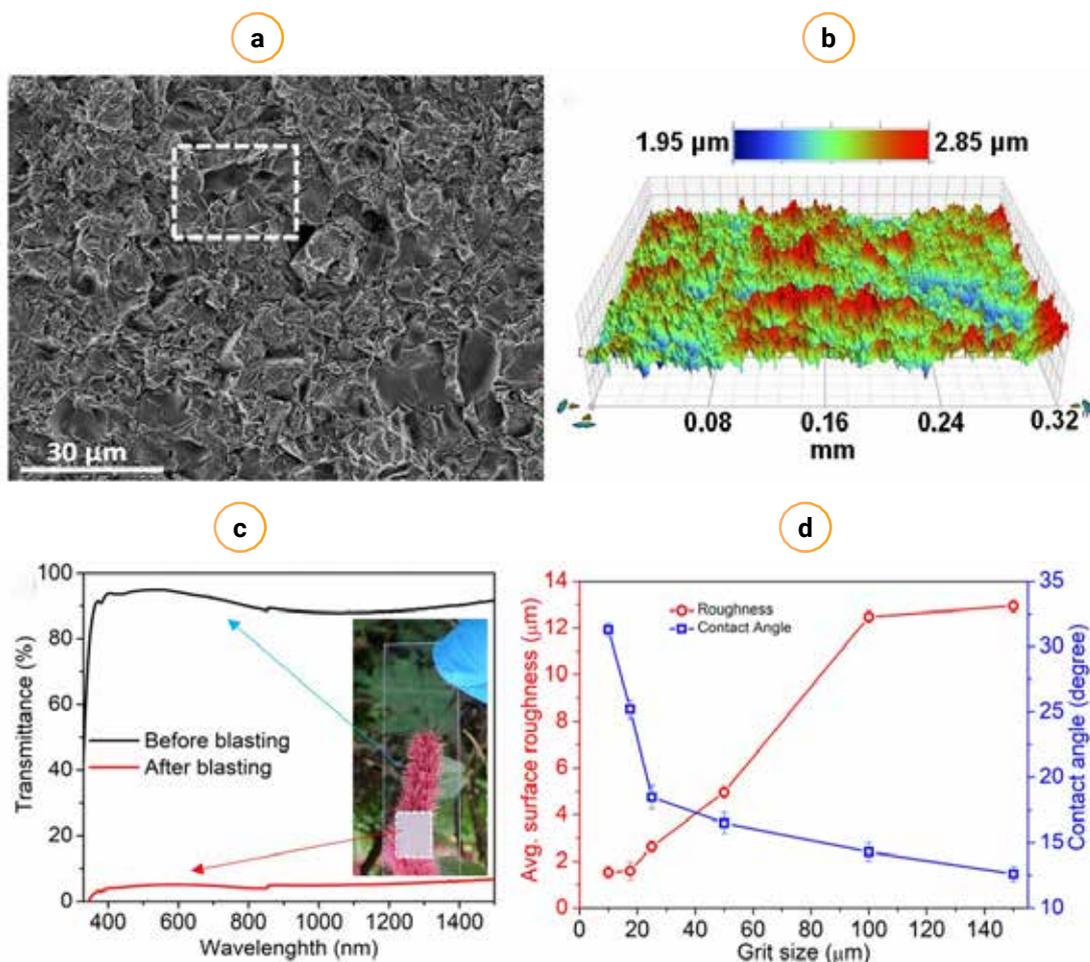
Fig 3. 80: **(a)** FESEM image of glass surface after blasting with Al_2O_3 grits, **(b)** Surface profile obtained using Optical Profilometer of the roughened area of the glass marked with white dash line in the inset of fig. (a), **(c)** shows the transmittance spectra comparison between the roughened area of plain glass (after blasting with Al_2O_3 grits) and non-roughened area of glass, **(d)** shows the plot between average roughness variation created by varying the blasting grit size and their corresponding contact angle of the rough surface.

Fig 3.81: Shows the smart window device with bellow compression/expansion-based pumping mechanism wherein **(a)** is the device in the translucent state, **(b)** is the device in the transparent state, **(c)** is a close view of the pumping mechanism, and **(d)** provides operation of pumping mechanism with knob rotation.
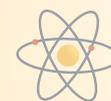
3.3 Gender And Social Inclusiveness

3.3.1 Promoting Opportunities for Women in Exploratory Research (POWER) Grant

To promote women working in the frontier areas of science and engineering, a new scheme SERB- POWER (Promoting Opportunities for Women in Exploratory Research) was launched. This scheme is open to emerging and eminent women researchers to carry out R&D activities by providing them with an individual-centric and competitive mode of research funding. This grant aims to bridge the gender gap in science and engineering research funding in various S&T programs to ensure equal access and weighted opportunities for Indian women scientists engaged in R&D activities.

F E A T U R E S

Project support for women researchers in regular position

Funding is under two categories. Level I : 60 lakh for three years for PIs from National and Central institutions. Level II – 30 lakh for three years for PI from State Universitities / colleges and private academic institutions

Duration of support is for three years
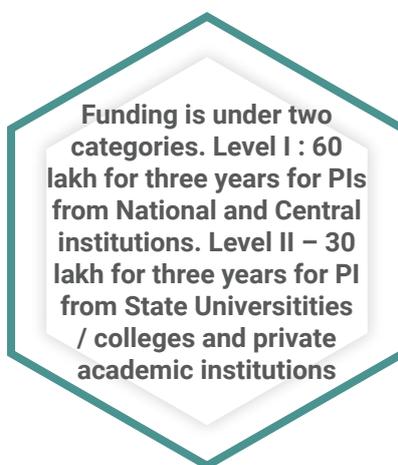
Website link: https://serb.gov.in/page/english/research_grants#SERB%20-%20POWER%20Research%20Grants

Areas Supported

Mathematical Sciences

Life Sciences

Chemical Sciences

Earth & Atmospheric Sciences

SERB- POWER

Physical Sciences

Engineering Sciences
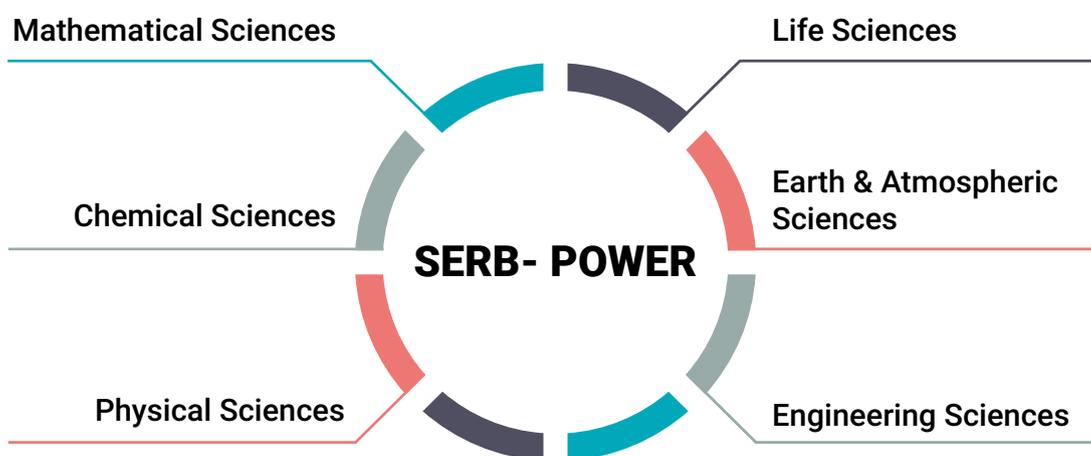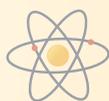
Research Highlights:

Theoretical Investigation of Metal-Organic-Framework and Covalent-Organic-Framework as Porous Platform to Design Novel Hybrid Catalyst for Key Small Molecule Activation

The rapid increase in global energy demands coupled with climatic concerns have intensified development of alternative energy perspective. In this context, water splitting provides practical solutions to a clean and green hydrogen fuel economy. The project focused on identifying an appropriate molecular water oxidation catalyst to be anchored on MOF or COF nodes. The PI's group found that unlike copper oxamidate complex, the analogous nickel complex is relatively unstable and undergoes ligand decomposition to yield oxides and hydroxides. The team first evaluated the reaction mechanism and identified accurate electronic states of the various intermediates that lead to the crucial O-O bond formation. It is found that [Ni(II)L4-]2- undergoes stepwise electron transfers (Figure 3.82(a)). A careful analysis of the one electron oxidized complex (intermediate B) shows that there is a partial removal of metal and ligand-based electrons (Figure 3.82 (b)). Thereby it is oxidized to a neutral [Ni(III)L3-]0 on the singlet surface which can undergo successive nucleophilic attack by OH- and thus leads to the (H)O-O(H) bond formation at a meagre expense of 8 kcal/mol at wb97x-d/LANL2TZ(f)(Ni)/6-311^{++}G(d,p) level of theory. Thereafter, two consecutive PCET leads to the release of triplet O_2 and ultimately give back the parent complex. This work is being carried out at the Institute of Chemical Technology, Bhubaneswar.
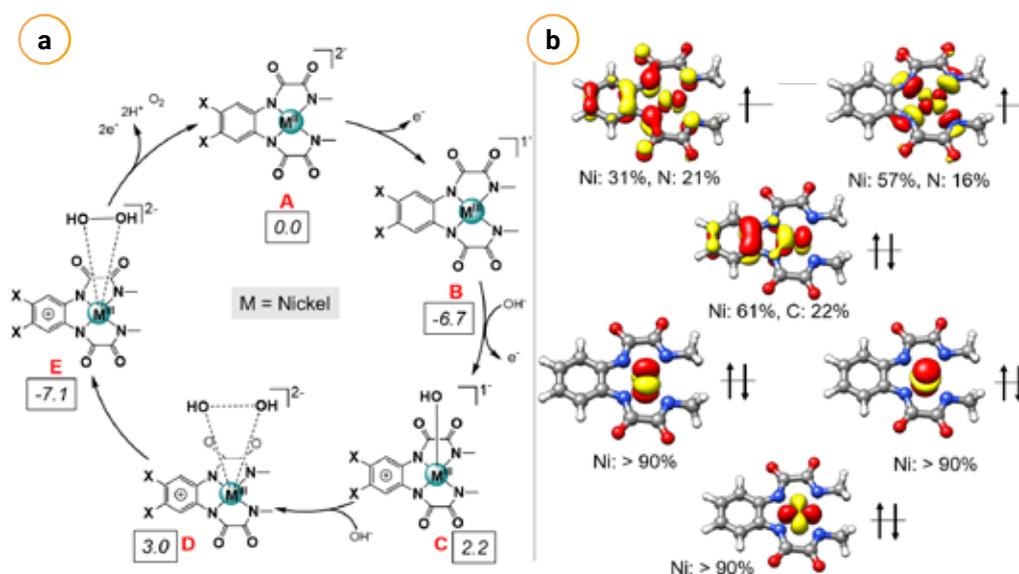
Fig 3.82: (a) Proposed catalytic cycle of water oxidation by nickel oxamidate complex. **(b)** Electronic structure of the one electron oxidized intermediate.
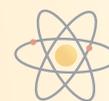
Design and Synthesis of Dendron and Dendrimer Derived Thermally Activated Delayed Fluorescence Emitters for Non-Doped Solution-Processed LEDs

Thermally activated delayed fluorescence (TADF) has gained attention because of its ability to achieve 100% internal quantum efficiency due to the up-conversion of non-radiative triplet excitons to the radiative singlet excitons, hence better replacement for noble metal based expensive phosphorescent emitters. Usually, TADF emitters are designed based on typical amine-based donors and acceptor units with strong electron-deficient groups. These donor and acceptor strategy is very important in sperate the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO). HOMO-LUMO separation is very important for reducing the ΔEST and a low ΔEST value is needed to up-covert dark triplet excitons emissive singlet excitons. Their many drawbacks in using polycyclic aromatic fused rings are 1. A fused polycyclic ring will have a low triplet energy gap, hence the team cannot get deep blue emission; 2. Poorly soluble in biocompatible solvents prevents the biological usage of long lived TADF emitters. The team discovered TADF properties without usual donor and acceptors units. The research group used an acylhydrazone core unit and it is decorated with poly(aryl ether) dendrons. The team observed these emitters show TADF properties with high photoluminescence quantum yield. The research group synthesized G0, G1 and G2 and characterized them using NMR and HR-MS to confirm the structure. The researchers completed all photophysical studies and device fabrication is in under progress.

Herein, for the first time, the team report a new design strategy for a highly efficient blue unconventional TADF dendrimer by attaching the novel poly(aryl) moiety with acyl hydrazone acceptor core. The unconventional core is expected to work as a novel unit with electron-accepting ability without significantly lowering the triplet state while reducing the energy of S1 states, resulting in a smaller singlet and triplet energy gap leads to efficient TADF property. Using this strategy, two dendrimers, G1 and G2, were synthesised, containing the first-/second-generation poly(aryl ether) dendron with acylhydrazone as an acceptor. Photophysical properties confirm that these emitters are having TADF properties. The photoluminescence quantum yield increased from 35% to 59% by increasing the generation of dendrimers (Figure 3.83). In addition, these TADF dendrimers show tunable morphology as well as chirality from achiral molecules (Figure 3.84). Further, we have also synthesized various type of conventional TADF dendrimers for solution processed OLEDs. Using this funding support, the group established the OLED performance measurement unit and related accessories for advanced OLED device fabrication and measurement. Four research articles were published in high impact journals. A few more manuscripts are under preparation. This work was done at the Indian Institute of Science, Bengaluru.
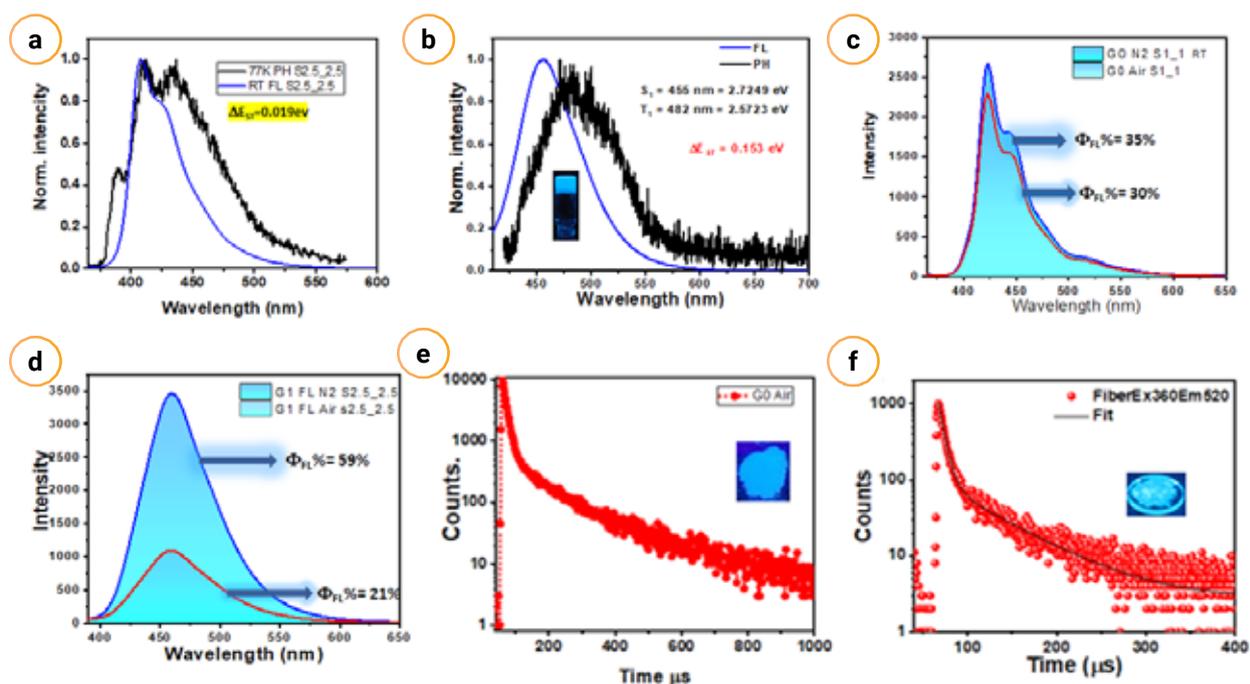
Fig 3.83: Fluorescence spectra and phosphorescence spectra of **(a)** G0, **(b)** G1; Luminescence intensity under air and nitrogen of **(c)** G0 and **(d)** G1; Lifetime decay of **(e)** G0 and **(f)** G1
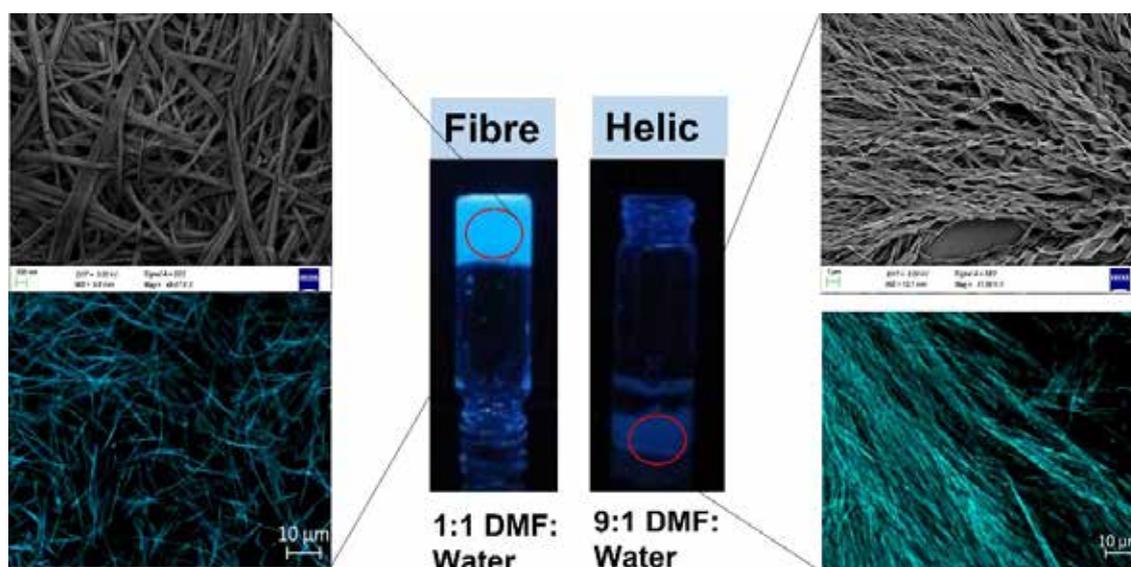
Fig 3.84: SEM and Confocal microscope image of the gel fibre and helical assembly.

3.3.2 SERB Women Excellence Research Grant

SERB Women Excellence award was launched during International Women's Day i.e 8 March 2013 to reward young women scientists who have excelled in science and got recognition from any of the following National Science Academics in India and are below 40 years of age.

- Indian National Science Academy, New Delhi
- Indian Academy of Science, Bengaluru
- National Academy of Science, Allahabad
- Indian National Academy of Engineering, New Delhi
- National Academy of Medical Sciences, New Delhi
- National Academy of Agricultural Sciences, New Delhi

FEATURES

Annual award for young women researchers in recognition of their outstanding achievements

Support consists of a research grant of Rs.5. lakh per annum

Duration is 3 years

Website link: https://serb.gov.in/page/english/awards_fellowship#SERB%20%20 Women%20Excellence%20Research%20Grant
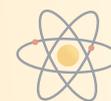
Projects Sanctioned: 3

Expenditure
(New and Ongoing)

0.92 cr

Research Highlight

A multi-pronged approach to understand the functional diversity of HSP40s in the human malaria parasites and explore small-molecule based pharmacological targeting

HSP40 family of proteins have undergone expansion and diversification in the malaria parasite (Figure 4.85). The proteins of this family are differentially localized in various cellular compartments such as cytosol, nucleus, mitochondrion, nucleus, ER and some are even exported into the human RBCs (Figure 4.86). These HSP40s have diverse client/substrate binding domains which allow them to exhibit diverse biological roles.

♦ What is the structural & functional diversity of plasmodial HSP40s?

♦ Do they have distinct substrate-recognition motifs/client repertoire?
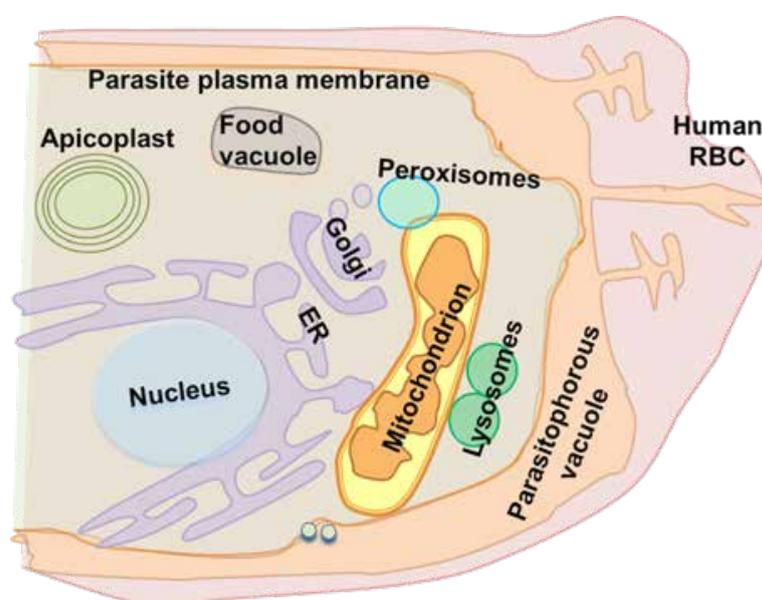
Fig 4.85: Localization of HSP40 protein in different cellular compartments of human RBCs

The peptide binding domain of representative cytosolic (Sis1), apicoplast (PfJ1) and exported (PFA0660w) were purified for biochemical activities (Figure 4.87). The purifications of Sis1 and PFA0660w were reported in previous reports. Challenges were encountered in purification of PfJ1. Firstly, the proteins had 3 degradation bands with a lot of bacterial contaminating proteins and also DnaK (bacterial HSP70) co-purified with it in Ni-NTA purification (Figure 4.88). This work was carried out at Council of Scientific & Industrial Research-Central Drug Research Institute, Lucknow.
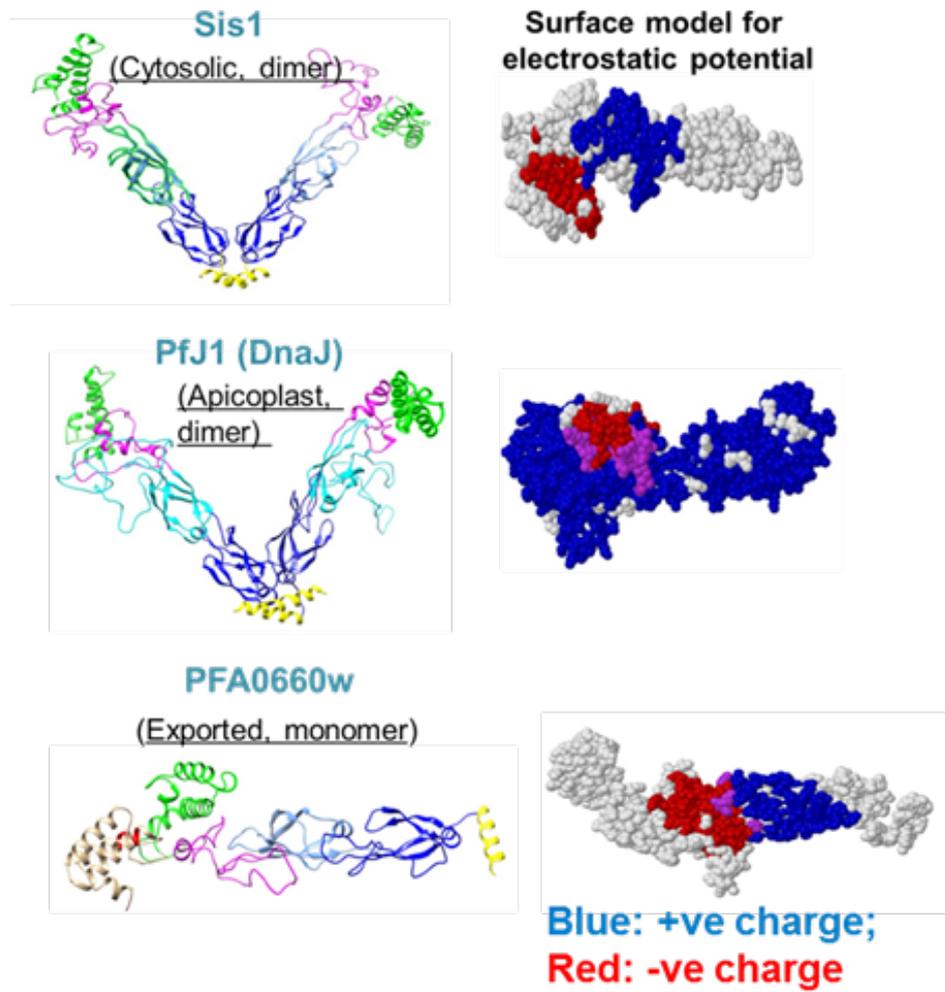
Fig 4.86: Surface electrostatic potential of different HSP40s localized in different compartments in malaria parasite.
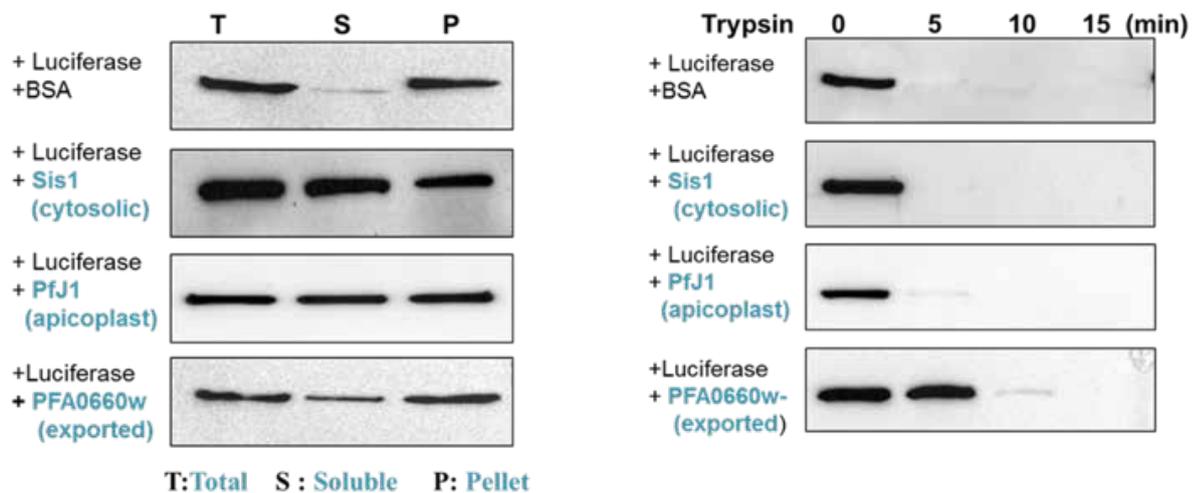
Fig 4.87: Their respective biochemical activities demonstrate the differences in capacity to protect proteins from thermal and misfolding stress.
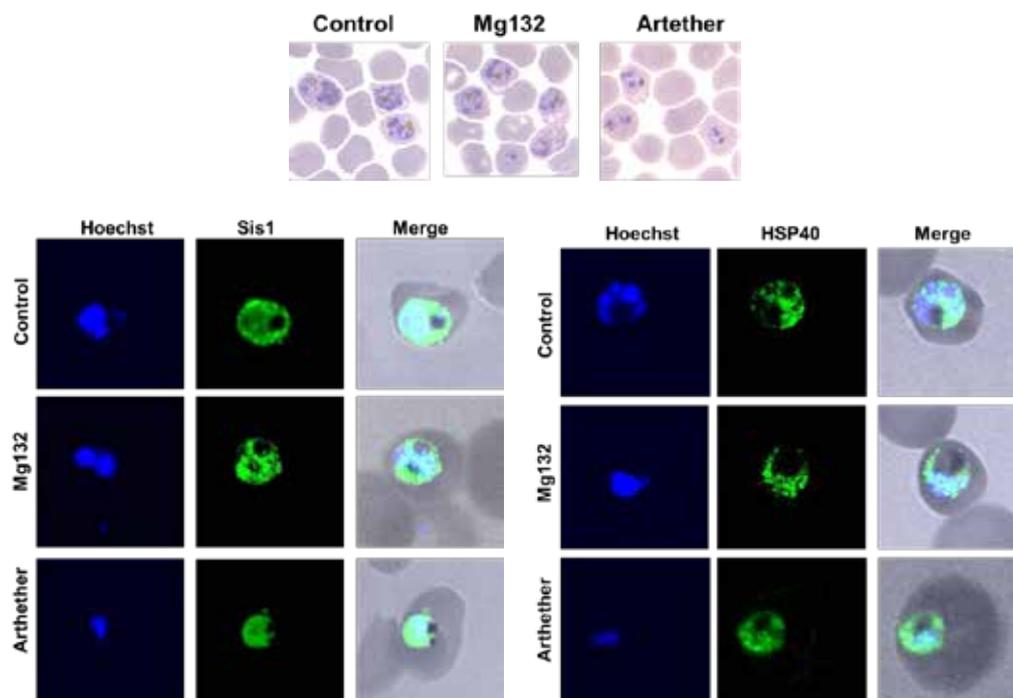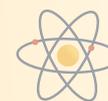
Fig 4.88: Differential localization of plasmodial HSP40s in human red blood cells under different drug-treatments.

3.3.3 Empowerment and Equity Opportunities for Excellence in Science (EMEQ)

The EMEQ scheme was launched with the aim to provide research support to the scientists belonging to the Scheduled Caste and Scheduled Tribe. The basic idea was to encourage them for undertaking research in newly emerging and frontier areas of Science and Engineering and to involve them in the National Science and Technology development process. This scheme has been successfully implemented since its launch in 2013 and so far above 2100 researchers have benefited from this scheme.

FEATURES

Project grant for researchers belonging to Scheduled Caste and Scheduled Tribe in regular position

Support across all disciplines of Science and Engineering

Funding is provided up to a maximum of 50 lakh for a period of three years

Website link: https://serb.gov.in/page/english/research_grants#Empowerment%20and%20Equity%20Opportunities%20for%20Excellence%20in%20Science%20(EMEQ%20)

266

Projects Sanctioned

Expenditure
(New and Ongoing)

67 cr

Research Highlights

Development of Electrochemical Immunosensor for Vitamin D Estimation

Vitamin D deficiency is a critical health condition which affects both the skeletal as well as non-skeletal systems of our body. Therefore, precise, and early detection of vitamin D is paramount to achieving overall well-being. Despite of high prevalence and fatal repercussions of vitamin D deficiency, till now very few reports have been published regarding the development of an electrochemical biosensing strategy for vitamin D estimation. Under this project, a novel electrochemical immunosensing technique for 25-hydroxy vitamin D_3 (25(OH)D_3) has been put forward based on the gold-platinum bimetallic nanoparticles (Au-Pt) deposited on 3-Aminopropyl triethoxy silane (APTES) modified fluorine tin oxide (FTO) electrode surface (Figure 3.89). The present Au-Pt/APTES based immunosensor has not been reported in the literature. The interaction of Au-Pt nanoparticles with the amine groups of APTES has been utilized efficiently so as to obtain robust and uniform anchoring of nanoparticles. Further, the immobilization of the antibody (Ab- 25(OH)D_3) is another critical parameter which is well taken care of via covalent binding of the antibody onto the Au-Pt/APTES/FTO surface by employing glutaraldehyde cross-linking chemistry. Finally, Ab/Glu/Au-Pt/APTES/FTO electrode was utilized for the electrochemical determination of 25(OH)D_3. The biosensor successfully reached up to the clinically significant limit of detection of 0.1 pg/mL 25(OH)D_3 concentration along with a quick response time of 12 min and shows a stable response for 15 days. A comparison with the previously reported sensors for vitamin D estimation, the present sensor is superior in terms of the limit of detection, since the previously reported sensors could only detect the concentration of 25(OH)D_3 in the nano range, thereby, the sensor advances the state of the art. In continuation to this, an attempt was made to further improve the analytical performance of the biosensor in terms of its shelf life, sensitivity and ultimately the limit of detection. This work comprises exploring the strong gold-sulphur interaction via the deposition of a thin conductive film of Au nanoparticles onto the layer of molybdenum sulphide (MoS$_2$) nanoflowers deposited onto the FTO surface. Further, a self-assembled monolayer of cysteamine was introduced onto the Au/MoS$_2$/FTO surface, which covalently binds to the Ab-25(OH)D_3, preventing the leaching out of the antibody while measurement. The Ab/Cys/Au/MoS$_2$/FTO electrode yielded promising results for electrochemical determination of 25(OH)D_3 such as an improved limit of detection of 0.38 pg/mL and satisfactory shelf life of 28 days. Aiming at further elevating the sensing characteristics, an aptasensor for vitamin D estimation based on Au/MSN@ZIF-8 nanohybrid is under progress at Punjab University, Chandigarh.
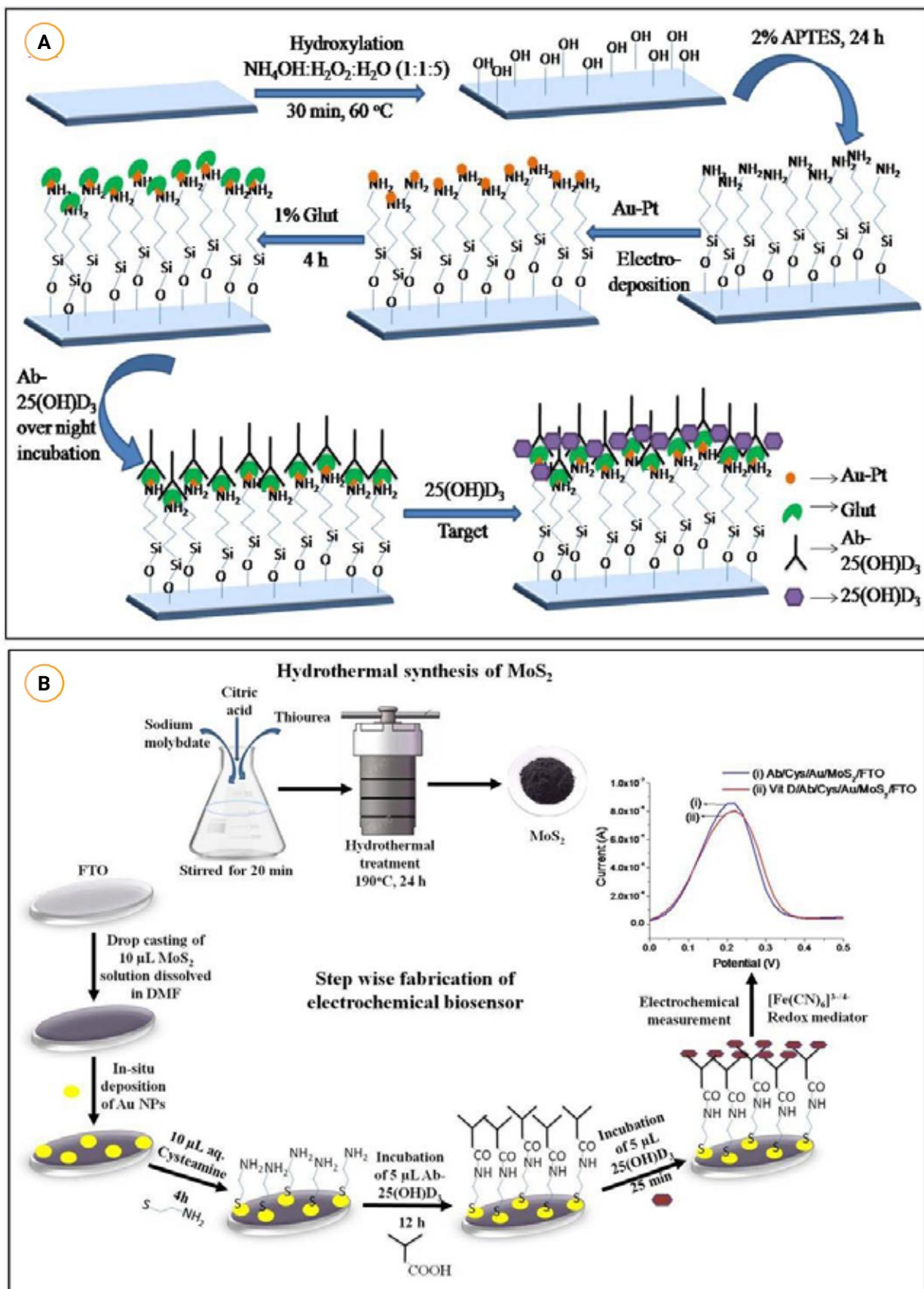
Fig 3.89: Schematic illustration of fabrication of electrochemical immunosensor for 25(OH)D3 determination using: **(A)** AB/Glu/Au-Pt/APTES/FTO and **(B)** Ab/Cys/Au/MoS2/FTO.

Nonlinear Particle Simulation of Radio Frequency Waves in Fusion Plasmas

The main goal of this simulation project is to develop the homegrown large-scale global particle in cell (PIC) simulation code for understanding the microturbulence in toroidal plasmas by coupling the core and scrape-off layer (SOL) regions across the separatrix and create human resources for our national fusion program (NFP). In this project, a few necessary numerical modules for the self-consistent microturbulence simulation for the given discharge of Aditya-U and DIII-D tokamak using GTC-X were developed (Figure 3.90). The field solver for realistic tokamak geometry was developed. Due to the complex nature of the tokamak geometry, a finite element (FEM) solver is better than a finite-difference (FD) one. For pushing the particle in the electromagnetic field, we need to calculate the field quantities from the potential. Usually, PIC codes used the finite difference method to calculate the field quantities from the potential. However, for a realistic geometry with an X point and SOL region, this process will provide ambiguity. The same FEM solver cannot be used to calculate the field from the potential because it will give the fields' discontinuity across the nodes and edges.
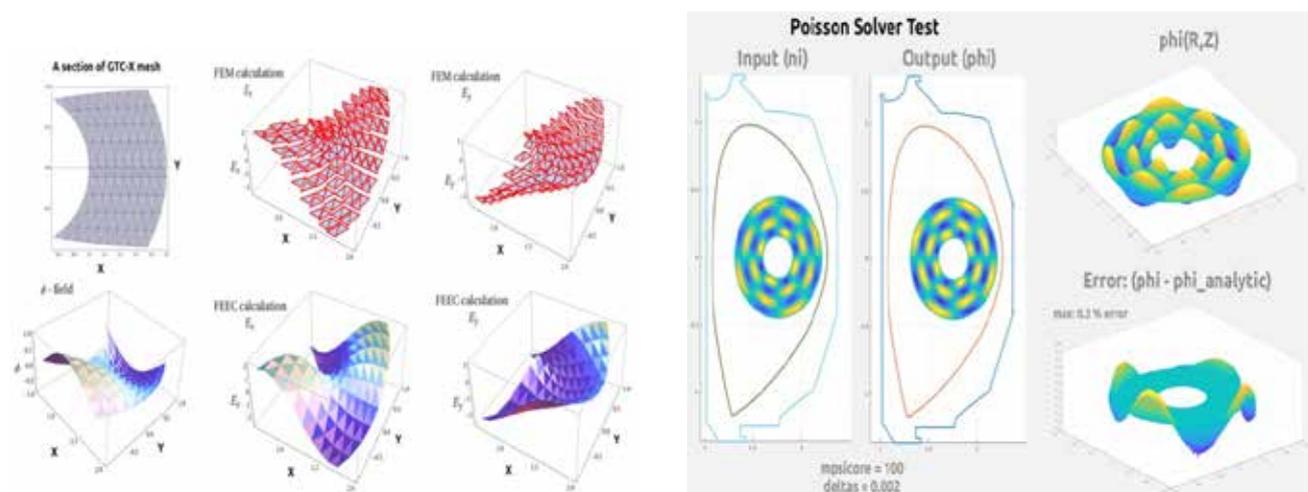
Fig 3.90: A. Verification of Poisson solver by solving the Poisson equation for $\nabla^2 \phi = \delta n$ analytically and numerically. 2D contour for source term and 2D contour of a numerical solution ϕ to Poisson's equation. Percentage error between analytical calculation and numerical solution. B. Calculation of electric field components using standard finite element method (upper panels) and weak form of the electric field equation (lower panels).

Hence, a weak form for the electric field equation was used to avoid this, which gives the continuous field across nodes and edges.

For most time scales of interest, charge particles in plasmas move over long distances along magnetic field lines. Also, they typically move much more rapidly along magnetic field lines than perpendicular to them; this causes the properties of a magnetized plasma to be very anisotropic relative to the magnetic field direction. In order to develop compact descriptions of magnetized plasmas it is most convenient to use coordinate systems based on the global structure of the magnetic field. In a tokamak plasma, ions have drift motions due to the gradient-B and curvature drift. As a result, ion orbits are shifted from a magnetic surface. Due to this shift of the ion orbit from the magnetic surface, the hot ions that exist close to the separatrix can pass near the X-point region. In this region, the poloidal magnetic field is very weak and the ions have a very small poloidal displacement in time. These ions experience vertical curvature, and grad-B drifts and moves toward the diverter, resulting in ion orbit loss.

To benchmark the capability of our GTC-X code, the group have carried out self-consistent gyrokinetic simulations of zonal flows in the core region of the Aditya-U and DIII-D tokamak. The collisionless damping of the zonal electric field to a nonzero steady-state value verifies the famous theory of Rosenbluth and Hinton on the collisionless damping of zonal flows. The rest of the necessary modules for the 3D version of the GTC-X code to benchmark self-consistent simulation of microturbulence and RF waves in DIII-D and Aditya-U tokamak are under development at the Indian Institute of Science, Bengaluru.

4

AWARDS AND FELLOWSHIPS

As a part of its vital activities, SERB offers several awards and fellowships to recognise and reward outstanding researchers who have performed exceedingly well in Science and Engineering and have proven track records. SERB provides recognition to brilliant young researchers, active superannuated scientists, and exemplary women scientists by providing them with awards and fellowships. The goal is to motivate scientists for excellence in scientific R&D.

Various awards and fellowships are aimed to generate an R&D ecosystem where quality research is recognized, supported, and empowered. These awards and fellowships cover a broad spectrum of basic, translational, and applied research initiatives across all the areas of Science and Engineering. The National Science Chair scheme enables active eminent superannuated scientists to continue their research after retirement.

Through SERB-STAR (Science and Technology Award for Research) and the Swarnajayanti fellowship, SERB aims to inspire young dynamic researchers and to uplift their impactful research to the forefront.

Prestigious fellowships like the J C Bose fellowship and Abdul Kalam Technology Innovations National (AKTIN) fellowship are awarded to Scientists and Engineers for their proven track records. In addition, the SERB Technology Translation Award (TETRA) is to support researchers who have generated Intellectual property (IP) in terms of patents/copyright etc. from SERB supported projects and wish to translate their IP.

Focusing on capacity building and aiming to retain young scientific talent in the country, SERB offers a National post-doctoral fellowship (NPDF) to such young researchers and provides funding support to them for pursuing research. Similarly, SERB also facilitates reverse brain drain by attracting trained minds from abroad through Ramanujan fellowship and helping them in starting careers in national labs and Indian institutions.

The need to bridge the gap between the premier institutes and private or state universities is recognized in schemes such as the Teachers Association for Research Excellence (TARE). While recognizing the importance of steering youth to take on the challenges of industrial research, SERB offers the Prime Minister's fellowship programme for doctoral research.

SERB is at the forefront of recognizing women scientists of extraordinary potential who have contributed immensely to transforming the scientific landscape. The SERB POWER fellowship honour eminent women scientists for their incredible contributions across disciplines in Science and Engineering.

In line with SERB's approach of being synergetic and inclusive, relevant organizations are partnered for specific awards, to ensure sharing of domain expertise and coordinate efforts. Notable partner agencies include the Indian National Academy of Engineering (INAE), Federation of Indian Chambers of Commerce and Industry (FICCI) and Confederation of Indian Industry (CII).
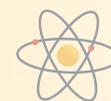
4.1 Recognition for Senior Scientists

4.1.1 National Science Chair (NSC)

SERB functioning NSC since the year 2019 by merging the erstwhile two schemes, "Distinguished Fellowship (DF)" and "Year of Science Chair Professorship (YoSCP)". The main aim of the scheme is to recognize the active eminent senior resident Indian superannuated scientists for their outstanding contributions both nationally and internationally, in the area of Science, Technology, Engineering, Mathematics (STEM) and Medicine, to promote excellence and growth in R&D. Six National Chairs were sanctioned during the reporting time.

NSC is implemented in two modes. Under Mode 1: Scientific Excellence, the support is extended to senior eminent scientists who after superannuation continue to be active in research but do not possess a formal supporting arrangement. Mode 2 recognizes outstanding superannuated scientists to establish a benchmark for stature, value, and eminence in national and international Science and Technology communities as a R&D leader.

Awardees of the National Science Chair in the reporting period under Mode 1 are:

Mode 1:

1. **Prof. Ajay Kumar Sood**
   Indian Institute of Science, Bangalore

2. **Prof. Raman Sukumar**
   Indian Institute of Science, Bangalore

3. **Prof. Ganesh Pandey**
   Banaras Hindu University, Varanasi

4. **Prof. Rakesh Bhatnagar**
   Jawaharlal Nehru University, Delhi

5. **Prof. Ganapati D. Yadav**
   Institute of Chemical Technology, Mumbai

6. **Prof. Deepak Pental**
   University of Delhi, South Campus, Delhi

The search cum selection committee did not recommend any applicants for the mode-2 category.

FEATURES

Fellowship of Rs 1.5 lakh per month under both modes

The Research Grant in the case of Mode-1 and Mode-2 is Rs 25 lakh per annum and Rs 5 lakh per annum respectively

The period is for 3 years, extendable to a maximum of another two years

Website link:https://serb.gov.in/page/english/awards_fellowship#National%20Science%20Chair

Research Highlights

Some challenging problems in non-linear dynamics

- **Nonlinear dynamics of spin transfer nano oscillators (STNOs)**

The research group has shown a systematic methodology to obtain high-frequency oscillations with frequencies about 72 GHz in a spin torque nano oscillator (STNO) by applying an in-plane field for a short duration of time (<1ns) corresponding to the low energy initial magnetization state through solving Landau−Lifshitz−Gilbert−Slonczewski (LLGS) equation. Also, the group achieved oscillations with frequencies above 300 GHz in a Co|RuFe|Co STNO with the bilinear and biquadratic couplings (Figure 4.1).
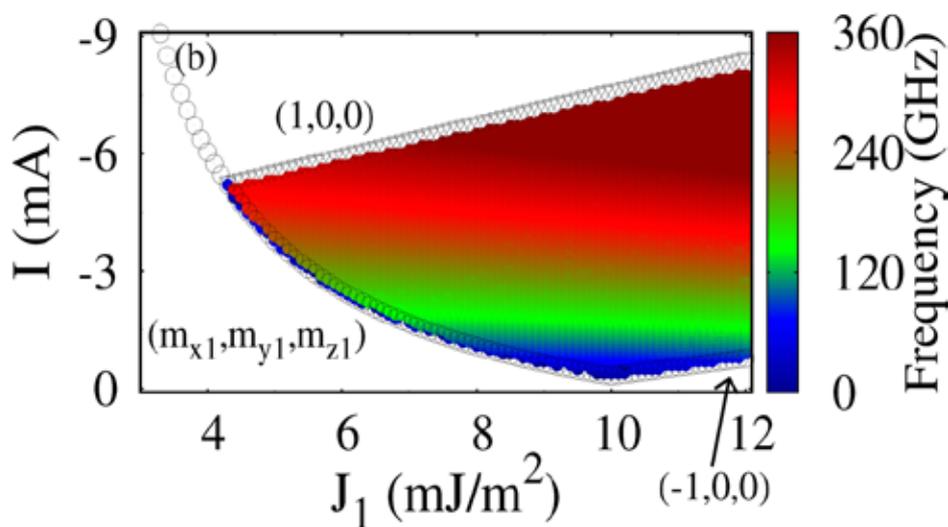
Fig 4.1: Frequency variation due to the current and bilinear coupling

- **Modelling for Covid-19**

The group studied the evolution of the second wave of Covid-19 in India by analysing the susceptible-exposed-infectious-removed (SEIR) dynamic model. It was found that the individual responses which may include personal hygiene, healthy habits, avoiding crowded places, wearing masks, washing hands frequently, etc. are equally or perhaps even more important than the government actions such as a lockdown. Also, by analysing the susceptible-exposed-infectious-removed-vaccinated (SEIRV) model the fellow's group proves the requirement of the vaccine, the infection rate may get higher, and people will get infected even if vaccinated. Booster vaccination campaigns may be effective in protecting people from infection.

• Nonlinear optics

The team demonstrated a new kind of Modulational Instability induced by third order dispersion with spatial dispersion accounting for Wannier exciton mass in a ZnCdSe/ZnSe semiconductor superlattice. Launching the light from the rear end of the device dramatically reduces the critical intensity to a value of 0.015 (approximately) which must be the lowest switching intensity ever reported in the context of nonlinear PT-symmetric gratings. The spatiotemporal soliton propagates without any change, except perhaps some phase shift after a collision with another spatiotemporal soliton in competing cubic and quintic nonlinear metamaterials. The fellow's group proposed system records the lowest switching intensities recorded in the perspective of PT-symmetric fibre Bragg gratings in the broken regime. The group achieved the stabilization of both vortex solitons and light bullets in negative index material channels with non-Kerr nonlinearity in contrast to the Kerr systems where the higher dimensional localized modes are always unstable. The team established ultra-lower optical bistable states in PT-symmetric Bragg structures with four-wave mixing and some inhomogeneous nonlinearities (Figure 4.2).
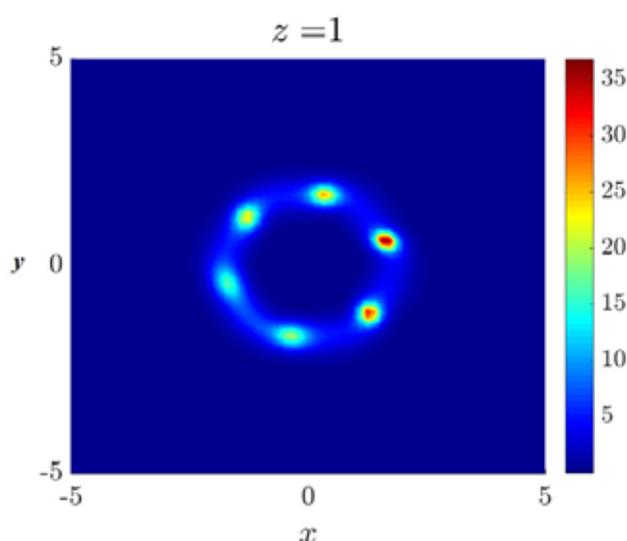
Fig 4.2: Filamentation of vortex beam with m=3 in metamaterials in the presence of cubic nonlinearity

• Soliton dynamics

In the long-wave–short-wave resonance interaction it was found that the shape-changing behaviour of the nondegenerate vector solitons was observed in the long-wave mode also, along with corresponding changes in the short-wave modes, and this nonlinear phenomenon has not been observed in the already known vector solitons. The corresponding multisoliton structure was identified (Figure 4.3).
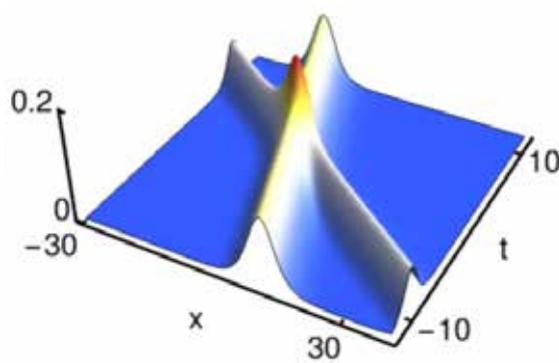
Fig 4.3: Nondegenerate one soliton with unequal velocities

- **Collective dynamical states in coupled nonlinear oscillators**

In a network of nonidentical and globally coupled Stuart-Landau (SL) oscillators, the team found that the observed dynamical states do not preserve the parity (P) symmetry in the absence of perturbation and the chimaera state is robust even in networks of larger sizes. In a globally coupled system of SL oscillators, the team discovered that the pulse discrete coupling decreases the aging region more effectively than the symmetric or asymmetric discrete coupling. Again, in the same globally coupled SL oscillators, it was found that the additional feedback results in the onset of symmetry breaking clusters and out-of-phase clusters. Also, the existence of explosive amplitude death along with disparate multistable states has been identified. The group succeeded to design and implement Dual Input Multiple Output logic gates by applying different coupling in uni-directionally and bi-directionally coupled double-well Duffing oscillators under an enhanced vibrational resonance condition.

- **Solvability of non-linear fractional Partial Differential Equations**

The group developed a generalization of the invariant subspace method for (m+1)-dimensional non-linear time-fractional PDEs. The method has been extended to coupled fractional equations and has been applied to reaction-diffusion nonlinear partial differential equations.

- **Quantum Solvability**

The group observed that a nonlinear system of the quadratic Liénard type, on quantization admits bounded solutions, similar to the well-known Mathews-Lakshmanan oscillator equation. Specifically, it was found that the coupling parameter of the system gets quantized. The work was done at Bharathidasan University, Tiruchirappalli.

Evolution of social behaviour and the balance between cooperation and conflict in insects and other animal societies

The research group investigated the social biology of the Indian paper wasp *Ropalidia marginata.* A striking feature of such insect societies is that only one or a small number of individuals reproduce while the rest remain sterile and work for the welfare of the colony. The study aimed to understand how the wasp society is efficiently organised so as to deal with the problems of gathering food, rearing brood and protecting itself from predators and parasites while at the same time managing to deal with internal strife and amicably balance cooperation and conflict.

The group succeeded in altering some of the factors that govern the social life of wasps and making them behave differently. This was achieved by rearing the wasp colonies in large walk-in cages (Figure 4.4) where, unlike in the previous small cages, the wasps had opportunities to play out their full potential for cooperation and conflict.

By providing the wasp with excess food the team succeeded in making them more selfish. Thus, this study showed that, when provided with excess nutrition, the normally non-reproductive wasps become less cooperative and altruistic, and either overthrow their queens to take their position or leave the nest to start their own new nests.

The fascinating of the study is that the wasp can be made more selfish at the human will of research. This work was done at the Indian Institute of Science, Bengaluru.

Fig 4.4: A student making observations while seated inside a large walk-in cage in which the wasps are reared.
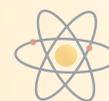
4.1.2 J C Bose Fellowship

This fellowship is awarded to active Indian scientists and engineers to recognize their outstanding performance and significant contribution towards scientific research. This scheme was started in the year 2006 to recognize eminent scientists and engineers in all areas of science and engineering. The fellowship is scientist-specific and very selective.

FEATURES

Support consists of (i) fellowship of Rs. 25,000 per month, (ii) research grant of Rs. 15 lakh per annum and (iii) Overheads of Rs.1 lakh per annum

The duration of the fellowship is initially for five years which may be extended for a subsequent term of five years based on rigorous assessment

A fellow can avail the fellowship till the age of 68 years

Website link: https://serb.gov.in/page/english/awards_fellowship#J%20C%20Bose%20National%20Fellowship

25
Fellowships Sanctioned

Expenditure
(New and Ongoing)

23.56 cr

Research Highlights

Novel and indigenous IZ4 spreading codes for the NavIC L1 SPS signal

Navigation with Indian Constellation (NavIC) is an indigenous navigation satellite system for India and surrounding regions, developed by ISRO, that aids in terrestrial, aerial and marine navigation, vehicle tracking and fleet management as well as disaster management. A new standard positioning service (SPS), the civilian signal is being introduced in the L1 frequency band, partly with a view towards providing increased availability of NavIC signals, to mobile phone users. This called for the design of a family of spreading codes with desirable properties such as balance, even and odd auto and cross-correlation properties. A challenging aspect of the design was the requirement, arising from the presence of an on-board atomic clock having a frequency of 10.23 MHz, that the designed signals have period 10230, while most existing signal designs have a period that is of the form p or $(p^n -1)$ for p prime, or else, $2(2^n-1)$. To overcome this hurdle, the designers of the Global Positioning System (GPS) and the Beidou Satellite System (BDS) started with a family of Weil sequences having a period that is a prime p close to the desired period, $p = 10223$ and $p = 10243$ respectively, and then employing either padding or truncation, to achieve the desired period of 10230. However, either truncation of padding results in a degradation of correlation properties.

A J C Bose fellow at the Indian Institute of Science, Bengaluru along with scientists of ISRO collaboratively came up with a design that enabled achieving the desired period of 10230, without the need for either truncation or padding.

This was achieved by interleaving a set of five Z_4-linear sequences, each of the period 2046. Here, Z_4 denotes the set of integers modulo 4 and a Z_4-linear sequence family is a nonlinear family of binary sequences that is interesting, the projection of a sequence family that is linear in the Z_4 domain. The incorporation of additional innovative features into the design such as interleaving based on the Chinese Remainder Theorem, intelligent selection and sign-flipping of the five constituent sequences, as well as extensive further computer-based optimization, led to the Interleaved Z_4-Linear (IZ4) spreading code family. IZ4 codes have even-correlation properties that improve significantly upon those of either GPS or Beidou signal sets. An added plus is that IZ4 sequences are simply generated using two 55-bit coupled shift registers along with some simple additional circuitry.

Following careful evaluation by an independent ISRO team, the decision was made by ISRO to incorporate the IZ4 design into the L1 signal of NavIC. The IZ4 code is a novel and indigenous joint IISc-ISRO signal design for the NavIC L1 signal that has improved even-correlation properties and is easy to implement (Figure 4.5) the novel and indigenous design of the IZ4 spreading code family was incorporated by ISRO into the L1 signal of India's NavIC navigation satellite system that is expected to be in use for many years. A joint IISc-ISRO Indian patent on the IZ4 design was granted.
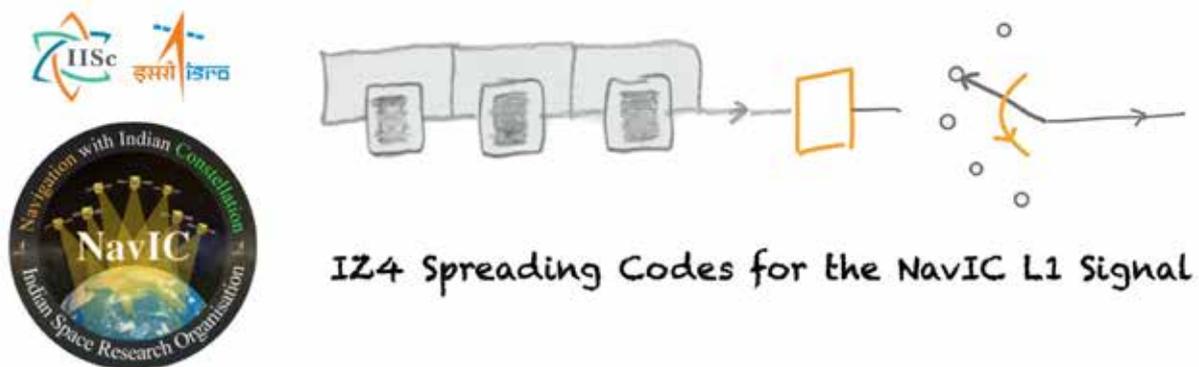
Fig 4.5: IZ4 spreading codes for the NavIC L1 signal
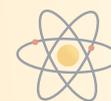
Portable, handheld and affordable blood perfusion imager for screening of sub-surface cancer in resource-limited settings

A research group led by a J C Bose fellow at the Indian Institute of Technology, Kharagpur innovated a new highly accurate, portable, yet user-friendly, affordable, and non-invasive device for detecting oral cancer in resource-limited clinical settings. This novel platform technology includes a portable handheld unit that combines various sensors and controllers and feeds the measured data to a computer simulation engine to classify normal, pre-cancer and cancer cases in the oral cavity, without needing referral to specialized medical centers for resource-intensive diagnostic procedures.

Cancer of the oral cavity remains to be one of the major causes of morbidity and mortality in socially-challenged and underserved communities, which reveals on-an-average 80 percent chance of a five-year survival rate if diagnosed early, whereas the survival rate drops to 65 percent or less in more advanced stages.

The group developed an elusively simple yet automated touch-free approach (Figure 4.6 A, B& C) to estimate blood flow variations in different regions of the potentially diseased tissue, specifically relating to the diseased condition. This has proven to be technologically superior as compared to thermal imaging-based screening technologies currently in use since the temperature in the tissue itself varies with the surrounding conditions, and also due to combined variabilities in the local blood flow and metabolism and is accordingly not always a specific indicator of the diseased state under investigation.
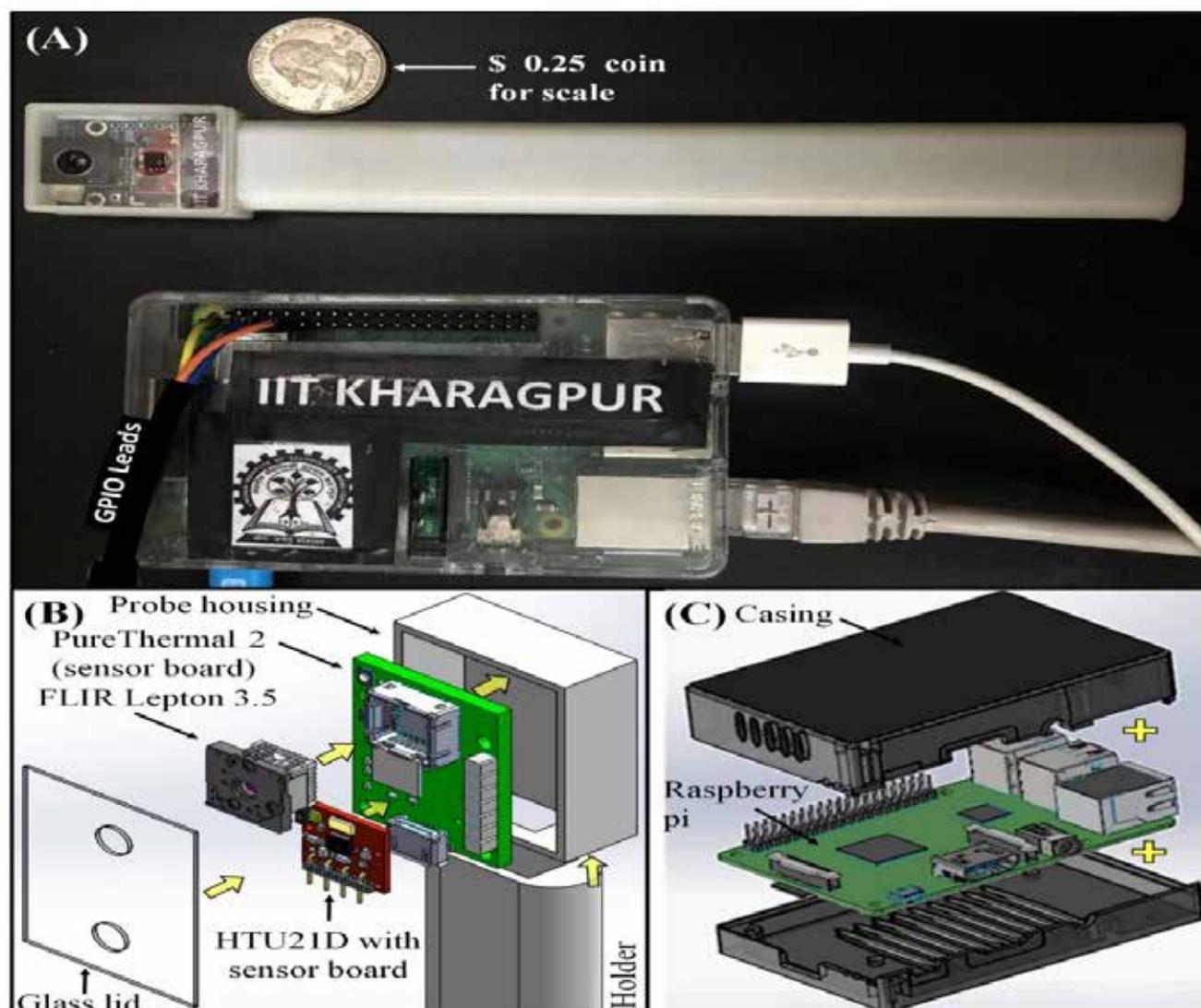
Fig 4.6: A) Photograph of the portable blood perfusion imaging device, **B)** Explored internal view of the device, **C)** Explored view of the electronic processor.

The new technology offers an invaluable possibility of detecting potential vulnerable cases early enough, during a first examination by a clinician in a community health centre, saving millions of lives in the process.

As an inexpensive co-option to the standard and established clinical practices, this value-added tool is thus likely to strengthen the confidence of doctors in preliminary decision-making.

4.1.3 Abdul Kalam Technology Innovation National (AKTIN) Fellowship

Launched by SERB in 2017, Abdul Kalam Technology Innovation National Fellowship recognize, encourage and support translational research by Indian Engineers. Indian National Academy of Engineering (INAE), in association with SERB, coordinates and awards Abdul Kalam Technology Innovation National Fellowships to outstanding engineers in the fields of engineering, innovation and technology development across all fields of studies.

FEATURES

To promote high calibre research in Engineering domain

The fellowship amount is Rs. 25,000 per month, in addition to regular income. Research grant is Rs.15.00 lakh per annum and an Overheads of Rs.1 lakh per annum

Duration of fellowship is three years which may be extended by up to two years depending on performance

Website link: https://serb.gov.in/page/english/awards_fellowship#Abdul%20Kalam%20TIN%20Fellowship

Research Highlights

Adsorption based fluoride removal technology from ground water by Aluminum substituted hydroxyapatite (Al-HAp) incorporated wood charcoal

The presence of excess fluoride (F^-) in groundwater from geogenic sources is one of the major environmental issues of drinking water contamination across the Globe. Around 200 million people in numerous locations in Asia, Europe and Africa are suffering from drinking water with an excess amount of fluoride. Excess fluoride can cause dental and skeletal fluorosis and also cause neurological disorders in severe cases. In India, fluoride concentration in groundwater is found as high as 35 mg/l, whereas, the guideline value of F^- in drinking water as suggested by the World Health Organization (WHO) is 1.5 mg/l. A wide range of methods were utilized to remove fluoride from drinking water, including adsorption, chemical

Expenditure
(Ongoing)

8.00 cr
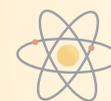
precipitation, membrane separation, ion exchange etc. Among these adsorption is the most utilized method using activated alumina, bone char, carbons, metal oxides etc., as adsorbents. These adsorbents may not be appropriate for commercial applications due to their low efficiency, difficulty to run in a packed column, and sometimes religious issues (e.g., bone char).

Under the ambit of Abdul Kalam Technology Innovation National Fellowship, the Fellow and his group at the Indian Institute of Technology, Kharagpur developed an innovative technology for fluoride removal. In this technology, Aluminum substituted hydroxyapatite (Al-HAp) incorporated wood charcoal was synthesized by a very simple chemical route at room temperature. Al-HAp was synthesized by soaking the aqueous solution of Al^{3+}, Ca^{2+} and $PO4^{3-}$ ions into the porous wood charcoal matrix followed by precipitation of Al-substituted HAp by alkali treatment. The material was washed and dried in an oven to get the final adsorbent. The adsorbent shows an excellent fluoride removal capacity of 105 mg/g. The adsorbent was packed in a column to develop the scalability of this application. Two filters of capacity 500 l/day are installed in two schools in the Bankura district (Figure 4.7). Two domestic filters with a maximum filtration capacity of 100 l/day have been deployed in the Bankura district of West Bengal. The Fluoride removal technology is transferred to M/s, Mondal Precision Pvt. Ltd., Howrah. They deployed 12 Nos of such community scale water filters (capacity: 10000 L/day) in the Purulia and Bankura districts of West Bengal. The water filters are running successfully with good results for the last six months without regeneration.

Fig 4.7: Installation at Laladhar Primary School, Bankura, West Bengal

Large scale validation and field trials of an indigenous non-invasive non-contact robust portable hand-held device for accurate measurement of Bilirubin level, haemoglobin concentration and oxygen saturation in a neonatal subject

The Fellow at SN Bose National Centre for Basic Sciences, Kolkata, who was conferred with Abdul Kalam Technology Innovation National fellowship in the year 2018 has developed a non-contact, non-invasive device for estimation of haemoglobin, bilirubin and oxygen saturation level from the nail bed (hospital trial grade prototype). This was a prospective observational study conducted over 25 months starting from January 2017 at the Department of Paediatric Medicine, Nil Ratan Sircar Medical College and Hospitals (NRSMH, a Govt. aided tertiary hospital), Kolkata, India. The device is tested on 4,318 neonates at the neonatal intensive care unit (NICU), NRS Medical College & Hospital, Kolkata (Figure 4.8). The subjects included neonates suffering from anaemia, hyperbilirubinemia, hypoxia, and congenital heart disease. Before the clinical trial, all necessary ethical clearances were taken from the competent authority. The device provided accurate bilirubin levels as analyzed using various statistical methods including simple linear regression analysis, and the Bland & Altman method of comparison. The validation of the developed non-invasive device in the measurement of haemoglobin, bilirubin and oxygen saturation simultaneously in neonates is underway.

system that is expected to be in use for many years. A joint IISc-ISRO Indian patent on the IZ4 design was granted.

In addition to the filing of two international patents, the team has installed the products to Govt. Hospitals and common people are getting benefits out of the development.

Fig 4.8: Technology Demonstration and Transfer (Ongoing activities)

4.2 Fostering Young Scientists

4.2.1 SERB Science and Technology Award for Research (SERB-STAR)

SERB Science and Technology Award for Research (SERB-STAR) is a prestigious award instituted by SERB to recognize and reward the outstanding performance of Principal Investigators (PIs) of SERB Projects. SERB-STAR is an initiative to acknowledge exemplary contributions to research and to motivate the PIs of ongoing projects for outstanding performance. The fourth Call for Nominations under SERB-STAR was made during June-August in the year 2022. A total of 49 nominations were received. In the first step, all the project completion reports were evaluated and 22 were recommended.

FEATURES

To reward excellence in SERB projects.

Fellowship of Rs. 15,000 per month, research grant of Rs. 10 lakh per annum and Rs.1 lakh per annum as Overheads charges for a period of three years.

Up to 30 awards per year and not more than 90 at any time

Website links https://serb.gov.in/page/english/awards_fellowship#SERB%20Science%20 and%20Technology%20Award%20for%20Research%20(SERB-STAR)
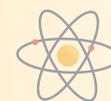
Research Highlights

Unveiling mechanism of AIE phenomenon by designing two-dimensional crystals at confined air-water interface towards efficient electroluminescence devices

Two-dimensional molecular crystals (2D crystals) represent an important class of materials for advanced electronic and photonic applications. In 2D crystals, conventionally the molecules are arranged periodically by interactions like hydrogen bonds, $\pi-\pi$, C-H·····π, and van der Waals interactions. Conventional organic 2D crystals are non-emissive or faintly emissive owing to the aggregation-caused quenching effect. The control of the molecular packing within 2D crystals is of utmost importance to realize intense emission. The team introduced a promising strategy to fabricate 2D crystals of AIE active complexes at the flat-water surface having small roughness.

Molecular thick stable 2D crystals with micron length are fabricated in a controllable way to obtain room temperature intense emission (Figure 4.9 (a-c)). The rational design leads to a small energy gap between singlet-triplet levels and the mixing of the singlet-triplet states by strong spin-orbit coupling for brilliant emission Figure 4.9(d). These findings emphasize the importance of the controlled organization of organic emitters to explore optimal luminescence properties for efficient lighting applications (Figure 4.9(e)). This work was done at the Indian Association for the Cultivation of Science, Kolkata.
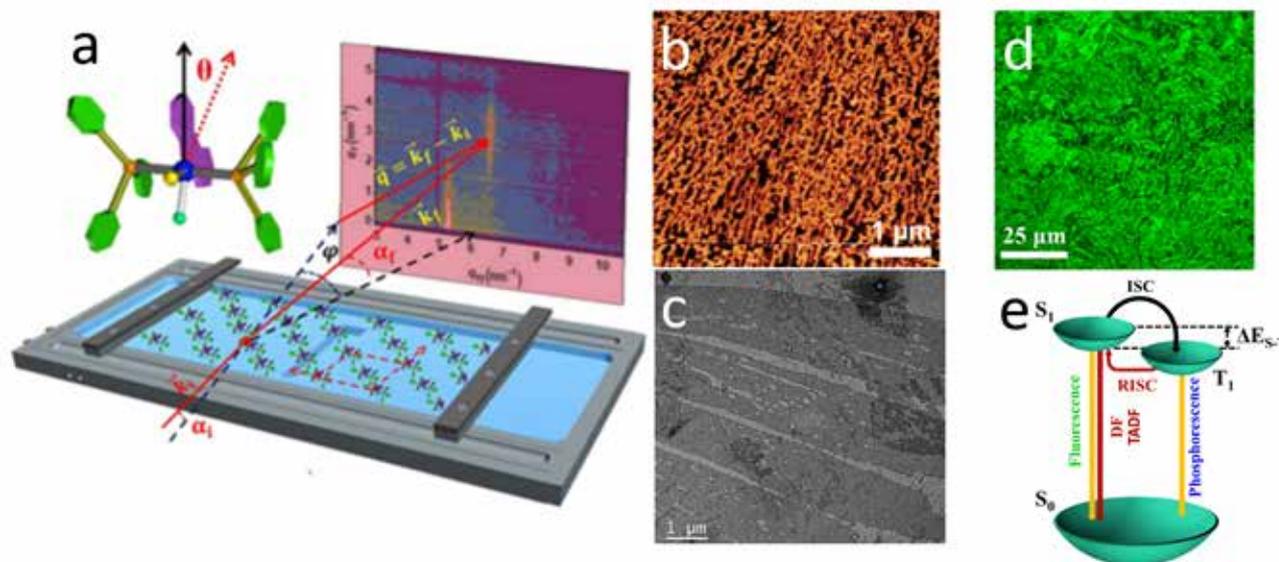
Fig 4.9: (a) Experimental set-up for the fabrication of 2D molecular crystals. **(b)** AFM image of 2D molecular crystals. **(c)** TEM image of 2D molecular crystals. **(d)** Confocal microscopic image of 2D molecular crystals showing intense green emission. **(e)** Luminescence pathways of 2D molecular crystals.

Elucidating vitamin B12-driven diet-gene interactions that regulate food choice and longevity

An organism encounters a wide variety of diet options in its natural habitat. The macro and micronutrient components of the diet direct complex physiological processes in the organism that determine its life history traits, including life span. Organisms use an array of adaptive mechanisms in response to diverse nutritional inputs in order to maintain an optimal life history. The group is beginning to comprehend how an organism's life span is regulated by an intricate interaction between genes and nutritional inputs. Since an organism can survive on a variety of diets and yet function normally, these interactions are challenging to study in the laboratory. But occasionally, a mutant lab animal with a single gene mutation may only show altered physiological features when fed a specific diet and not when fed another. These serendipitously identified "gene-diet pairs" then become instrumental in understanding how the quality of diet influences physiological traits like longevity and health.

The research group was interested in understanding the mechanism of a diet-gene pairing that the team identified earlier. In the nematode C. elegans, the flr-4 gene mutant was found to exhibit a diet-responsive increase in life and health span. The mutant lives longer on one bacterial diet but not on the other. The team identified Vitamin B12 as the micronutrient whose quantity is different between the two bacterial strains. Importantly, the bacteria with higher Vitamin B12 content can drive life span extension in the mutant worm. The team showed that the increased Vitamin B12 content in the bacteria, coupled with the increased sensitivity of the mutant to this micronutrient, engages downstream metabolic processes (the One-carbon cycle or One-C) and signaling pathways (the p38 MAPK cascade) to activate cytoprotective programs (CyTP) required for extending life span. Following up on this study, the team found that the One-C is required in the neurons while the p38 MAPK functions in the intestine
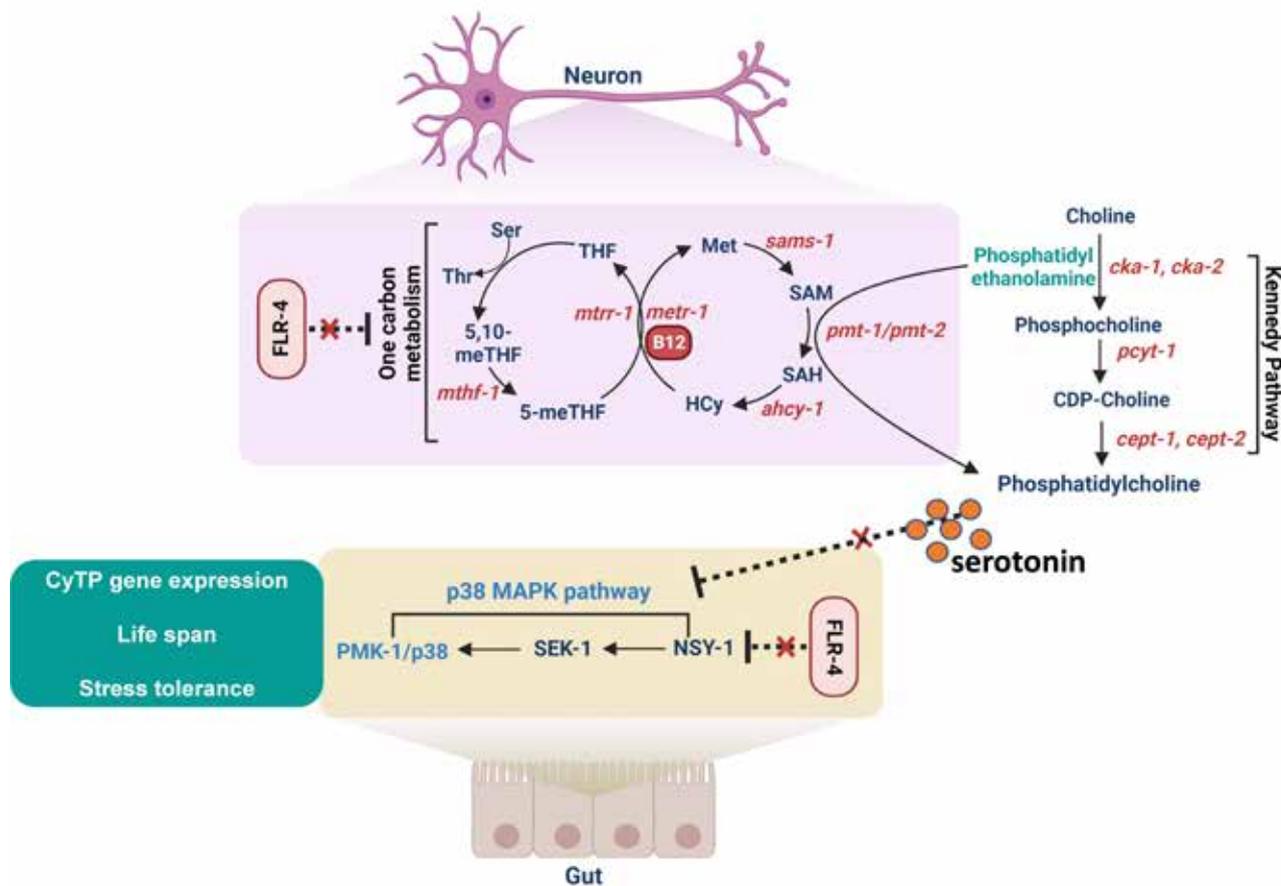
Fig 4.10: A model depicting the possible mechanism by which *C. elegans* FLR-4 maintains adaptive capacity to bacterial diet differing in B12 content. On high B12 diet, flux through the neuronal one-carbon metabolism in the *flr-4* mutant increases to potentially lower PC levels; this leads to activation of the p38-MAPK pathway in the gut/intestine. However, FLR-4 prevents aberrant activation of the p38-MAPK pathway leading to normal life span in wild-type worms. In the *flr-4(-),* the lower PC levels activate the p38-MAPK, increase CyTP gene expression, enhance osmotic tolerance and increase life span. The signal from neurons is transmitted to the intestine through serotonergic neurotransmission.
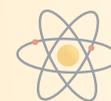
to regulate CyTP gene expression, stress tolerance and life span. Further, the neuronal One-C communicates to the intestinal p38 MAPK cascade through serotonergic neurotransmission in order to regulate gene expression and longevity (Figure 4.10).

It may be emphasized that humans are fully reliant on food and their gut-dwelling bacteria (microbiota) for the supply of vitamin B12. For the nematodes, the bacteria serve both as the food source and the microbiota that provides micronutrients like vitamin B12. Therefore, molecular genetic characterization of such gene-diet interactions that are micronutrient-responsive offers a comprehensive understanding of how a variety of dietary and nutritional inputs, each with a unique micronutrient content, affect organismal health. More importantly, the inter-tissue crosstalk that maintains gene regulatory homeostasis to ensure optimal life history traits on a diet with different micronutrient content is not well understood. This study opens a unique window of understanding to this complex problem. The work was carried out at the National Institute of Immunology, New Delhi.

4.2.2 Swarnajayanti Fellowship

Initiated in the year 1997-98 to commemorate the 50th year of India's independence, the Swarnajayanti Fellowship scheme entails fellowships and research grants to young scientists in contemporary areas of science and technology. Presently, DST is executing the scheme, and SERB will be providing additional funding to meet the required expenditure pertaining to the research objectives enumerated in the proposal submitted by the selected applicants.

FEATURES

Prestigious fellowship awarded annually by DST for notable and outstanding research by young scientists

The award consists of a Fellowship of Rs 25000 per month in addition to the salary drawn from the parent Institute for a period of five years

The fellows selected along with projects will be considered for funding by SERB

Website link: https://dst.gov.in/scientific-programmes/scientific-engineering-research/ human-resource-development-and-nurturing-young-talent-swarnajayanti-fellowships- scheme

1 Fellowship Sanctioned

Expenditure (New and Ongoing)

4.67 cr

Research Highlights

Understanding the role of dynamin-related proteins (DRPs) in mitochondrial remodelling and inter-organelle communication in the human malaria parasite

Studies done in eukaryotes with multiple mitochondria suggest that the Dynamin-related protein (DRPs) family coordinates fission-fusion events for organellar membrane remodelling. However, the molecular events downstream of DRP-mediated remodelling of organellar membranes remain elusive. The role of DRPs becomes even more intriguing in human pathogens which harbor a single mitochondrion such as *Plasmodium* spp. The mitochondrion in this intracellular parasite undergoes stage-specific dramatic morphological remodelling and DRPs influence mitochondrial contacts with other cellular organellar such as apicoplast, ER and lysosomes. In a project supported under Swarnajayanti Fellowship, the group at Central Drug Research Institute (CDRI), Lucknow found that plasmodial DRPs (*Pf*-DYN1, 2 and 3) have significant evolutionary divergence from orthologs in both human and closely related parasitic species (Figure 4.11). The work aims to study the role of a diverged family of dynamin-related proteins in organellar remodelling and inter-organellar communication. The biochemical assays and resources developed may help to identify parasite-specific inhibitors and will be useful for the exploration of probable modes of action of potential lead molecules.
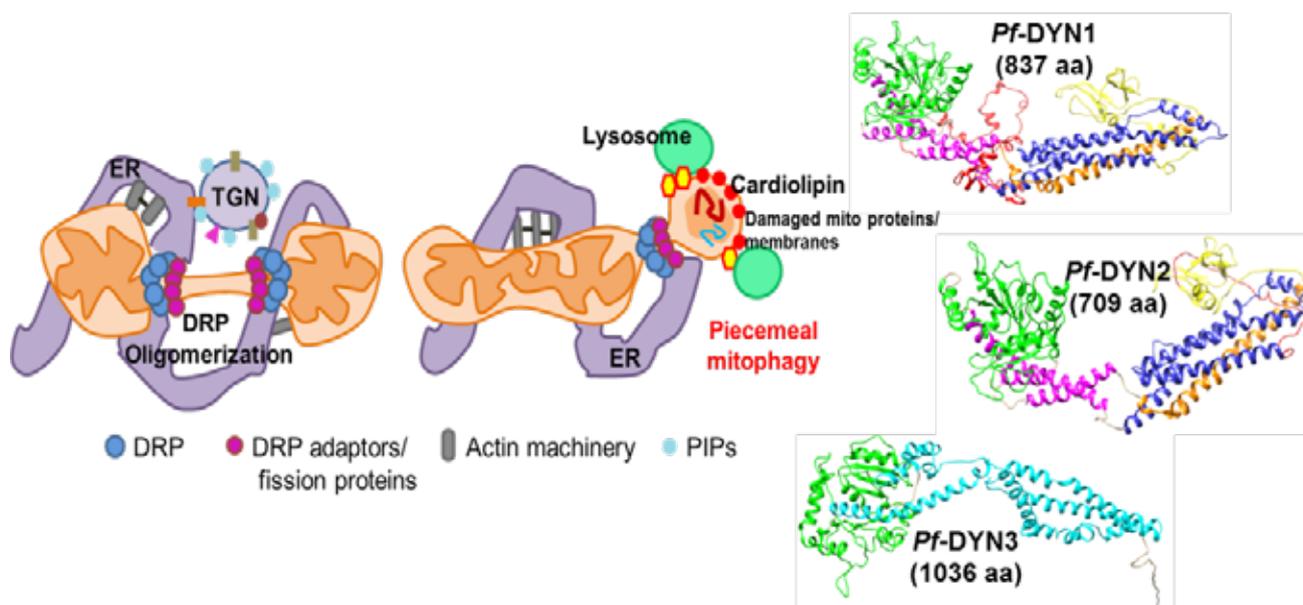
Fig 4.11: Schematic representation of probable participation of DRPs in inter-organelle contacts and homology models of P. *falciparum* Dynamin proteins (*Pf*-DYN1-3).
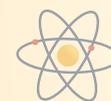
High-throughput determination of the neural basis of olfactory preference

The group at the Indian Institute of Technology, Kanpur addresses the question of "How our brains determine our behaviour" using experiments on the brains of simple organisms such as flies.

Neuroscientists often use various model organisms, such as mice, fish and worms, to perform detailed experiments: these smaller brains are less complex than the human brain and thus provide a stepping stone to building a detailed understanding, and it is possible to do invasive experiments on them, which would be impossible or unethical to do in humans. Because the fundamental principles of brain processing have been conserved during the course of evolution, one can learn about these principles using model organisms. The group aim to use a technique called optogenetics to activate neurons in the fly brain, while the fly walks over a custom-built treadmill-like setup (Figure 4.12). Using this approach, one can activate specific neurons and simultaneously see their effect on the behaviour of the fly. This experimental setup help to generate a large number of activation patterns and use them to identify the logic that governs the translation of the neural activity in the insect brain into behavioural preference. The studies also plan to extend these experiments to mosquitoes. If successful, these experiments will provide, for the first time, a large-scale and direct mapping between brain activity and behaviour in mosquitoes. The comparisons of the results between flies and mosquitoes will help in finding out the general principles of sensory coding across species.
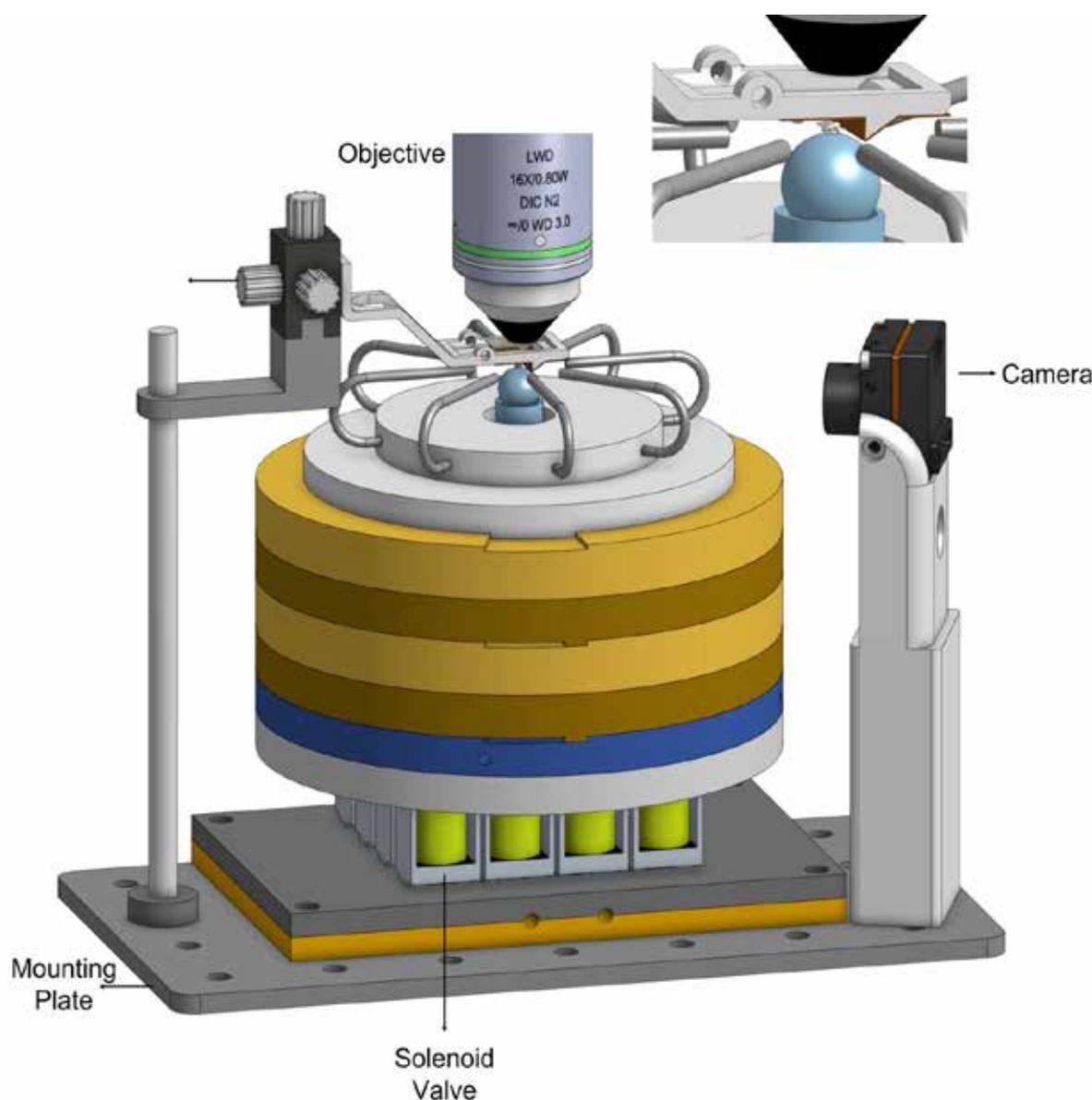
Fig 4.12: Experimental system for measuring behavior and brain activity simultaneously.

4.2.3 Ramanujan Fellowship

Ramanujan Fellowship is meant for brilliant Indian scientists and engineers working abroad who aspire to take up scientific research positions in India.

FEATURES

The Fellowship amount is Rs. 1,35,000 per month (consolidated including HRA)

Each Fellow will receive a research grant of Rs. 7 lakh per annum and Rs. 60,000 per annum as Overheads charges

The duration of the fellowship is for five years, and not extendable

Website link: https://serb.gov.in/page/english/awards_fellowship#Ramanujan%20 Fellowship

19 Fellowships Sanctioned

Expenditure (New and Ongoing)

17.47 cr

Research Highlights

A computational systems biology approach to understand the dynamics of cancer metastasis.

Despite advancements in cancer therapies over the past few decades, metastasis and therapy resistance remain two clinically unsolved challenges, that drive tumor relapse and claim over 90% of cancer-related deaths. A hallmark of cancer metastasis and drug resistance is phenotypic plasticity – the ability of cells to reversibly switch their phenotypes in response to their varying environments. Understanding the dynamics of how cancer cells switch their phenotypes (cell-states) and how can this switching be controlled for a better therapeutic outcome has been the focus of this research.

Epithelial Mesenchymal Plasticity (EMP) is a well-studied example of phenotypic plasticity implicated in metastasis and drug resistance. It involves reversible transitions among the epithelial (E; high cell-cell adhesion, low migration), mesenchymal (M; low cell-cell adhesion, high migration) and hybrid epithelial/mesenchymal (E/M; intermediate cell-cell adhesion, high migration) states. Recent preclinical and clinical evidence has suggested that hybrid E/M phenotypes have maximum plasticity and are the "fittest" for cancer metastasis. What features enable such salient behaviour of hybrid E/M cells remains elusive.

It was demonstrated that the higher plasticity of hybrid E/M phenotypes is a direct consequence of the underlying topology of the EMP regulatory networks. These networks are comprised of two "teams" of molecular players such that players within a "team" effectively activate one another, but players across teams effectively inhibit each other. While the two "teams" stabilized E and M phenotypes respectively, no such "team" existed for hybrid E/M states (Figure 4.13(A&B)). Such topology reinforced E and M phenotypes, but the lack of "teams" that stabilize hybrid E/M states increased their propensity to switch to E or M, consequently increasing their plasticity. The lower the overall team strength in a network, the easier it is for cancer cells to switch among diverse phenotypes (Figure 4.13(C)), and thus the higher the metastatic "fitness". The group proposed overall team strength as a systems-level biomarker to assess metastatic potential. The work was carried out at the Indian Institute of Science, Bengaluru.
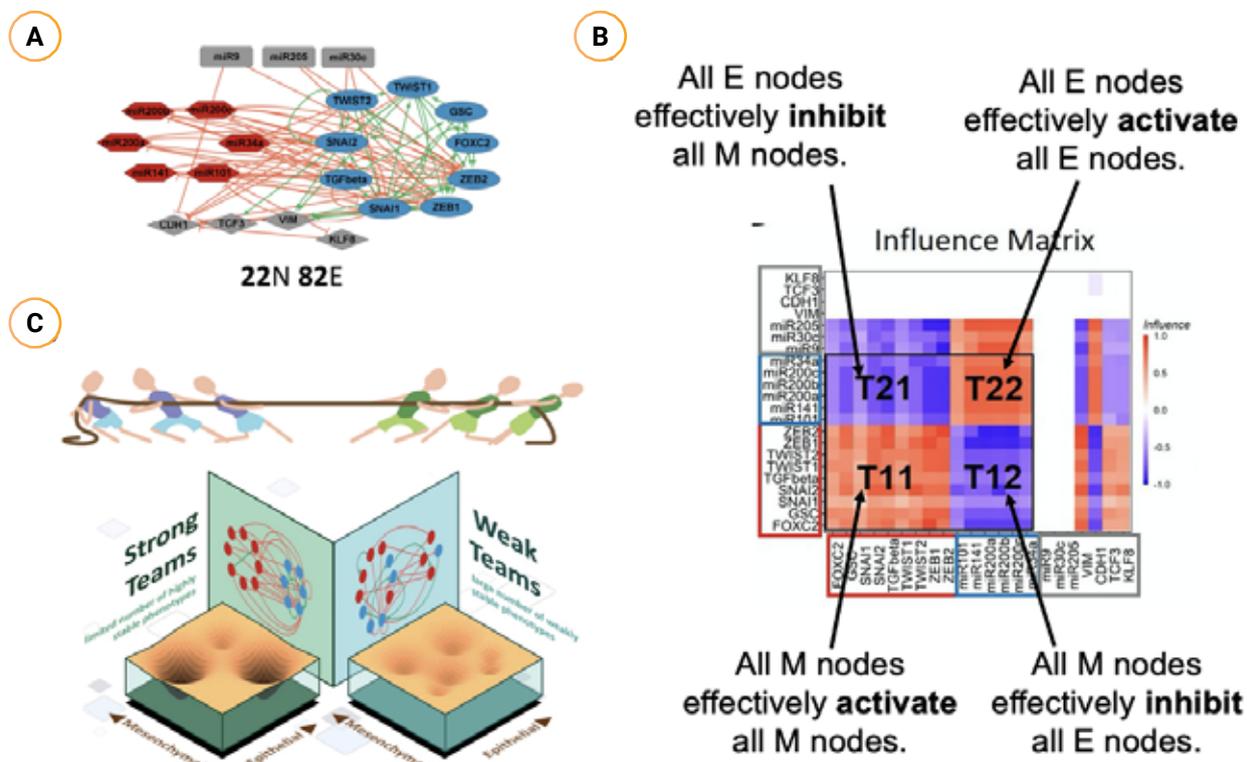
Fig 4.13: Design principles of networks driving epithelial-mesenchymal plasticity (EMP). **A)** A representative regulatory network for EMP; blue colored nodes drive a mesenchymal (M) state; red colored nodes drive an epithelial (E) phenotype. **B)** Influence matrix for the network shown in A) showcasing the presence of mutually antagonistic "teams" stabilizing E and M states; no such "team" exists for hybrid E/M state. **C)** (Top) Schematic showing the presence of "teams". (Bottom) Schematic showing how team strength controls the stability (or plasticity) of phenotypes.

Decoding the mechanism of specific RNA targeting by ribosomal methyltransferases

Proteins are one of the macromolecules in any living cell and they are produced by a complex machinery called ribosomes. The ribosomes are made up of both ribonucleic acids (RNA) and proteins and consist of more than 50 polypeptide chains and multiple rRNAs. The active site of the ribosomes is made up of RNA and the bases in the RNA can undergo natural modifications such as methylation during their biogenesis. These modifications are essential in the proper folding of the rRNAs and in the function of ribosomes. In prokaryotes, resistance to antibiotics is often mediated by the methylation

of particular nucleotides using specific enzymes called methyltransferases. The methyltransferases share a similar structure and are required for both the biogenesis of ribosomes and also in gaining antimicrobial resistance. Despite their similarity, methyltransferases are extremely specific and one of the intriguing questions is to understand how this specificity is achieved.

Using cryoEM, the fellow's group determined multiple structures of methyltransferase KsgA bound to the 30S prokaryotic ribosome (Figure 4.14). This is a highly dynamic complex i.e., it can adapt different structures/conformations and using an image processing algorithm the fellow's group was able to computationally separate different populations. In a particular class, the enzyme KsgA occupies the space between rRNA helices h44 and h45, which allows for rearrangements and the bases for modification to be presented to the active site of the enzyme. The team generated ribosomal variants with mutated versions in helices 24, 27, 44 and 45 of the 16s rRNA and the efficiency of methylation was evaluated biochemically. This analysis along with the structures allows to postulate how KsgA is able to selectively methylate only two bases in the rRNA and the importance of the RNA structure and its position. Specific structural features in the enzyme interact with the rRNA to act as an anchor and position the enzyme to attain specificity.

Thus, the cryoEM structures along with the biochemical analysis expand the understanding of the possible mechanism of methyltransferase KsgA, targeting and recognition of specific bases in the rRNA. The observed structures and the possible mechanism of the methylation of target bases can potentially be used in the design of small molecules in inhibiting individual methyltransferases. This work was carried out at National Centre for Biological Sciences, Bengaluru.
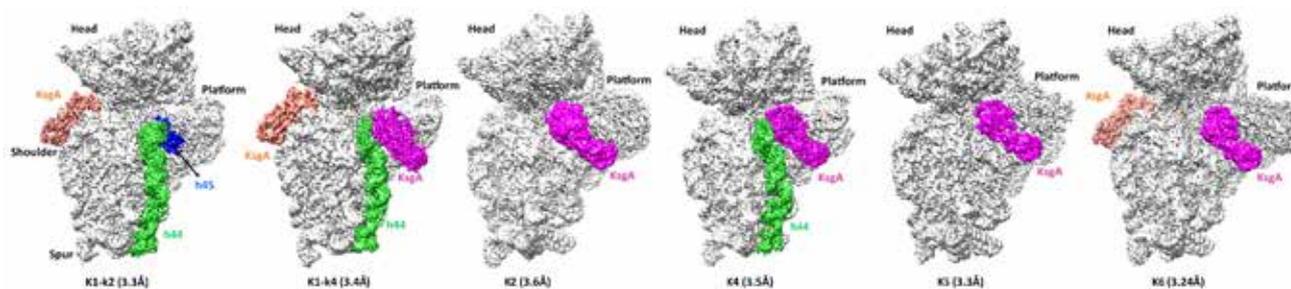
Fig 4.14: Structures of KsgA-30S complex determined by cryoEM. The maps of six different populations of KsgA-30S complex after three-dimensional classification are shown with key regions colored and labelled. Class K1-K2 has KsgA density in a non-cognate position near helix 16 and also very weak density at the platform region. This might reflect a state, where the enzyme is performing an initial scanning event on the 30S platform. In class K1-K4 KsgA, the enzyme is found bound both at the platform as well as near h16 and the remodeled helix 44 suggesting a potential mode of KsgA binding to the cognate site. In two classes (K2 and K5), KsgA is observed at cognate position, while class K4 is similar to K1-K4 class but only one KsgA at cognate position is observed. Class K6 resembles K2 and K5 classes but with two KsgA molecules bound both at cognate and non-cognate sites.

4.2.4 SERB Research Scientist (SRS) Scheme

The INSPIRE Faculty Scheme of DST and Ramanujan Fellowship Scheme of SERB offer opportunities for young scientists in various fields of Science and Engineering. These schemes do not offer an extension of the fellowship after the completion of five years. The support link is broken after the end of the tenure of the respective fellowships. To provide a platform for sustainment of their research for some more time, SERB initiated a scheme called SERB Research Scientists (SRS) Scheme in 2018-19 for the awardees of INSPIRE Faculty scheme and Ramanujan Fellowship, who fail to secure regular positions after completion of the regular tenure of five years in the respective schemes. The scheme provides an opportunity for them to continue their research activities and explore regular positions during the intervening period.
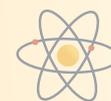
FEATURES

Fellowship scheme to sustain research careers of INSPIRE Faculty and Ramanujan Fellow for two more years

Fellowship of Rs. 1,25,000 per month (consolidated including HRA), a research grant of Rs.7 lakh per annum and Rs.1 lakh per annum as Overheads charges

The duration of the fellowship is two years

Website link: https://serb.gov.in/page/english/awards_fellowship#SERB%20Research%20Scientists%20Scheme

18
Fellowships Sanctioned

Expenditure (New and Ongoing)
5.48 cr

Research Highlight

Porphyrazine-sensitized solar cells: Rational molecular design, photoinduced processes, panchromatic sensitization and devices

The project aims to create novel solar energy and sensory materials while also investigating their photophysical properties for future applications. As a first step, it has been provided with a method for converting vehicle exhaust waste soot into water-soluble fluorescent carbon dots. This study demonstrates the transformation of the air pollutant soot into value-added fluorescent nanomaterials for sensing applications. The synthetic optimization of carbon dots and their application in sensing picric acid from latent fingerprints using a smartphone-based RGB tool was demonstrated through this project. Furthermore, using a standard hydrothermal method, the Fellow's group meticulously tuned the carcinogenic Congo red dye to environmentally benign fluorescent carbon dots. It was also demonstrated that CDs produced from Congo red dye could be a valuable asset in the fields of bioimaging and biosensing research. Using steady-state and time-resolved fluorescence methods, a thorough

investigation into the mechanism of fluorescence quenching of $CsPbBr_3$ QDs with porphyrazine was executed. This work provides a research hint for designing and improving light harvesting assemblies for solar-energy harvesting devices. The design and development of innovative chromophoric materials for luminescent solar concentrators (LSCs) is an emerging area of research in the pursuit of low-cost photovoltaic technology. The optically active fluorescent probe $NBDNH_2$ based on the skeleton of a benzoxadiazole was devised and developed.

The NBDNH2 based LSC ($5 \times 5 \times 0.3$ cm^3) showed internal and external photon efficiencies as high as 29.4% and 3.84%, respectively. When connected with the photovoltaic cell, the champion device yielded power conversion efficiency of 1.32% and 0.64% with scattering and black background, respectively. Overall, notable novel materials were developed and successfully exploited for a wide range of applications (Figure 4.15) through this project which was carried out at Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai.
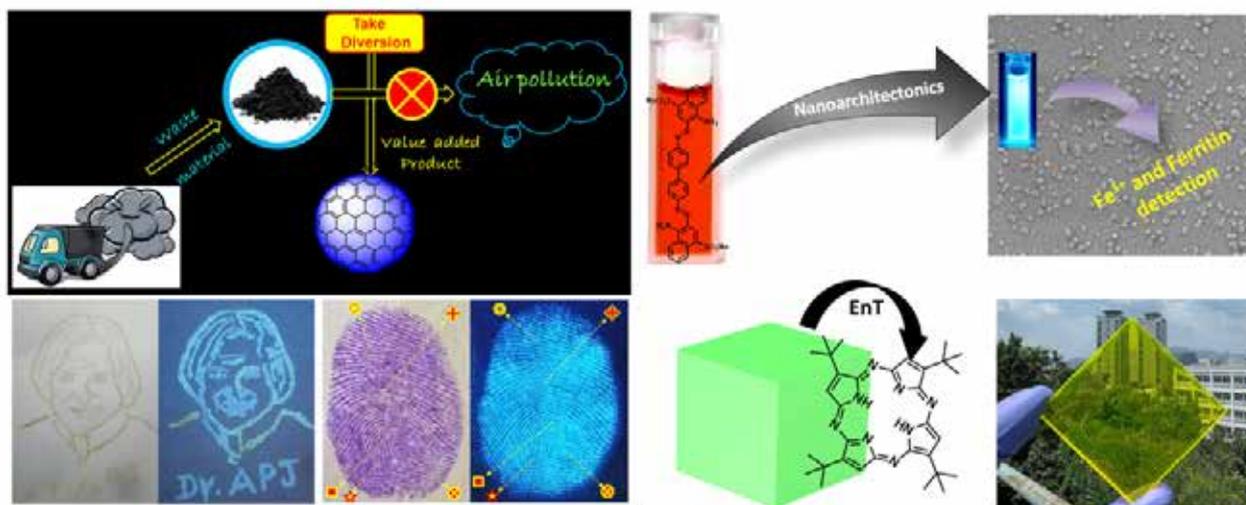
Fig 4.15: Wide range of applications executed through this project.

4.2.5 Teachers Associateship for Research Excellence (TARE)

This scheme facilitates the mobility of faculty members working in a regular capacity in State Universities / Colleges and in private Academic Institutions to get experience and carry out research work in established publicly funded institutions such as IITs, IISc, IISERs, National Institutions (NITs, CSIR, ICAR, ICMR labs and other central institutions) and Central Universities, located preferably nearer to the institution where the faculty member is working. Research work is planned in a manner such that the PI continues to work in the host institute as well as in the parent institute on mutually agreed terms between the PI and the mentor.
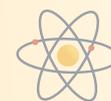
FEATURES

Support to young faculty working in State Universities, college, and private academic institutions to carry out research in established institution

Fellowship of Rs. 60,000 per year, Research grant of Rs. 5 lakhs per annum (50% each to host and parent institution) and overheads

Duration is for 3 years

Website link: https://serb.gov.in/page/english/awards_fellowship#Teachers%20 Associateship%20for%20Research%20Excellence%20(TARE)

102
Associateships Sanctioned

Expenditure
(New and Ongoing)

10.74 cr

Research Highlights

Elucidation of molecular basis of drug and multidrug tuberculosis resistance of mycobacterium tuberculosis in Kashmir valley

The clinical isolates of M. tuberculosis from the State Training cum Demonstration Centre & Intermediate Reference Lab (STDC-IRL), Chest Disease Hospital, Srinagar UT of Jammu & Kashmir India were isolated. The procured samples after screening and isolation were tested for susceptibility/resistance to various clinical anti-TB drugs. Out of the samples isolated and screened the 17 samples bearing Lab Nos 201, 208, 307, 322, 368, 403, 482, 500, 506, 2208, 2300, 2325, 2418, 2500, 2568, 2600 and 2687 were found to be resistant for both first-line anti-TB drugs like Isoniazid and Rifampicin. The 17 samples discussed above were processed and these processed samples have been sent for DNA sequencing purposes to the company to complete the fourth objective of the study. The results will be analyzed and will be sent for molecular characterization as per the established protocols.
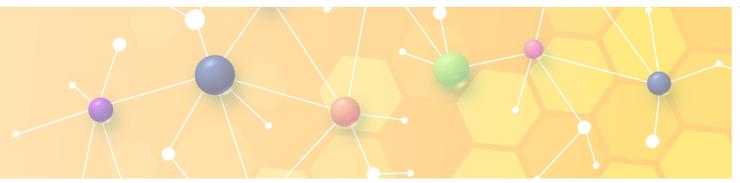
Out of the samples isolated and screened the 17 samples bearing Lab Nos 201, 208, 307, 322, 368, 403, 482, 500, 506, 2208, 2300, 2325, 2418, 2500, 2568, 2600 and 2687 were found to be resistant for both first-line anti-TB drugs like Isoniazid and Rifampicin.

In silico approach to find a Novel Prognostic Biomarker with the Potential of High Diagnostic Accuracy in Pulmonary Tuberculosis. A total of 210 differentially expressed genes (DEGs) were identified, out of which 59 were upregulated, while 151 were downregulated. Gene ontology results revealed that the deregulated genes were enriched in immune response regulation, cytokine pathways, and response to the bacterium. Also, the Kyoto Encyclopedia of Genes and Genomes (KEGG) pathway analysis revealed that deregulated genes are involved in the fork head box transcription factors (FOXO) signaling pathway, oxidative phosphorylation, and osteoclast differentiation pathways. Based on the combined score and degree of connectedness, novel genes like amyloid-beta precursor protein (APP), Transmembrane Immune Signaling Adaptor (TYROBP), Annexin A2 (ANXA2), Proteasome 20S Subunit Beta 2 (PSMB2), CD58 Molecule (CD58) (upregulated genes), and Thyroid Hormone Receptor Interactor 12 (TRIP12), RNA Polymerase III Subunit A (POLR3A), Nuclear Factor of Activated T Cells 5 (NFAT5), DEADBox Helicase 17 (DDX17), DNA Topoisomerase III (TOP3A) (downregulated genes) were identified as hub genes of which TRIP12 and POLR3A are cytokines (type1) biomarkers. Further analysis through ROC divulged TRIP12 as a potential diagnostic biomarker. Overall findings revealed that TRIP12 is a novel cytokine biomarker in *Mycobacterium tuberculosis*-infected patients with the highest diagnostic accuracy SAMPLE FORMAT. Principle Component Analysis (PCA) and heat map of differentially expressed genes in TB. PCA for DEGs indicates a total variance of 80.6% (PC1) and 4.9% (PC2) between TB at 0 months vs TB at 2 months (Figure 4.16(A)) while 82.9% (PC1) and 3.3% (PC2) between TB at 0 months vs TB at 12 months (Figure 4.16(B)). Heat-map for DEGs were also constructed which imparts a data matrix through different colour patterns that disclose an outline of numerical variations Figure 4.16(C & D). The blue to orange gradation represents the gene expression values change from small to large. ClustVis tool was used to draw a heat map.Protein-Protein interaction (PPI) of differentially expressed genes. PPI for all DEGs (Figure 4.17(A)) shows a total of 526 edges and 2708 nodes, and a separate PPI network for DEGs having a combined score >0.9 shows total 121 nodes and 178 edges (Figure 4.17(B)). Red Circle and Red Diamond represent up-regulated genes, while Blue Circle and Blue Diamond represent down-regulated genes. Lines are the correlation between genes. The thickness of lines (edges) is proportional to the combined score. Cytoscape v 3.2.1 was used to construct the network. Few DEGs were forming separate networks from main networks and were extracted separately (Figure 4.17 (C-F)) Sample Format (Figure 4.18) Proposed mechanism of TRIP12 action. TRIP12 belongs to E3 ubiqitine ligase family. SMURF1 is also a family member of E3 ubiqitine ligase family and has been found to be directly involved in MTB degradation. TRIP12 contains a HECT domain which is E3 ubiquitine ligase, its function is largely unknown in mammals. Since TRIP12 and SMURF1 belong to same family and have similar functions hence it can be hypothesised that TRIP12 will also be involved in degradation of MTB via recruiting proteasome and several other downstream protein like LC3, p62 and NBR1.

A

B
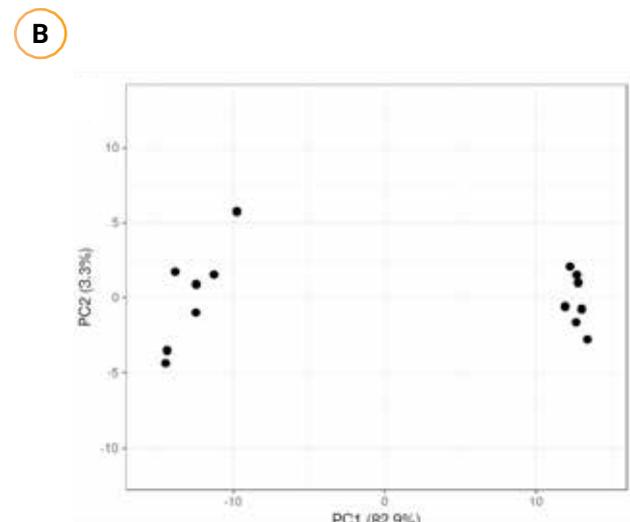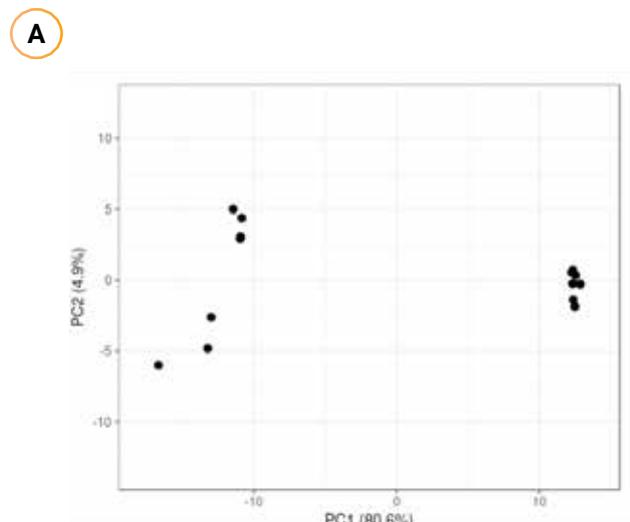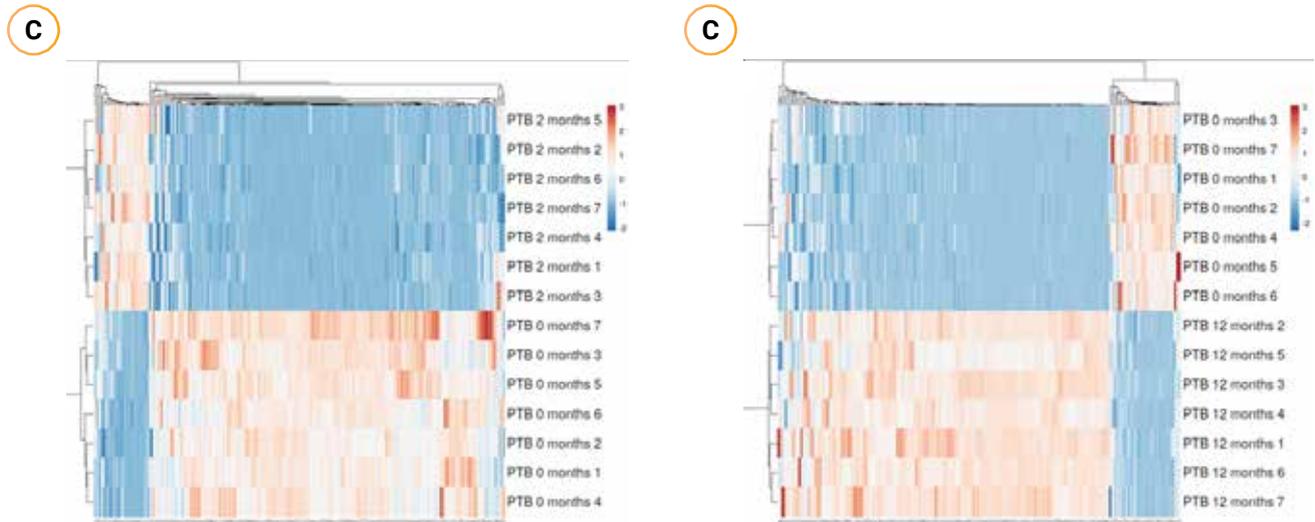
Fig 4.16: Principle Component Analysis (PCA) and heat map of differentially expressed genes in TB.

PCA for DEGs indicates a total variance of 80.6% (PC1) and 4.9% (PC2) between TB at 0 months vs TB at 2 months while 82.9% (PC1) and 3.3% (PC2) between TB at 0 months vs TB at 12 months. Heatmap for DEGs were also constructed which imparts a data matrix through different colour patterns that disclose an outline of numerical variations. The blue to orange gradation represents the gene expression values change from small to large. The ClustVis tool was used to draw a heat map.
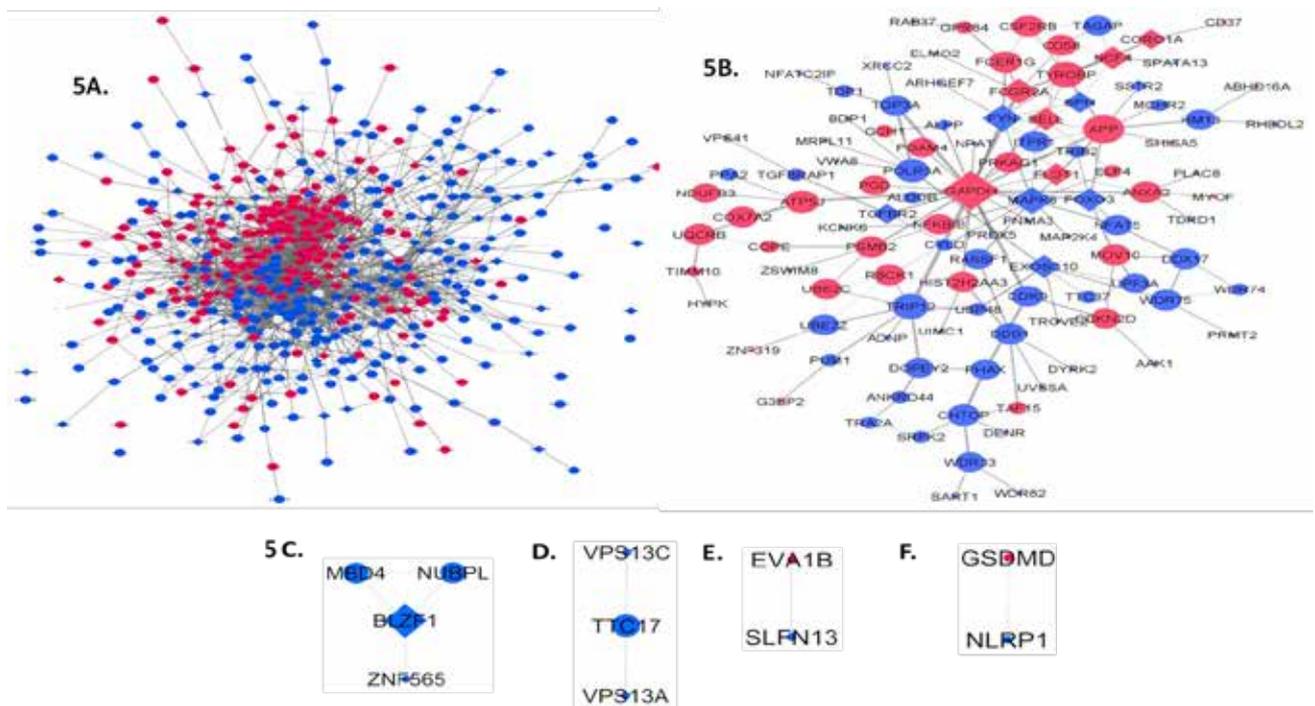
Fig 4.17: Protein-Protein interaction (PPI) of differentially expressed genes.

PPI for all DEGs (Figure 4.17 (A)) shows a total of 526 edges and 2708 nodes, a separate PPI network for DEGs having a combined score >0.9 shows a total of 121 nodes and 178 edges. Red Circle and Red Diamond represent up-regulated genes, while Blue Circle and Blue Diamond represent down-regulated genes. Lines are the correlation between genes. Thickness of lines (edges) is proportional to the combined score. Cytoscape v 3.2.1 was used to construct the network. Few DEGs were forming separate networks from the main networks and were extracted separately.
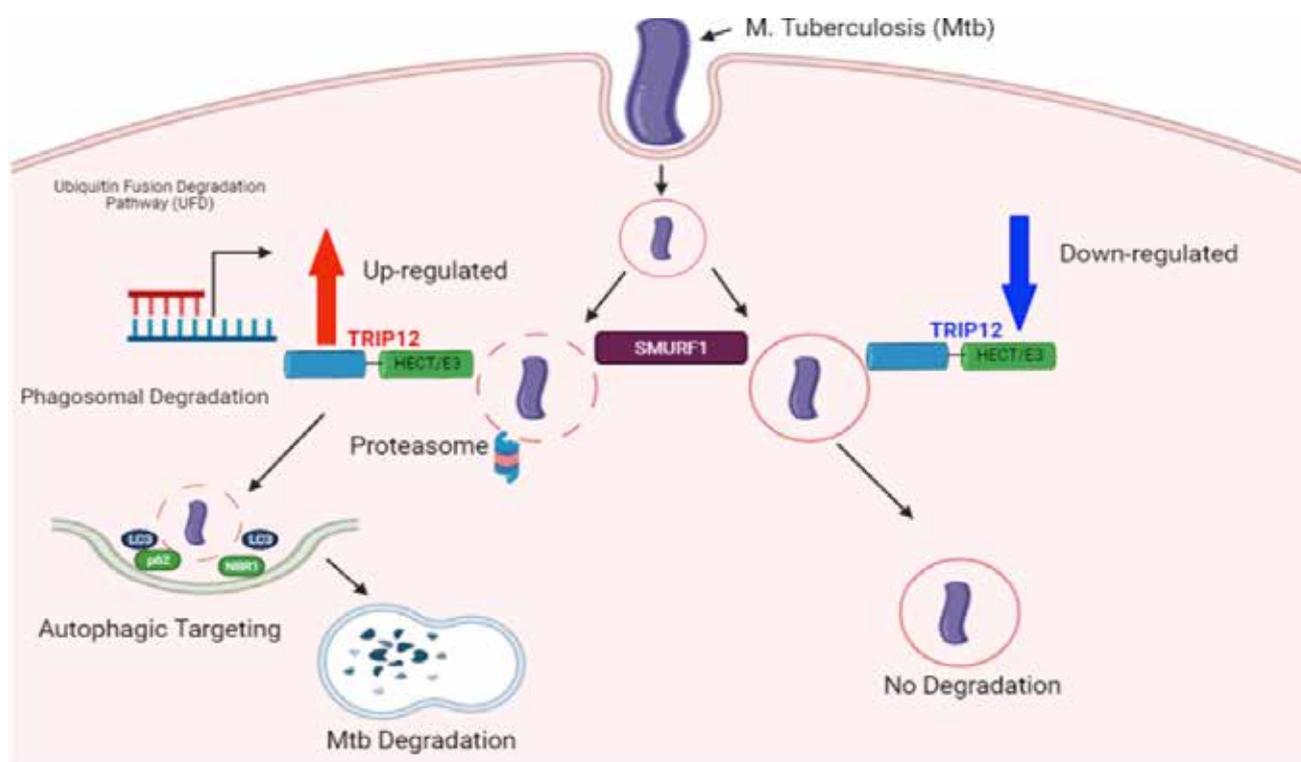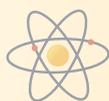
Fig 4.18: Proposed mechanism of TRIP12 action.

TRIP12 belongs to the E3 ubiqitine ligase family. SMURF1 is also a family member of E3 ubiqitine ligase family and has been found to be directly involved in MTB degradation. TRIP12 contain a HECT domain which is E3 ubiqitine ligase, its function is largely unknown in mammals. Since TRIP12 and SMURF1 belong to the same family and have similar functions hence it can be hypothesised that TRIP12 will also be involved in the degradation of MTB via recruiting proteasome and several other downstream proteins like LC3, p62 and NBR1. The work was done at Kashmir University, Srinagar.

Optical spectroscopy to optimize the composition of hybrid perovskite for photoluminescence, photovoltaic and photocatalysis applications

In alkyl ammonium lead halide-based perovskites, replacing toxic Pb2+ with a suitable nontoxic divalent metal cation without losing the photovoltaic performance is one of the prime challenges to this research project. Here the effect of replacing Pb^{2+} on the structural and optical properties of alkyl ammonium lead halide-based perovskites, and after that, correlating their photovoltaic performances, comprise a fundamental study that is important towards developing efficient and non-toxic solar cells was understood. In the present research, a wet chemical process to substitute Pb^{2+} with Sn^{2+} in different proportions into $CH_3NH_3Pb_xSn_{(1-x)}Cl_3$ was used. The value of the Goldschmidt tolerance factor, a measure of structural stability of the perovskite lattice, was theoretically estimated. The theoretical calculations were correlated further with the experimentally obtained X-ray diffraction patterns of the original and substituted perovskites. The optical properties of $CH_3NH_3Pb_xSn_{(1-x)}Cl_3$ perovskite thin films were investigated by ultraviolet-visible (UV–Vis) absorption spectroscopy. The optical absorption spectra estimated the bandgap energy (Eg) for $CH_3NH_3Pb_xSn_{(1-x)}Cl_3$. The Urbach energy (EU), which predicts defects, disorder, and crystalline imperfections within semiconducting thin films, was estimated for the prepared perovskite thin films. The steepness parameter, which apprises the strength of electron-phonon interaction within perovskites, was also estimated from the optical absorbance spectra to understand the effect of replacing Pb^{2+} with Sn^{2+}. In addition, the variations in the surface morphologies of the prepared perovskites were studied using scanning electron microscopy. The I–V characteristics of the different cells were analyzed (Figure 4.19), and finally, it was attempted to correlate their photovoltaic performances with the opto-structural properties.

Fig 4.19: The I−V characterization of CH₃NH₃PbₓSn₍₁₋ₓ₎Cl₃ -based thin-film perovskite solar cells
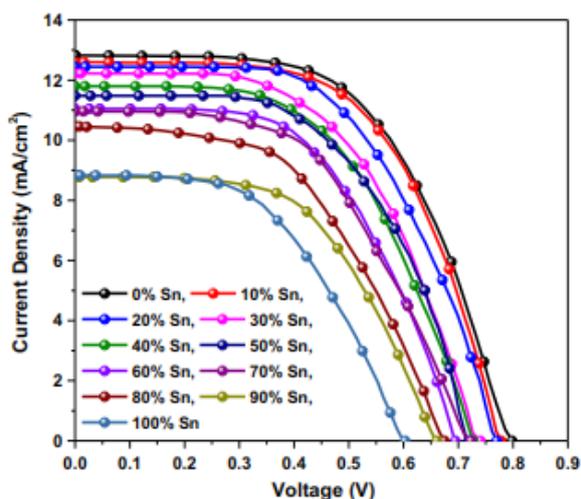
Table III. The extracted photovoltaic parameters of the CH₃NH₃Pb₍₁₋ₓ₎SnₓCl₃ (0 ≤ x ≤ 1)-based thin film perovskite solar cells

Sn (wt.%)	V_{OC} (V)	J_{SC} (mAcm^{-2})	PCE (%)	FF
0	0.798	12.82	5.85	0.57
10	0.778	12.60	5.75	0.59
20	0.770	12.44	5.39	0.56
30	0.740	12.23	4.91	0.54
40	0.727	11.80	4.69	0.55
50	0.719	11.48	4.65	0.56
60	0.695	11.05	4.24	0.53
70	0.723	10.96	4.18	0.54
80	0.675	10.46	3.61	0.51
90	0.660	8.77	3.23	0.53
100	0.603	8.83	2.71	0.49

Table I. The tolerance factor (t) and average ionic radii of the divalent cation (R_{Bavg}) at site B of CH₃NH₃Pb₍₁₋ₓ₎SnₓCl₃ perovskite structure

Sn (%)	0	10	20	30	40	50	60	70	80	90	100
t	0.935	0.943	0.950	0.958	0.965	0.973	0.981	0.989	0.997	1.005	1.013
$R_{B(avg.)}$ (Å)	1.190	1.167	1.144	1.121	1.098	1.075	1.052	1.029	1.006	0.983	0.960
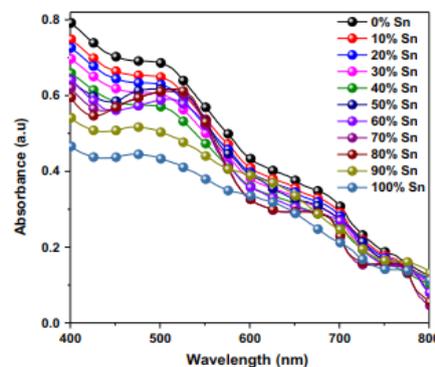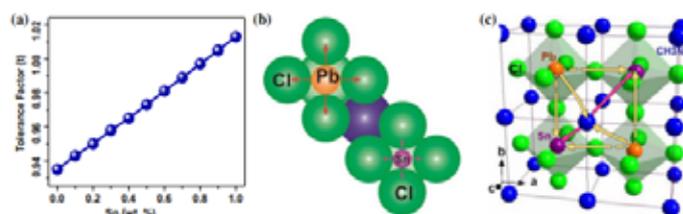
Fig 4.20: The tolerance factor (t) of CH₃NH₃PbₓSn₍₁₋ₓ₎Cl₃ perovskite solar cells. The effect of PbCl6 and SnCl6 cubo-octahedron unit on the CH₃NH₃PbₓSn₍₁₋ₓ₎Cl₃ perovskite structure

In this part of the research work, facile and economic borohydride reduction of ferric chloride was undertaken to study the kinetics of phenol photodegradation under simulated sunlight conditions. Further, a photoluminescence study was undertaken to calculate the lowest energy transition of the synthesized inorganic nanoparticle luminophores. The photodegradation studies showed a promising result, degrading nearly the complete phenol concentration within 24 hours. Photoluminescence study reported the lowest energy transition at 1.72 eV, which alternatively confirms its application as a photocatalyst in diverse fields of wastewater remediation.
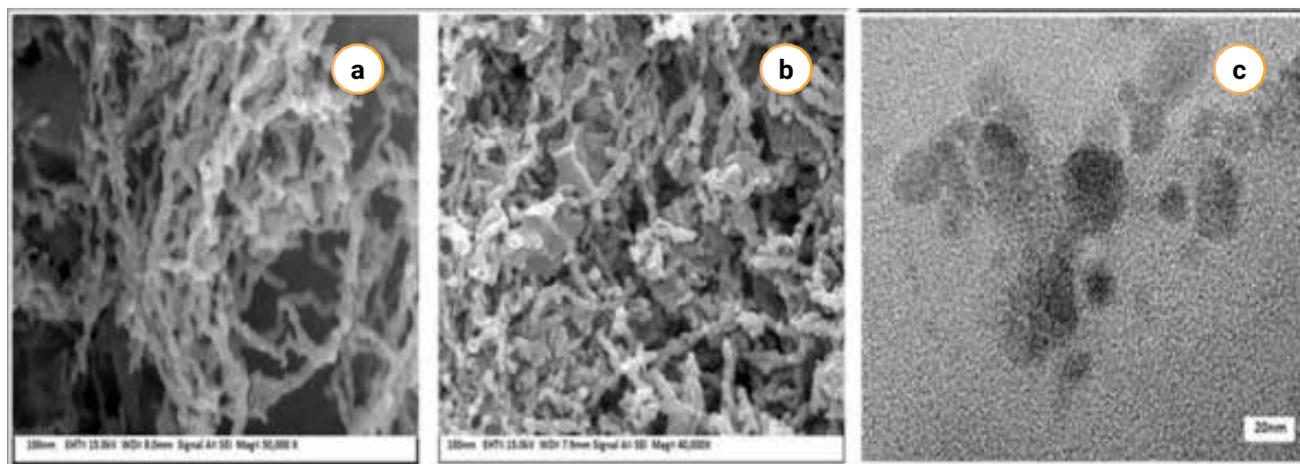
Fig 4.21: (a)&(b) FESEM of the nZVI characterization and **(c)** TEM images of the experimentally obtained nZVI particles.
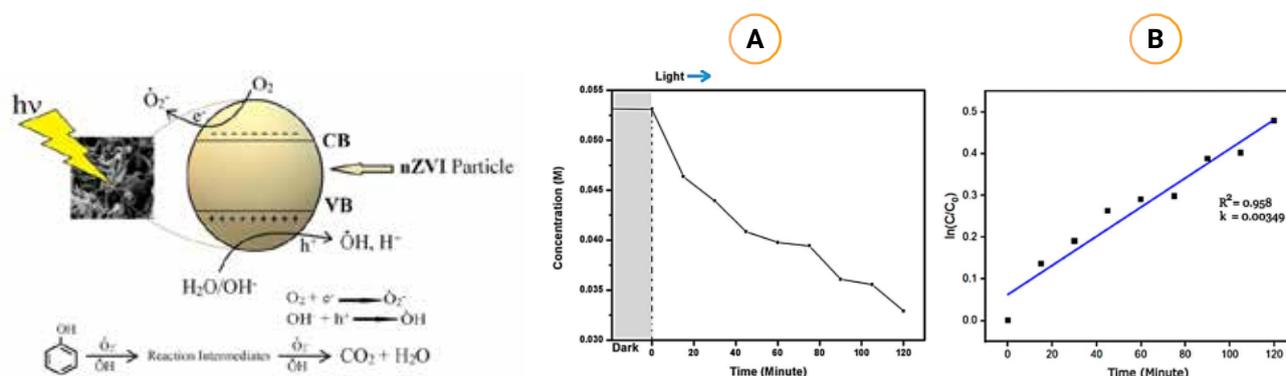
Fig 4.22: Mechanism of Phenol degradation using nZVI particle in the presence of light. **(A)** Transient concentration profile of phenol with incident irradiation of AM 1.5, and **(B)** Kinetic study of the photodegradation mechanism by nZVI particles.

Several attempts were made to fabricate perovskite-based devices, achieving high efficiencies in respective photovoltaics and energy storage fields. Literature shows perovskite suffers majorly from the extrinsic defects at their interfaces and grain boundaries, ultimately affecting the perovskite film crystallinity. Moreover, they additionally depreciate the band alignment and charge transport. Defect engineering is, therefore, the aspired option to enhance device performance and stability. It was observed that the initial substrate formation plays a consequential role in determining the morphology of the structure. Therefore, different materials were tested as precursors through different initial fabrication strategies to develop quality perovskite films. Composition engineering was also practised with dopants added at various levels of fabrication. In some cases, synthesizing defects also improves device performance with reasonable stabilities. Herein, categorizing the defect should be of up teen importance given that defect structuring is very important to upgrade the perovskite performances for commercial applications (Figure 4.20).

The team synthesized light-emitting redox polymers for sensing and removal-reduction of Cu(II) and has a role of hydrogen bonding in nonconventional fluorescence.

The group synthesized ratiometric pH sensing, photophysics, and cell imaging of nonaromatic light-emitting polymers. Four nontraditional fluorescent polymers (NTFPs) of varying N, N-dimethyl-2-propenamide (DMPA), and butyl prop-2-enoate (BPE) mole ratios, i.e., 2:1 (NTFP1), 4:1 (NTFP2), 8:1 (NTFP3), and 16:1 (NTFP4), were prepared via random polymerization in water. The maximum fluorescence enhancement of NTFP3 makes it suitable for ratiometric pH sensing, Cu(II) sensing, and pH-dependent cell imaging of Madin-Darby canine kidney (MDCK) cells.

The present study aimed to develop a lead-based halide perovskite solar cell model by simulating different parameters like thickness, defect densities of absorbing layer, doping concentration of HTM (hole transport material), ETM (electron transport material) layer to optimize the efficiency of the solar cell.The simulated perovskite solar cells have the layer-by-layer architecture of ETM/perovskite/HTM, and their performances were simulated by Solar Cell Capacitance Simulator (SCAPS).TiO_2 as an ETM, lead-based perovskite material $CH_3NH_3PbI_3$ as a light-absorbing material, and copper thiocyanate as HTM was used. The thickness of the $CH_3NH_3PbI_3$ layer varied from 0.2 to 0.6 µm. The absorber layer's total defect density varied between 1014 and 1018 cm-3, and the doping concentration of ETM, HTM varied between 1014 and 1018 cm^{-3} for simulation purposes. Finally, the simulated performance of the solar cell was tested under AM 1.5G solar illumination using 1000 W/m2 irradiation as an external parameter. Furthermore, the simulated performance was recorded at elevated temperatures, and the photovoltaic parameters were analyzed. Optimized results resemble a power conversion efficiency (PCE) of 20.18%, open-circuit voltage (Voc) of 1.309 V, short circuit current density (Jsc) of 20.76 mA/Cm^2, and fill factor FF 74.24% at 298 K (Figure 4.21).

An Extensive review was done on Z/S – scheme heterojunction for photocatalytic applications based on metal halide perovskite material. and therefore, it would be imperative to lay down a future roadmap on the development of these photocatalysts.

This study reports the performance analysis of an organic dye-sensitized solar cell (DSSC), introducing MnO_2 as an electron transport layer in TiO_2/MnO_2 bilayer assembly. The DSSCs have been fabricated using TiO_2 and TiO_2/MnO_2 layer-by-layer architecture flms onto fluorine-doped tin oxide (FTO) glass and sensitized with natural dye extracted from Malvaviscus penduliforus fower in ethanol medium. The doctor's blade method prepared the counter electrode to layer copper powder containing paste onto FTO's conductive side. Photoanodes' optical, morphological, and structural properties were explored via ultraviolet−visible, field emission scanning electron microscopy, and
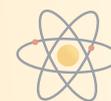
X-ray diffraction analyses. Moreover, dye complexity and thermostability of dyes were characterized via Fourier-transform infrared spectroscopy and thermogravimetric analyses. The iodide/triiodide (i.e., I $-$/I3 $-$) redox couple of electrolyte solutions was employed as a charge transport medium between the electrodes. Finally, photoanode and counter electrode sandwiches were assembled to envisage the photovoltaic performance potential under simulated AM 1.5G solar illumination using 100 mW cm^{-2} light intensity. The as-fabricated DSSC comprising TiO$_2$/MnO$_2$ bilayer assembly exhibited 6.02 mA cm^{-2} short circuits current density (Jsc), 0.38 V open-circuit voltage (Voc), 40.38% fll factor, and 0.92% conversion efficiency, which is about 200% higher compared to the assembly devoid of MnO$_2$ layer (Figure 4.22).

The major focus of this research was comparing the performance of QD-based solar cells with and without the addition of synthesized dielectric nanomaterials for reducing recombination problems and higher exciton generation. The dielectric nanomaterial was selected based on their good field-effect passivation, screened columbic attraction, enactment as a back reflector, and recombination inhibitor in solar cells. According to the different factors, lanthanum-doped lead titanate Pb La0.15 TiO$_3$ (PLT15) was a promising material for the research work. For improving the performance of QD based solar cells, the PLT15 paired mesoporous TiO$_2$ electron transport layer (ETL) film was deposited onto fluorine-doped tin oxide (FTO) coated glass substrate using doctor blading technique followed by annealing the QD deposition onto the coated glass substrate was carried out via dipping of the glass into the QD solution for overnight. The QD used in this research work was namely – PbI$_3$. Finally, the performance study was carried out, which indicates that the introduction of dielectric material into the QDSC has proven to be as innovative and as well as efficient for improving the photocurrent conversion efficiency. The work was done at the University of Calcutta, Kolkata.

4.2.6 National Post-Doctoral Fellowship (NPDF)

The SERB-National Post-Doctoral Fellowship (NPDF) is aimed to identify motivated young researchers and provide them support for doing research in frontier areas of science and engineering. The fellows will work under a mentor, and it is hoped that this training will provide them with a platform to develop as independent researchers.

FEATURES

To train and inspire promising young researchers in conducting cutting-edge research with guidance from established scientists

Fellowship amount is Rs. 55,000 per month plus HRA and research grant is Rs.2.00 lakh per annum plus overhead of Rs.1 lakh per annum

Duration of fellowship is two years

Website link: https://serb.gov.in/page/english/awards_fellowship#National%20Post%20Doctoral%20Fellowship

4.2.6.1 Chemical Sciences

In the reporting period, 48 new fellowships were sanctioned. The areas supported under NPDF - Chemical Sciences are shown in the following figure.

Areas Supported

Biophysical and Biochemistry

Medicinal Chemistry

Inorganic Chemistry

Spectroscopy

Chemical Sciences

Energy

Materials

Physical Chemistry

Nanotechnology

48 Fellowships Sanctioned

Expenditure (New and Ongoing)

7.91 cr
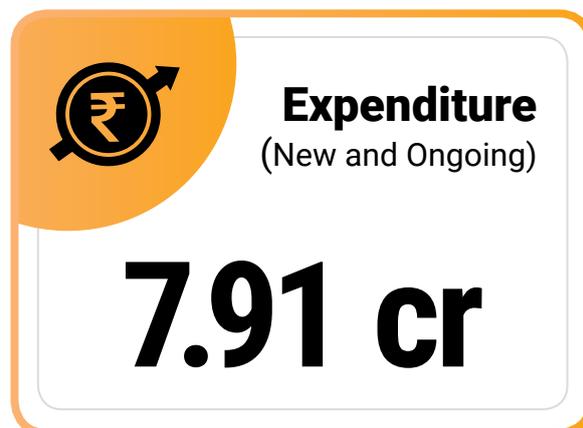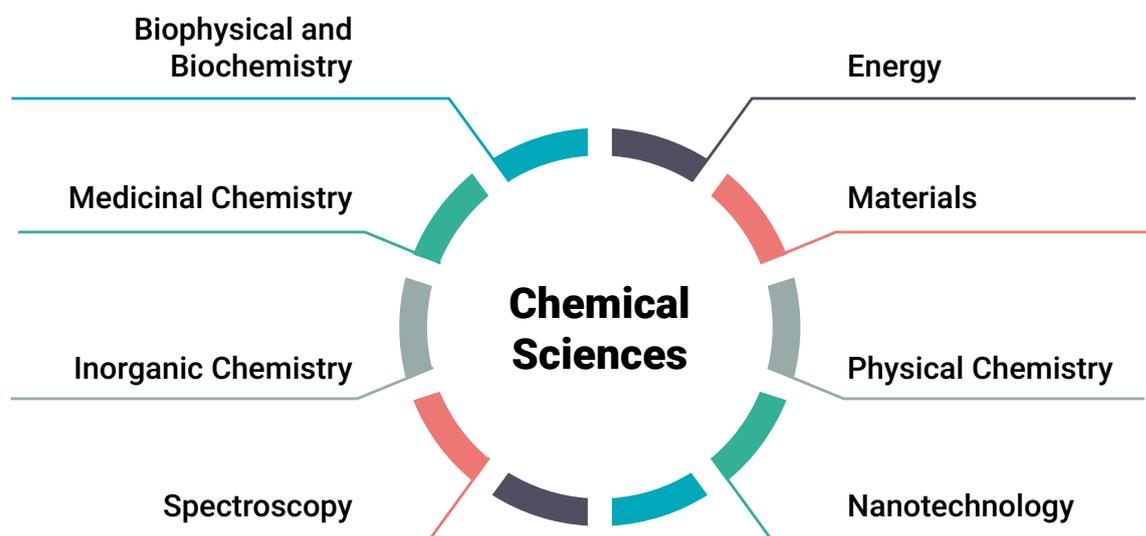
Research Highlights

Exploration of new facets in halide perovskite nanocrystals photocatalysts for enhanced and product selective CO_2 reduction with simultaneous methanol oxidation

Artificial photo-assisted conversion of solar energy to useable fuels and chemicals has assumed significance in mitigating the effects of energy crisis. In this regard, Halide perovskite (HP) nanocrystals have emerged as one of the potential materials for light harvesting and photovoltaic applications. These nanocrystals are capable of driving solar to chemical production through carbon dioxide (CO_2) reduction. The chemical formula of conventional HP materials can be described as ABX_3 where A is 12-fold coordinated cation occupying the cuboctahedra cavity created by B cations with 6-fold coordination with X anions at corner sharing BX6 octahedra. These perovskites have remarkable photo physical, optical, and transport properties, such as long charge carrier lifetimes, low trap densities, long electron and hole diffusion lengths, large absorption coefficients, and a widely tunable band gap that enables light harvesting from UV to near IR spectral range. More importantly, the band positions of most halide perovskites satisfy the thermodynamic requirements for CO_2 reduction and hydrogen production. Perovskite materials with variable shape and size with different active facets are quite impressive in the catalytic application due to preferable adsorption/desorption mechanism. Cubic shaped halide perovskite nanocrystals have six facets
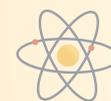
four (110) and two (002), these are not so much active for CO_2 reduction. Non-cube shaped nanocrystals have many numbers of active facets. The group at the Indian Association for Cultivation of Science (IACS), Kolkata explored the synthesis of non-cube shaped halide perovskite nanocrystals ($CsPbBr_3$) and new active facets with an evaluation of the activity of the developed facets to generate chemical fuels like CH_4 and CH_3OH through CO_2 photoreduction (Figure 4.23). Simultaneous evaluation of oxidation product during catalytic reduction reaction was examined, upon addition of methanol as oxidant. The underlying mechanisms of the catalytic reaction over the designed materials through spectrochemical method are expected to throw light on the ability of these materials to drive solar to chemical synthesis.
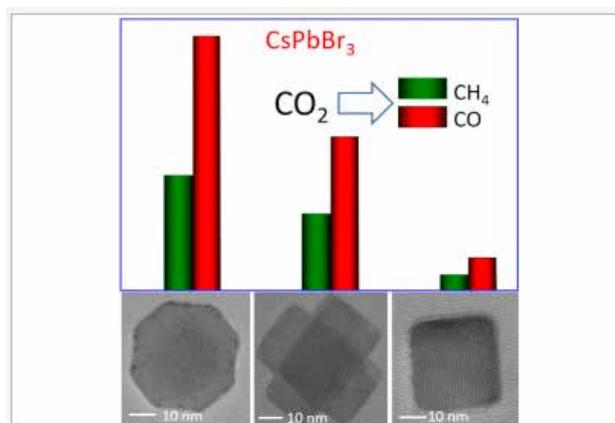
Fig 4.23: Photocatalytic CO_2 reduction activity of the different facet perovskite nanocrystals after 2h of catalytic reaction.

Polyoxometalate-immobilized carbon nanotube constructs triggered by host–guest assembly result in excellent electromagnetic interference shielding

An effective EMI shielding material must both reduce undesirable emissions and protect the component from stray external signals. 2D nanomaterials, specially, MXenes constitute a well-defined family of compounds exhibiting large aspect ratio, versatile processing, hydrophilicity, native defects, tunable electrical property, and availability of abundant functional groups (OH, O, and/or F groups). However, pure MXene is unsatisfactory as the electromagnetic absorbing material due to its ultrahigh conductivity. As a result, MXene is often combined with other materials to improve its impedance matching, stronger conductive loss and more considerable polarization loss at a lower content in the polymer matrices. As a result, magnetic and dielectric components are added in the MXene to achieve synergy between permeability and magnetic loss to achieve the optimized MA performance. In the project the group at the Indian Institute of Science, Bengaluru explored fabrication of 3D hierarchial Ti_3C_2Tx (Mxene)/ZnO terapod)/hollow Fe_3O_4 ternary nanocomposites (Figure 4.24). Typically, unique 3D morphology of T-ZnO offers more chemically
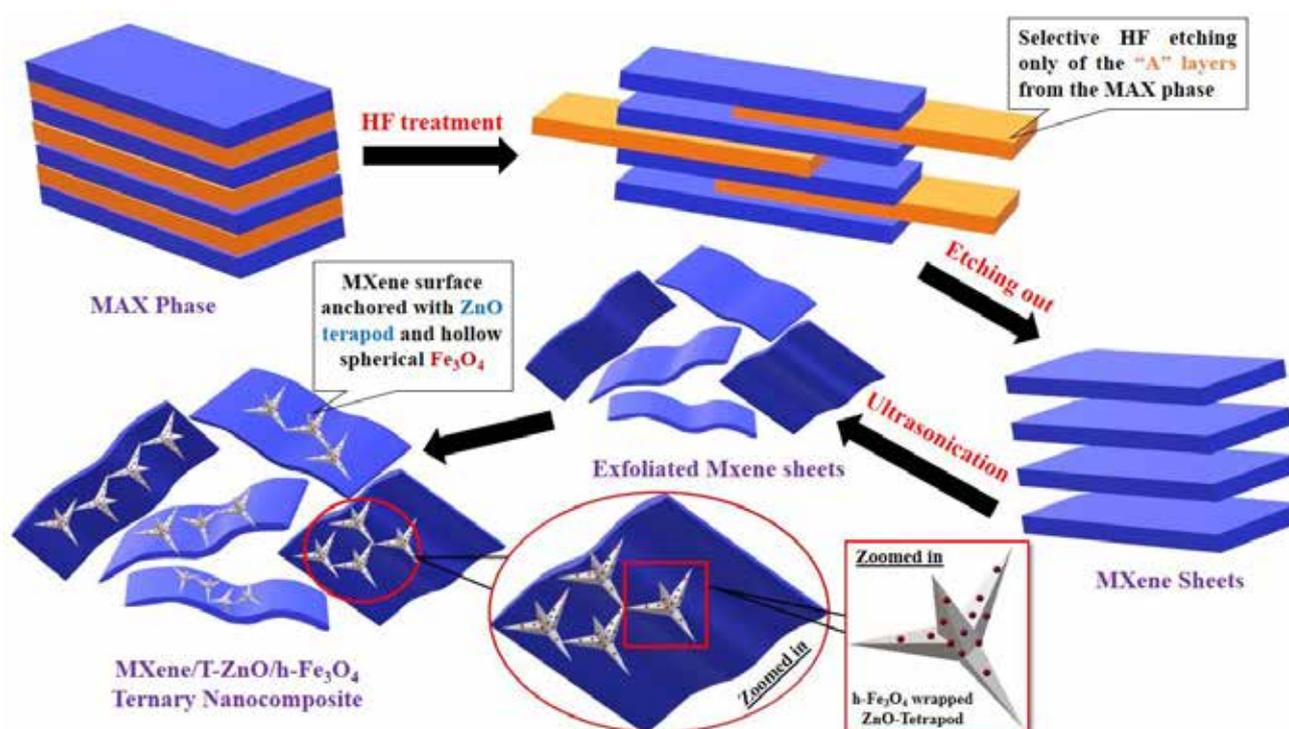
Fig 4.24: 3D hierarchial Ti_3C_2Tx (Mxene)/ZnO terapod)/hollow Fe_3O_4 ternary nanocomposites

active facetted hexagonal surfaces. Moreover, on accumulation of a large number of tetrapods anonymously construct a unique macroscopic interconnected architecture with very high porosity. Therefore, it could be anticipated that, on account of such unique features of their high surface accessibility, and highly porous 3D interconnected networks, their nanocomposites could be explored as microwave absorber to impart high dielectric loss. Further, the magnetic loss could be manipulated through the growth of hollow spherical Fe_3O_4, due to their porous structure, low effective density, lightweight and larger specific surface area, to meet the essential prerequisite of lightweight microwave absorbers and to modulate the impedance matching along with reflection loss (RL).

4.2.6.2 Earth and Atmospheric Sciences

In the reporting period, 18 new fellowships were sanctioned. The areas supported under NPDF – Earth and Atmospheric Sciences are shown in the following figure.

Areas Supported

Earth Surface Processes

Solid Earth

Earth & Atmospheric Sciences

Atmospheric Sciences

Ocean Sciences

18
Fellowships Sanctioned
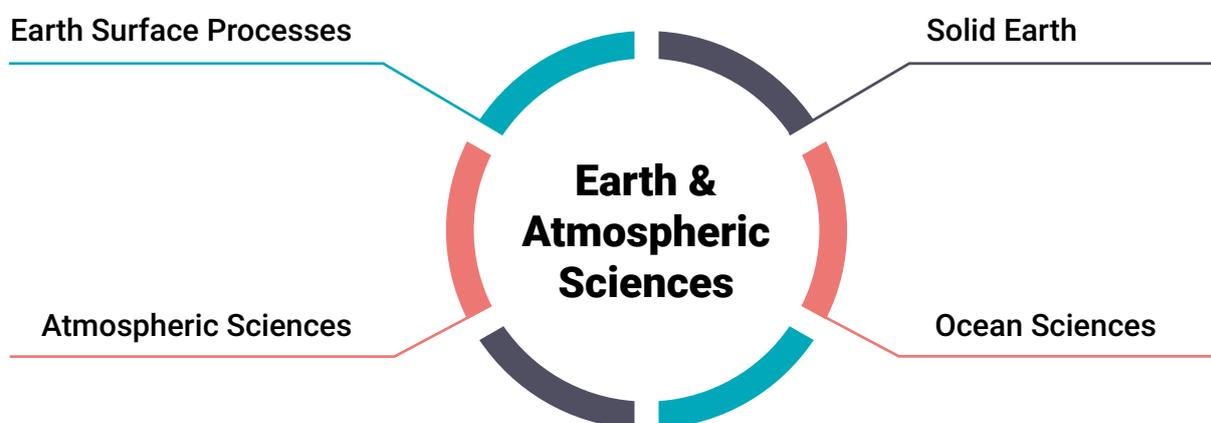
Expenditure
(New and Ongoing)

3.17 cr
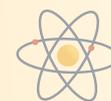
Research Highlights

Measurement of oxidative potential of fine particulate and its constituents in urban environments

The research involves the overall explicit understanding of the complexity of PM with substantial rethinking of research strategy in amelioration of interventions. PM research framework advocates replacement of old paradigms with new paradigms such as exploration of granulometric PM spectrum, particle surface area, bioavailability and oxidative potential as the new toxicity metric, use of sensors than traditional monitoring stations (Figure 4.25). The research includes introduction of novel research aspects like granulometric PM spectrum (size distribution of PM into dimensional classes), virusols (virus laden aerosol particles), human body linked PM emissions.

Bimodal size distribution of PM mass concentration in coarse mode at 9 & 3.3µm was noted whereby the highest metal to PM mass contribution followed the order: fine (31%)>coarse (7%)>large (2%) mode PM. Metals in the size range 2.1-3.3µm recorded the highest value of HQ (Ni) & ELCR (Cr(VI)) (Figure 4.26). Correlation and multiple linear regression analysis suggested that transition metal pose greater effect on OP during winters (increased bioavailability). PCA identified crustal, resuspended dust, industrial & traffic emission as major source. Metals explained about 38% on average of PM10 induced ROS indoors whereby Fe, Cu, Mn were the most dominant metals with >76% of PM induced oxidative stress, attributed to their ability of these metals to catalyse ROS generation in ambient air. Overall, OP than HI (hazard index) was found to be a poor metric for measuring PM exposure to human health.

The findings of this study offer an opportunity in developing of the improved particle monitoring programme in residential areas and have been/will aid too in establishing a relatively small international elemental modality and OP dataset that could be incorporated in the exposure and risk assessment of atmospheric particles. This work was carried out at Savitribai Phule Pune University, Pune.

Fig 4.25: Changing paradigms of Particulate Matter Research (Reference: Rohra et al. Sci Total Environ., 841, 156676 (2022))
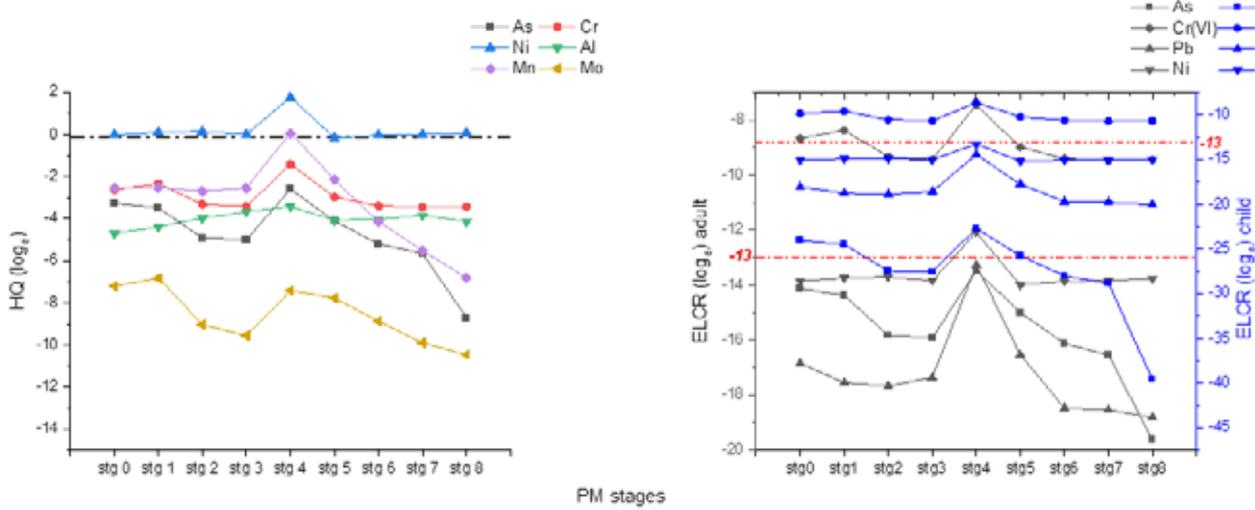
Fig 4.26: Hazard Quotient (HQ) and Excess Lifetime Cancer Risk (ELCR) (in loge) of metals through inhalation exposure pathway in various size fractions of PM.

4.2.6.3 Engineering Sciences

In the reporting period, 57 new fellowships were sanctioned. The areas supported under NPDF Engineering Sciences are shown in the following figure.

Areas Supported
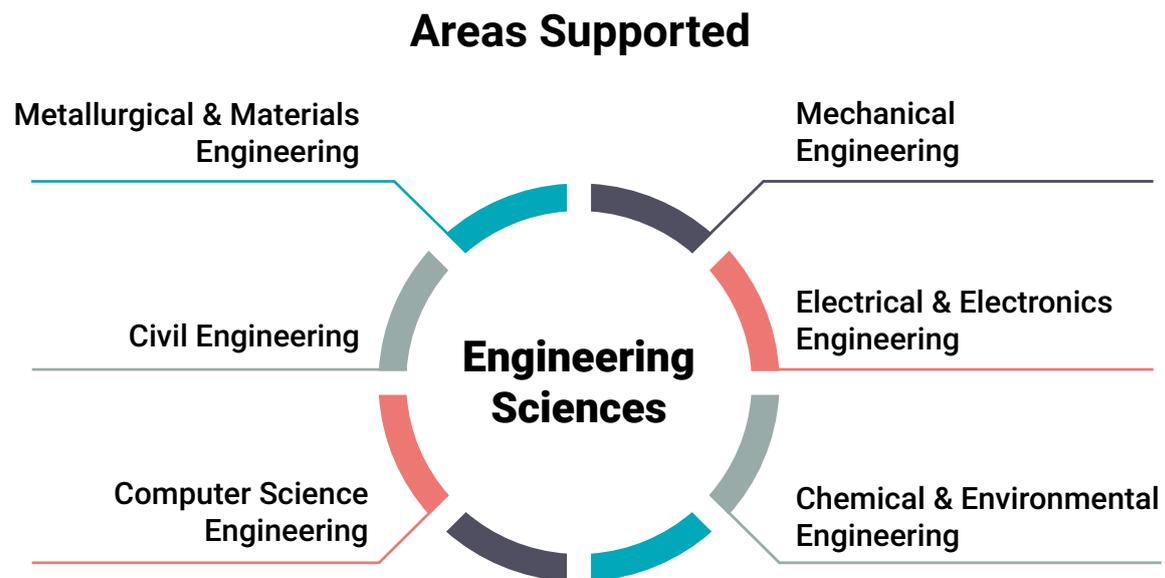
57 Fellowships Sanctioned

Expenditure (New and Ongoing)

9.89 cr
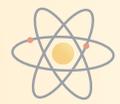
Research Highlights

Frequency agile RF power amplifier for 5G wireless application

In this project, a Doherty Power Amplifier for 5G Wireless Communication has been developed. Two Driver amplifiers of 45W and 30W have also been developed to drive it. All three designs function for frequency band 3.3GHz to 3.67GHz assigned for India. The measurement results of the Doherty PA show that the developed DPA delivers 41.1 to 45.7dBm power at back-off while maintaining gain variation between 6.71 to 10.26 dB for the operating 3.3GHz to 3.67 GHz. The Drain Efficiency (DE) of the DPA varies between 21.99 to 28.54% at back-off. However, if the driver considers as part of the Doherty PA, in that case, the overall efficiency of the DPA is 13.67 to 19.41%. While the total gain of the DPA varies between 16.5 to 20.72 dB. By applying a two-tone signal, the adjacent channel Power Ratio (ACPR) of the Doherty is also checked. It can be observed from Figure 4.27 that the DPA achieves at least -19dB ACPR over the band. This work was done at the Indian Institute of Technology, Roorkee.

Fig 4.27: Measurement setup for Doherty power amplifier (DPA).

Shock wave oscillations over double cone bodies in high-speed flow

Shock wave interactions over double-cone bodies in Mach 6 flow have been investigated. Time-resolved schlieren visualization revealed the presence of multiple flow regimes over these conical bodies. Three states of shock interactions were identified. They are non-trivial steady state, large-amplitude oscillation state and small-amplitude oscillation state. The large amplitude oscillations were characterized by periodic growth and collapse of the separation region over the conical surface. The small-amplitude oscillations were characterized by the shear layer instabilities and the breathing motion of the recirculation region. Figure 4.28(a,b&c) shows the instantaneous schlieren images of these three flow states. This work was done at the Indian Institute of Science, Bengaluru.
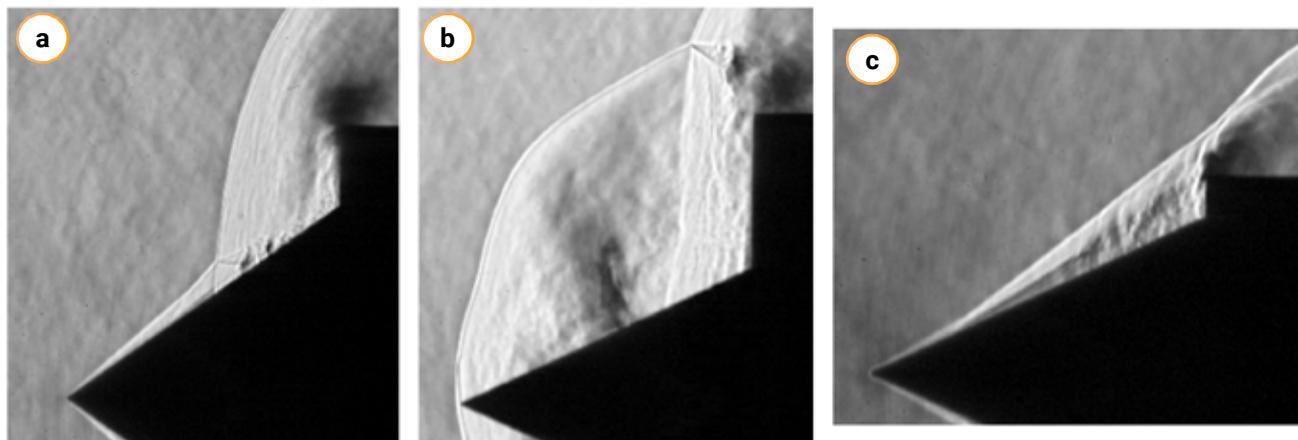
Fig 4.28: Instantaneous schlieren images of three flow states observed over the double cone geometry; **(a)** non-trivial steady state, **(b)** large-amplitude oscillation state and **(c)** small-amplitude oscillation state.

4.2.6.4 Life Sciences

In the reporting period , 60 new fellowships were sanctioned. The areas supported under NPDF – Life Sciences are shown in the following figure.

Areas Supported

Animal Sciences

Plant Sciences

Life Sciences

Biochemistry, Microbiology & Molecular Biology

Health Sciences
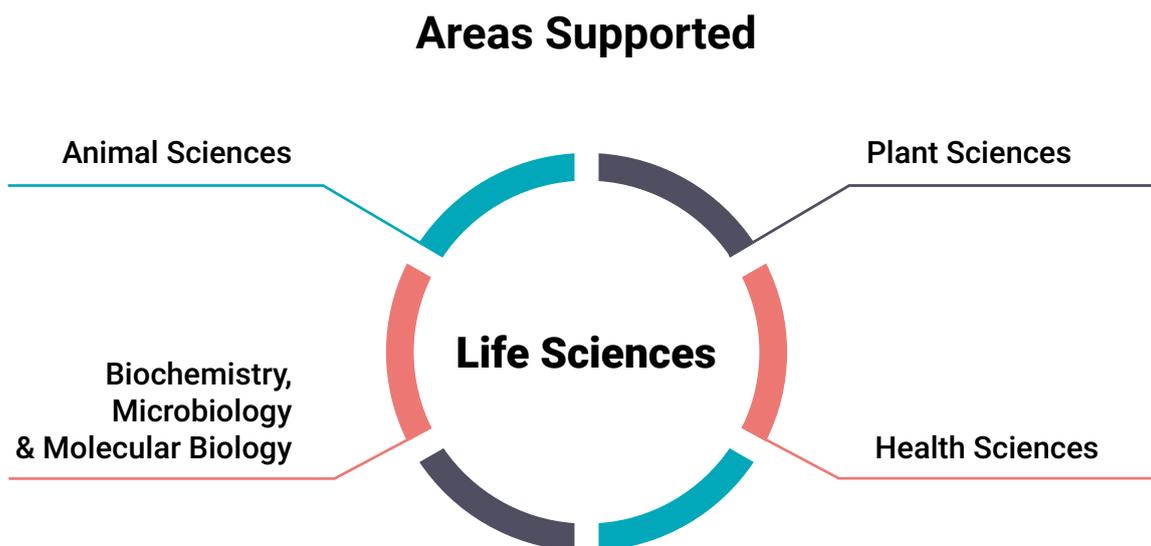
60
Fellowships Sanctioned

Expenditure
(New and Ongoing)

13.91 cr
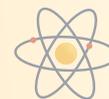
Research Highlights

An approach towards hybrid time-series-neural network analysis and dynamic simulation of GIS data to detect algal bloom events in aquatic bodies.

System level organizations are important characteristics of any animate biological organisms. Hence, community organization studies are an indispensably important part of ecological research. Community patterns fluctuate with perturbations in the environmental composition – like changes in temperature, light, water quality parameters. Thus, it is an important aspect that might significantly impact the system's health in general. Accordingly in the present work, investigator probed the organization of zooplankton communities of an aquatic ecosystem.

Zooplankton is a crucial part of any aquatic ecosystem, and a heterogeneous assemblage of zooplankton is an indicator of good ecosystem health. They also serve as indicators of trophic status of the water body. Zooplankton are essential links in transferring nutrients and energy from the first level autotrophs to the higher trophic levels, and regulate the chlorophyll-a concentration in an aquatic system via top-down control over the phytoplankton. Some specific zooplankton groups respond to environmental fluctuations physico-chemical attributes of the system and can thus be used as indicators.

The Bakreswar reservoir in the Birbhum District of West Bengal, India was selected as primary study site for this study. Investigator used machine learning approach, more specifically, Self-Organizing Maps to visualize and examine the distribution of zooplankton community this reservoir system. Correlation analysis revealed the inter-relationship among different zooplankton groups as well as with the different deterministic environmental factors. Variance inflation factor (or VIF) extraction was next used to determine and remove multicollinearity among the data set.

Air and water temperatures were highly correlated amongst themselves and after VIF extraction, AT was removed as an explanatory variable. Further, Humidity (HUM) was also removed from further analysis since atmospheric humidity is not particularly useful as a descriptor of aquatic zooplankton.

Investigator used principal component analysis (or PCA) to determine the most important factor in the data matrix of zooplankton and environmental descriptors.

From the data, it was observed that solar irradiation (SRAD), dissolved oxygen (DO), and net primary production (NPP) were the most important descriptors, closely followed by water pH, phosphates (PHOS-P), nitrates (NIT-N), alkalinity (ALK).

Next, the data was clustered using (i) k-means cluster, followed by (ii) self-organizing map clustering and visualization and analyses. An optimal representation of data was observed using 4 and 3 clusters for environmental and zooplankton data respectively. However, this analysis did not reveal the closeness relationship of individual data points. and proceeded to SOM analysis.

From the analyses, it was revealed that the zooplankton communities of Bakreswar reservoir showed varied temporal distribution over the different seasons, as well as spatial variations with respect to different data points (sites of data collection). There was a high positive correlation between the pairs cladocera and copepoda ($r = 0.339$, $p < 0.001$), and rotifera and ostracoda ($r = 0.499$, $p < 0.001$); however, copepods were the dominant zooplankton group of the reservoir. There was a similarity in distribution of both water quality parameters among stations 1 and 3 in comparison to station 2 (data collection stations along the reservoir). The primary reason behind this was the fact that station 2, situated near the lock gate of the reservoir dam, experienced periodic fluctuations when water was released from the system (Figures 4.29, 4.30 & 4.31). This work was done at Indian Statistical Institute, Kolkata.

(a)
Correlation plot for all the variables - environmental and zooplankton

(b)
Principal Component Analysis of environmental data

(c)
Principal Component Analysis of zooplankton data
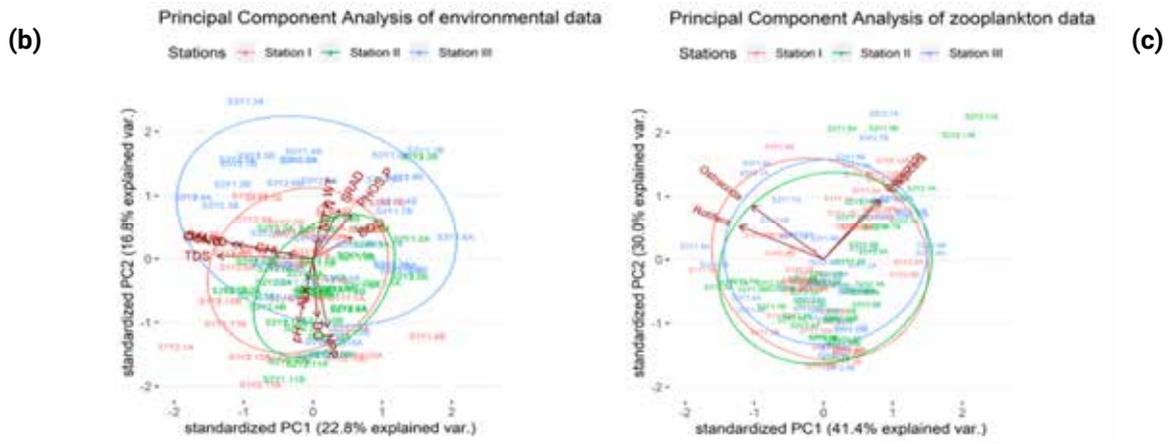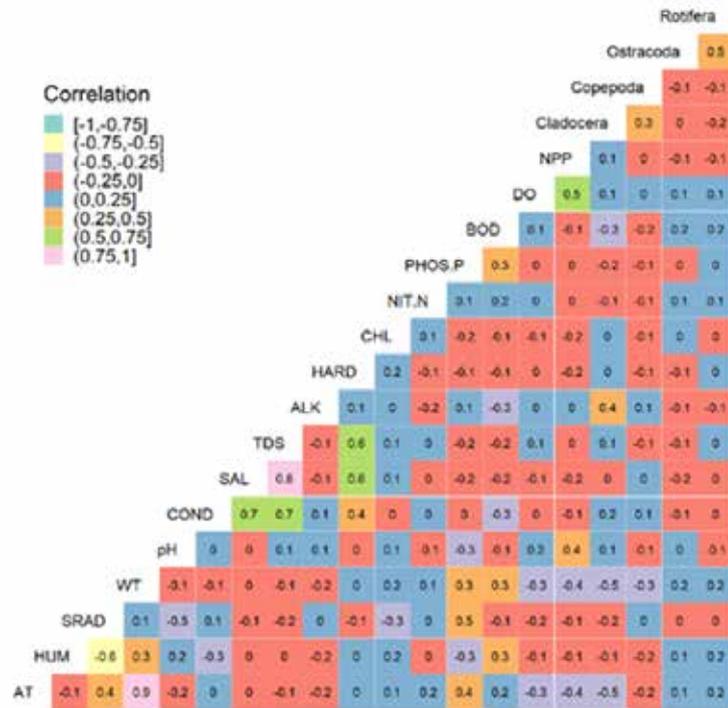
Fig 4.29: (a, b & c) Statistical interpretation of the data.
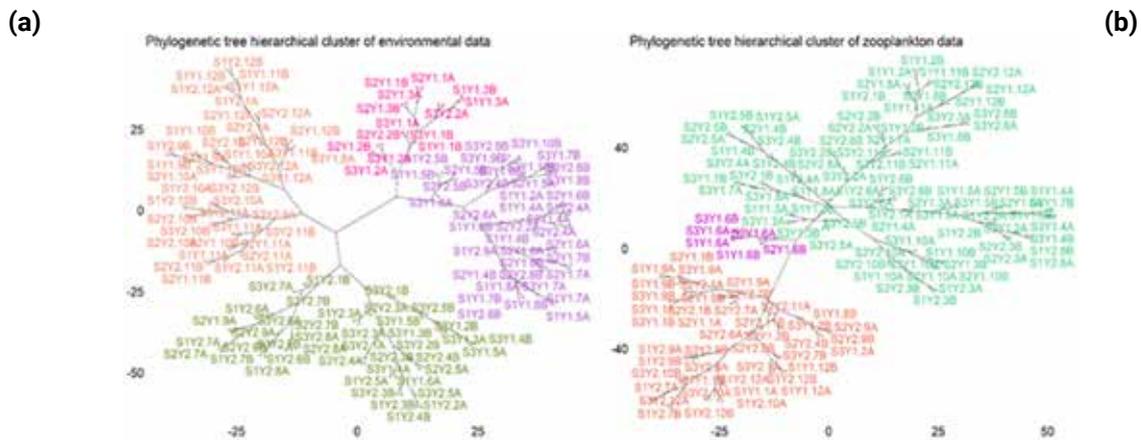
Fig 4.30: (a & b) Phylogenetic analysis.
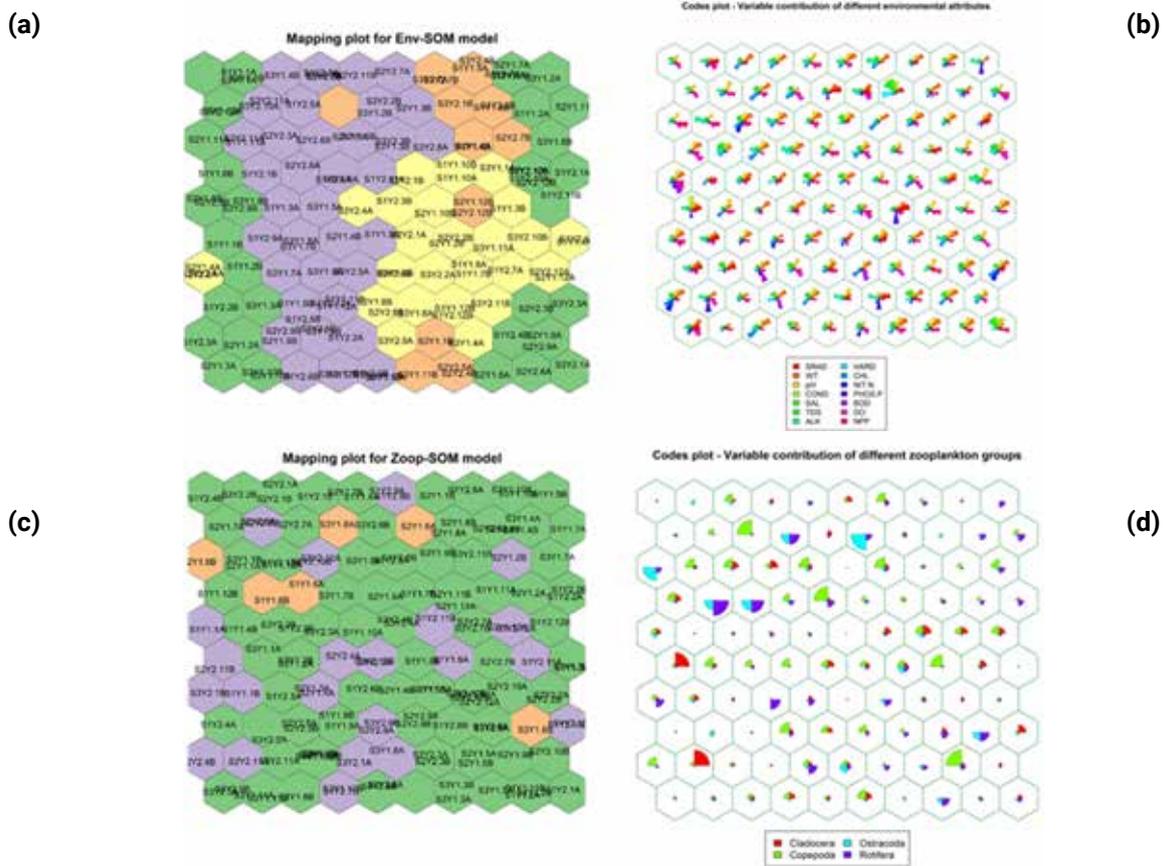
Fig 4.31: (a-d) Mapping and code plots for different zooplankton groups
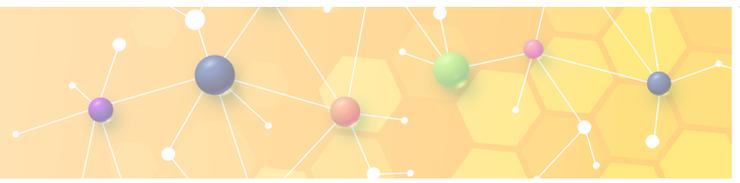
Development of bacterial blight and sheath blight resistant rice plants through CRISPR/Cas-mediated genome editing of host susceptibility gene

Rice *(Oryza sativa)*, a staple food crop, belongs to the family Poaceae, has been cultivated for more than 10,000 years, is the second most worldwide cultivated cereal. *Xanthomonas oryzae* pv. *oryzae (Xoo),* the causal agent of bacterial blight, is the deadliest bacterial disease of rice, causing 75% annual yield loss. Xoo activates host susceptibility gene (S) through its transcription activator like effectors (TALE). Although CRISPR/Cas9 is an efficient tool to disrupt or knock out the target genes in plant, it cannot precisely install point mutation. CRISPR/Cas9 generates random insertion/deletion (indel) at the targeted genomic region. Recently developed base editing technology can precisely perform targeted A-to-G or C-to-T substitution in DNA. Rice *SWEET11* and *OsSWEET14* genes are the members of a transporter gene family, Sugars Will Eventually Be Exported Transporters (SWEET). These genes are well known susceptibility genes for bacterial blight pathogen *Xanthomonas oryzae pv. Oryzae (Xoo).* Xoo secretes TALE effector protein which binds to specific sequence (effector blinding element) of the promoters of *OsSWEET* genes to increase the transcription of the genes (Figure 4.32(a&b)). Increased production of the transporter proteins facilitates *Xoo* pathogenesis. Thus, in the experiment the fellow's group has procured dual base editor (ACBE) plasmid from Addgene and used to construct the base editor vector for rice transformation. Here, ACBE-nCas9 expression cassette is driven by the rice ubiquitin promoter. Guide RNA to modify the EBEs for rice *SWEET11* and *SWEET14* gene promoters harbouring suitable PAM is designed. The base editors in both pRGE32 and pRGEB32 background for transient expression and stable transformation are cloned. Oligo annealing was performed to clone the spacer sequences(Figure 4.33). It was aimed to modify the EBE sequences for the two promoters using dual base editor to inhibit the binding of *Xoo* TALEs and ultimately reduce *Xoo* pathogenicity. Indica rice cultivar Naveen was selected for target variety for OsSWEET gene's promoter modifications using dual base editor. Presence of target sequence for *OsSWEET11*, and OsSWEET14 within Naveen was confirmed through sanger sequencing (Figure 4.34). To validate the base editor construct, the team developed a highly efficient protoplast isolation system from rice, transfection using PEG (polyethylene glycol), and validating the accessibility of sgRNA into target plant genomic loci. In protocol, the transfection efficiency of isolated protoplast was counted as high as 81%. Plasmid vector harbouring the Cas9 and sgRNA was introduced into protoplast using PEG mediated transfection. After 48 hours GFP fluorescence was visualized under fluorescent microscope using a GFP filter. After 72 hours, genomic DNA was isolated from the protoplast transfected with dual base editors (Figure 4.35(A&B)). PCR was performed from isolated genomic DNA to amplify the target genomic site. Sanger or deep sequencing of PCR products was accomplished to check the editing efficiency of specific sgRNAs. After validating the dual base editor vectors in the protoplast, it will proceed into stable transformation using *Agrobacterium tumefaciens* in rice calli. Furthermore, base-edited rice plant lines will be challenged with bacterial blight and sheath blight pathogens along with their wild type counterpart for enhanced resistance. The work was carried out at Central Rice Research Institute, Cuttack.

a

b
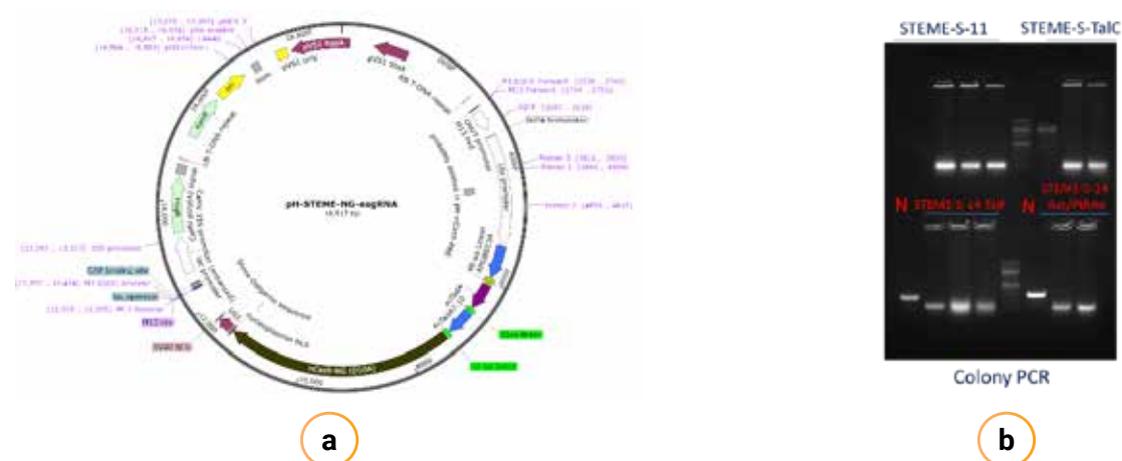
Fig 4.32: (a) Plasmid map of pH-STEME-NG-esgRNA. (b) Result of colony PCR: Colony PCR was performed with respective primer sets. Positive colony of pH-STEME-NG-SWEET11, pH-STEME-NG-SWEET14 (AVRXa7/PthXo3), pH-STEME-NG-SWEET14 (TalF), and pH- STEME-NG-SWEET 14 (TalC) showing bands at specific position in 2% agarose gel.
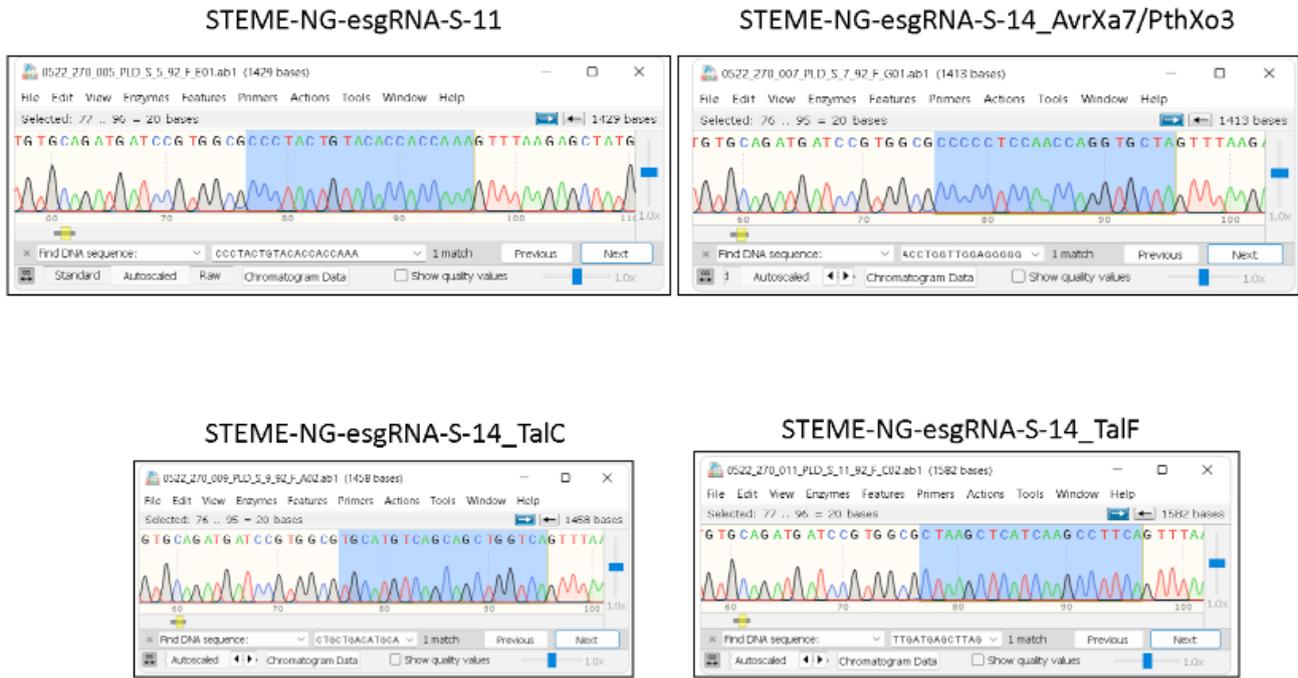
Fig 4.33: Sanger sequencing of positive clones showing intact guides for target modifications under pH-STEME-NG-esgRNA background.
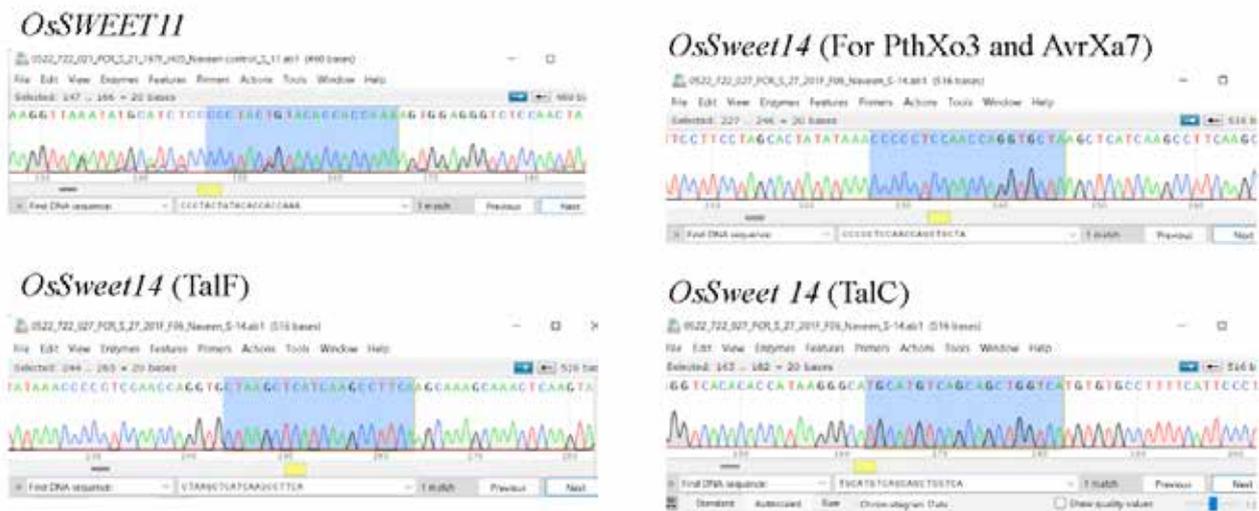
Fig 4.34: Sanger sequencing of different SWEET gene promoter showing sgRNA target sites in bacterial blight susceptible rice variety Naveen.
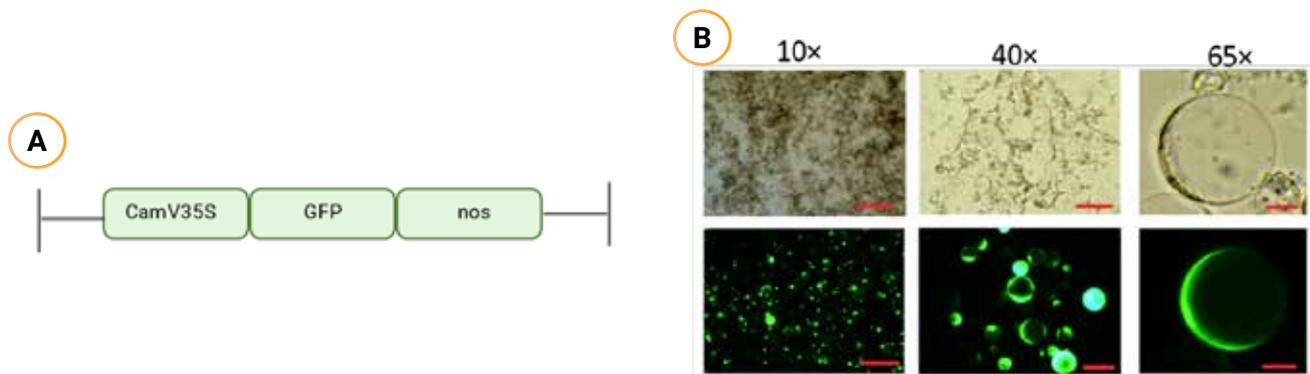
Fig 4.35: Bright field and fluorescence images of transfected protoplast expressing GFP. (A) Schematic showing the construct for GFP expression. (B) After three days of transfection, protoplast was harvested using centrifugation, and GFP fluorescence was visualized under fluorescence microscope.

4.2.6.5 Physical and Mathematical Sciences

In the reporting period, 52 new fellowships were sanctioned. The areas supported under NPDF – Physical and Mathematical Sciences are shown in the following figure.

Areas Supported

Physical and Mathematical Sciences

- Mathematical Sciences
- Plasma Physics, Nonlinear dynamics
- High Energy, Nuclear Physics
- Astronomy & Astrophysics
- Lasers Optics, Atomic & Molecular Physics
- Condensed matter physics/ Material Science
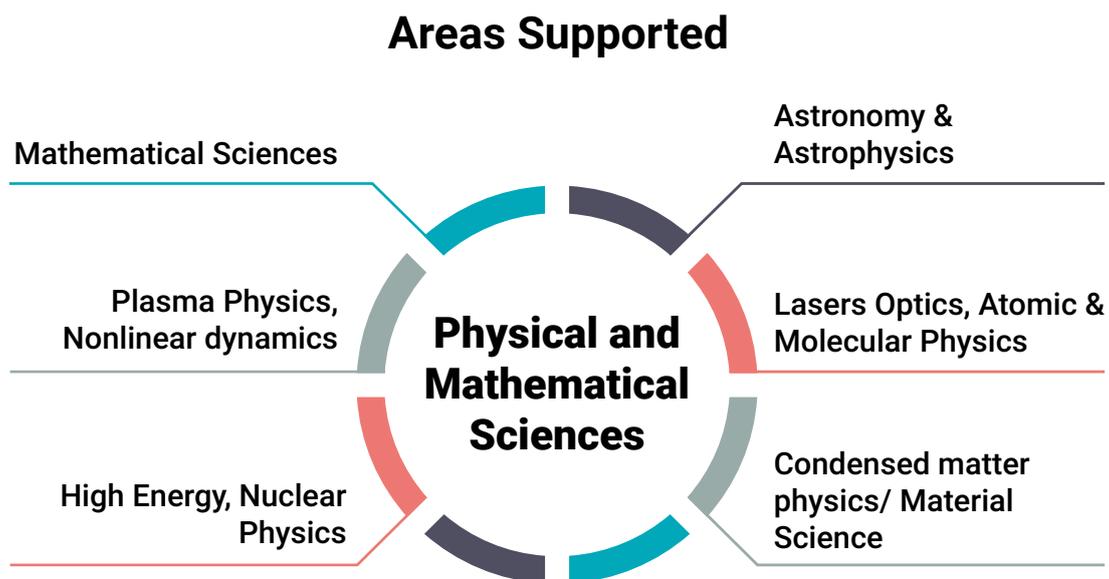
52 Fellowships Sanctioned

Expenditure (New and Ongoing) **8.73 cr**

Research Highlights

Novel phases and phase transitions in spin-S models

The Discovery of novel phases and phase transitions in quantum spin models with S>1/2 was the main objective of the project. The main goal was to determine the nature of the transition and determine the critical exponents of second order and the second closely related objective was to use the same technique to study possible valence-bond loop ordered phases of two-dimensional higher spin magnets. Transitions to such phases may constitute a new universality class of quantum critical phenomena.

A new quantum Monte Carlo (QMC) algorithm was introduced that overcomes a generic limitation of a well-known algorithm widely used to simulate quantum spin and bosonic systems, the stochastic series expansion (SSE) algorithm. SSE is extremely efficient for simulations in the semi-classical magnetic phases but suffers deep inside quantum paramagnetic phases. Algorithms introduced were demonstrated to perform substantially better than SSE in simulating these phases, which are of great interest to the community because of their highly non-classical nature and connections to spin liquid states. This algorithm alleviated the difficulties faced during simulating the phases, namely the HN and VBS phases.

An SU(N) symmetric designer four spin Hamiltonian with a two-column representation was constructed. It was demonstrated that this interaction realizes a novel interesting ground state called the plaquette-VBS (pVBS) phase. For N>9 it was found that the Heisenberg model with a two column representation realized a phase which is a coexistence of the HN and a spin liquid, contradicting a previous work which claimed it to be a pure HN phase. While the HN phase breaks only the rotational symmetry of the square lattice, the pVBS phase breaks only translations. The transition out of this phase into the pVBS phase was studied and found that there is an intermediate phase between the two phases for the lowest temperatures studied. This intermediate phase is an interesting phase that has plaquette ordering at wave vector (pi,pi). This is a novel phase whose nature is still a mystery, and the group is investigating this phase further using a variational wavefunction to minimize the ground state energy of the Hamiltonian in this region.

It was shown that a direct application of the recently developed resummation-based SSE QMC algorithm (mentioned above) provides an ergodic sampling of the QMC configurations for the Heisenberg models on frustrated lattices which can be an issue when using the standard SSE updates, however, severely limited by the sign problem. The notions laid out in these notes may be useful in the design of better algorithms for geometrically frustrated magnets.

A spin-1 Hamiltonian with Heisenberg (JH) and biquadratic (JB) exchanges supplemented further by a Q-term made out of biquadratic terms was studied. For JH = 0, this is equivalent to a SU(3)-symmetric Hamiltonian where deconfined critical behaviour has been found earlier. When Heisenberg exchange is turned on, the symmetry is now reduced to that of SU(2) and it will be interesting in understanding the nature of the Antiferromagnetic-Valence Bond solid transition in the reduced symmetry case of SU(2), S = 1. The possibility of a continuous transition in the presence of JH was investigated.

A numerical technique was introduced to measure the nonlinear response of a 1d spin system using matrix product states (MPS) techniques. The results were benchmarked with an exactly solvable transverse field Ising model (TFIM). This technique can have wide applications to explain experimental responses of various materials, one example being $CoNb_2O_6$. The nonlinear response has been shown to be able to differentiate between homogeneous and non-homogeneous broadening of peaks in linear response, thus giving qualitatively new information. This work was carried out at the Tata Institute of Fundamental Research, Mumbai.

Mathematical modeling of various ecological and epidemiological phenomena: An in-depth study

The main aim was to frame a mathematical model with the help of reaction-diffusion systems which is capable of producing the following scenario as a solution. Suppose, a large two-dimensional domain is considered such that whatever boundary conditions (no-flux or periodic) are chosen, the boundary effect is negligible. Let there be a small region in that considered area where the resource population is present while the remaining part of the domain has zero resource population. Now, within that particular area, in a relatively smaller region, a species population is introduced such that they can feed on the resource, and grow in that area for a considerable amount of time making a peak like structure. This peak is a soliton or standing pulse type structure. Now as the resources decrease considerably with time, the

species population peak ultimately collapses making two or four or six equal parts which move out from that particular region to the remaining area making soliton or pulse type structures. A two-dimensional pulse solution is basically a heap like structure with a peak with maximum population density and boundaries with population density approaching zero. It does not change its shape or size with the evolution of time. If it is a moving pulse solution then the structures do not change shape and size while moving as time evolves. Accordingly, two mathematical models were worked upon.

The single species spatio-temporal model with global con- sumption of resources

The spatio-temporal extension of the single-species population with logistic growth is considered. Global consumption of resource by the species population is considered in the following form,

$$\frac{\partial u(x,y,t)}{\partial t} = d_1 \Delta u + r(x,y,t)u \left(1 + \frac{\alpha}{\kappa}u - \frac{(1+\alpha)}{\kappa}J(u)\right) \qquad (0.1)$$

where

$$J(u) = \frac{1}{L^2} \int_0^L \int_0^L u(x,y,t)dxdy$$

and

$$r(x,y,t) = \left(exp\left(-\int_t (exp(-\beta t)u(x,y,t)dt)\right)\right)$$

on the square spatial domain [0, L] × [0, L] with periodic or no-flux boundary conditions. The global average term $J(u)$ is considered to model the scenario in the population individuals can consume resources from any point in the considered domain and κ is the carrying capacity. Growth rate $r(x, y, t)$ is dependent on both space and time. It is modelled in a way such that as the population grows to the maximum, the growth rate automatically starts decreasing such that the population density also decreases eventually. Parameter β is the measure of dependence on time and the value lies between $0 < \beta < 1$. The term αu is a measure of the advantage to individuals in aggregating or grouping. Aggregation in a community of animals is often interpreted as a defence against predators. Alternatively, it may be used for social reasons, as a means of foraging efficiently, or, in the case of flocks of birds or schools of fish, as a means of travelling advantageously, e.g. travelling together in formation is known to reduce drag. Here $u \equiv (x, y, t)$ denotes the species population density at spatial point (x, y) and time t in the bounded spatial domain. The random movement of the prey and predator populations on the considered spatial domain is taken care of by the Laplacian $\Delta \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ and $d1$ is the diffusion coefficient of the species population. It should be mentioned that,the domain to be large such that the effects of boundary conditions are negligible. The group used either no-flux or periodic boundary conditions.

Two species model formulation

A two species model was considered where, $u(x, y, t)$ denotes pathogen population density and $v(x, y, t)$ denotes immune response of the host population. The spatial domain is considered as the phenotypic space (x, y) where the phenotypic characters are virulence (y: pathogen's or microorganism's ability to cause damage to a host) and evolvability/mutability (x: capacity of a system for adaptive evolution). A few parameters are considered to be space dependent instead of being constants. The main purpose of setting up this model was to check whether the pulse solutions are formed for the two species model and

how to their dynamics change as the parameters become spatially dependent. Depending on this a study can be done on whether the pathogen is prone to showing virulence or does it evolve to a new genotype which actually leads to the coexistence of both the host population as well as the pathogen population. The mathematical model is of the following form:

$$\frac{\partial u}{\partial t} = (d_1 + k(x))\Delta u + \frac{\partial k}{\partial x} \cdot \frac{\partial u}{\partial x} + (\gamma + k_2 y)u(1 - I(u)) - \frac{\alpha u^c v}{b^c + u^c} - (\delta + k_3 xy)u,$$

$$\frac{\partial v}{\partial t} = \xi(x,y) + \frac{\alpha u^c v}{b^c + u^c} - \delta_1 v, \tag{0.2a}$$

$$k(x) = k_1 x, \tag{0.2b}$$

$$\frac{\partial k}{\partial x} = k_1, \tag{0.2c}$$

$$\frac{\partial u}{\partial x} = \frac{u(x + dx, y, t) - u(x - dx, y, t)}{2dx}, \tag{0.2d}$$

$$\xi(x,y) = e_1(sgn(e_2 - rand(200, 200)) + 1)/2. \tag{0.2e}$$

The non-constant parameters are $\gamma(y)$ is a function of virulence which is the intrinsic growth rate of the pathogen population, $d_1(x)$ is a function of mutability and is the diffusivity of the pathogen population, $\delta(x, y)$ is the death rate of the pathogens, a joint function of virulence and mutability. There is an advection term involved $k_1\frac{\partial u}{\partial x}$ The interaction term between the pathogen and host population is given by $\frac{\alpha u^c v}{b^c + u^c}$ where, α, b and c are positive constants. Parameter δ_1 is the rate at which the immune responses are dying. It was consider a noise term ξ(x, y) for the immune response since they generate randomly in the phenotypic space. The global interaction term was involved to take care of the fact that the quality and quantity of genotypes are fixed. The pulse formations are seen and also solutions driven towards higher virulence and higher mutability depending on the choice of parameters. This work was carried out at the Institute of Mathematical Sciences, Chennai.

4.2.7 Prime Minister's Fellowship Programme for Doctoral Research

This scheme is aimed at encouraging young, talented, enthusiastic, and result-oriented scholars to take up industry-relevant research. Under this scheme, full-time PhD scholars get double the JRF/SRF as a scholarship. While one-half of this scholarship comes from the government, the second half comes from a partner company which also works closely with the candidate on the research project. It is a prestigious fellowship initiated by SERB towards the advancement of university research in line with the industry. The first batch commenced in 2013. The scheme is being implemented in partnership with CII and FICCI.

FEATURES

Support for full-time Ph.D. scholars for carrying out industry-relevant research

The scheme has the provision to award up to 100 new scholarships every year

Scholarship is given for a maximum period of four years, 50 per cent of which comes from SERB and 50 per cent from the partner company

Website links https://serb.gov.in/page/english/research_networking#Prime%20 Minister%E2%80%99s%20Fellowship%20for%20Doctoral%20Research

Research Highlight

Haptic and VR based laparoscopic training simulator

Force is one of the important factors for tissue damage in Laparoscopic surgery. Most of the existing laparoscopic VR simulators provide no or less accurate force feedback and are expensive. A cost-effective laparoscopic VR simulator with haptic feedback has been developed (Figure 4.36) at Indian Institute of Technology Madras, Chennai. The developed haptic device has ten degrees of freedom motion sensing and force feedback and its end effectors were modified to attach the real laparoscopic instrument handles. A haptic controller board with USB communication has been developed to implement the haptic control loop, where the end effector position and joint torque are estimated in real-time. Eight Laparoscopic surgical part tasks have been simulated in the VR, rendering continuous interaction force to the user. A custom VR haptic plugin was developed to interface the device and the haptic library with the simulation. Various assessment metrics such as time, tool movements, applied force, interactions, etc have been implemented to evaluate surgeon performance in real-time. The simulator has been validated through face and content validity.

Expenditure (Ongoing)

9.50 cr
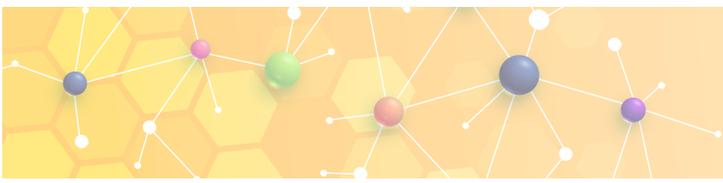
To improve the realism of interaction force, the force model of the LI (Laparoscopic Instrument) tooltip has been implemented in the simulation and studied through a psychophysical gripper force matching task. It was observed that there was a reduction in the JND (Just Noticeable Difference) at middle force values when the tip force model was added to the simulation. The Cholecystectomy surgical procedure has been simulated in the VR and interfaced with the haptic device for force feedback. The Position Based Dynamics (PBD) algorithm and the haptic library have been extended to simulate the soft body mechanism and tool interactions. A Fitts's law experiment has been conducted and it showed a possible correlation between the movement time and the inverted movement of the laparoscopic tool.
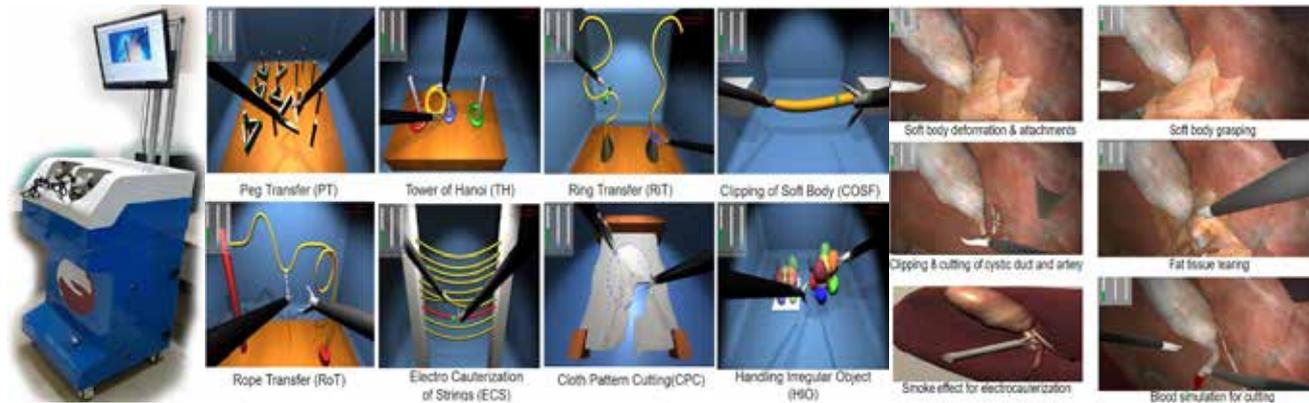
Fig 4.36: Haptic simulator for Laparoscopic surgical training; Force part tasks simulated in VR with haptic feedback; Simulated Cholecystectomy procedure with haptic tool interactions.

4.3 Recognition for Women

4.3.1 SERB POWER Fellowship

POWER Fellowship Scheme aims to identify and reward outstanding women researchers and innovators working in Indian academic institutions and R&D laboratories, in any branch of Science and Engineering. POWER Fellowship is a one-time award for women researchers between 35-55 years of age. The scheme was initiated in 2020-21 and the first call was made in November 2020 to identify and reward outstanding women researchers and innovators working in Science and Technology. A total of 22 POWER Fellowships were recommended out of which 9 fellowships have been sanctioned in the reporting period. Research Highlights of some of the proposed work that is supported are given below:

FEATURES

Fellowship for women researchers in regular service in academic and research institutions

Support consists of Fellowship of Rs. 15,000 per month in addition to regular income, research grant of Rs. 10 lakh per annum along with 90,000 Overheads for host institute

Fellowship duration is three years

Website link: https://serb.gov.in/page/english/awards_fellowship#SERB%20POWER%20Fellowship

9
Fellowships Sanctioned

Expenditure
(New and Ongoing)

4.51 cr

Research Highlights

Morphological perspectives to quantify and mitigate liquefaction in sands

The individual effects of grain size and shape on the pre-liquefaction, liquefaction, and post-liquefaction shearing behaviour of granular ensembles were investigated through a series of multi-stage constant volume simple shear tests. Three different granular materials (glass ballotini, river sand, and manufactured sand) of three different sizes (fine, medium, and coarse) with distinct shape descriptors without fines were chosen for the study. Hence, a total of nine different granular ensembles, namely, rounded fine (RF), rounded medium (RM), rounded coarse (RC), subrounded fine (SF), subrounded medium (SM), subrounded coarse (SC), angular fine (AF), angular medium (AM), and angular coarse (AC) ensembles were tested. Shape parameters of the granular materials including roundness, sphericity, regularity, and angularity and their grain level kinematic behavior were determined from the microscopic images using image analysis algorithms. Experiments were carried out on reconstituted specimens prepared at a relative density of 30% and the results are interpreted in the light of critical state framework. Undrained monotonic shear tests showed that assemblies with similar grain shapes have reached a unique critical state line (CSL) and exhibited a unique phase transformation line (PTL), irrespective of the grain size. However, assemblies with different grain shapes reached different CSLs and exhibited different PTLs. Irrespective of grain shape, an increase in grain size increased the liquefaction resistance because of an increase in the tendency for dilation. An increase in the particle angularity and irregularity increases the liquefaction resistance due to an increase in interlocking tendency at grain contacts. Grain size and shape significantly affect the post-liquefaction shear strength of the granular assemblies. Figure 4.37(a,b&c) shows the cyclic liquefaction resistance curves for all nine tested materials, where the cyclic stress ratio is plotted against the number of cycles needed for liquefaction. Irrespective of the shape and size of the grains and their source of origin, the results of liquefaction tests are following well-established regression models. The liquefaction model coefficients for sands of different morphology are quantified, as shown in Figure 4.37. The computed residual excess pore pressure plotted against the normalized cycle number shown in Figure 4.38(a-e) exhibited a reverse S shape, the shape of which is quantified for sands of different morphologies through the cyclic simple shear tests.
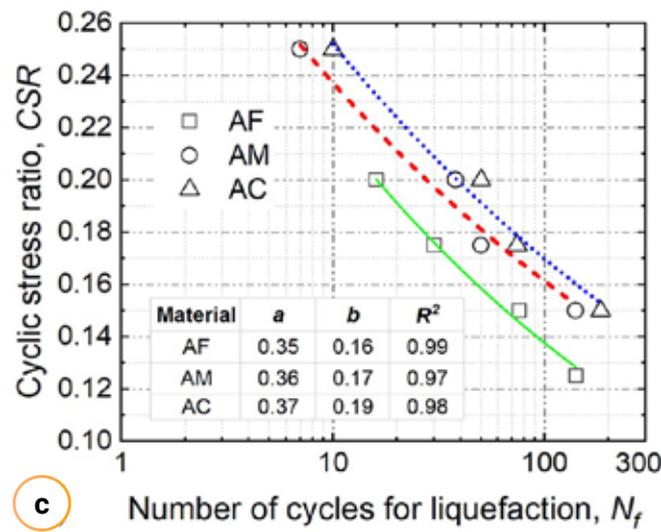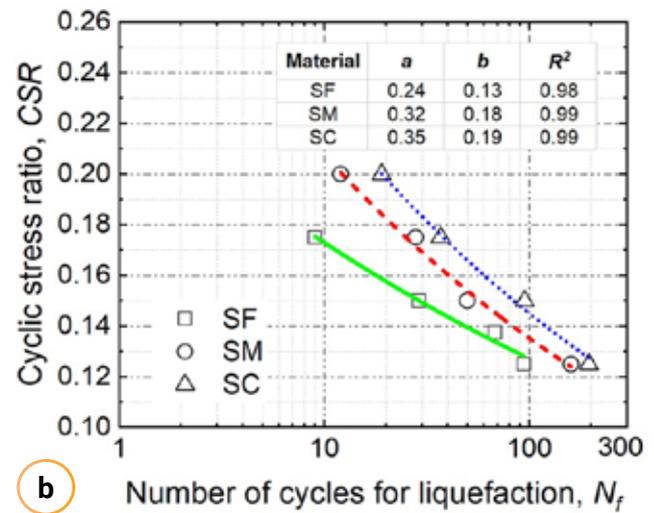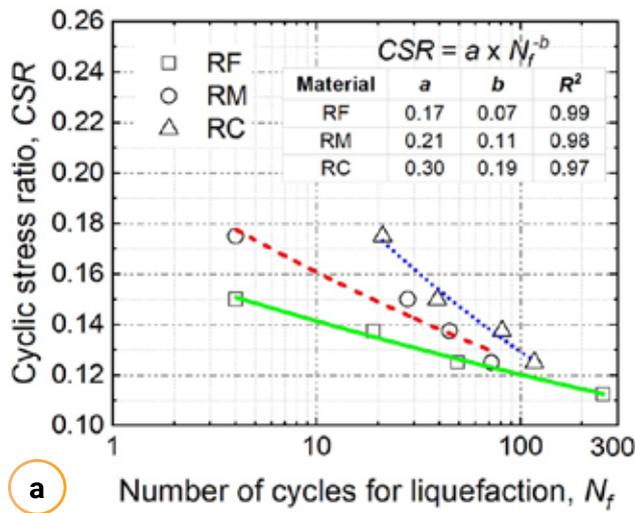
Fig 4.37: Liquefaction resistance curves for the tested materials: **(a)** rounded particles, **(b)** sub-rounded particles, and **(c)** angular particles.
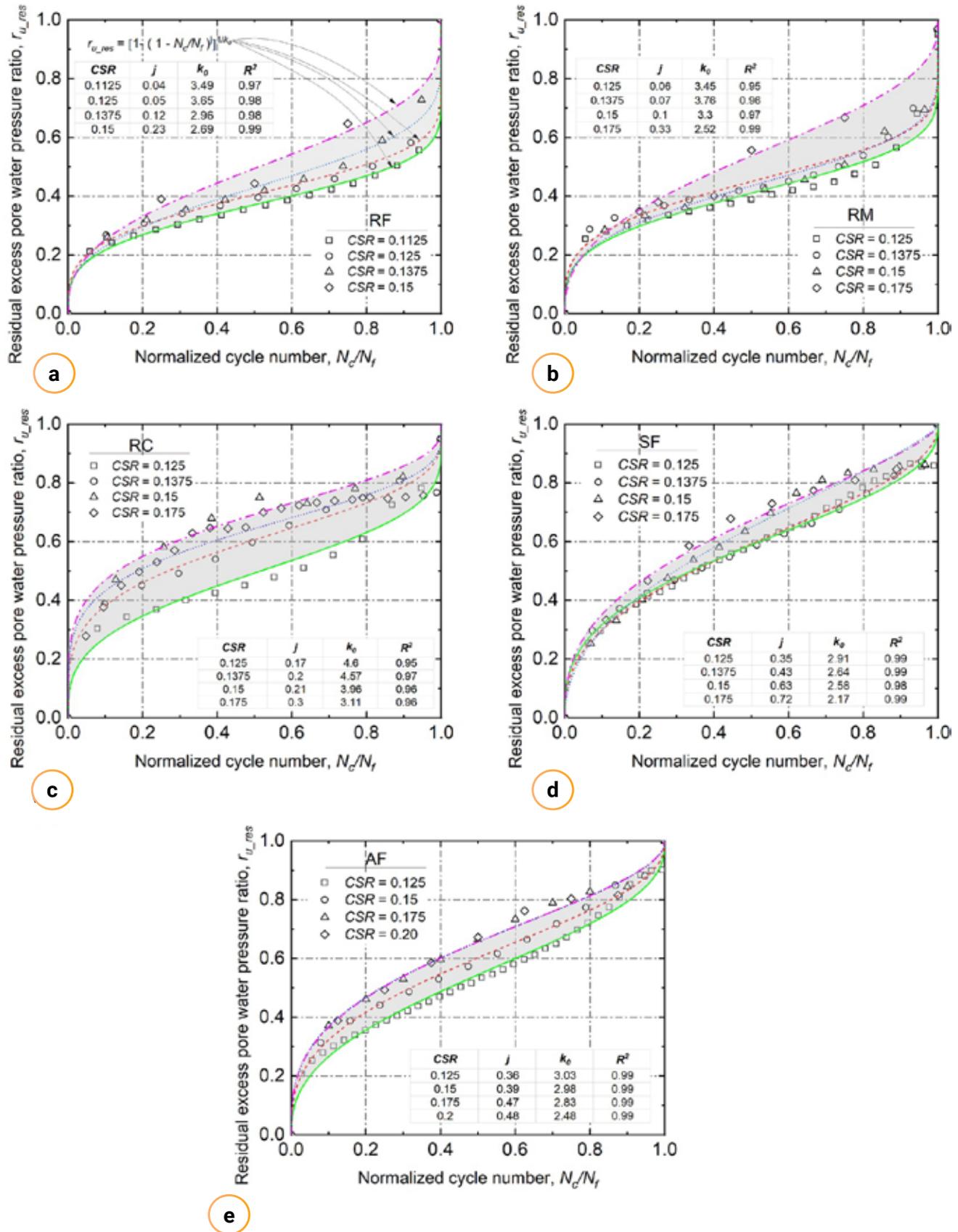
Fig 4.38: Residual excess pore water pressure development in granular ensembles with varying CSR values **(a)** RF specimens, **(b)** RM specimens**, (c)** RC specimens, **(d)** SF specimens, and **(e)** AF specimens.

Further, the efficacy of various sustainable alternatives for mitigating liquefaction in sands, including the use of polymeric geotextiles, geofoam, coir fibers, and encased granular columns, and compares their performance. For this, a series of constant volume cyclic simple shear tests were performed on sand in its natural condition and after modification with different sustainable techniques. Loading intensity is varied to simulate different seismic scenarios. Results are interpreted in terms of pore pressures, shear strains, energy dissipation, and modulus degradation, and the efficacy of these techniques for liquefaction mitigation is quantified. Findings from this study have direct relevance for capacity building against earthquakes through different sustainable methods. All the sustainable mitigation techniques considered in this study were able to improve the performance of sand against liquefaction. However, their efficacies were found to be different. Currently, some new innovative liquefaction techniques in the form of 3D printed geocells and geofoam tubes are being investigated. Guidelines are being worked out for the selection of a suitable method for the desired improvement in the response. This work was done at the Indian Institute of Science, Bengaluru.

Engineering mechanistically rational peptide based immuno combination therapy for managing metastasis and drug resistant breast cancer

The research group designed and synthesized peptides targeting CD47 and its protease-stable variant to block the interaction of CD47 and SIRPα protein. To establish the efficacy of CD47 binding peptides the team performed a phagocytosis assay in co-culture of macrophage (RAW 264.7) and mouse breast cancer (4T1) cells. Macrophage RAW 264.7 cells are labelled with FITC-anti-CD11b antibody and 4T1 cancer cells are labelled with CM-Dil dye(Figure 4.39(a&b)). Upon treatment, it is found that cancer cell debris (red) was observed inside the macrophages (green) giving a co-localized fluorescence (yellow) in the peptide treated groups. Whereas, in vehicle, no cancer cell debris was observed inside the macrophages. Thus, the group concluded that the designed peptides are promoting the phagocytosis of cancer cells by macrophages. Quantification by flow cytometry further revealed that peptide treatment led to 1.7 times more phagocytosis of the cancer cell population compared to the vehicle Figure 4.40(a-d). The group also designed a bispecific peptide targeting both CD47 and SIRPα proteins and validated it through computational studies (docking and MD simulation). This work was done at the Indian Institute of Science Education and Research (IISER), Kolkata

a In-vitro study - Phagocytosis assay with CD47 binding peptides and its variant
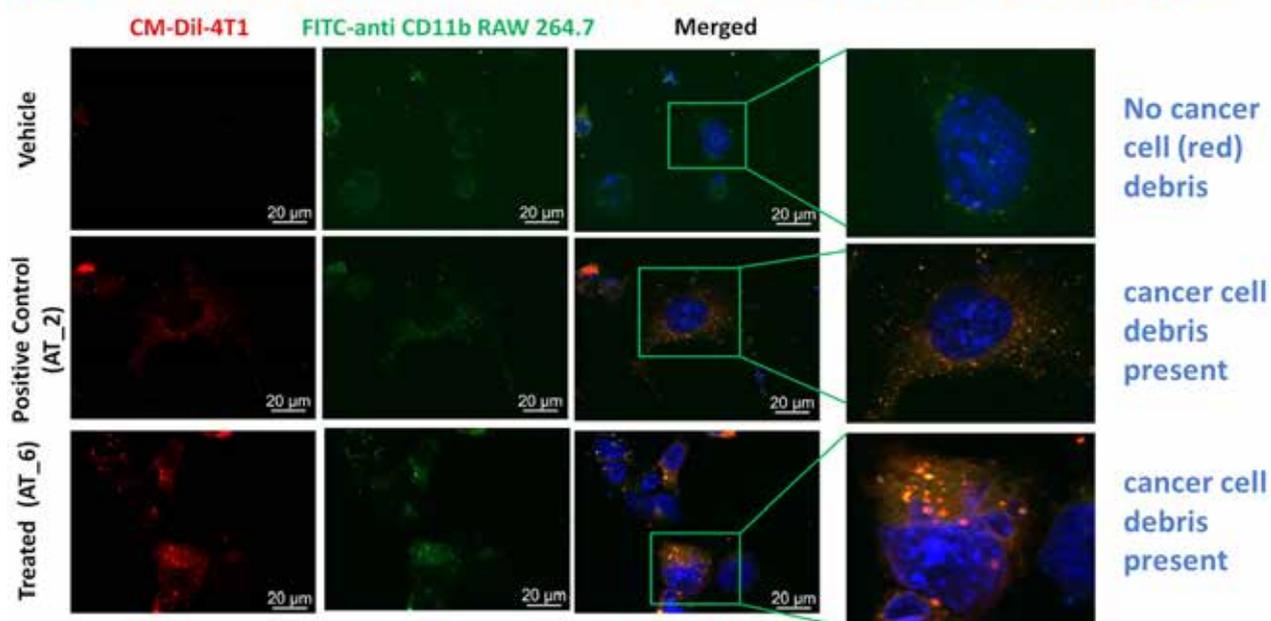
b) Quantification of phagocytozed cancer cells by macrophages
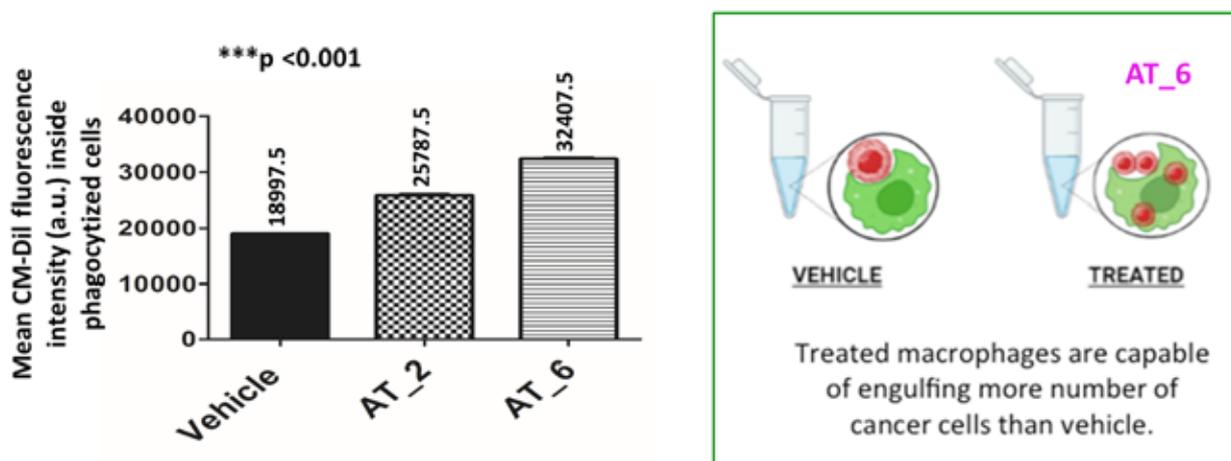
Fig 4.39: *In-vitro* phagocytosis assay of the designed CD47 binding peptide and its protease stable variant. **(a)** Cancer cell debris (red) was observed inside the macrophages (green) giving a co-localized fluorescence (yellow) in the peptide treated groups. Whereas, in vehicle, no cancer cell debris was observed inside the macrophages. **(b)** Flow cytometry-based quantification of phagocytosis. Peptide AT_6 treatment led to 1.7 times more phagocytosis of cancer cell population compared to vehicle.
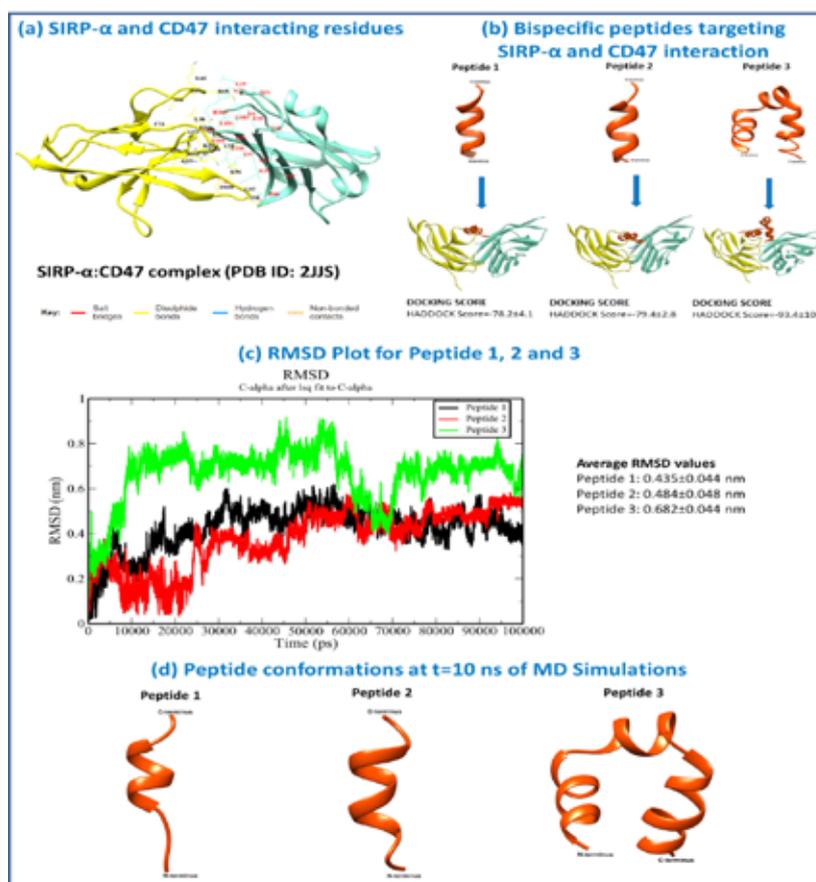
Fig 4.40: Computational studies for designing and validating bispecific peptides. **(a)** Interacting residues of SIRPα and CD47 protein from CD47-SIRPα complex (PDB ID : 2JJS). **(b)** Docking of the designed bispecific peptides with CD47-SIRPα complex was performed using HADDOCK. All the three peptides are predicted to have helical structures. From our computational studies we can rank these three peptides in descending order of their binding affinity to the SIRPα-CD47 complex as follows: Peptide 3> Peptide 2 > Peptide 1. **(c)** The root mean square deviation (RMSD) plot for Peptide 1, Peptide 2 and Peptide 3. RMSD plot of the Cα atoms gives an overview of the conformational changes in the peptide with respect to the initial structure. The order of stability of peptides in terms of RMSD values can be represented as Peptide 1> Peptide 2 > Peptide 3. **(d)** Peptide conformation at t=10 ns of MD simulation.

4.4 Enabling Innovation and Technology Development

4.4.1 SERB Technology Translation Award (SERB-TETRA)

SERB-TETRA (Technology Translation Award) is a scheme for catalysing technology translation in academic setting. SERB-TETRA will challenge scientists executing SERB grants, such as CRG, to establish an effective, functional and synergistic working collaboration with an industry partner to elevate their breakthrough results and technologies to TRL level 5 and beyond. It is envisaged that a well-defined strategy to augment research innovation, via technology incubators, will add value to the CRG and other funding mechanisms supported by SERB. .

FEATURES

Funding support to kickstart new venture processes

The funding will be provided normally for a period of two years

The award will entail an unstructured budget up to 15 Lakh per year

Website link: https://serb.gov.in/page/english/awards_fellowship#SERB%20 Technology%20Translation%20Award%20(SERB-TETRA)

1
Fellowship Sanctioned

Expenditure
(New and Ongoing)

1.13 cr

Research Highlights

Exoskeleton device for upper limb rehabilitation

A series of Virtual Reality (VR) tasks have been developed in Vizard (python-based software) and integrated with a Logitech joystick and was tested on 40 healthy subjects (n=40) and two patients with stroke (n=2) for a 90-minute session to identify the objective key performance parameters for wrist and fingers movements. The joystick motions are useful for executing and learning the most useful functional movements required for independently performing activities of daily living. The VR tasks were optimized according to the feedback of healthy-subjects and an intervention protocol was established.

To evaluate the rehabilitation impact of the developed novel VR tasks, a case report was performed on twenty sessions of 45 min each given to a 50-year-old male patient with chronic (13-month) stroke (n=1). Clinical scales, cortical-excitability measures, functional MRI (fMRI), and Diffusion Tensor Imaging (DTI) data were acquired pre-and post-therapy to evaluate the motor recovery. Increase in Fugl-Meyer Assessment (wrist/hand) by 2 units, Barthel Index by 5 units, Brunnstrom Stage by 1 unit, Addenbrooke's Cognitive Examination by 3 units, Wrist Active Range of Motion by 5⁰ and decrease in Modified Ashworth Scale by 1 unit were observed. Ipsilesional Motor Evoked Potential (MEP) amplitude (obtained using Transcranial Magnetic Stimulation) was increased by 60.9µV with a decrease in Resting Motor Threshold (RMT) by 7%, and contralesional MEP amplitude was increased by 56.2µV with a decrease in RMT by 7%. The fMRI-derived Laterality Index of the Sensorimotor Cortex increased in precentral-gyrus (from 0.28 to 0.33) and in postcentral-gyrus (from 0.07 to 0.3) (Figure 4.41). The DTI-derived FA-asymmetry decreased in precentral-gyrus (from 0.029 to 0.024) and in post central gyrus (from 0.027 to 0.017) (Figure 4. 42). Relative reductions in task-specific performance metrics, i.e., time taken to complete the task (31.6%), smoothness of trajectory (76.7%), and relative percentage error (80.7%), were observed from day 1 to day 20 of the VR therapy (Figure 4.43(a-d)). VR therapy resulted in improvement in clinical outcomes in a patient with chronic stroke.

Once the clinical effect of VR tasks was observed, the form factor was reduced by employing a Raspberry Pie for processing and a small screen for the VR task to avoid the use of a computer, resulting in a more compact and low-cost solution. VR tasks were integrated with the EMG triggered exoskeleton for the intervention and given to two patients with stroke for 45 minutes for twenty sessions with pre and post-therapy design. Clinical scales, cortical-excitability measures, functional MRI (fMRI), and Diffusion Tensor Imaging (DTI) data were acquired pre-and post-therapy to evaluate the motor recovery. An increase in Fugl-Meyer Assessment (wrist/hand), Barthel Index, Brunnstrom Stage, Addenbrooke's Cognitive Examination, Wrist Active Range of Motion and a decrease in Modified Ashworth Scale were observed. Dose matched physiotherapy was given to 2 patients in the control group. This work was carried out at the Indian Institution of Technology, Delhi.
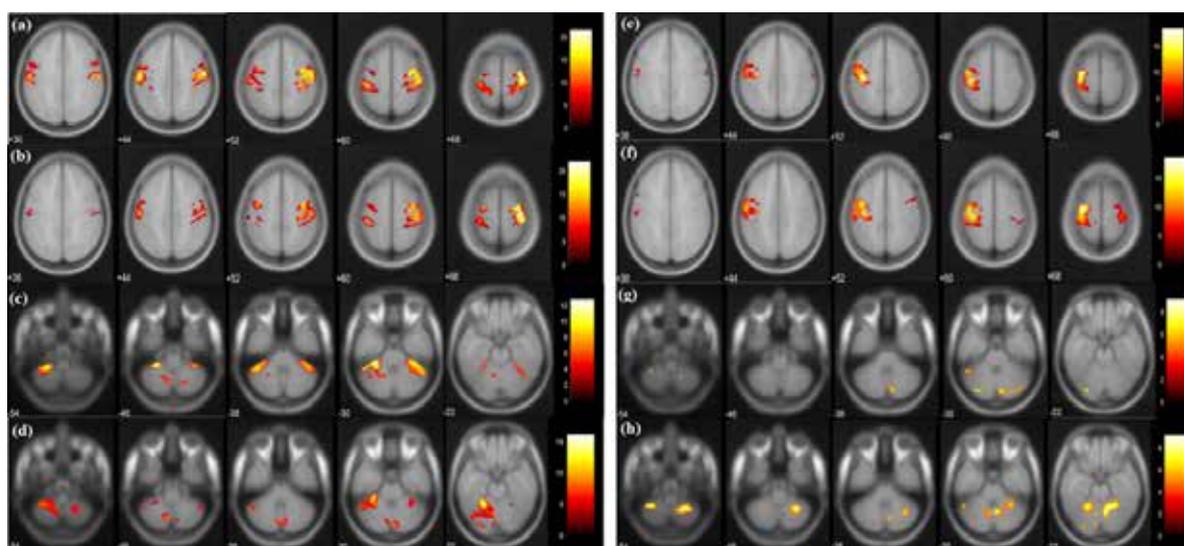
Fig 4.41: BOLD functional MR images for wrist extension task of 1 patient with voxel level threshold p < 0.05 (FWE corrected) and cluster level threshold of 5 voxels. Talairach-client was used to correlate MNI coordinates with gray and white matter. (a,c) pre-therapy activations and (b,d) post-therapy activations during affected hand trial; (e,f) pre-therapy activations and (f,h) post-therapy activations during unaffected hand trial for the masked regions of sensorimotor cortex (36:8:72 slices) and cerebellum (−54:8:−22 slices).
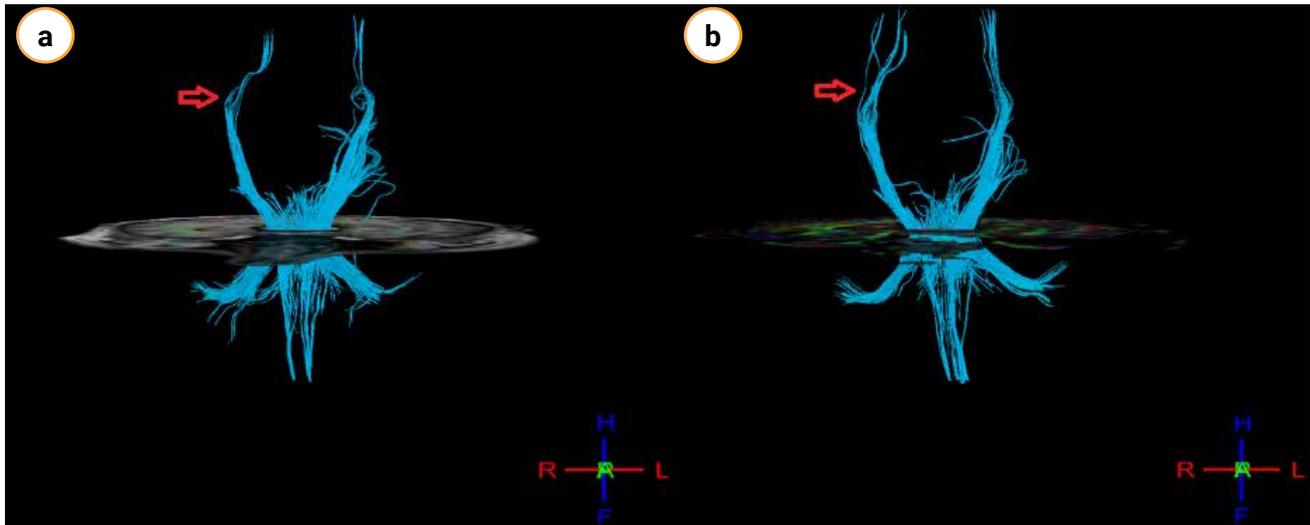
Fig 4.42: 3D tractography images of CST of both hemispheres (a) pre- and (b) post-therapy. Post-therapy image of affected (right) hemisphere indicating denser and more intact tracts as compared to pre-therapy
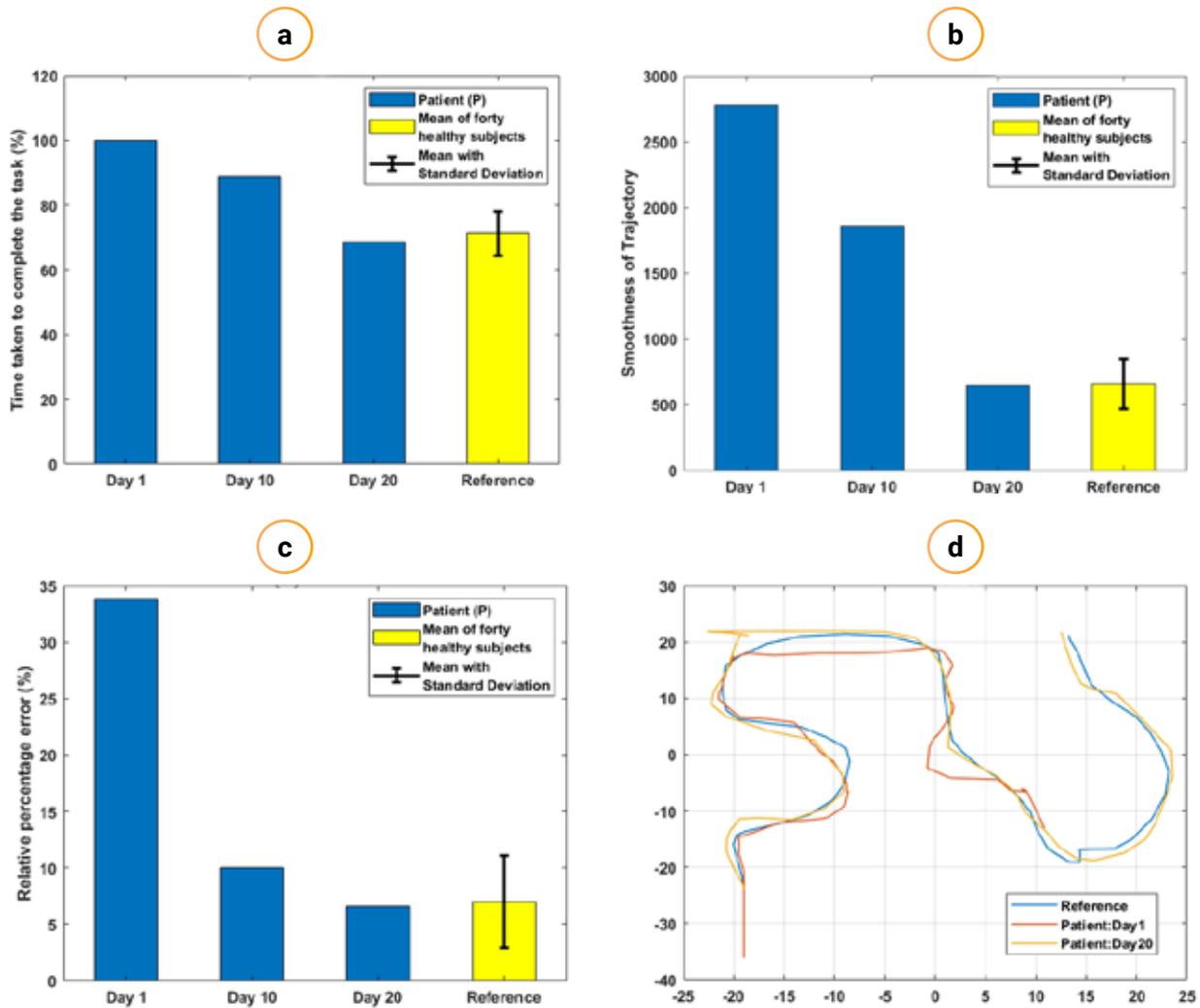
Fig 4.43: Variation in quantitative task-specific performance metrics: **(a)** TCT, **(b)** smoothness of trajectory, and **(c)** relative % error obtained from the patient (P) at day 1, 10, and 20 of VR therapy. A relative decrease in TCT, smoothness of trajectory, and relative % error values was observed from day 1 to day 20. The reference values shown were obtained from the average performance metrics of 40 healthy subjects in our earlier work. **(d)** shows qualitative trajectory plots for day 1 and 20 obtained from P. At day 1, the trajectory of P was incomplete; it became identical with that of a representative healthy subject (obtained from our previous work) on day 20.
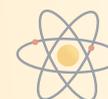
Synthesis of Fmoc protected morpholino monomers and their use in the synthesis of morpholino oligomer

Phosphorodiamidate Morpholino oligonucleotide (PMO) is an important molecule because it is used for the manufacturing of four FDA approved drugs called eteplirsen, golodirsen, viltolarsen, and casimersen for the treatment of Duchenne muscular dystrophy (DMD). At this moment, there is no suitable protocol for the synthesis of PMO and its drug. The group worked on the synthesis of PMO and evaluation of its biological properties. In order to screen the PMO for biological applications, number of sequences are required for finding out the lead sequence for drug discovery research. It was necessary to develop a protocol for making PMO by automated oligo synthesizer which has been achieved. The protocol developed successfully to make as long as 30-mer eteplirsen drug. The method has been explored for the synthesis of Phosphorodiamidate Piperidino Oligomers (PPOs). PPOs are hydrolytically more stable and more lipophilic than PMOs, considered to have better biological activity than PMO (Figure 4.44).
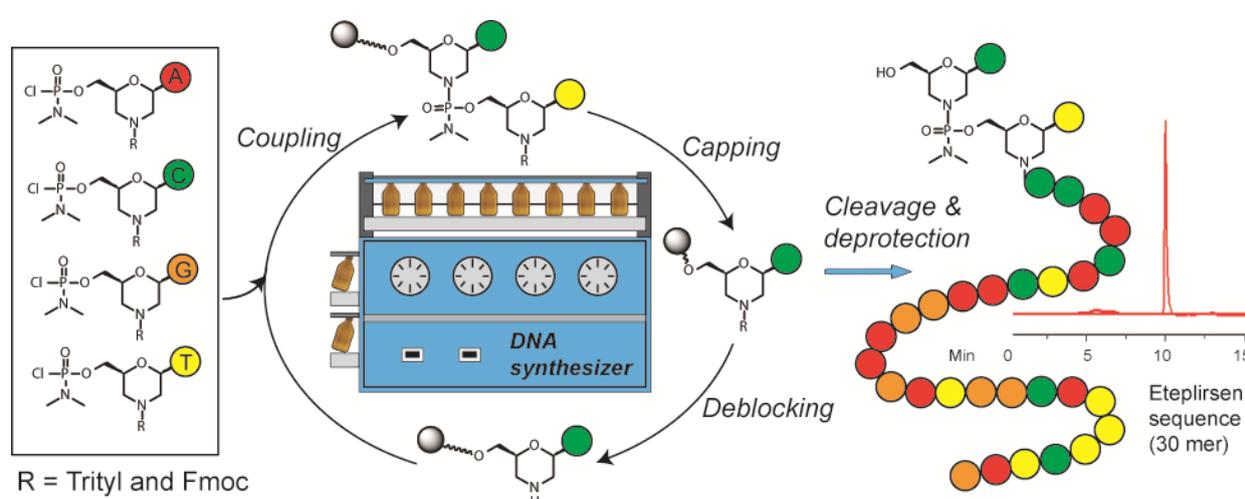
Fig 4.44: Synthesis of Phosphorodiamidate Morpholino Oligonucleotides Using Trityl and Fmoc Chemistry in an Automated Oligo Synthesizer.

(a) Phosphorodiamidate morpholino oligonucleotides (PMO) constitute four FDA-approved drugs. However, PMO synthesis has remained challenging for a variety of reasons: inefficient deprotection, coupling methods and instability of monomers. The Study developed a suitable combination of resin supports and reaction conditions for synthesizing PMO using either trityl or Fmoc-protected chlorophosphoramidate monomers. Synthesized PMOs have been validated for gene silencing in the zebrafish model in IISER Pune. The protocol was successfully transferred into automated DNA-synthesizer to make several PMO sequences, demonstrating the first-time adaptation of regular PMOs in commercial DNA-synthesizer. Moreover, PMOs with longer than 20-mer sequences, including FDA-approved Eteplirsen (30-mer) were achieved in 20-22 % overall yields that is superior to previous reports. Hybridization study shows that PMO/DNA duplex is more stable than DNA/DNA duplex. Additionally, the introduction of Fmoc chemistry into PMOs opens up the possibility for PMO synthesis in commercial peptide synthesizers for future development. (b) Further extension of the protocol gave Phosphorodiamidate Piperidino Oligomer (PPO) where the morpholino ring was replaced by piperidine ring. A PMO containing piperidino residues formed duplexes with both DNA and RNA. PPO had higher stability at endosomolytic pH than PMO. It was the collaboration with Alnylam Pharmaceuticals, Boston where piperidino monomers were supplied by them. Monomers were then converted to active monomers followed by the synthesis of PPOs. (c) At the same time C5-Pyrimidine-Functionalized Morpholino Oligonucleotides was synthesized and evaluated their biophysical studies. (d) The study also synthesized G-clamp PMO and multi-Guanidinium containing cell-permeable morpholino oligonucleotides. Later was synthesized using Fmoc-chemistry and evaluated their cell transfection properties (Manuscript attached in annexure I & II). (e) For biological validation, PMO sequence targeting AUF-1 gene in mouse was synthesized which showed desired gene silencing results in mice model. (f) After standardizing of 1 μmol 25-mer PMO (10 mg, mol wt. ~ 10000) synthesis in machine, the group now working on the synthesis of a DMD drug called casimersen in 15 μmol scale (~ 150 mg). As casimersen is attached with a linker X at the 5'-end (5'-X-CAA TGC CAT CCT GGA GTT CCT G-3'), hence, the drug was made by keeping all the atoms same and obtained in 70% HPLC purity with 49% yield as per trityl assay (vide infra). This work was done at Indian Association for the Cultivation of Science, Kolkata.

5

SYNERGETIC PROGRAMMES

Synergetic programmes are meant for cooperative action to create a globally competitive research environment in the country. To strengthen the research in the country, a number of Intra and International partnership programmes in collaboration with other Ministries, Departments and Industries have been implemented by SERB. This synergistic approach is a set of core principles within a conceptual framework which may connect the need with the expertise to enable groundbreaking research and lead to the solution of complex problems. Outreach activities and SERB connect with researchers and a robust ePPMS platform is enormously helpful to cater for the needs and linkages of the research fraternity.

The two partnership programmes, Impacting Research, Innovation and Technology (IMPRINT)

and the Uchhatar Avishkar Yojana (UAY) are being implemented jointly with the Ministry of Education (previously Ministry of Human Resource Development) are ongoing in SERB.

For building national capacity in frontier areas of Science and Engineering in the country SERB provides research opportunities such as Overseas Visiting Doctoral Fellowships for young researchers and VAJRA Faculty Scheme to attract the expertise of overseas scientists as visiting faculty to undertake high-quality collaborative research in public funded academic and research institutions in India. Recently SERB has started a new program SERB-International Research Exposure (SIRE) to impart high-end research training in frontier areas of Science and Technology for young scientists.

5.1 National Partnership Programmes

5.1.1 Impacting Research Innovation and Technology (IMPRINT II)

IMPacting Research INnovation and Technology (IMPRINT) was launched in 2015 with a view to promoting innovation of a higher order that directly impacts the needs of the industry and thereby improves the competitive edge of Indian manufacturing.

The Scheme promotes technology development where DST, and MoE (steered by SERB) have equal sharing support.

IMPRINT II Scheme funded projects which were capable of translating research knowledge into viable technology with the collaboration of academia and

industry under 10 broad technology domains (1) Environment and Climate, (2) Energy Security, (3) Health care Technology, (4) Sustainable Habitat, (5) Water Resources, (6) Advanced materials, (7) Information & Communication Technology, (8) Manufacturing Technology, (9) Nano Technology and (10) Security & Defense. In this program, a total of 176 projects under IMPRINT II A&B and IIC.1 were sanctioned. In the F.Y 2022-23, 08 new projects under Imprint IIC.2 are recommended out of which 3 projects have been sanctioned.

FEATURES

Joint initiative by MoE and DST which is being implemented by SERB

Principal objective is to translate knowledge into viable technology

Industry Support is mandatory
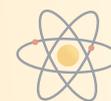
Website link: https://serb.gov.in/page/english/research_networking#Impacting%20Research%20Innovation%20and%20Technology%20(IMPRINT%20%E2%80%93%20II)

Areas Supported

Environmental Science and Climate change

Sustainable Habitat

Advanced materials

Energy Security

IMPRINT-II

Nano Technology hardware

Healthcare Technology

Security and Defence

Information and Communication Technology

Water resources and river systems

Manufacturing Technology
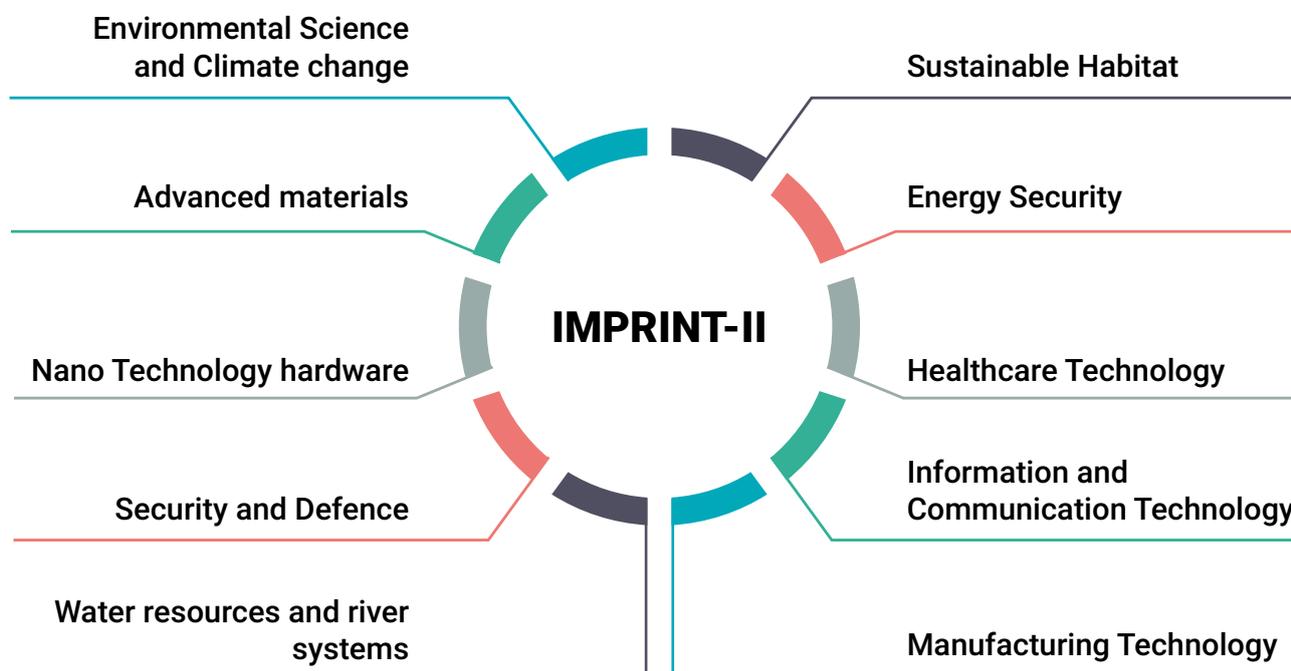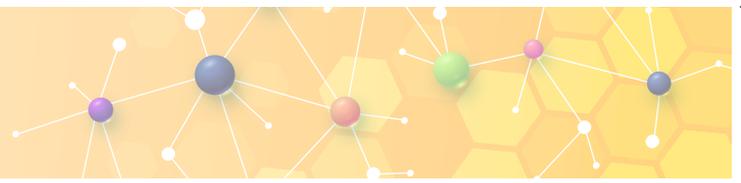
Research Highlights

Design and development of textile-based metamaterial absorber for RADAR Stealth

Under the domain "Security and Defence" an innovation is made, and the main objective of the project was to design and develop novel textile-based metamaterial absorbers, which can be worn by soldiers (integrated into bullet-proof jackets, and helmets) or can be wrapped around army vehicles/tanks, for RADAR Stealth.

The Broadband textile-based metamaterial absorber for C, X and Ku Band (6 to 18 GHz) with 80% absorptivity and 8 to 18 GHz with 90% absorptivity have been designed and fabricated (Figure 5.1). Here the metamaterial resistive ink patterns have been printed on optically camouflage cloth. The pattern is printed on the back side of the cloth, whereas on the front side, the optical pattern remains undisturbed and there was no deterioration of optical camouflage performance (Figure 5.2). The developed sample was lightweight and flexible, and it can be conformed on any regular and irregular surface. Field trials of the absorber were carried out in the open area at Jaisalmer. For this test absorber tiles were joined together to form a Gypsy cover. The total area of the cover was approximately 30 m^2 (Figure 5.3). The field test shows promising results for the developed absorber as there was a reduction of about 28% in the radar detection range. To further improve the absorber for practical applications specifically where ventilation is required, a lightweight perforated TWC based absorber was realized for 6.61 to 17.91 GHz. For the ruggedization of the sample adhesion test, coating the sample with PDMS and packaging the absorber was carried out such that the absorber maintains its response in adverse environmental conditions. The sample was also tested for various environments such as at high temperatures, below-freezing temperatures, humid conditions and underwater. It has been observed that the response of the absorber does not change significantly under various environmental conditions. M/s Raksha Supreme Camouflage Pvt. Ltd. has manufactured large area textile-based absorbers (220 square meters) for covering the big-armed vehicle. The sample of the industry has been tested by IIT Kanpur. The process of commercialization of this product is ongoing. Soon the technology would be transferred officially to the industry partner. The work was carried out at the Indian Institute of Technology, Kanpur.

3
Projects Sanctioned

Expenditure
(New and Ongoing)

8.97cr
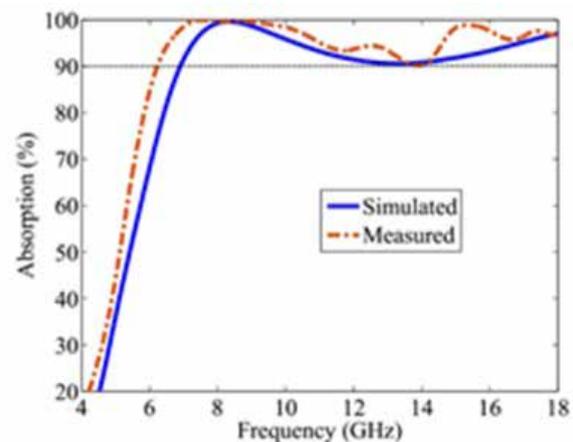
Fig 5.1: A fabricated sample of Textile based Metamaterial absorber and its measured response.
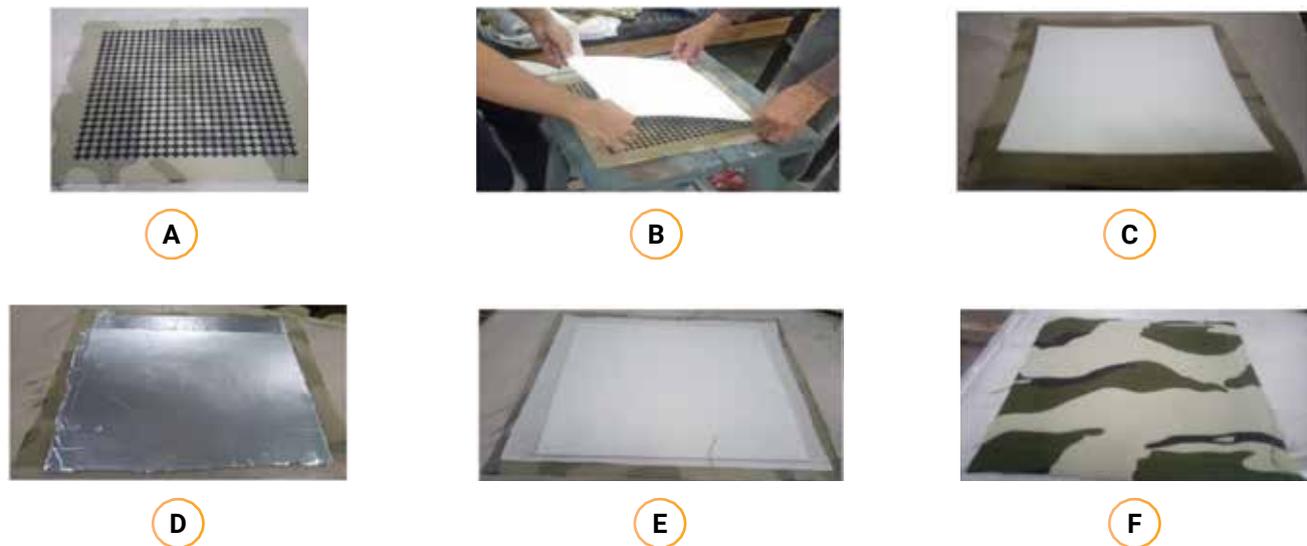
Fig 5.2: (A-F) Steps showing integration of textile metamaterial absorber on optically camouflage cloth.

Fig 5.3: Test vehicle covered with textile-based metamaterial absorber and reference vehicle. The Vehicle window is covered with an optically transparent absorber.

Cultural heritage preservation and restoration using digital 3D Models

Under the domain "Information and Communication Technology" a project was supported with the aim to preserve Indian cultural heritage sites and artefacts digitally by estimating their accurate geometry, surface, texture, etc. Point cloud generation of a scene is a primary step in 3D scene modelling and understanding.

The research work was carried out to detect the 3D global reflection symmetry of a 3D object represented as a point cloud. A descriptor-free approach was adopted, in which the problem of reflection symmetry detection as an optimization problem was addressed.

3D Repository is prepared for Digitally Preserved Models by scanning of artefacts in Archaeology Site Museum, Lothal - 19 artefacts scanned using a structured light-based 3D scanner. Large Scale Scanning at Dwarka & Dholavira: Terrestrial Laser Scanner used to generate large scale 3D models of the following locations: 2 Temples, SwamiNarayan and SamudraNarayan, Dwarka. Water Reservoir, Northern gate and Southern gate of Archaeological
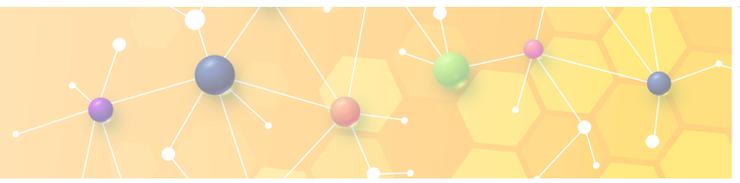
Site, Dholavira. 3D repository for digitally preserved scans and will be made publicly available soon.

The tree graph convolution idea was used to come up with an efficient point cloud encoder-decoder model (TreeGCN-ED). A trained decoder for the single-view image reconstruction problem has been used. The proposed model TreeGCN-ED shows significant improvement over previously proposed methods and reconstructs more accurate 3D shapes (Figure 5.4).
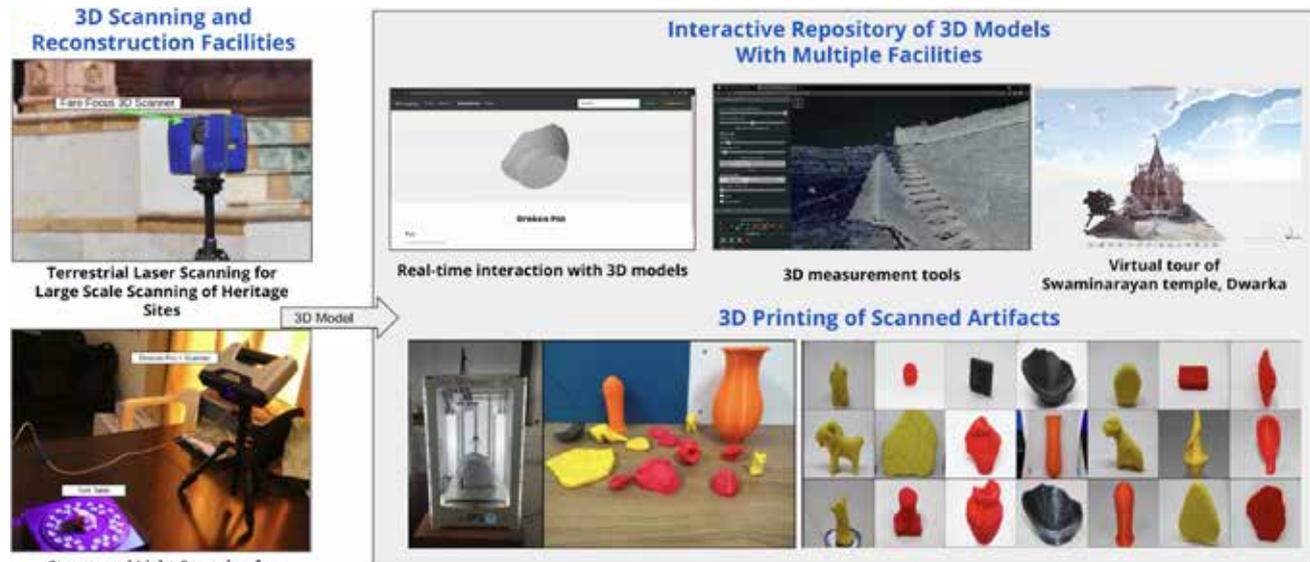
Fig 5.4: Reconstruction of more accurate 3D Shapes

The study can increase awareness about cultural heritage by creating virtual tours and public 3D repositories. Revive the cultural and archaeological significance of places in India. It is an easy, efficient system to digitally preserve ancient artefacts and monument sites. The work was carried out at the Indian Institute of Technology, Gandhinagar.

Photonic radiative cooler for passive sub-ambient cooling

Under the domain "Energy Security" an innovation is made and new advances in material science and engineering now make it possible to create structured material tailored to reflect sunlight very strongly while simultaneously emitting infrared light. This enables us to develop a photonic radiator made of multiple nanolayers, nanoparticles embedded in polymer, and porous polymer structure for daytime sub-ambient cooling. Hence, this project consists of three stages:

(i) Design, development and characterization of various metamaterials for photonic radiative cooler which are highly reflective of sunlight while emitting for atmospheric transparency window. Simulation and energy analysis of photonic cooler for various climatic conditions (effect of various climatic parameters) in India to assess the application potential.

(ii) Field testing of developed photonic radiative coolers and selection of best-performing coolers. Exergy and economic analyses of photonic radiative coolers. Performance forecasting of photonic radiative coolers in India considering climate change.

(iii) The developed radiator will be implemented directly as a roof envelope and embedded with cooling tubes for hydronic and water-cooling purposes. Also, the system will be tested for integration with conventional cooling systems.

The optimized photonic structure of the developed daytime radiative cooler to observe dropped the maximum surface temperature from ambient 6 °C (17 °C from the roof surface) during noontime and 9 °C during the evening. The developed photonic radiative cooler performs better in low humidity locations. However, it is less likely to recommend for monsoon season and highly humid cities. It was also observed that windshield was necessary with the developed radiative cooler for only high wind velocity, as it may also give the heating effect at

low wind velocity. Further, a cooling load reduction of 36% was observed for low-humidity locations when the developed radiative cooler was used as a roof envelope for the air-conditioning room. A huge temperature difference (20-21°C) between the developed radiative cooler enveloped roof and the bare roof was observed. A bulk air temperature difference between two rooms (with and without cooler) of 7-8°C was observed (Figures 5.5 & 5.6). The cooling capacity of 50 W/m² was obtained for the radiative water cooler and operational cost saving was maximum for month and city with minimum humidity and cloud fraction. By using the photonic radiative cooler with the trans critical CO_2 air-conditioning system, the cooling COP increment of 33.8% was observed. Annual energy saving was found to be comparable to solar photovoltaic integration. The work was carried out at the Indian Institute of Technology (BHU), Varanasi.
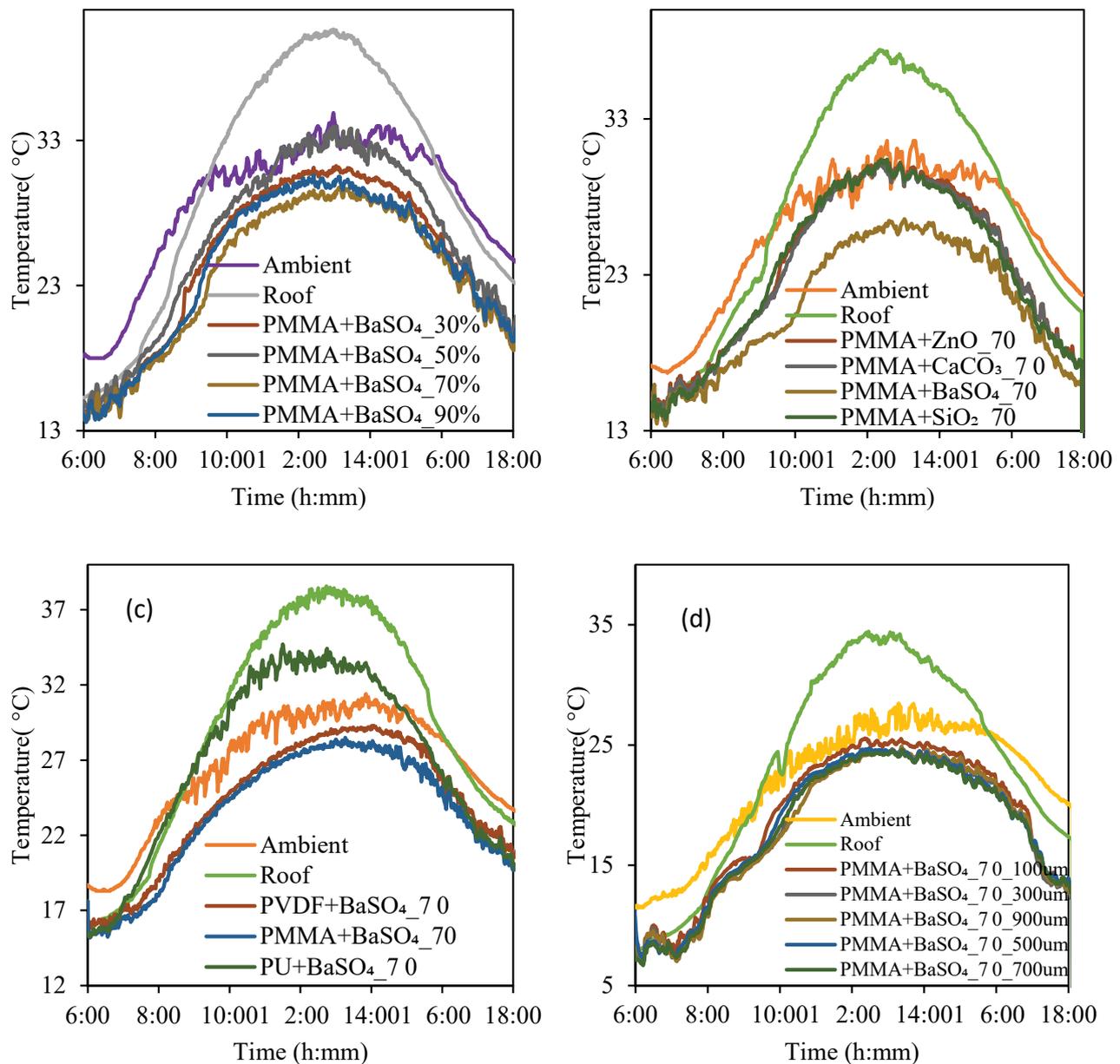
Fig 5.5: Ambient and surface temperatures of developed coolers **(a)** concentration optimization **(b)** particle selection **(c)** polymer selection **(d)** thickness optimization
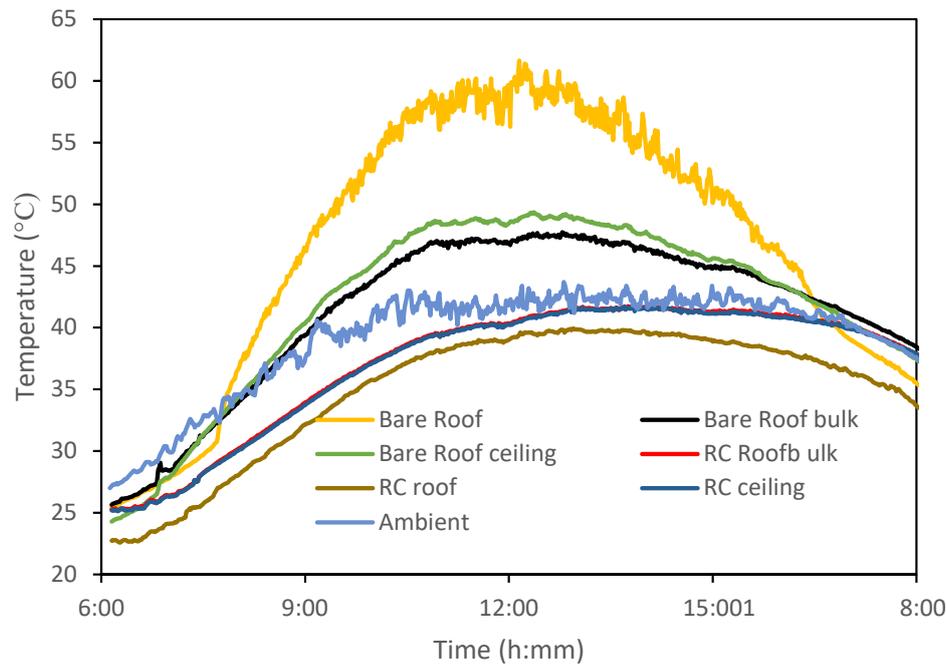
Fig 5.6: Performance of roof envelope radiative cooler

5.1.2 Uchhatar Avishkar Yojana (UAY)

The Uchhatar Avishkar Yojana (UAY) was launched by then Ministry of Human Resource Development (MHRD) with a view to promoting innovation of a higher order that directly impacts the need of the industries, thereby improving the competitive edge of Indian manufacturing capabilities. The industry-sponsored, outcome-oriented research projects were funded. While MOE funds 50% of the project cost, industry and other participating Ministries share the balance of project cost (25% each). SERB is partnering with MoE in funding UAY projects with partial funding support for 39 projects under UAY-Phase-I and Phase-II.

Research Highlights

Rapid Foam Casting (RFC)

The foam-cast process was introduced by the industry partner and is a hybridization of Lost Foam Casting and Lost Wax Casting. The die moulding process is utilized for pattern making, although it is slower and limited to mass production due to the higher initial cost. The industry's current demand is for rapid casting development and benchmarking of casting processes to enable customized solutions.

In response to this need, a Foam 3D Printer has been developed for pattern making, enabling the use of 3D printed patterns in the foam-cast process. By leveraging indigenization and innovation, the price of the Foam 3D Printer has been reduced by 1/10th. This printer stands out due to its unique features, such as the novel visible slicing approach and its effective kinematics, surpassing other available foam prototyping machines. Its hybrid approach combines additive (hot melt glueing) and subtractive (hot wire slicing and machining) processes to create accurate foam patterns or entire foam clusters quickly, eliminating staircase defects without requiring special tooling.

The integration of the Foam 3D Printer with the foam-cast process has been named Rapid Foam Foundry. A module for visible slicing has been developed in the custom-made software called Gati. Several case studies have been conducted to demonstrate the effectiveness of the Foam 3D Printer for pattern making and the Rapid Foam Casting process (Figure 5.7).

This project has also contributed to research by introducing the EPS foam machining theory and a novel mathematical model. These findings will assist industries involved in foam machining by enabling the selection of appropriate machining parameters to achieve the desired surface roughness. Additionally, the stringing mechanism in hot wire slicing has been observed and the impact of stringing on surface roughness has been studied.

Throughout the project, two PhD and four MTech students have received training. Seven research articles have been published, with more in progress. The patent for the Foam 3D Printer has been updated, and the Technology Transfer (TT) process has been initiated on the IRCC, IIT Bombay website (Link: http://rnd.iitb.ac.in/technology/segmented-object-manufacturing-foam-3d-printer). Lost Foam Foundries in India have expressed interest in the technology transfer and plans for commercializing the Foam 3D Printer are underway. This work was done at the Indian Institute of Technology, Bombay.
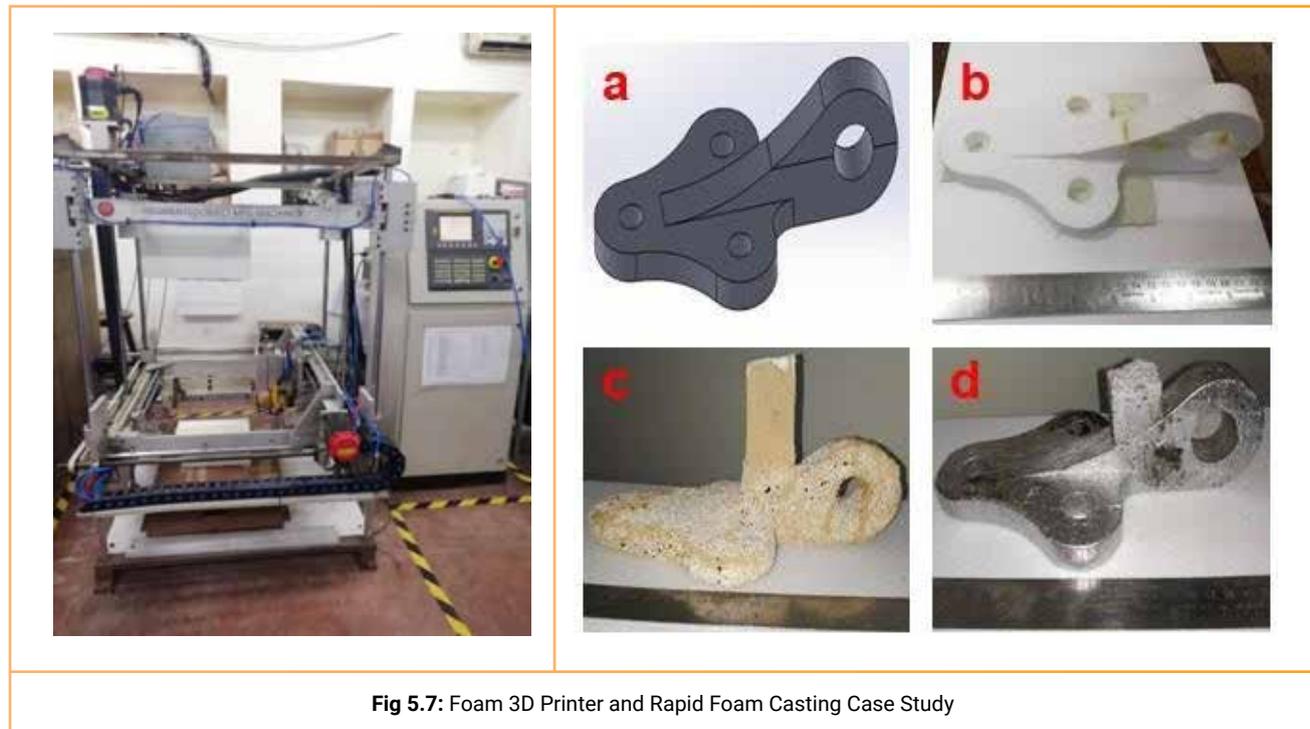
Fig 5.7: Foam 3D Printer and Rapid Foam Casting Case Study

Cold spray technology development for repair and coating of aircraft engine components

Cold spray, a promising spray coating technology, holds great potential for the repair of aviation engine components. It offers numerous advantages, including high-density coatings, efficient deposition, and strong bonding. The process involves accelerating fine solid particles using high-pressure gas flow to supersonic velocities. These particles then impact and adhere to a substrate material, forming a coating.

To establish a cutting-edge high-pressure cold spray system at IIT Madras and develop repair techniques for aircraft engine components, this project was proposed under the UAY (Uchchatar Avishkar Yojana) scheme and secured funding from the MOE, SERB, and industrial partner GE Aviation. The project successfully acquired a high-pressure cold spray system (Figure 5.8) from Plasma Giken, Japan, and installed it in the SMART (Surface modification and Additive Research Technologies) laboratory at IIT Madras.

Notably, the project achieved the successful development of Ni-based superalloy coatings (Figure 5.9) for gas turbine engine components. Additionally, manpower was trained in repair and coating technologies, making use of the new cold spray capability at IIT Madras. Furthermore, the project investigated post-spray heat treatment methods to enhance the material properties of the coatings.

The cold spray process offers versatility in depositing various materials such as metals, polymers, ceramics, and composites. It finds applications in additive manufacturing, dimensional restoration, electrical and thermal conductivity, corrosion protection, and solder pre-placing, among others. This technique holds significant economic value for manufacturing and repair processes. The work was carried out at the Indian Institute of Technology-Madras, Chennai.
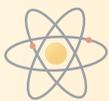
Fig 5.8: High-pressure cold spray system (IITM)
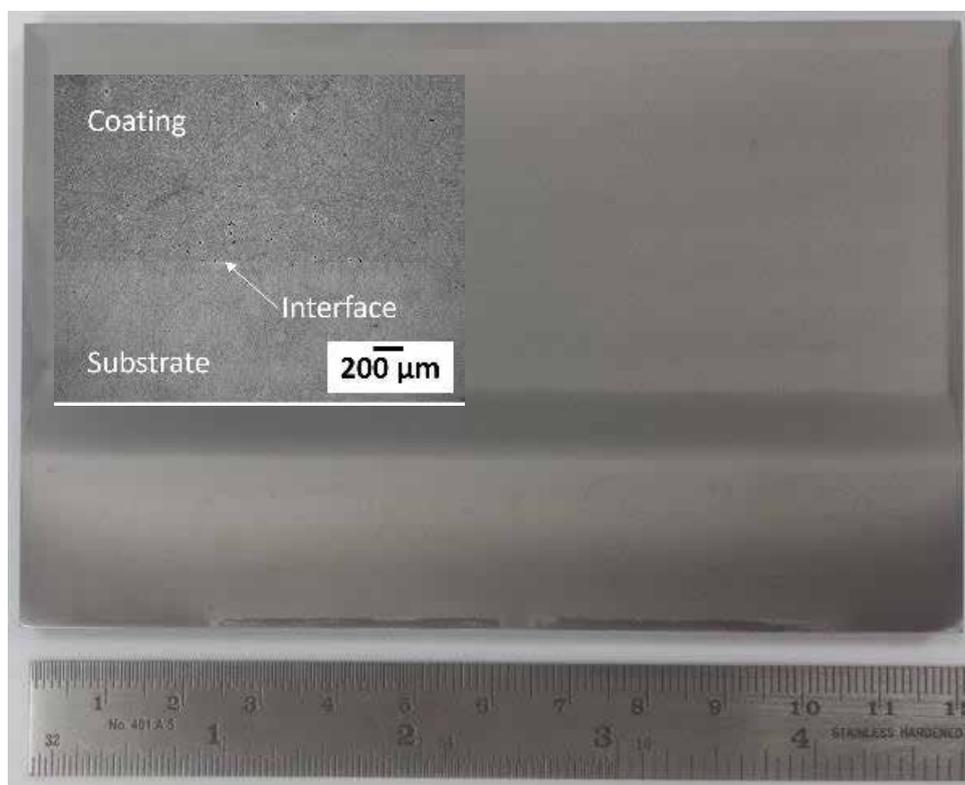
Fig 5.9: Ni-based superalloy coating deposited over Ni-base substrate.
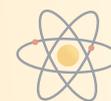
5.2 International Linkages

5.2.1 Visiting Advanced Joint Research (VAJRA) Faculty Scheme

VAJRA Faculty Scheme aims to tap the expertise of overseas scientists including Non-resident Indians (NRIs) & OCIs. It offers adjunct/visiting faculty positions to overseas scientists / R&D professionals to undertake high-quality collaborative research in publicly funded academic and research Institutions in India. The Scheme facilitates collaborative research in frontier areas of S&T including the interdisciplinary areas of national priorities such as energy, water, environment, health, security, nutrition, waste processing, advanced materials, high-performance computing, cyber-physical systems, smart machines, and manufacturing etc. and stimulates the latent potential of our academic and research sector. During the reporting period 19 new VAJRA Facultyships were sanctioned

F E A T U R E S

The scheme strives to bring an international dimension to the R&D ecosystem of India by leveraging expertise of overseas scientists

Initial assignment in for one year extendable to subsequent years based on collaborative outcome and interest. Residency period in one to three months per year

VAJRA faculty are provided US $15000 in the first month of residence and US $10000 in each of the subsequent month

Website link: https://serb.gov.in/page/english/research_networking#Visiting%20Advanced%20Joint%20Research%20(VAJRA)%20Faculty%20Scheme

19
Facultyships Sanctioned

Expenditure
(New and Ongoing)

5.88 cr

Investigating recent changes in the currents and eddies in the north-western Bay of Bengal

Diurnal variation of biophysical parameters in the upper mixed layer

The research group studied the diurnal variations of biophysical parameters like temperature, salinity, chlorophyll-a and dissolved oxygen throughout the vertical column using a 5-hour cycle Argo float in the Bay of Bengal (Figure 5.10). It was found that the column temperature and chlorophyll are strongly linked to the solar insolation, with the biomass amount peaking at around 18:00 local time. On a diurnal scale, the mixing process of temperature and dissolved oxygen is affected by disturbances due to wind speed. The stability of the water column was depicted by the Brunt Vaisala Frequency and was found that the rising SST led to the formation of more stable waters. On relatively cooler days within a season, a stable water column formed in the noon traps the heat keeping the lower depths cooler. The group also used the Sverdrup model to determine the luminosity and used an accumulation time of 12 hours which showed a strong correlation with diel chlorophyll variation. The work is being carried out at the Indian Institute of Technology, Bhubaneswar and the University of Massachusetts Dartmouth, USA.
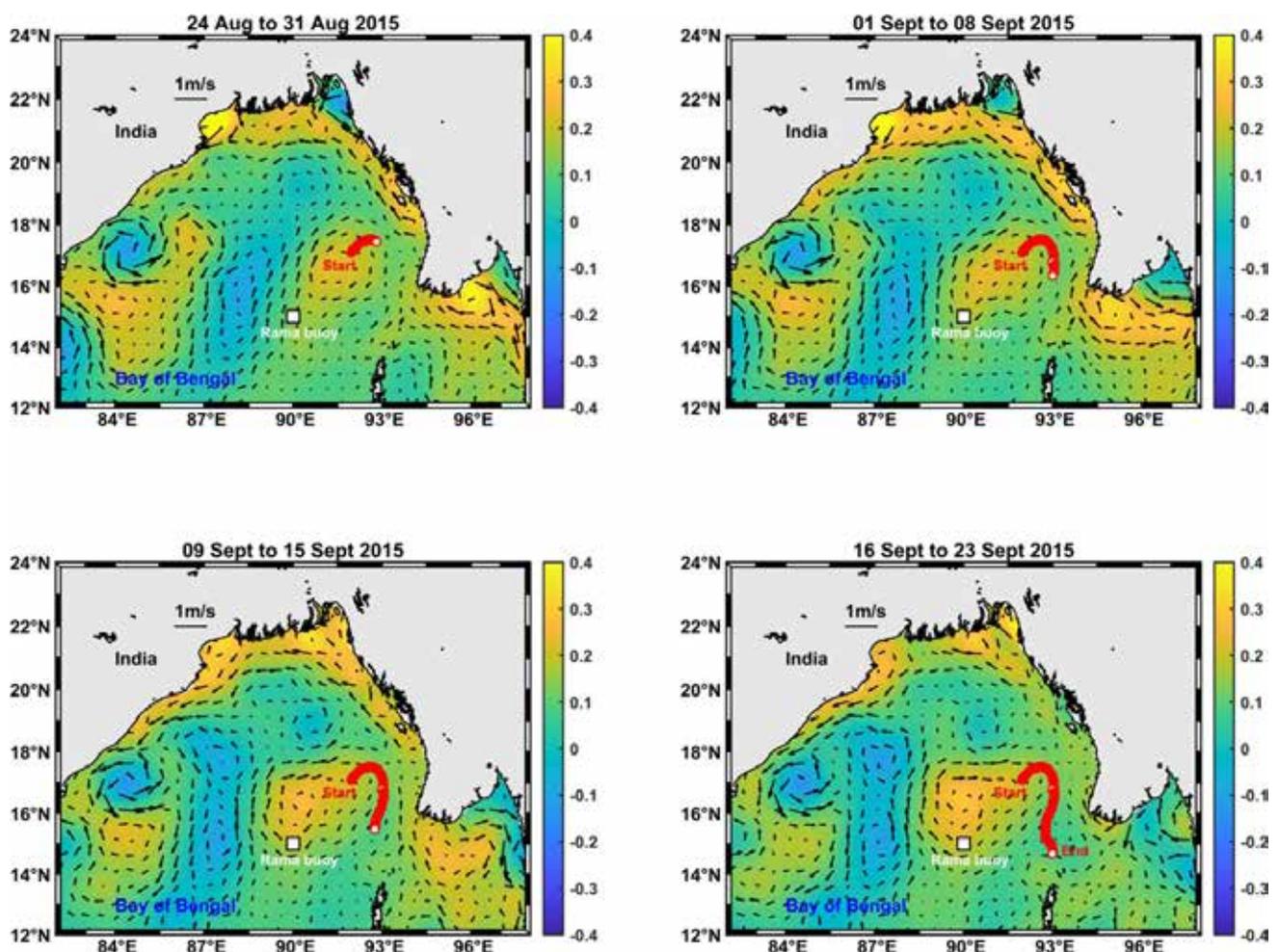
Fig 5. 10: Argo Float (WMO ID: 2902161) trajectory for the given time under a 5-hour cycle period. The background represents surface geostrophic current vectors on the contour map of sea surface height anomaly.
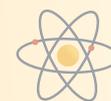
5.2.2 SERB Overseas Visiting Doctoral Fellowships (OVDF)

SERB OVDF scheme aims to build national capacity in frontier areas of Science and Engineering, which are of interest to India by providing research training in overseas universities/institutions of repute to PhD students admitted to Indian institutions. The scheme provides an opportunity for performing Indian research students to gain exposure and access to top-class research facilities in academia and labs in specific Overseas Universities. The scheme also envisages creating opportunities to build long-term R&D linkages and collaborations with accomplished scientists and technologists from around the world. The scheme will help to tap the expertise gained by these young scientists to strengthen/initiate national programmes in their domain knowledge.

Applications are invited from PhD students to work with Overseas Institutions who had signed an Agreement / MoU with SERB for student mobility:

1. Purdue University, West Lafayette, USA (intake of 25 students)

2. University of Alberta, Edmonton, Canada (intake of 10 students)

During the reporting period, 25 fellows were selected for SERB - Purdue University Overseas Visiting Doctoral Fellowship and 10 fellows were selected for SERB-University of Alberta Overseas Visiting Doctoral Fellowship.

1 Fellowship Sanctioned

Expenditure (New and Ongoing)

7.71 cr

FEATURES

The student should have registered for full-time Ph.D. degree in any of the recognized Institutions / Universities in India in STEM.

The duration of the research training is upto a period of 12 months.

Monthly fellowship of US$ 2000, one-time Contingency/ Preparatory allowances of Rs. 60,000/- and round-trip air fare are provided.

Website link: https://serb.gov.in/page/english/research_networking#Overseas%20Visiting%20Doctoral%20Fellowship

Research Highlights

The Anti-prostate cancer natural product MPC1001–Synthetic studies and biological testing

TA combined research work of the University of Delhi and the University of Alberta, Canada. In this project, the research group has explored a synthetic route to construct two of the rings of a very complicated anti-cancer natural product. The work deals with the synthetic routes to develop the AB ring of the MPC1001 molecule. The molecule represents an unusual compound type, and the fact that it is incredibly potent against a prevalent form of cancer indicates that it is essential to explore its mode of action and identify what parts of the structure contribute to the biological activity. This information is essential for designing medicines based on the unique MPC1001 structure. In seeking a convenient and scalable route to an AB ring system of MPC1001, the group has converted 4-hydroxyproline into hydroxy ketone, iminoketone and hydroxy ester. These compounds set the stage for further research on how to complete the formation of the dihydrooxepine ring present in the natural product. The research fellows have established a multi-step synthesis of the AB ring of the MPC1001 molecule. The developed route would help in the total synthesis of the target MPC1001 molecule as a chemotherapeutic agent.

Effective online decision making in IoT computing environments through machine learning

A combined research work of the Indian Institute of Technology Indore and Purdue University, USA. Internet of Things (IoT) deployments often comprise extremely resource-constrained devices with limited capability in terms of memory, computing capability, and energy. The norm is for such deployments to depend on the cloud for analysis of collected data and taking decisions. The issue with regular use of the cloud, however, is significant energy expenditure for communicating data to the cloud and temporal latency and unreliability thanks to the often fragile and adhoc connection with the cloud. The endeavour of our work, therefore, is to effectively handle and classify streaming data at the IoT node rather than sending it back to the cloud. The approach taken comprises first reducing the dimensions of the streaming data through a sparse matrix learned online. Next, the large amount of data points in the stream is substituted with a few representative data points called prototypes. This is done using a neighbourhood search method. Finally, classifying the data using a decision tree method that is effective in identifying boundary data points that facilitate classification. The efficacy of the approach is validated through comparisons with existing state-of-the-art techniques over various datasets. A prototypical implementation of the approach over resource constrained IoT deployments is done to demonstrate its practical feasibility.

Morphological characterization and viscoelastic response of auxetic polyurethane foams for rehabilitation applications

A combined research work of the Vellore Institute of Technology (VIT) and Purdue University, USA. The researcher group have studied the viscoelastic properties of auxetic foams fabricated using tri-axial compression and two-stage heating. Twelve variations of PU foams with and without castor oil (CO) and silver nanoparticles (SNPs), both non-auxetic and auxetic were subjected to compressive cyclic and stress relaxation tests. A visco-hyper elastic material model (Hereditary integral and Ogden model) was used to fit the data obtained from the compressive cyclic tests. A modified Ogden model with Poisson's function was used to replace the regular Ogden hyperelastic material model. Both the hereditary integral model and the Ogden model showed good fits with the cyclic data. Energy dissipation and RMS error between the model-fit and experimental data for all the foams were calculated using MATLAB. The energy dissipation values for the auxetic foams were higher than that of the conventional foams. There is a good agreement between experimental and model results. The biggest outcome was the development of a visco-hyperelastic model of auxetic foams. A visco-elastic material model (prony series) was used to fit the data obtained from the stress relaxation tests using MATLAB. Optimized fit parameters were used to assign as a material property of foams in Abaqus-Finite Element Analysis (FEA) software.
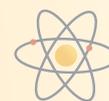
5.2.3 SERB International Research Experience (SIRE)

SERB International Research Experience (SERB-SIRE) program aims to impart high-end research training in frontier areas of Science and Technology, which are of interest to India by providing an opportunity to visit leading institutions/universities across the globe for a period of 02-06 months.

The second call for proposals under SERB-SIRE was made in August-September 2022. A total of 828 proposals are received for the fellowships and 148 fellowships have been sanctioned.

FEATURES

To build national capacity in frontier areas of Science and Technology by providing opportunities for International R&D experience by SIRE fellows

To tap the expertise gained by SIRE fellows to strengthen/initiate national programmes in their domain knowledge.

To encourage research activities in priority areas which are still less explored in the Indian context

Website link: https://serb.gov.in/page/english/research_networking#SERB%20International%20Research%20Experience%20(SIRE)

148
Fellowships Sanctioned

Expenditure (New)
17.49 cr

6

COVID-19 R&D INITIATIVES

The epidemiological, virological, and immunological picture of coronavirus disease 2019 (COVID-19) has changed dramatically after the onset of the pandemic. As the global COVID-19 pandemic continued in the form of new variants and to improve early detection and warning of COVID-19 spreading in a community, SERB ramped up R&D activities towards wastewater-based epidemiological monitoring of SARS-CoV-2 virus in the open drainage system across the country. SERB-supported R&D initiatives in response to the first COVID-19 outbreak made a significant contribution towards understanding the evolution of SARS-CoV-2 infection and plausible therapeutic intervention, as well as the dynamics of the humoral immune response during and after COVID-19 recovery. The studies supported in the direction of diagnostics resulted in the development of in-house antigen and antibody-based COVID-19 detection kits and prototypes. In addition, SERB continued to provide R&D support on critical components and innovations relating to make-in-India oxygen concentrators.

The details of the important insights on COVID-19-related R&D activities are highlighted in this chapter.

6.1 Special Call on Wastewater-based Epidemiological Monitoring for SARS-CoV-2 (New)

The projects supported under the CRG COVID-19 special call in the year 2020 generated important insights towards understanding the biology of the disease, affordable diagnostics, computational validation of COVID molecular targets etc. and resulted in products, models, publications, etc. In that, one of the projects supported on monitoring the SARS-CoV-2 virus in the drains of the river in Pune provided important insights towards the identification of prevalent strains in the circulation and also correlated significantly with the infectivity of the particular strain and the affected population. Based on the scientific knowledge generated out of this project, a special call on "Wastewater-based Epidemiological Monitoring for SARS-CoV-2 Virus" was made in the year 2022. A total of 15 projects covering the major cities/towns of the country were supported (Table 1).
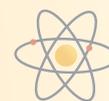
Table1: List of cities/towns covered under the waste water based monitoring for SARS-CoV-2 virus

S. No.	State	Area coverage
1	Assam	Jorhat
2	Chandigarh	Chandigarh
3	Delhi	NCR Delhi
4	Goa	Goa Airport site
5	Haryana	Hisar
6	Himachal Pradesh	Mandi
7	Karnataka	Udupi
8	Kerala	Thiruvananthapuram
9	Madhya Pradesh	Bhopal
10	Maharashtra	Dharavi
11	Rajasthan	Jaipur
12	Tamilnadu	Chennai
13	Tamilnadu	Vellore
14	Uttar Pradesh	Varanasi
15	Uttarakhand	Dehradun and Ahmedabad

FEATURES

Special call for COVID-19 related research

Rapid/Short-term Projects on Oxygen concentrators

The duration of the Project is upto 1 year

Wastewater surveillance to monitor the Covid-19 outbreak

As part of this project, for the Delhi state, the National Institute of Immunology sampled sewage water from 10 different sewage treatment plants (STPs) spread across Delhi. The sites are Okhla, Molarband in Southeast Delhi, Kondli & Akshardham in East Delhi, Yamuna Vihar in Northeast Delhi, Coronation Pillar, Rithala in North Delhi, Pappankala and Keshopur in West Delhi, and Delhi Gate in Central Delhi.

Investigators collaborated with the wastewater monitoring laboratories associated with some of these STPs. The team obtained the samples from multiple sewage pump stations across the Delhi state and the sample size was increased from 10 to 52 (Figure 6.1). In the month of October, the team made 21 samplings out of which three were positive. These three were Okhla on 13th October 2022, Akshardham on 20th October 2022, and Molarband on 31st October 2022. All three sites were in the eastern part of Delhi. All these positive samples were sequenced to understand the distribution of genomic variants in these samples. It was found that all three were enriched for subvariants of BA.2.75. In the month of November, 62 samplings were done and found 5 of them to be positive (Civil Mill Drain and Supplementary Drain on 18th November 2022, Delhi gate on 22nd November 2022, Molarband and Saroj Nursing Home on 29th November 2022). Sequencing of these samples found the distribution of BA.2.75 subvariants to be enriched in the samples. In the month of December, out of 97 samples, only one was found positive (Akshardham on 29th December 2022) whereas in the month of January two samples were found positive out of 96 (Okhla on 4th January 2023 and Akshardham on 5th January 2023). Sequencing of all these samples found the presence of BA.2.76, BQ.1.125, and BF.7 variants. Similarly, BQ.1 and BA.5 subvariants were enriched among the January samples.

15

Projects Sanctioned

Expenditure (New)

6.10 cr
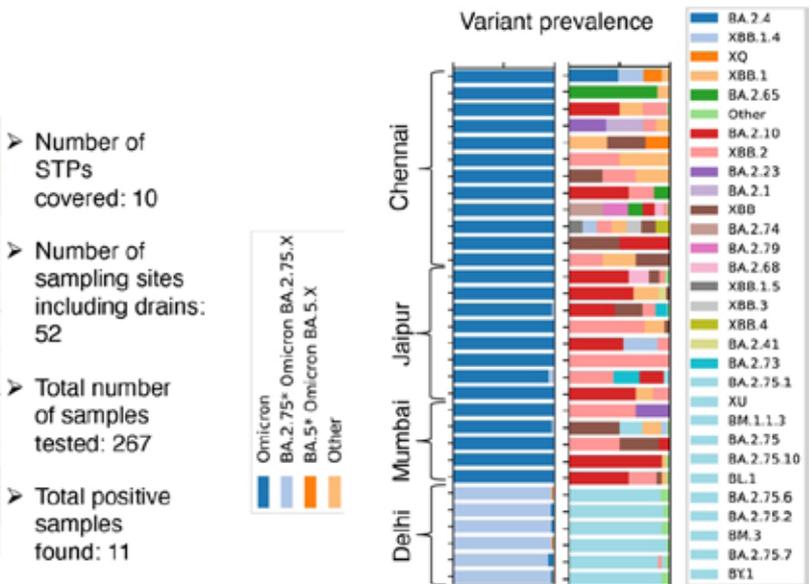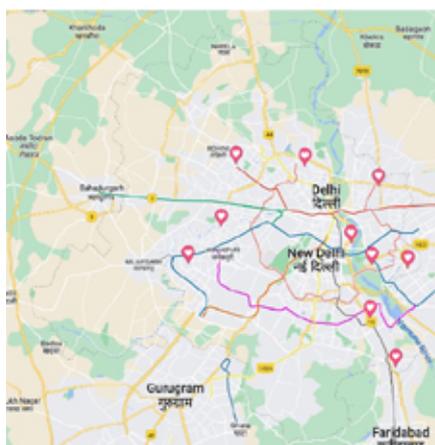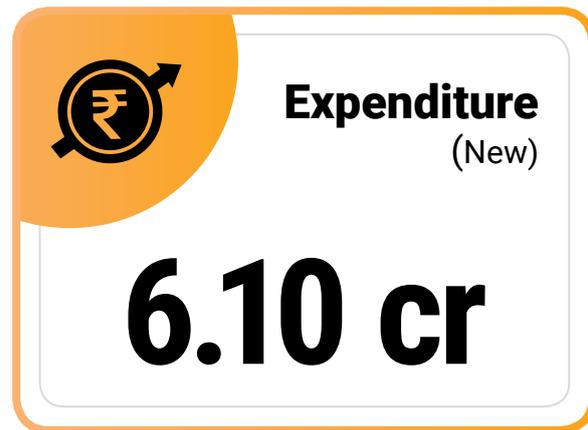
Fig 6.1: Wastewater Surveillance for SARS-coV virus in Delhi
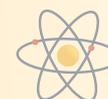
To summarize, during the study period, only 11 sewage samplings were positive in Delhi state. During that period in Delhi state, the COVID-19 positivity rates were increased which was correlated with the sewage sampling positivity observation. As per the publicly available data, daily positive rates ranged between 70-150 in October and November 2022, a time period where it was also noted 8 positive samples out of 83. During December 2022 and January 2023, daily cases fell to 0-16 a day in Delhi and corresponded to only three positive samples out of 193. In general, the wastewater surveillance data follows the same trend as the covid positivity rates and the viral load in the population. However, the variants observed during October and November 2022, showed that the variants were mostly BA.2.75 subvariants, but in January 2023 the presence of variants such as BF.7 also started appearing in the population. The study is under progress at the National Institute of Immunology, New Delhi.

6.2 Special Call on COVID-19 (Ongoing)

6.2.1 Critical Components and Innovations in Oxygen Concentrators

Development of Zeolite-based Adsorbents for Oxygen Concentrator

Zeolite-X-based adsorbents are generally used as adsorbents for the oxygen concentrator and all are imported from different countries like China (Zalon), USA (Honeywell UOP), Germany (BASF), France (Arkema) at an exorbitant price. A project has been supported to develop indigenous Zeolite using sodium aluminate liquor and Alumina trihydrate (ATH) obtained from the Alumina industries. Investigators optimized the Zeolite preparation according to the composition of raw material obtained from the industry. Investigator successfully developed Zeolite-X powder (Figure 6.2) having specifications comparable with Zeolite-X powder imported from ZeoChem, BASF, and Sigma Aldrich. (Surface area, up to 710 m^2/g, Nitrogen adsorption capacity 9-10 cc/g, nitrogen/oxygen selectivity of 3.1) for oxygen concentrator application. The zeolite 13X powder (Figure 6.3) process is scaled up at Kg scale using the raw material provided by National Aluminium Company (NALCO) Ltd. and Hindalco Ltd.

An Indian Patent (IN 202211070211, 2022) was filed for the developed Zeolite-X preparation process and based on this patent filed, investigators are now focusing on scaling up the Zeolite-X production and pilot studies are initiated to enhance the technology from TRL-3 to TRL-6. This work is being carried out at Central Salt and Marine Chemicals Research Institute, Bharnagar. The developed technology can contribute to national initiatives of Make in India and Atmanirbhar Bharat.

Expenditure
(Ongoing)

0.07 cr
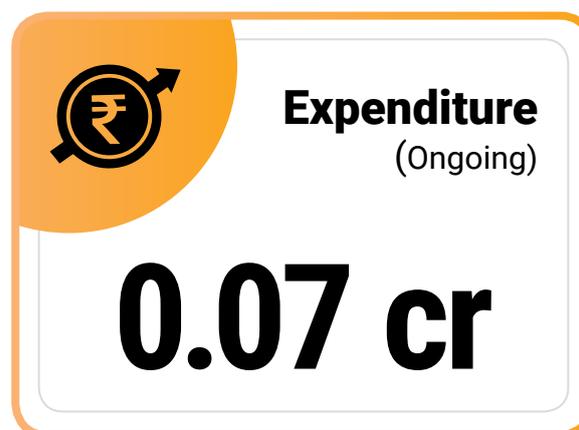
Fig 6.2: Zeolite 13X powder preparation process
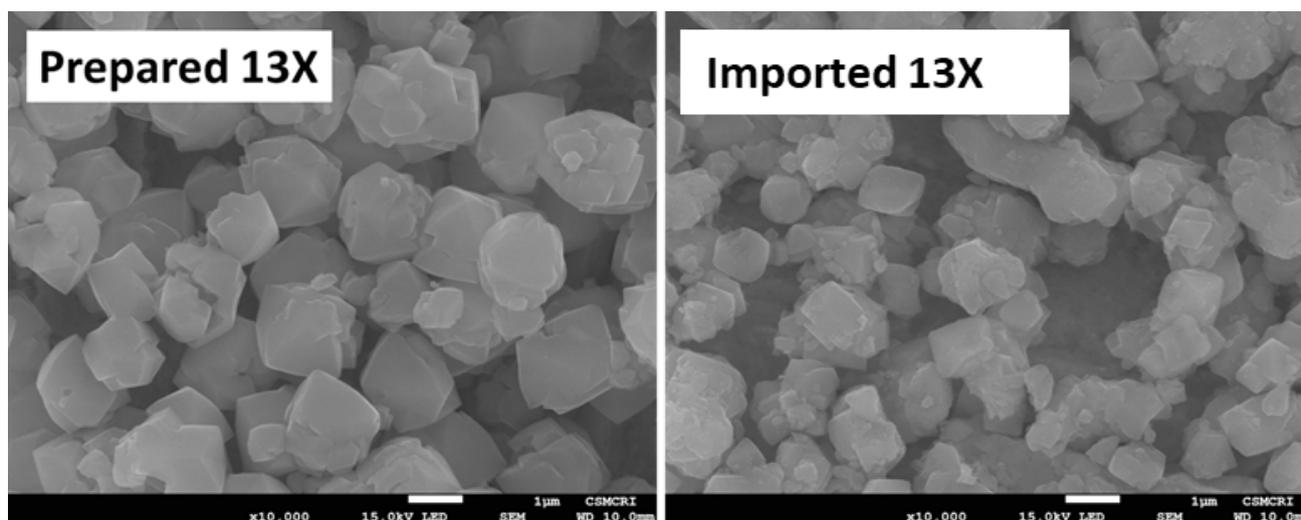
Fig 6.3: SEM images for prepared and imported Zeolite 13X.

6.2.2 IRHPA-Special call on COVID 19

Immuno-epigenetics study of the humoral immune response in COVID-19 patients from India

BBV152/Covaxin vaccine is based on an Asp614Gly variant and formulated with a toll-like receptor (TLR) 7/8 agonist molecule (imidazoquinolin) adsorbed to alum. It was the first alum- imidazoquinolin adjuvanted vaccine produced in India and received emergency use authorization from WHO for use in a large population. Despite its global distribution and potential in providing clinically substantial protection, limited evidence is available on the mechanism of immunity and the traits of immune memory established by BBV152.

A multi-centric study has been initiated to understand the detailed humoral and cellular memory under BBV152 vaccinated conditions. Investigators examined the immune memory in SARS-CoV-2, unexposed 97 individuals who had received 2 doses of the BBV152 vaccine with a median interval of 4 months between two doses and compared the vaccine-induced response with the immune memory in 99 individuals recovered from mild COVID-19 (Figure 6.4).
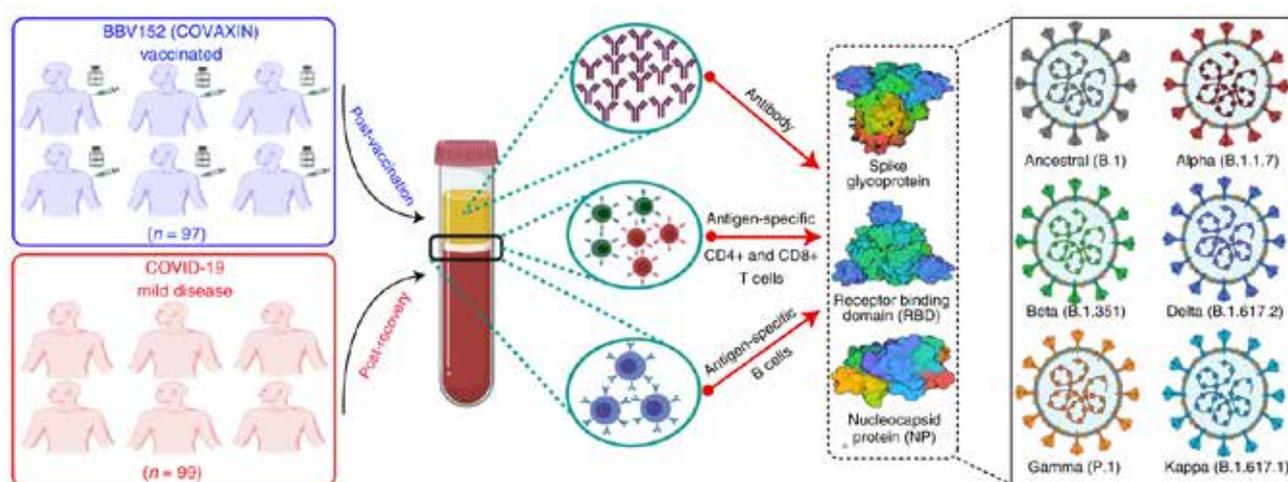
Fig 6.4: Study design to investigate the BBV152-elicted immune memory against SARS-CoV2 and its variant.

Investigators examined the efficacy of vaccine-induced antibodies against a receptor binding domain (RBD) protein of the ancestral virus (B.1) and its variants-Alpha (B.1.1.7), Beta (B.1.351), Gamma (P.1), Kappa (B.1.617.1) and Delta (B.1.617.2) and found that the 43/46 tested subjects showed the presence of anti-RBD IgG. The Gamma and Kappa variants showed no impact on RBD-IgG, however, the levels were significantly reduced in the case of Beta, Delta and Alpha (Figure 6.5(A)). The neutralizing potential of vaccine-induced antibodies declined significantly against the Delta and Beta variants, with a significant impact on the Alpha variant. However, a significant 3- to 4-fold reduction was observed in the neutralizing ability of the antibodies against these variants in the infection group (Figure 6.5 (B&C)).
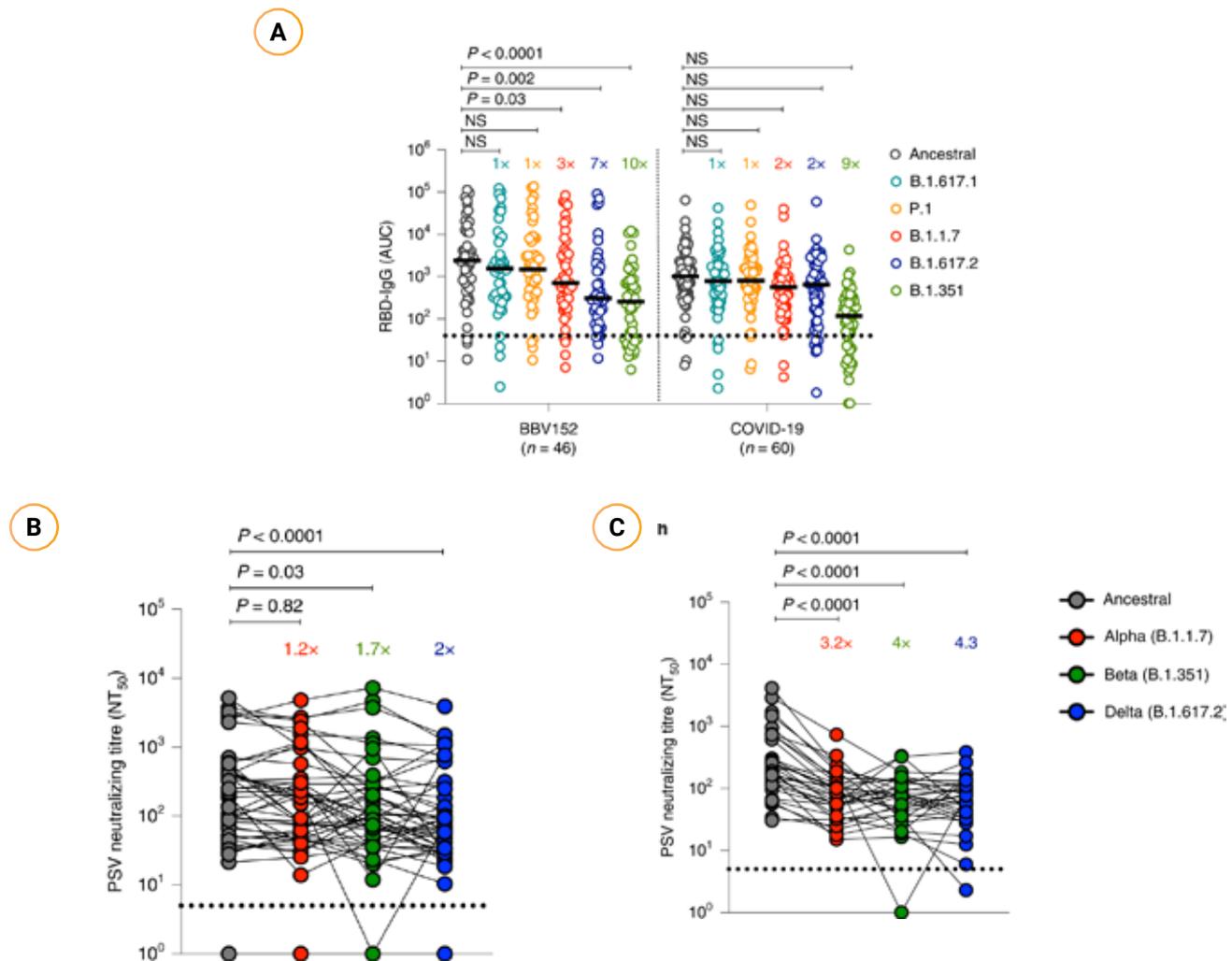
Fig 6.5: (A) Comparison of anti-RBD IgG levels measured as AUC in response to ancestral SARS-CoV-2 and its Alpha, Beta, Gamma, Kappa and Delta variants in vaccinated and mild COVID-19 recovered individuals. **(B &C)** NT50 estimated using the SARS-CoV-2 and its alpha, Gamma, Kappa and Delta variants in BBV152 and mild COVID-19.

Similar to natural infection, the anti-spike, anti-nucleoprotein IgG and neutralizing antibodies were detectable at least for six months after the 2-dose vaccination. Altogether antibody analyses established that BBV152 elicits potent antibodies against virus spike and nucleoprotein, these antibodies having the capability to neutralize virus entry and persist for at least up to 6 months. B-cell memory is crucial for the durability of vaccine-induced protection.

SARS-CoV-2 RBD-specific memory B cells, IgG and IgM levels were detected in the majority of the vaccinated

and infected subjects. The vaccine-induced IgG+ B-cells represent around 0.44 ± 0.1% of total IgG+ B cells, which was comparable to the proportion in the infection group (0.48 ± 0.2%). The vaccine-induced IgA+ B cells were also present in a similar frequency as in natural infection. The proportion of IgM cells was higher with vaccination, albeit non-significant, in the range of 1.3 ± 0.16% of the total IgM+ B cells. These results indicate BBV152 is capable of inducing the memory B cells. (Figure 6.6 (A, B &C)).
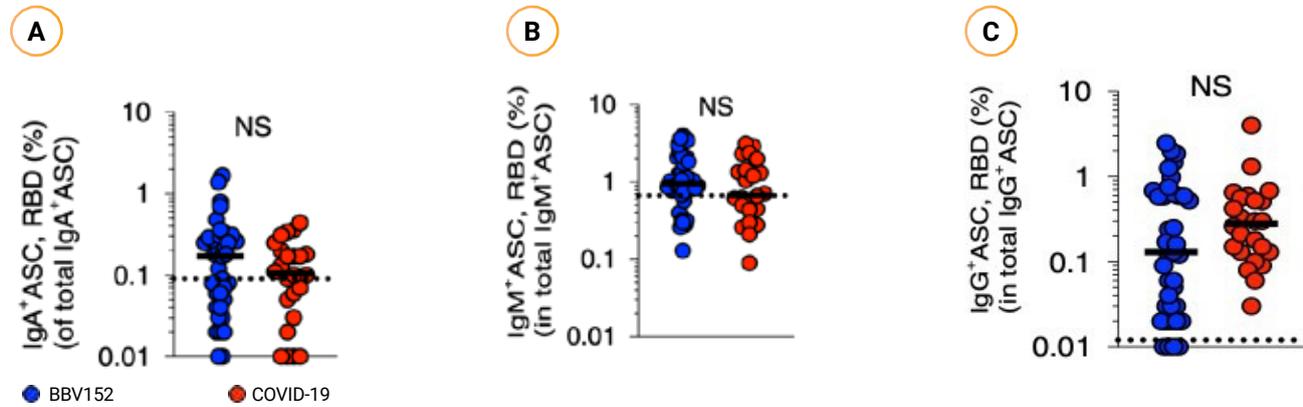
Fig 6.6: (A, B & C) Proportion of SARS-CoV-2-RBD specific ASCs calculated in the total corresponding isotype of ASCs in 1 million PBMCs for IgG ASCs **(A)**, IgA ASCs **(B)** and IgM ASCs **(C)**

T cells are vital mediators in the protective response to SARs-CoV2 and investigators studied the SARS-CoV-2 specific memory CD4+ T Cells induced in response to BBV152 vaccination. The magnitude of the total CD4+ T cells was not different between the vaccinated and recovered individuals. BBV152 induced a robust spike-specific CD4+ T cells response which was similar to the response to infection (Figure 6.7(A &B)). In addition, the spike-specific T cells were present in detectable levels in vaccinated study subjects compared to the infected groups.
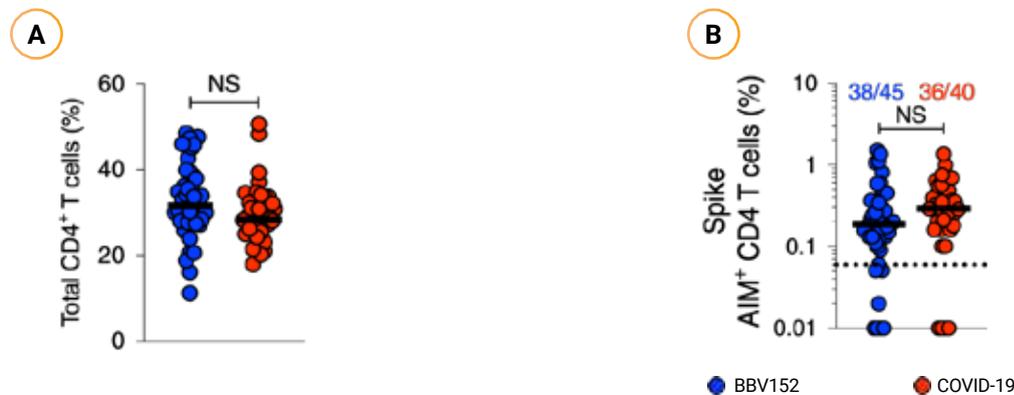
Fig 6.7: (A&B) Frequency of total CD4 T cells in BBV152 and COVID-19 groups.

The above results were published and the work is under progress at the National Institute of Immunology and All India Institute of Medical Science, New Delhi.

COVID-SCAN (Novel diagnostic platforms for point-of-care SARS CoV-2 detection)

A new sandwich-based lateral flow immunoassay (LFIA) for the detection of the Receptor Binding Domain (RBD) of severe acute respiratory syndrome-coronavirus-2(SARS-CoV-2) could provide an efficient substitute for RT-PCR tests. It can detect the RBD antigen of SARS- CoV-2 at an early stage of infection with a visual line of detection (LOD). Popularly used techniques such as RT-qPCR and ELISA are usually time-consuming and require skilled labour and specific equipment, which is one of the major impediments to on-site detection. A project has been supported for the development of novel diagnostics alternate point of care for SARS- CoV-2 detection.

Based on the principle of Lateral Flow Immunoassay (LFIA), a paper-based device, investigators developed point-of-care which works on the principle of antigen-antibody interaction. To achieve the proposed objectives, investigators developed an in-house antibody (Ab) against the SARS- CoV-2 RBD gene. Using various biochemical confirmations and assays, investigators purified the recombinant RBD protein (Figure 6.8 (A)) and performed indirect ELISA to ensure the detection ability of in-housed generated RBD Ab (Figure 6.8 (B)).
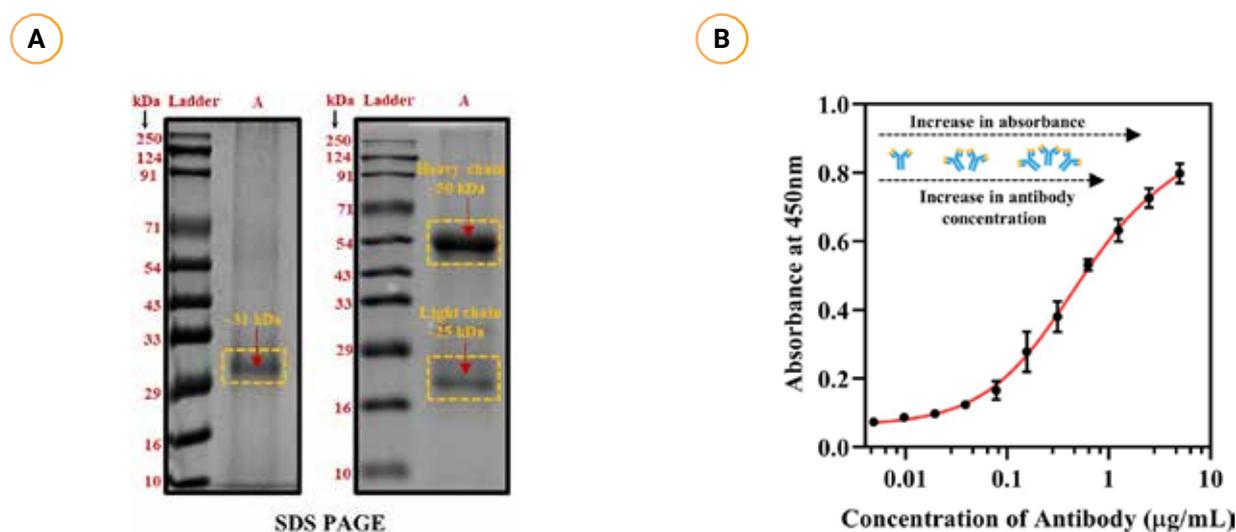
Fig 6.8: (A) SDS-PAGE analysis of IPTG-induced RBD protein depicting ~31 kDa molecular weight. **(B)** Indirect binding assay to confirm SARS-CoV-2 RBD gene.

Investigators labelled the Ab with gold (Au) nanoparticles (AuNPs) and characterized the particle size, surface charge and elemental composition. Using atomic force microscopy (AFM) investigators found that Ab conjugated AuNPs showed increased signal intensity compared to the AuNPs alone. (Figure 6.9 (A-D)).
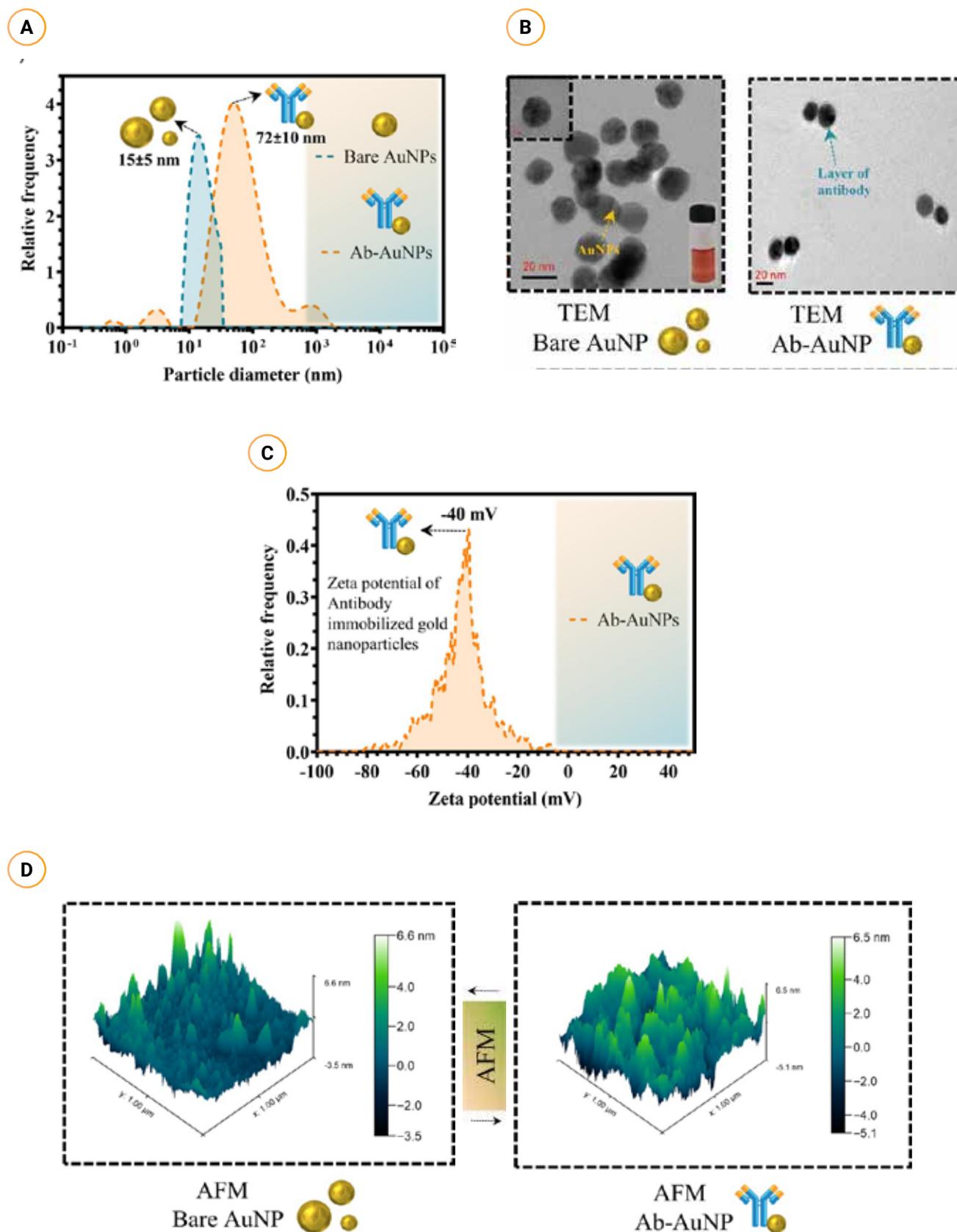
Fig 6.9:(A) Characteristic UV-Vis spectra of AuNPs were observed at 521 nm with a redshift of 14nm, for Ab-AuNPs. **(B)** Representative Transmission Electron Microscope (TEM) image monodispersed AuNPs and thin proteinaceous layer of Ab coated around AuNPs. **(C)** Zeta potential analysis for Ab-AnNPs. **(D)** Representative of AFM micrograph for AuNPs and Ab-AuNPs.
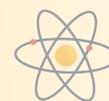
Following the synthesis of antibody-conjugated gold nanoparticles, it was optimized various components such as target analyte, blocking of a sample pad, antibody conjugation and incubation time required for the preparation of LFIA strips. To analyze the performance of fabricated LFIA strips a linear range of dilutions from 1pg/ml-1µg/ml of RBD protein was tested and 1ng/ml was considered as LOD (line of the detector). To further verify the analytical and clinical sensitivity of LFIAs, Investigators were able to detect RBD Ag in COVID-19 patient samples with 94.3% sensitivity and 90.9% specificity with a response time of 15 minutes both visually and via smartphone colorimeter application with no cross-reactivity with influenza virus. The schematic representation of the workflow of the developed LFIA and smartphone analysis were depicted below (Figure 6.10). The above results were published and the study is under progress at the National Institute of Animal Biotechnology, Hyderabad.

Expenditure
(Ongoing)

1.70 cr
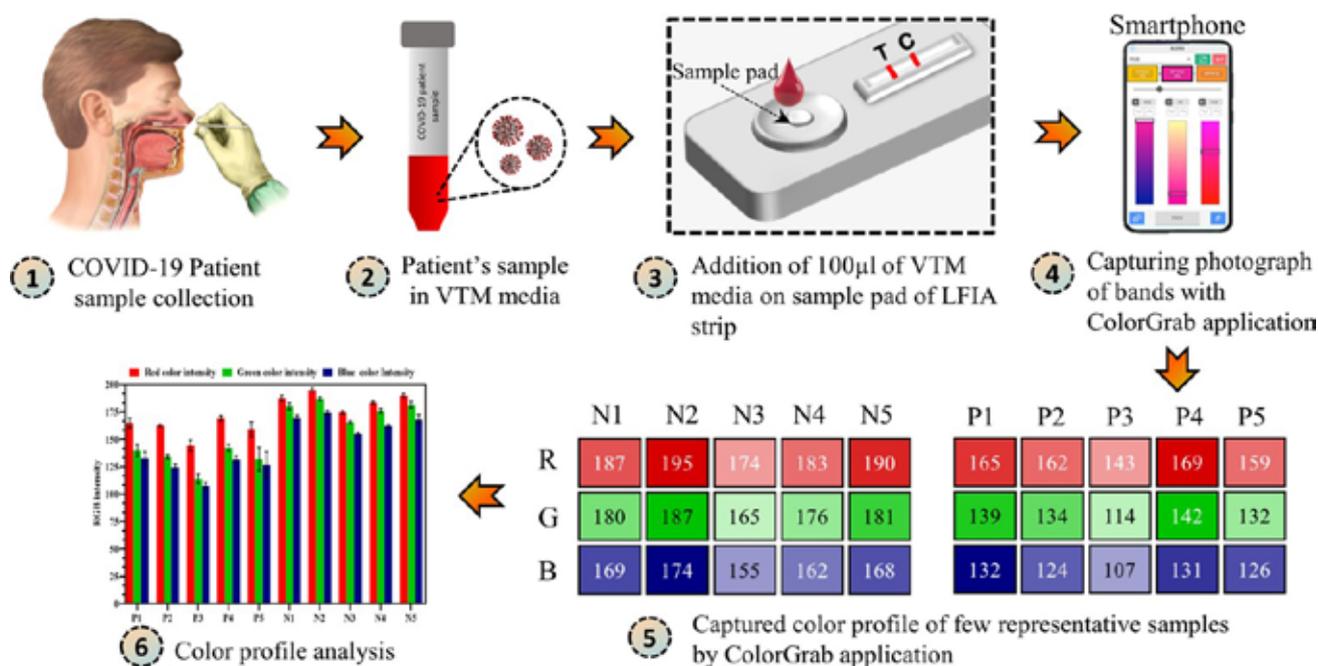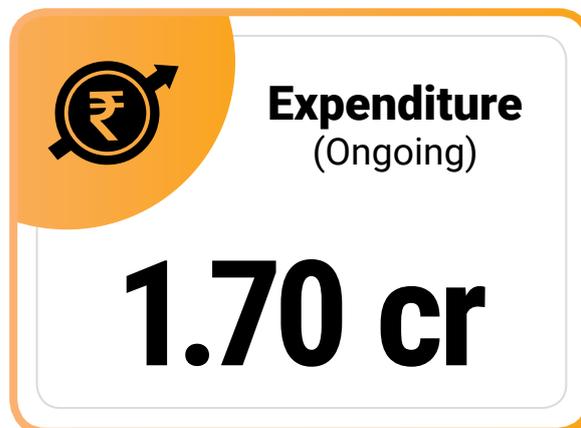
Fig 6.10: RBD Ag detection in COVID-19 patient samples -Schematic representation of the workflow of the developed LFIA and smartphone analysis.

7

SUPPORT FOR SCIENCE AND TECHNOLOGY EVENTS

Among important aspects for the growth of researchers as well as for the advancement of science, is the dissemination and exchange of scientific knowledge. SERB supports Science and Technology events through its schemes, Assistance to Professional Bodies & Seminar / Symposia, International Travel Support (ITS), and Accelerate Vigyan to provide productive opportunities for the research community to come together to discuss issues of common interest and foster new collaborations.

7.1 Assistance to Professional Bodies and Seminar/Symposia

Partial financial support is extended by SERB on a selective basis, for organizing technical meetings, seminars, conferences, and workshops events (National as well as International). Academic institutions, research laboratories, professional bodies, and other non-profit organizations engaged in promoting scientific research are eligible for financial support under the scheme. The support is mainly given to encourage the participation of young scientists and research professionals in such events along with nominal support for pre-operative expenses like announcements brochures, etc.

The primary focus of the scheme is to support events having a strong orientation towards scientific research in the areas of basic sciences, engineering, technology, agriculture and medicine. The scientific/ technical contents of the events, thematic relevance, contextual impact, and extent and level of participation are key components for deciding the support worthiness and quantum of support for individual events.
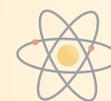
FEATURES

Provides a platform to science professionals to have a dialogue on S&T issues of national and international importance

The support is primarily to encourage participation of young scientists and researchers in such events

Support is also provided to S&T professional bodies for publishing their work

Website link: https://serb.gov.in/page/english/research_grants#Assistance%20to%20Professional%20Bodies%20&%20Seminars/Symposia

In the financial year (2022-23), the seminar/symposia scheme received 1384 applications towards partial support from all the States / UTs across the country in various fields of Science and Technology, out of which 592 applications were recommended for financial support (Table 7.1). In addition, 24 applications were received towards partial support from Professional Bodies / Institutes / Societies for publication in Journals, out of which, 20 applications were recommended for support. Out of 1384 received applications, 592 applications in different subjects/disciplines were recommended for support (Table 7.2).

Table 7.1: Support provided in 2022-23:-

S. No.	Items	Seminar / Symposia	Professional Bodies
1.	Application Received	1384	24
2.	Application Recommended	592	20

Table 7.2: Subject-wise summary of considered & recommended Applications (2022-23):-

S.No.	Broad Subject Area	Received	Recommended
1.	Chemical Sciences	71	39
2.	Earth Sciences	59	35
3.	Engineering Science	593	201
4.	Life Science	342	150
5.	Mathematical Science	85	46
6.	Other	147	66
7.	Physical Sciences	87	55
	Grant Total	**1384**	**592**
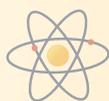
534

Total number of Sanctions

Expenditure (New)

10.92 Cr

7.2 International Travel Support (ITS)

International Travel Support (ITS) Scheme provides financial assistance to Indian researchers for presenting a research paper at an international scientific event (conference, seminar, workshop etc.) held abroad. In addition, support is also provided to young scientists (age limit below 35 years as on the date of start of the event) for attending training programmes, Short-term schools, and Workshops. For senior scientists (more than 35 years of age), support is also provided to chair a session or deliver a keynote address.

During the financial year (2022-23), the ITS Scheme considered 3880 applications for various Conferences/Workshops towards partial support from all the States/ UTs across the country in various fields of Science and Technology. Out of these, a total of 1644 participants were recommended for support for presenting their scientific and technical findings (Table 7.3). 1644 applications in different subjects/disciplines were recommended for support. Among them, 1287 were young scientists and 357 were senior scientists. (Table 7.4).

Table 7.3: Recommended number of applications during the year 2022-23:-

S.No	Items	Conference/Workshop
1.	Application Considered	3880
2.	Application Recommended	1644

FEATURES

Provides opportunity to emerging and eminent scientists to present their research findings in international scientific events held abroad

Economy class airfare by shortest route, airport-tax and visa fees are provided under the scheme

Registration fee as per actual or Rs. 50,000 whichever is less is provided to young scientists

Website link: https://serb.gov.in/page/english/research_grants#International%20Travel%20Support%20(ITS)

The participants were supported to attend various conferences held in different countries across the world, among them countries are Australia (41), Austria (58) Canada (75), France (80), Germany (104), Japan (54), Italy (101), Spain (89), Singapore (38), United Kingdom (76), and United States of America (715). The important events supported under the Scheme are American Physical Society March 2023, SPIE Photonics West, Gordon Research Conferences& Seminar, 2022 MRS Fall & Exhibit, American Geophysical Union Fall Meeting 2021, Experimental Biology, European Materials Research Society-2022 Fall Meeting, EGU General Assembly 2022, ASM Microbe 2022, FEMS Conference on Microbiology 2022.

721
Total number of Sanctions

Expenditure (New)
10.27 Cr

Table 7.4: Subject-wise summary of considered & recommended Applications (2022-23):-

Sr. No.	Name of discipline	Considered Proposals	Recommended Projects	Gender		Category	
				M	F	Senior Scientists >35 Years)	Young Scientist (<35 Years)
1.	Chemical Sciences	323	169	90	79	26	143
2.	Earth & Atmospheric Sciences	350	119	77	42	23	96
3.	Engineering Sciences	1034	434	331	103	96	338
4.	Life Sciences	1461	576	298	278	172	404
5.	Mathematical Sciences	199	81	48	33	10	71
6.	Physical Sciences	513	265	165	100	30	235
	Grand Total	**3880**	**1644**	**1009**	**635**	**357**	**1287**

Table 7.5: Institute- wise summary of considered & recommended Applications (2022-23): -

S.No	Institution Type	Considered Proposals	Recommended Projects
1	Industry/ NGO	38	13
2	Laboratory	87	44
3	Private College/University	600	228
4	State/Central government Institution	2501	1100
5	State/Central- College/University	654	259
Grand Total		**3880**	**1644**

7.3 Accelerate Vigyan (AV)

Accelerate Vigyan (AV) strives to provide a big push to high-end scientific research and prepare scientific manpower who can venture into research careers and a knowledge-based economy. The aim of the scheme is to expand the research base, with three broad goals - consolidation/aggregation of all national scientific training programs, initiating High-end Orientation Workshops and creating opportunities for Research Internships.

This scheme is primarily to focus on young researchers from universities, colleges, private academic institutions and newly established institutes with an aim to give an opportunity to them to spend quality time in the pre-identified premier institution, labs/organizations of the esteemed research environment and positively reinforce their strengths so that they acquire the requisite skills and vision for undertaking future research assignments requiring high standards.

During the reporting period, a total of 886 applications were received in AV-ABHYAAS. A total of 281 and 152 applications were sanctioned, respectively, under High-End Workshop (Karyashala) and Training & Skill Internship (Vritika) components during the reporting time.
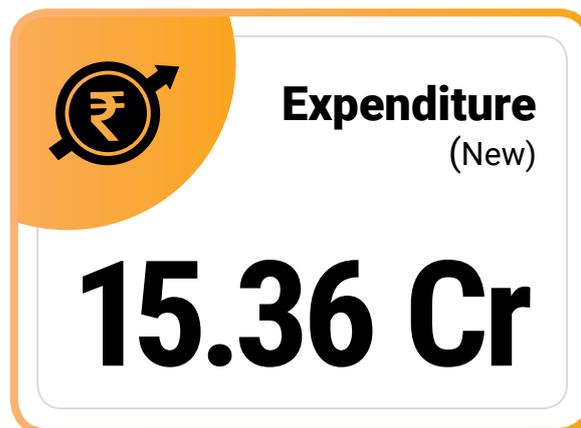
Website links
https://serb.gov.in/page/english/research_grants#Accelerate%20Vigyan

www.acceleratevigyan.gov.in

433
Total number of Sanctions

Expenditure
(New)

15.36 Cr
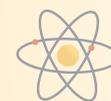
7.4 Outreach Activities

7.4.1 Vision Oriented Thought Exchange (VORTEX)

Vision Oriented Thought Exchange (VORTEX) on Present Status and Future Prospects on Preparedness of Utilization of SERB National Cryo-Electron Microscopy Facilities.

One day Vision Oriented Thought Exchange (VORTEX) on Present Status and Future Prospects on Preparedness of Utilization of SERB National Cryo-Electron Microscopy Facilities was held at the Indian Institute of Technology Bombay, Mumbai on 5th May 2022. About 10 subject experts and 75 participants attended the one day event. The conference started with the introductory words from Dr Ruchi Anand. Dr Subhashish Chowdhury, Director, IIT Bombay delivered the welcome address and stressed the importance of interdisciplinary research and setting up interdisciplinary facilities SERB-Cryo Electron Microscopy Facilities.

Prof. Sandeep Verma, Secretary, SERB delivered the Special Address and introduced the program and explained the meaning of VORTEX which stood for Vision Oriented Thought Exchange. VORTEX serves as a platform for brainstorming and understanding the problems faced by investigators and specifically young PIs. Dr Verma spoke about the inception of the idea for setting up these facilities. During the COVID pandemic, the importance of structural biology and the requirement of infrastructure for testing / understanding the structures of the newly synthesized compounds were realized. SERB went on to put aside 120 crore rupees for setting up four Cryo Electron Microscopy Facilities. These CryoEM facilities would have a strong impact on the structural biology research in India. It would further help to attract young talent to come back to India and start their labs.

Experts in the field of Cryo-Electron Microscope and structural biology were invited to deliver talks on various aspects of the field in four sessions on the following topics:

- Expanding the capabilities and infrastructure for cryo-EM.
- Structural and functional insights into infectious disease biology using cryo-EM.
- Structure determination of the GTP-dependent endonuclease McrBC: challenges faced and techniques used.
- Structure, function and modulation of G protein-coupled receptors.
- De-orphaning the Orphan Glutamate Delta Receptors: Structural and Functional Insights.
- A tale of overcoming the preferred orientation problem.
- Time-resolved cryo-EM: Emerging technique to capture short lived intermediate states of biomolecular reactions.
- Cryo-EM of virus capsids and viral proteins.
- Stories in Ice: the power of cryo-electron tomography with sub-tomogram averaging.

Followed by the technical sessions, a Panel Discussion on improving the infrastructure and utilizing the facilities at their fullest efficiency had been conducted with the following experts, Dr. Shekhar C. Mande, Former DG-CSIR, New Delhi, Dr. Amit Sharma, Director, NIMR, New Delhi, Dr. Vinothkumar Kutti Ragunath, NCBS, Bangalore, Dr. Jayant Udgaonkar, Director, IISER Pune and Dr. Sandeep Verma, Secretary SERB. Based on the discussion the workshop ended with workable recommendations for further consideration by the SERB.

Fig 7.1: Participants of the Vision Oriented Thought Exchange (VORTEX) programme on Cryo-Electron Microscope.

7.4.2 Conclave

Professional Advancement Program for Indian Women Researchers in STEM

A two-days Professional Advancement Program for Indian Women Researchers in STEM, sponsored by Science and Engineering Research Board (SERB), Department of Science and Technology, Government of India was organized at Doon University Dehradun (Uttarakhand) during 02nd-03rd June 2022. Enhancing the skills and competence of women scientists and academicians (engaged in research and development activities) was the main purpose of the program. Additional objectives were to sensitize, inspire and orient the women researchers in STEM for translational research and enable them to acquire competence for ensuring equal access and weighted opportunities in government funding schemes and their scientific growth. About 200 participants including, POWER (Promoting Opportunities For Women in Exploratory Research) grantee, women researchers and young faculty members from various states of the country attended the program. Some researchers from high hills of Uttarakhand also participated.

The workshop provided a platform to women researchers to interact with each other and catalyzed the collaboration among them in interdisciplinary areas. The program had highly relevant and significant interactive sessions on the following topics with eminent scientists:

1. Funding opportunities at the Science and Engineering Research Board (SERB), Department of Science and Technology, Government of India.

2. Science and Technology landscape: opportunities and challenges for women in Uttarakhand.

3. Selection of the research problem in the present scenario and formulation of a suitable research proposal for funding from national agencies.

4. Women and leadership.

5. Importance of translational research and ethics in research and publications.

6. Effective manuscript writing for publication in high impact journals.

7. Intellectual property rights: introduction of IPR, objectives and outcomes, identifying, acquiring, preserving and protecting the IPR.

Women in Science &Technology: Fostering Innovation

The conclave was organised during 29-30th September 2022 at Indian Institute of Technology Gandhinagar, Gujarat with the aim to encourage women researchers, scientists and engineers to translate their innovative ideas into technology. For that the women PIs working in SERB projects under POWER, IMPRINT-II and CRG (Engineering) with the potential of translational research were invited to participate. Around 150 participants were present during the Conclave. They were provided a platform through this conclave to interact with Industry and academicians with experience to work with industry. Women speakers who excel in their field of work were invited to share their experiences and to deliver motivational talks. A few speakers to name are- Dr. Archana Sharma, Senior Advisor for relations with International Organisations, CERN, Geneva, Switzerland was the Keynote Speaker, Dr. Ravinder Kaur from Seimens Health care Pvt. Ltd., Bengaluru, Dr. Kamala Rai from Novartis, Hyderabad. The event was a success with approx. 150 women participants, it helped the participants to instil within them, the spirit of entrepreneurship as it facilitated the face-to-face discussions with Industry people about the translational research. SERB is in receipt of many positive responses both from the Industry people and PIs. The women PIs also got an opportunity to showcase their work to the Industry and to discuss the way ahead.

Fig 7.2: Women conclave organised by SERB at IIT- Gandhinagar during 29th -30th September,2022.

8

PATENTS AND PUBLICATIONS

8.1 Patent Filed/Granted

Patents resulting from research and supported by SERB (Patents filed/granted during FY 2022-2023)

Scheme	Number of Patents filed
Core Research Grant (CRG)	71
Early Career Research Award (ECRA)	32
Impacting Research Innovation and Technology (IMPRINT-2)	27
Empowerment and Equity Opportunities for Excellence in Science (EMEQ)	22
Teachers Associateship for Research Excellence (TARE)	10
Intensification of Research in High Priority Area (IRHPA)	6
Start-up Research Grant (SRG)	24
SERB Power Fellowship	1
SERB Power Grant	1
Other Schemes	23

Note: Data till 31st March 2023 and generated on 12th April 2023
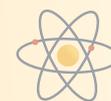
8.2 Publications

Publications resulting from SERB-funded projects/fellowships (Paper Published during FY 2022-2023)

Scheme	SCI	Non-SCI	Total
Core Research Grant (CRG)	2180	464	2644
Early Career Research Award (ECRA)	648	138	786
Empowerment and Equity Opportunities for Excellence in Science (EMEQ)	461	153	614
National Post-Doctoral Fellowship (N-PDF)	225	38	263
MATRICS	314	105	419
Start Up Research Grant (Young Scientist)	13	0	13
Start-up Research Grant (SRG)	667	287	954
Impacting Research Innovation and Technology (IMPRINT-2)	72	44	116
Teachers Associateship for Research Excellence (TARE)	152	36	188
Distinguished Investigator Award (DIA) Scheme	26	0	26
Intensification of Research in High Priority Areas (IRHPA)	45	2	47
Scientific and Useful Profound Research Advancement (SUPRA)	6	2	8
Ramanujan Fellowship	51	5	56
J C Bose Fellowship	92	3	95
SERB Power Fellowship	25	9	34
Promoting Opportunities for Women in Exploratory Research (POWER)Grant	36	16	52
SERB Science and Technology Award for Research (SERB-STAR)	23	7	30
SERB Technology Translation Award (SERB-TETRA)	21	6	27
Other Schemes	53	21	74

Note: Data till 31st March 2023 and generated on 12th April 2023

8.3 Human Resources Development

Manpower sanctioned under different schemes/programmes during FY 2022-23

Scheme	JRF / SRF	Other than JRF / SRF	Total
Core Research Grant (CRG)	655	169	824
Start-up Research Grant (SRG)	286	97	383
Empowerment and Equity Opportunities for Excellence in Science (EMEQ)	171	67	238
SERB-POWER Grant	151	87	238
Scientific and Useful Profound Research Advancement (SUPRA)	19	22	41

Note: Data till 31st March 2023 and generated on 12th April 2023

9

ADMINISTRATION

The Administration of any organisation plays a vital role in meeting its objectives. All efforts are made to ensure that SERB gets the institutionalised environment for producing results and targets. SERB provides motivation to the workforce and makes them conceive their goals.

9.1 Administration and Recruitment

SERB has a total sanctioned strength of 24 including 20 Scientific and 4 non-technical Positions. Out of 20 scientific posts, 19 posts have already been filled up and one post of Scientist G (Level-14) fell vacant during the said period, for which action is taken to fill up the post. Out of the four posts of non-technical three posts have already been filled up, except for one post of Section Officer (SO). The post of SO in SERB has been upgraded from Level-6 to Level-7 in the pay matrix with the approval of the Department of Expenditure, Ministry of Finance and action is underway to amend the Recruitment Regulations (RRs) of SERB, before filling up the second post of SO.

9.2 Implementation of Official Language

The Science & Engineering Research Board (SERB), since its inception, has been implementing the guidelines issued by the Department of Official Language, Ministry of Home Affairs in order to increase the progressive use of Hindi in official work. Hindi Pakhwada was celebrated in SERB from 14th to 28th of September 2022. To promote the Official Language, various activities were organized for Hindi and non-Hindi-speaking staff/officers. Cash prizes and certificates were distributed to the winners of Hindi competitions to motivate the officers and staff of SERB to promote the usage of Hindi in official work.

In order to create a positive environment & enhance the working knowledge of Hindi, four Hindi Workshops were organized on 29.06.2022, 28.09.2022, 30.12.2022 and 17.03.2023 for officers/staff of SERB. The expert faculty shared their experience, expertise, knowledge and appraised participants about the rules, regulations and guidelines of the official language. A large number of officers and staff participated in these Workshops. A new English - Hindi work was displayed on a daily basis on a digital board to increase the word power of employees.

Fig 9.1: Hindi Pakhwara Celebration at SERB

Quarterly meetings of the Official Language Implementation Committee were held regularly on 29.06.2022, 28.09.2022, 30.12.2022 and 16.03.2023 to review the progressive use of the Hindi language in SERB. Quarterly Reports in connection with the Progressive use of Hindi in SERB were sent to the Department of Science and Technology (DST) well in time. Two half-yearly Town Official Language Implementation Committee (NARAKAS) meetings were organized on 24.06.2022 & 29.11.2022 and NARAKAS conference on 16.03.2023 by the Indian Institute of Mass Communication, New Delhi. SERB, being a member of the committee participated in the said meetings/conferences.

9.3 Right to Information Act, 2005 (RTI)

The provisions of the RTI Act, 2005 are being followed and requisite information is provided to the Applicants under the RTI Act. A total of 51 applications were received during the financial year 2022-23. Out of which, 19 were received as transfers from other public authorities u/s 6(3). Six appeals were also received during the year and disposed of by the Appellate Authority. A total fee of Rs.10/- was received by SERB for providing information under the RTI Act, 2005 during the year 2022-23.

9.4 Vigilance Awareness

Vigilance Awareness Week was observed by SERB from 31st October 2022 to 6th November 2022. The theme of the week was "Corruption-free India for a Developed Nation". All officers/staff of SERB took an integrity pledge to abide by the principles of honesty and integrity to fight against corruption on 4th November 2022.
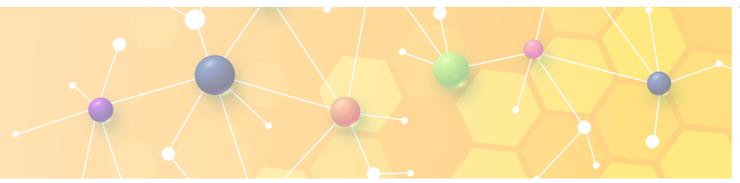
Fig 9.2: Oath taking during Vigilance Awareness Week

9.5 Internal Complaints Committee (ICC)- Women

Internal Complaints Committee (ICC) – Women, has been functioning in SERB since 2017. The Committee meets regularly and discussions on relevant issues are held. The composition of the committee, complaint procedures and related information are available on the website of SERB.

9.6 Audited Annual Statement of Accounts

As per the provisions laid down in Section 13 of the Science and Engineering Research Board (SERB) Act, 2008, the Annual Accounts of the Board are required to be prepared in the prescribed format and audited by the Comptroller and Auditor General of India (C&AG) or by their appointed auditors annually. Accordingly, the annual accounts for the financial year 2022-23 have been prepared and audited by a team of auditors from C&AG. The duly audited financial statement and annual accounts for the financial year 2022-23 form a part of the Annual Report.

ANNUAL STATEMENT OF AUDITED ACCOUNTS FOR THE YEAR 2022-2023

Science and Engineering Research Board

Amount in Rs.

Balance Sheet as at 31.03.2023

	Schedule	Current Year	Previous Year
CORPUS / CAPITAL FUND AND LIABILITIES			
Corpus / Capital Fund	Schedule 1	50,81,45,252.16	34,54,69,814.81
Reserves and Surplus	Schedule 2	-	-
Earmarked / Endowment Funds	Schedule 3A, 3B, 3C, 3D, 3E, 3F,3G,3H,3I& 3J	10,75,77,31,213.41	21,34,34,978.88
Secured Loans and Borrowings	Schedule 4	-	-
Unsecurred Loans and Borrowings	Schedule 5	-	-
Deferred Credit Liabilites	Schedule 6	-	-
Current Liabilites and Provisions	Schedule 7	1,59,13,353.73	7,10,70,423.96
Total		**11,28,17,89,819.30**	**62,99,75,217.65**
ASSETS			
Fixed Assets (Net)	Schedule 8 & 8A	12,99,40,566.72	12,07,59,632.00
Investments-From Earmarked / Endowment Funds	Schedule 9	-	-
Investments-Others	Schedule 10	-	-
Current Assets, Loans, Advances etc.	Schedule 11	11,15,18,49,252.58	50,92,15,585.65
Miscellaneous Expenditure			
(to the extent not written off or adjusted)			
Total		**11,28,17,89,819.30**	**62,99,75,217.65**
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES

Chartered Accountants

For Science and Engineering Research Board

CA Pulkit Agrawal

(Partner)

M. No. 431102

Date : 15.05.2023

Place : New Delhi

UDIN: 23431102BGVWAV9099

Secretary
SERB

Date :

Place : New Delhi

Director-Finance
SERB

Amount in Rs.

Income & Expenditure Account for the Year Ended on 31.03.2023

	Schedule	Current Year	Previous Year
Income			
Income from Sales / Services	Schedule 12	-	-
Grants / Subsidies *	Schedule 13	7,98,62,03,811.99	8,95,29,55,499.00
Fees / Subscriptions	Schedule 14	-	-
Income from Investments	Schedule 15	-	-
Income from Royalty, Publication etc	Schedule 16	-	-
Interest Earned	Scheduel 17	-	-
Other Income	Schedule 18	3,40,19,802.00	1,53,81,245.00
Increased/(Decrease) in stock of Finished Goods and Works-in-Progress	Schedule 19	-	-
Total (A)		**8,02,02,23,613.99**	**8,96,83,36,744.00**
Expenditure			
Establishment Expenses	Schedule 20	14,08,07,033.00	12,87,10,551.00
Other Administrative Expenses	Schedule 21	7,94,00,588.25	10,75,14,109.62
Expenditure on Grant, Subsidies etc	Schedule 22	7,81,89,35,638.26	8,82,21,23,847.18
Interest	Schedule 23	-	-
Depreciation (Net Total at the Year end)	Schedule 8	3,40,19,792.00	1,53,81,235.00
Total (B)		**8,07,31,63,051.51**	**9,07,37,29,742.80**
Excess of Income over Expenditure (A-B) (Before PPI & PPE)		**-5,29,39,437.52**	**-10,53,92,998.80**
Excess of Expenditure over Income (A-B) (Before PPI & PPE)		-	-
Prior Period Income	Schedule 24	44,00,95,139.96	31,50,39,853.40
Prior period Expenditure	Schedule 25	78,27,251.00	33,80,582.68
Excess of Income over Expenditure (A-B) (After PPI & PPE)		-	-
Excess of Expenditure over Income (A-B) (After PPI & PPE)		**37,93,28,451.44**	**20,62,66,271.92**
Transfer to Special Reserve (Specity each)		-	-
Transfer to / from General Reserve		-	-
Balance Being Surplus (Deficit) carried to Corpus/Capital Fund		**37,93,28,451.44**	**20,62,66,271.92**
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

* CY- This amount reflect total grant received by SERB of Rs. 803,00,00,000/- less Fixed Assets purchased of Rs. 4,37,96,188.01/- (transferred to Corpus Fixed Assets Sch. 1)

* PY- This amount reflect total grant received by SERB of Rs. 900,00,00,000/- less Fixed Assets purchased of Rs. 4,70,44,501/- (transferred to Corpus Fixed Assets Sch. 1)

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES

Chartered Accountants

For Science and Engineering Research Board

CA Pulkit Agrawal

(Partner)

M. No. 431102

Date : 15.05.2023

Place : New Delhi

UDIN: 23431102BGVWAV9099

Secretary
SERB

Director-Finance
SERB

Date :

Place : New Delhi

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 1 - Corpus / Capital Fund

Particulars	Current Year	Previous Year
Corpus Balance at the beginning of the year	22,64,61,240.81	28,10,25,883.89
Add: Sale/Exchange of Fixed Assets (Laptop & Printer)	-	-
Less: Interest earned on refunds during FY 2019-20 transferred to GOI, Consolidated Fund	-	-
Less: Current Period Surplus in Capital Corpus transferred to GOI, Consolidated Fund	-	-
Less: Prior period Surplus in Capital Corpus transferred to GOI, Consolidated Fund	-22,64,61,240.81	-26,08,30,915.00
Add/(Deduct) : Balance of net income/(Expenditure) transferred from the Income & Expenditure Account	37,93,28,451.44	20,62,66,271.92
Corpus Balance at the end of the year (A)	**37,93,28,451.44**	**22,64,61,240.81**
Corpus (Fixed Assets) Balance at the beginning of the year	11,90,08,574.00	9,38,21,609.00
Add: Contributions towards Corpus/Capital Fund (Fixed Assets)		
FY 2021-22	-	4,70,44,501.00
FY 2022-23	4,37,96,188.01	-
Sale/Exchange of Fixed Assets (Laptop & Printer)**	31,830.71	1,76,190.00
Fixed Assets (Interior work) written off /discard	-	-66,52,491.00
Deferred Revenue Grant for FY 2021-22*	-	-1,53,81,235.00
Deferred Revenue Grant for FY 2020-21*	-3,40,19,792.00	-
Corpus (Fixed Assets) Balance at the end of the year (B)	**12,88,16,800.72**	**11,90,08,574.00**
Total of Corpus & Corpus (Fixed Assets) (A) + (B)	**50,81,45,252.16**	**34,54,69,814.81**
*Refer Point No. 12 In Schedule 26 Significant Accounting Policies		
**Refer Point No. 9 In Schedule 27 Significant Accounting Policies		

Schedule 2 - Reserve and Surplus

Particulars	Current Year		Previous Year	
1. Capital Reserves :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
2. Revaluation Reserves :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
3. Special Reserve :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
4. General Reserve :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
Total		-		-
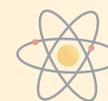
Science and Engineering Research Board

<div align="right">Amount in Rs.</div>

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3A - Earmarked/Endowment Funds MOFPI

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	1,43,91,778.00	1,39,86,179.00
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (MFPI)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest from SERB on Saving Balance	4,17,362.00	4,05,599.00
Interest on MFPI Refund	53,371.00	-
Refund from previous year Grant FY 2013-14 (Ann. 1 & 1A)	-	-
Refund from previous year Grant FY 2014-15 (Ann. 2 & 2A)	-	-
Refund from previous year Grant FY 2015-16 (Ann. 3 & 3A)	-	-
Refund from previous year Grant FY 2016-17 (Ann. 4 & 4A)	-	-
Refund from previous year Grant FY 2017-18 (Ann. 5 & 5A)	-	-
Refund from previous year Grant FY 2018-19 (Ann. 6 & 6A)	-	-
Total (a+b)	**1,48,62,511.00**	**1,43,91,778.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (MFPI- Capital) (Ann. 7 & 7A)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (MFPI- General) (Ann. 8 & 8A)	-	-
Total c)	**-**	**-**
d) Less: Amount given back to Ministry of Food Processing	**-**	**-**
Net Balance as at the year end (a+b-c-d)	**1,48,62,511.00**	**1,43,91,778.00**

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3B - Earmarked/Endowment Funds S & T Programme

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	2,39,70,299.79	1,99,57,631.59
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (S & T Programme - Schedule Castes)	-	-
Grant in Aid (S & T Programme - Schedule Tribe)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
S & T SC-Interest from SERB on Saving Balance	6,60,812.00	5,75,298.00
S & T ST-Interest from SERB on Saving Balance	4,295.00	3,473.00
S & T SC- Refund from previous year Grant FY 2013-14 (Ann. 9 & 9A)	-	10,59,083.50
S & T SC- Refund from previous year Grant FY 2015-16 (Ann. 10 & 10A)	-	86,574.00
S & T SC- Refund from previous year Grant FY 2016-17 (Ann. 11 & 11A)	-	1,03,282.00
S & T SC- Refund from previous year Grant FY 2018-19 (Ann. 12 & 12A)	38,51,514.00	8,92,177.97
S & T - Interest on Refund -ST	-	2,44,331.00
S & T - Interest on Refund -SC	5,40,255.17	10,48,448.73
Total (a+b)	2,90,27,175.96	2,39,70,299.79
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (S & T- Schedule Castes - Capital)	-	-
Grant-in-aid (S & T- Schedule Tribe - Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Excess interest on refund Transferred to Cental Government	12,92,779.73	
Grant-in-aid (S & T- Schedule Castes - General)	-	-
Grant-in-aid (S & T- Schedule Tribe - General)	-	-
Total c)	12,92,779.73	-
Net Balance as at the year end (a+b-c)	2,77,34,396.23	2,39,70,299.79
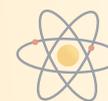
Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3C - Earmarked/Endowment Funds ICPS

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	81,55,379.00	79,19,175.00
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid- ICPS	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (ICPS: 349902010049636)	2,39,072.00	2,36,204.00
Total (a+b)	**83,94,451.00**	**81,55,379.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (ICPS- Capital) (Ann. 13 & 13A)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure- Bank Charges	-	-
Grant-in-aid (ICPS- General) (Ann. 14 & 14A)	-	-
Total c)	**-**	**-**
Net Balance as at the year end (a+b-c)	**83,94,451.00**	**81,55,379.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3D - Earmarked/Endowment Funds DOT

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	80,05,744.00	77,80,121.00
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (DOT- General)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest from SERB on Saving Balance	2,32,167.00	2,25,623.00
Total (a+b)	**82,37,911.00**	**80,05,744.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (DOT- Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (DOT- General) (Ann. 15 & 15A)	-	-
Total c)	**-**	**-**
Net Balance as at the year end (a+b-c)	**82,37,911.00**	**80,05,744.00**
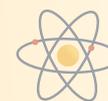
Science and Engineering Research Board

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3E - Earmarked/Endowment Funds IMPRINT-II -MHRD

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	1,41,15,893.00	11,10,55,497.00
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (IMPRINT-II)	-	92,00,000.00
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (IMPRINT-II: 349902010049001)	4,51,289.00	17,04,366.00
Interest earned on Saving Balance General	-	-
Refund from previous year Grant FY 2018-19 (Ann. 16 & 16A)	26,49,326.00	12,57,124.00
Refund from previous year Grant FY 2019-20 (Ann. 17 & 17A)	58,29,444.00	2,232.00
Refund from previous year Grant FY 2021-22 (Ann. 18 & 18A)	22,37,413.00	11,87,535.00
Interest on IMPRINT-II Refund	23,49,176.00	3,89,139.00
Total (a+b)	2,76,32,541.00	12,47,95,893.00
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (IMPRINT-II- Capital) (Ann. 19 & 19A)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (IMPRINT-II- General) (Ann. 20 & 20A)	1,19,60,000.00	11,06,80,000.00
Total c)	1,19,60,000.00	11,06,80,000.00
Net Balance as at the year end (a+b-c)	1,56,72,541.00	1,41,15,893.00

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3F - Earmarked/Endowment Funds Industrial Research Engagement (FIRE)

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	63,00,000.00	
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (FIRE)	-	63,00,000.00
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions (TDS Recoverable)	7,00,000.00	-
Interest earned on Saving Balance	2,04,263.00	-
Total (a+b)	**72,04,263.00**	**63,00,000.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (Fire- Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Other Administrative Expenditure		
Grant-in-aid (Fire- General)	-	-
Total c)	**-**	**-**
Net Balance as at the year end (a+b-c)	**72,04,263.00**	**63,00,000.00**
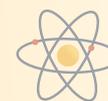
Science and Engineering Research Board

<div align="right">Amount in Rs.</div>

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3G - Earmarked/Endowment Funds Innovation TechnologyDevelopment and Deployment (ITDDF)*

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	-	
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (ITDDF)	6,80,43,13,676.39	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance	4,38,58,917.00	-
Total (a+b)	**6,84,81,72,593.39**	**-**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (ITDDF)	1,98,66,03,625.49	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Other Administrative Expenditure		
Grant-in-aid (Fire- General)	-	-
Total c)	**1,98,66,03,625.49**	**-**
Net Balance as at the year end (a+b-c)	**4,86,15,68,967.90**	**-**

*The ITDDF fund is controlled and operated by Department of Science and Technology, Govt. of India. For Details Refer to note 11 in schedule 27 notes to accounts.

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3H - Earmarked/Endowment Funds Research and Development (RAD)*

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	-	
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (RAD)	6,76,96,50,642.45	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance	3,91,72,270.00	-
Total (a+b)	**6,80,88,22,912.45**	**-**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (RAD)	1,21,67,65,216.86	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Other Administrative Expenditure		
Grant-in-aid (Fire- General)	-	-
Total c)	**1,21,67,65,216.86**	**-**
Net Balance as at the year end (a+b-c)	**5,59,20,57,695.59**	**-**

*The RAD fund is controlled and operated by Department of Science and Technology, Govt. of India. For Details Refer to note 11 in Schedule 27 notes to accounts.
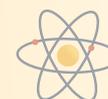
Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3I-Earmarked/Endowment Funds Industrial Research Engagement (AMAT FIRE)

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	-	
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (AMAT Fire)	25,61,690.00	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance	13,252.00	-
Total (a+b)	**25,74,942.00**	**-**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (AMAT Fire) (Ann. 21& 21A)	25,61,690.00	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Other Administrative Expenditure		
Grant-in-aid (Fire- General)	-	-
Total c)	**25,61,690.00**	**-**
Net Balance as at the year end (a+b-c)	**13,252.00**	**-**

Science and Engineering Research Board

<div align="right">Amount in Rs.</div>

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 3J - Earmarked/Endowment Funds Asean India Science and Technology Development Fund (AISTDF)

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds		
ii) Opening Balance of AISTDF (Fixed Assets Fund Corpus Fund)	17,51,058.00	27,91,113.00
Add : Contribution towards AISTDF (Fixed Assets Corpus)	7,300.00	-
Less : Deferred Revenue Grant	-6,34,592.00	-10,40,055.00
Closing Balance at the end of year AISTDF (Fixed Assets) Fund	11,23,766.00	17,51,058.00
b) Opening Balance of the Funds		
i) Opening Balance of AISTDF (Corpus Fund)	**13,67,44,827.09**	14,86,84,363.11
c) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (AISTDF)	15,30,00,000.00	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (AISTDF)	35,82,609.00	40,52,000.00
Interest earned on Saving Balance General	-	-
Refund from previous year Grant F Y 2017-18 (Ann. 22 & 22A)	-	5,78,346.00
Refund from previous year Grant F Y 2018-19 (Ann. 23 & 23A)	18,08,413.00	6,38,085.44
Refund from previous year Grant F Y 2019-20 (Ann. 24 & 24A)	1,48,08,567.60	68,39,093.54
Refund from previous year Grant F Y 2020-21 (Ann. 25 & 25A)	14,68,125.00	28,58,187.00
Refund from previous year Grant F Y 2021-22 and other (Ann. 26 & 26A)	8,20,241.00	77,77,329.00
Interest on AISTDF Refund	12,66,078.00	-
Deffered Revenue Grant	6,34,592.00	10,40,055.00
Total (b+c)	**31,41,33,452.69**	**17,24,67,459.09**
d) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	7,300.00	-
Other Additions	-	-
Grant-in-aid (AISTDF) (Ann. 27 & 27A)	-	-
ii) Revenue Expenditure		
Establishment expense Salary, Wages and allowance etc	4,88,252.00	3,80,028.00
Rent	-	-
Other Administrative Expenditure	44,96,046.00	19,56,239.00
Fixed Assets Depreciation Expenditure	6,34,592.00	10,40,055.00
Grant-in-aid (AISTDF- General) (Ann. 28 & 28A)	8,76,45,804.00	3,23,46,310.00
Total d)	**9,32,71,994.00**	**3,57,22,632.00**
Total e) Net Balance as at the year end (b+c-d)	**22,08,61,458.69**	**13,67,44,827.09**
Total f) Net Balance Corpus Fund as at the year end (a+e)	**22,19,85,224.69**	**13,84,95,885.09**
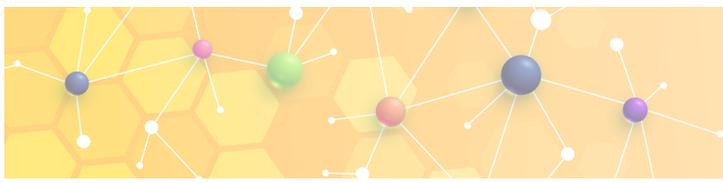
Science and Engineering Research Board

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 4 - Secured Loans and Borrowings

Particulars	Current Year		Previous Year	
1. Central Government		-		-
2. State Government		-		-
3. Financial Institutions				
a) Term Loans	-		-	
b) Interest accrued and dues	-	-	-	-
4. Banks :				
a) Term Loans	-		-	
Interest accrued and due	-		-	
b) Other Loans	-		-	
Interest accrued and due	-	-	-	-
5. Other Institutions and Agencies		-		-
6. Debentures and Bonds		-		-
7. Others		-		-
Total		**-**		**-**

Schedule 5 - Unsecured Loans and Borrowings

Particulars	Current Year		Previous Year	
1. Central Government		-		-
2. State Government		-		-
3. Financial Institutions				
4. Banks :				
a) Term Loans	-		-	
b) Other Loans	-	-	-	-
5. Other Institutions and Agencies		-		-
6. Debentures and Bonds		-		-
7. Fixed Deposites		-		-
8. Others		-		-
Total		**-**		**-**

Schedule 6 - Deferred Credit Liabilites

Particulars	Current Year	Previous Year
a) Acceptances secured by Hypothecation of Capital Equipment & other assets	-	-
b) Others	-	-
Total	**-**	**-**

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
A) Current Liabilities				
1. Acceptances		-		-
2. Sundry Creditors				
a) For Goods		-		-
b) Others:				
National Mission on Bamboo Application	-		-	
Uneecode Inc., Delhi (RSM Enterprises, New Delhi)	-		-	
VPCA and Associates	13,91,220.00		13,41,660.00	
VPCA and Associates (AISTDF)	29,500.00		59,000.00	
FDS Management Services Private Limited				
Mansarover Industrial Corporation, New Delhi				
S. N Solutions, Delhi	1,36,444.00		1,65,615.00	
Suncity Projects Private Limited, New Delhi				
Balmer Lawrie & Co. Ltd., New Delhi	2,85,265.00			
Dinesh Singh Tomer, New Delhi				
Darsheel Enterprises, New Delhi	51,777.00		44,832.00	
Shalu Tour And Travels, New Delhi	2,37,532.00		1,78,178.00	
R S Travels Solution Private Limited				
Sonpal	25,770.00		20,570.00	
Sr. Post Master Sarojini Nagar, H.P.O.	7,033.00		9,534.00	
Deldsl-Digital NTC				
Digital NTC-New Delhi				
Airtel	33,941.52		33,941.52	
K B Enterprises, New Delhi				
MV Infotech India, New Delhi				
Nandini Flower Decoration, New Delhi	16,300.00			
Uneecops Technologies Limited, New Delhi				
Gung HO Marketing Services Private Limited, New Delhi				
J W Marriott, New Delhi				
A P Enerprises New Delhi	-		21,240.00	
NIT Ram Choudhary Tempo Services	-		10,780.00	
Adeptech Solutions Private Limited, New Delhi	-			
NSDL E Governanace Infrastructure Limited	-		799.00	
Net Creative Mind Solutions Private Limited	-	22,14,782.52	-	18,86,149.52
3. Advances Received		-		-
4. Interest accrued but not due on :				
a) Secured Loans / Borrowings		-		-
b) UnSecured Loans / Borrowings		-		-
5. Statutory Liabilities				
a) Over Due		-		-
b) Others : TDS - Section 194C	-		7,008.00	
TDS - Section 194J	-		-	
TDS - Section 194I	-		-	
TDS - Section 192	10,62,880.00		10,10,610.00	
GST -TDS	2,03,449.00	12,66,329.00	3,29,288.00	13,46,906.00
Total (1)		34,81,111.52		32,33,055.52

Science and Engineering Research Board

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
6. Other Current Liabilities				
Expenses Payable				
Salary Payable	94,30,112.00		83,75,061.00	
Salary Payable (AISTDF)	33,250.00		59,202.00	
Wages Payable	10,000.00		10,000.00	
EPF Payable Employee Contribution	14,400.00		9,000.00	
EPF Payable Employer Contribution	16,220.00		10,213.00	
EPF Payable (AISTDF)	3,803.00		3,802.00	
NPS Contribution Payable	9,16,904.00		7,72,828.00	
Audit Fee Payable	10,59,000.00		9,04,500.00	
Audit Fee Payable (AISTDF)	23,600.00		70,800.00	
Telephone Expenses Payable (Reimbursement)	2,35,039.00			
Children Education Allowance Payable (Reimbursement)	4,59,000.00			
Medical Expenses Payable (Reimbursement)				
Newspaper Expenses Payable (Reimbursement)	87,638.00			
Travelling Expenses Payable (Domestic)	1,07,016.93			
Hospitatlity Expense Payable	11,916.00			
AMC Payable	75,961.00		1,34,263.00	
Housekeeping and Other Office Expenses Payable	5,79,361.00		6,22,340.00	
Honorarium Expenses Payable (Non-Official)	-	1,30,63,220.93	4,000.00	1,09,76,009.00
Deductions Payable				
Secretary Deduction Payable (IIT Kanpur)	-		28,036.00	
Secretary Leave Salary & Pension Contribution Payable	-		6,28,119.00	
Other Employees Deduction Payable	43,040.00		1,03,165.00	
Other Employees Contribution Payable	-	43,040.00	5,23,128.00	12,82,448.00
Expenses (Current Liabilities Staff)				
Satish Marar	-		-	
Raja Ravi Verman	-		-	
Pradeep Kumar (IT Technician)	-		-	
Deepak Krishna	-		5,291.00	
Manisha Sethi	-	-	1,215.00	6,506.00
	-		-	
MINISTRY OF FOOD PROCESSING (PY's Meeting Refund)		5,54,552.00		5,54,552.00
GOVERNMENT OF INDIA, CONSOLIDATED FUND		-2,75,37,480.72		3,35,49,642.44
Total (2)		-1,38,76,667.79		4,63,69,157.44
Total (A) =(1) + (2)		-1,03,95,556.27		4,96,02,212.96
B. Provision	-		-	
1. For Taxation	-		-	
2. Gratuity	1,07,65,449.00		88,57,000.00	
3. Superannuation / Pension	-		-	
4. Accumulated Leave Encashment	1,55,43,461.00		1,26,11,211.00	
5. Trade Warranties / Claims	-		-	
6. Others	-		-	
Total (B)		2,63,08,910.00		2,14,68,211.00
Total (A+B)		1,59,13,353.73		7,10,70,423.96

Science and Engineering Research Board

Schdeule 8

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2023

Amount in Rs.

SCHEDULE 8-FIXED ASSETS		GROSS BLOCK				DEPRECIATION					NET BLOCK	
(PURCHASED OUT OF GRANT-IN-AID RECEIVED FROM DST) DESCRIPTION	Rate of Depre-ciation	Cost / valuation as at beginning of the year	Additions during the year	Deductions during the year	Cost / valuation at the year end	As at the beginning of the year	On Opening balance	On Additions during the year	On Deductions during the year	Total up to the year end	As at the current year end	As at the previous year end
A. FIXED ASSETS												
1. LAND												
a) Freehold		-	-	-	-	-	-	-	-	-	-	-
b) Leasehold		-	-	-	-	-	-	-	-	-	-	-
2. BUILDING												
a) On Freehold Land		-	-	-	-	-	-	-	-	-	-	-
b) On Leasehold Land		-	-	-	-	-	-	-	-	-	-	-
c) Ownership Flats/Premises		-	-	-	-	-	-	-	-	-	-	-
d) Interior work	10%	67,25,028.00	50,55,102.00		1,17,80,130.00	21,50,116.00	4,57,491.00	3,43,385.00		29,50,992.00	88,29,138.00	45,74,912.00
3. PLANT & MACHINERY	15%	16,03,116.00	35,400.00		16,38,516.00	9,28,382.00	1,01,210.00	5,310.00		10,34,902.00	6,03,614.00	6,74,734.00
4. VEHICLES		-			-	-				-	-	-
5. FURNITURE & FIXTURES	10%	1,60,24,082.00	22,37,514.00		1,82,61,596.00	78,38,593.00	8,18,551.00	1,60,219.00		88,17,363.00	94,44,233.00	81,85,489.00
6. OFFICE EQUIPMENT	15%	52,04,211.00	15,53,697.01		67,57,908.01	29,51,332.00	3,37,932.00	2,24,914.00		35,14,178.00	32,43,730.01	22,52,879.00
7. COMPUTER/PERIPERALS		-			-	-				-	-	-
A) COMPUTER SOFTWARES	40%	5,92,45,802.00	65,905.00		5,93,11,707.00	5,60,24,292.00	12,88,605.00	19,020.00		5,73,31,917.00	19,79,790.00	32,21,510.00
B) PERIPHERALS	40%	34,60,053.00	1,99,097.00		36,59,150.00	18,79,690.00	6,32,144.00	64,949.00		25,76,783.00	10,82,367.00	15,80,363.00
C) PRINTERS/SCANNERS	40%	50,27,911.00	14,95,625.00	6,85,696.29	58,37,839.71	41,38,229.00	3,55,645.00	4,37,138.00	6,85,127.00	42,45,885.00	15,91,954.71	8,89,682.00
D) COMPUTERS	40%	1,71,96,468.00	9,86,220.00		1,81,82,688.00	1,04,40,092.00	27,02,551.00	3,44,416.00		1,34,87,059.00	46,95,629.00	67,56,376.00
8. ELECTRIC INSTALLATIONS	10%	25,50,385.00	-		25,50,385.00	15,88,335.00	96,205.00	-		16,84,540.00	8,65,845.00	9,62,050.00
9. LIBRARY BOOKS	40%	1,30,394.00	-		1,30,394.00	1,09,891.00	8,201.00			1,18,092.00	12,302.00	20,503.00
10. TUBEWELL & W. SUPPLY		-	-		-	-				-	-	-
11. INTANGIBLE ASSETS	25%	3,30,61,703.00	8,38,37,182.00		11,68,98,885.00	98,63,221.00	57,99,622.00	1,98,22,284.00		3,54,85,127.00	8,14,13,758.00	2,31,98,482.00
TOTAL OF CURRENT YEAR (A)		15,02,29,153.00	9,54,65,742.01	6,85,696.29	24,50,09,198.72	9,79,12,173.00	1,25,98,157.00	2,14,21,635.00	6,85,127.00	13,12,46,838.00	11,37,62,360.72	5,23,16,980.00
PREVIOUS YEAR		13,03,33,737.00	4,05,52,763.00	2,06,57,347.00	15,02,29,153.00	9,64,55,464.00	57,61,786.00	96,19,449.00	1,39,24,526.00	9,79,12,173.00	5,23,16,980.00	3,38,78,273.00
B. CAPITAL WORK IN PROGRESS		6,66,91,594.00	3,19,64,028.00	8,36,01,182.00	1,50,54,440.00						1,50,54,440.00	6,66,91,594.00
TOTAL (A+B)		21,69,20,747.00	12,74,29,770.01	8,42,86,878.29	26,00,63,638.72	9,79,12,173.00	1,25,98,157.00	2,14,21,635.00	6,85,127.00	13,12,46,838.00	12,88,16,800.72	11,90,08,574.00
PREVIOUS YEAR		19,02,77,073.00	7,29,69,694.00	4,63,26,020.00	21,69,20,747.00	9,64,55,464.00	57,61,786.00	96,19,449.00	1,39,24,526.00	9,79,12,173.00	11,90,08,574.00	9,38,21,609.00

Science and Engineering Research Board

Schdeule 8A

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2023

Amount in Rs.

SCHEDULE 8-FIXED ASSETS (AIS'TDF) DESCRIPTION (PURCHASE OUT OF GRANT-IN-AID)	Rate of Depre-ciation	GROSS BLOCK				DEPRECIATION					NET BLOCK	
		Cost / valution as at beginning of the year	Additions during the year	Deductions during the year	Cost / valuation at the year end	As at the beginning of the year	On Opening balance	On Additions during the year	On Deductions during the year	Total up to the year end	As at the current year end	As at the previous year end
A. FIXED ASSETS												
1. LAND												
a) Freehold		-	-	-	-	-	-	-	-	-	-	-
b) Leasehold		-	-	-	-	-	-	-	-	-	-	-
2. BUILDING												
a) On Freehold Land		-	-	-	-	-	-	-	-	-	-	-
b) On Leasehold Land		-	-	-	-	-	-	-	-	-	-	-
c) Ownership Flats/Premises		-	-	-	-	-	-	-	-	-	-	-
d) Interior work	10%	3,43,204.00	-	-	3,43,204.00	1,40,546.00	20,266.00	-	-	1,60,812.00	1,82,392.00	2,02,658.00
3. PLANT & MACHINERY		-	-	-	-	-	-	-	-	-	-	-
4. VEHICLES		-	-	-	-	-	-	-	-	-	-	-
5. FURNITURE & FIXTURES	10%	40,410.00	-	-	40,410.00	13,897.00	2,651.00	-	-	16,548.00	23,862.00	26,513.00
6. OFFICE EQUIPMENT		-	-	-	-	-	-	-	-	-	-	-
7. COMPUTER/PERIPERALS	40%	1,15,56,623.00	7,300.00	-	1,15,63,923.00	1,00,34,736.00	6,08,755.00	2,920.00	-	1,06,46,411.00	9,17,512.00	15,21,887.00
8. ELECTRIC INSTALLATIONS		-	-	-	-	-	-	-	-	-	-	-
9. LIBRARY BOOKS		-	-	-	-	-	-	-	-	-	-	-
10. TUBEWELL & W. SUPPLY		-	-	-	-	-	-	-	-	-	-	-
11. INTANGIBLE ASSETS		-	-	-	-	-	-	-	-	-	-	-
TOTAL OF CURRENT YEAR (A)		1,19,40,237.00	7,300.00	-	1,19,47,537.00	1,01,89,179.00	6,31,672.00	2,920.00	-	1,08,23,771.00	11,23,766.00	17,51,058.00
PREVIOUS YEAR		1,19,40,237.00	-	-	1,19,40,237.00	91,49,124.00	10,40,055.00	-	-	1,01,89,179.00	17,51,058.00	27,91,113.00
B. CAPITAL WORK IN PROGRESS		-	-	-	-	-	-	-	-	-	-	-
TOTAL (A+B)		1,19,40,237.00	7,300.00	-	1,19,47,537.00	1,01,89,179.00	6,31,672.00	2,920.00	-	1,08,23,771.00	11,23,766.00	17,51,058.00
PREVIOUS YEAR		1,19,40,237.00	-	-	1,19,40,237.00	91,49,124.00	10,40,055.00	-	-	1,01,89,179.00	17,51,058.00	27,91,113.00

Science and Engineering Research Board

<div align="right">Amount in Rs.</div>

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 9 - Investments from Earmarked/Endowment Funds

Particulars	Current Year	Previous Year
1. In Government Securities	-	-
2. Other approved Securities	-	-
3. Shares	-	-
4. Debentures and Bonds	-	-
5. Subsidiaries and Joint Ventures	-	-
6. Others (to be Specified)	-	-
Total	-	-

Schedule 10 - Investments - Others

Particulars	Current Year	Previous Year
1. In Government Securities	-	-
2. Other approved Securities	-	-
3. Shares	-	-
4. Debentures and Bonds	-	-
5. Subsidiaries and Joint Ventures	-	-
6. Others	-	-
Total	-	-

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 11 - Current Assets, Loans, Advances Etc

Particulars	Current Year		Previous Year	
A) Current Assets				
1.Inventories :				
a) Stores and Spares (Stationery Stock)		11,36,740.35		11,26,084.00
b) Loose Tools		-		-
c) Stock-in-Trade				
Finished Goods		-		-
Work-in-Progress		-		-
Raw Material		-		-
2. Sundry Debtors :				
a) Debts outstanding for a period exceeding six months		-		-
b) others:		-		-
3. Cash Balances in Hand (including Cheques / Drafts and Imprest)				
Petty Cash Account		-		20,000.00
Cash in Hand		-		75,000.00
4. Bank Balances :				
a) With Scheduled Banks :*				
On Current Accounts	-		-	
On Deposit Accounts	-		-	
On Savings Accounts - SERB (Union Bank of India)	16,58,713.30		28,96,60,216.10	
SERB EPFO Account (UBI)	2,14,385.62		3,27,072.02	
SERB RTI Account (UBI)	924.00		890.00	
SERB NM ICPS (UBI)	83,34,856.00		80,97,481.00	
SERB FSER II (UBI)	43,55,96,534.13		3,93,27,848.44	
SERB Intel FIRE (UBI)	64,58,087.00		63,00,000.00	
SERB ITDDF (UBI)	4,82,95,73,214.90		-	
SERB AMAT Fire (UBI)	13,163.00			
SERB Bank of Maharashtra (RAD)	5,59,20,57,695.59			
IMPRINT-II Account (UBI)	1,42,24,325.00		1,30,69,000.00	
AISTDF Account (UBI)	21,88,90,682.69	11,10,70,22,581.23	13,46,40,971.09	49,14,23,478.65
b) With non-Scheduled Banks :				
On Current Accounts	-		-	
On Deposite Accounts	-		-	
On Savings Accounts	-	-	-	-
5. Post Office - Savings Accounts		-		-
Total (A)		11,10,81,59,321.58		49,26,44,562.65

* Refer note 12 and 13 in Schedule 27 Notes to the Accounts.

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2023

Schedule 11 - Current Assets, Loans, Advances Etc

Particulars	Current Year		Previous Year	
B) Loans, Advancees and Other Assets :-				
1. Loans:				
a) Staff Loan		-		-
b) Other entities engaged in activities/objectives similar to that		-		-
c) Others		-		-
2. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account	-		-	
b) Prepayments				
Computer software expenses	5,36,815.00		3,08,525.00	
Video Conferencing License	-		8,07,896.00	
Vajra Website-Updation Expenses	1,20,263.00		-	
Membership Fee - India International Centre, New Delhi	1,06,200.00		1,06,200.00	
AMC Covid-19 Portal	-		-	
AMC Retired Scientist Portal	9,42,348.00			
Prepaid Internet Charges	-		45,50,080.00	
Lifesize Device Software Subscription-ICON 400	-		-	
Cyberoam Firewall - Licence Fee	-	17,05,626.00	-	57,72,701.00
c) Security Deposit				
Deldsl-Digital NTC (Security Deposit)	-		-	
Digital NTC (Security Deposit)	-	-	-	-
d) Others-				
Centre for Development of Advanced Computing, Noida (AISTDF)	13,28,680.00		13,52,280.00	
Mahanagar Telephone Nigam Limited, New Delhi	33,88,262.00		33,32,945.00	
Red fox Hotel Aerocity, New Delhi	-		-	
Bureau of Outreach & Communication, New Delhi (DAVP)	2,111.00		2,111.00	
Deepak Krishna	-		-	
Magesh Kumar - LTC Advance				
Pankja Kumar Rawat - LTC Advance				
Recoverable from AISTDF	-			
Amount Recoverable from Revenue Authority	7,00,000.00			
Department of Science & Technology (IMPRINT-II Expenditure by SERB)	-		-	
Ministry of Human Resource Development	5,13,668.00	59,32,721.00	5,13,668.00	52,01,004.00
3. Income Accrued:				
a) On Investments from Earmarked/ Endowment Funds	-		-	
b) On Investment – Others	-		-	
c) On Loans and Advances	-		-	
d) Others (includes income due unrealized)	-		-	
Interest accrued on Saving A/c Balance - SERB UBI	30,22,501.00		45,46,972.00	
ICPS (UBI)	59,595.00		57,898.00	
AMAT Fire (UBI)	89.00			
Intel Fire (UBI)	46,176.00			
ITDDF (UBI)	3,19,95,753.00			
IMPRINT-II (UBI)	95,702.00		48,068.00	
AISTDF (UBI)	8,31,768.00	3,60,51,584.00	9,44,380.00	55,97,318.00
4. Claim Receivable		-		-
Total = (B)		4,36,89,931.00		1,65,71,023.00
Total (A) + (B)		11,15,18,49,252.58		50,92,15,585.65

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 12 - Income From Sales / Services

Particulars	Current Year	Previous Year
1. Income from Sales		
a) Sale of finished Goods	-	-
b) Sale of Raw Material	-	-
c) Sale of Scraps	-	-
2. Income from Services		
a) Labour and Processing Charges	-	-
b) Professional / Consultancy Services	-	-
c) Agency Commissions and Brokerages	-	-
d) Maintenance Services (Equipment/Property)	-	-
e) Others	-	-
Total	-	-

Schedule 13 - Grants / Subsidies

Particulars	Current Year		Previous Year	
1. From Central Government				
a) Grant in Aid (General)	5,10,00,00,000.00		5,50,00,00,000.00	
Transferred to Corpus/Fixed Assets (Schedule 1)	-4,37,96,188.01	5,05,62,03,811.99	-4,70,44,501.00	5,45,29,55,499.00
b) Grant in Aid (Capital)		2,20,00,00,000.00		2,66,00,00,000.00
c) Grant in Aid (Scheduled Castes - General)		29,00,00,000.00		35,00,00,000.00
d) Grant in Aid (Scheduled Castes - Capital)		23,00,00,000.00		25,00,00,000.00
e) Grant in Aid (Scheduled Tribe - General)		9,00,00,000.00		10,00,00,000.00
f) Grant in Aid (Scheduled Tribe - Capital)		6,00,00,000.00		8,00,00,000.00
g) Grant in Aid (Salaries)		6,00,00,000.00		6,00,00,000.00
2. State Government(s)		-		-
3. Government Agencies		-		-
4. Institutions Organisations		-		-
5. International Organisations		-		-
6. Other		-		-
Total		7,98,62,03,811.99		8,95,29,55,499.00

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 14 - Fees / Subscriptions

Particulars	Current Year	Previous Year
1. Entrance Fees	-	-
2. Annual Fees / Subscriptions	-	-
3. Seminar / Program Fees	-	-
4. Consultancy Fee	-	-
5. Others	-	-
Total	-	-

Schedule 15 - Income From Investments (Income on Invest. From Earmarked/Endowment Funds transferred to Funds)

Particulars	Investment from Earmarked Funds		Investment -Others	
	Current Year	Previous Year	Current Year	Previous Year
1. Interest				
a) On Govt. Securities	-	-	-	-
b) Other Bonds/Debentures	-	-	-	-
2. Dividends				
a) On shares	-	-	-	-
b) On Mutual Fund Securities	-	-	-	-
3. Rents	-	-	-	-
4. Others : Interest on MFPI Balance in Saving Account	4,17,362.00	4,05,599.00	-	-
Interest on S & T SC Balance in Saving Account	6,60,812.00	5,75,298.00	-	-
Interest on S & T ST Balance in Saving Account	4,295.00	3,473.00	-	-
Interest on DOT Balance in Saving Account	2,32,167.00	2,25,623.00		
Total	13,14,636.00	12,09,993.00	-	-
Transferred to Earmarked/Endowment Funds	13,14,636.00	12,09,993.00		

Schedule 16 - Income from Royalty, Publication Etc.

Particulars	Current Year	Previous Year
1) Income from Royalty	-	-
2) Income from Publications	-	-
3) Other	-	-
Total	-	-
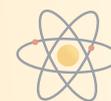
Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 17 - Interest Earned

Particulars	Current Year		Previous Year	
1. On Term Deposits				
a) With Scheduled Banks	-		-	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	-	-	-	-
b)With Non-Scheduled Banks		-		-
c) With Institutions		-		-
d) Others		-		-
2. On Savings Accounts				
a) With Scheduled Banks	1,00,19,611.00		1,48,54,056.00	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	-1,00,19,611.00	-	-1,48,54,056.00	-
b) With Non-Scheduled Banks		-		-
c) Post Office Savings Accounts		-		-
d) Others		-		-
3. On Loans :				
a) Employees / Staff		-		-
b) Others		-		-
4. Interest on Debtors and Other Receivables		-		-
5. Interest on Refund *	4,68,33,554.47		1,86,95,586.44	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	-4,68,33,554.47	-	-1,86,95,586.44	-
Total		-		-

* Note: Interest on Refund earned during the FY 2022-23 has also been transferred to GOI, Consolidated Fund in Current FY .

Schedule 18 - Other Income

Particulars	Current Year	Previous Year
1. Profit on sale/disposal/exchange of Assets		
a) Owned assets	-	-
b) Assets acquired out of grants, or received free of cost	-	-
2. Export Incentives realized	-	-
3. Fees for Miscellaneous Services	-	-
4. Deferred Revenue Grant (AS-12)	3,40,19,792.00	1,53,81,235.00
5. Miscellaneous Income- Other Income RTI Receipts	10.00	10.00
Total	**3,40,19,802.00**	**1,53,81,245.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 19 - Increase / (Decrease) in stock of Finished Goods & Work in Progress

Particulars	Current Year	Previous Year
a) Closing Stock		
Finished Goods	-	-
Work-in-Progress	-	-
b) Less : Opening Stock		
Finished Goods	-	-
Work-in-Progress	-	-
Total	**-**	**-**

Schedule 20 - Establishment Expenses

Particulars	Current Year	Previous Year
a) Salaries and Wages	12,59,60,101.00	11,51,73,183.00
b) Allowances and Bonus	-	-
c) Contribution to Provident Fund- Employer	1,88,733.00	
d) Contribution to Other Fund : NPS Employer Contribution	58,45,096.00	51,54,822.00
e) Staff Welfare Expenses	-	-
f) Expenses on Employee's Retirement & Terminal Benefits	-	
Leave Encashment Provision	30,48,839.00	49,10,473.00
Gratuity Expense	19,08,449.00	-
Secretary Leave Salary Contribution	1,54,089.00	2,97,000.00
Others Leave Salary Contribution	2,22,980.00	4,09,115.00
Secretary Pension Contribution	2,79,041.00	6,20,802.00
Other Pension Contribution	3,25,673.00	4,21,071.00
g) Others		
Telephone Expenses Reimbursement	4,72,815.00	2,98,293.00
School Fee Reimbursement	4,59,000.00	54,000.00
Newspaper Reimbursement	1,44,135.00	80,700.00
Medical Reimbursement	6,28,926.00	6,21,440.00
Transfer Expenses Reimbursement	-	-
Leave Encashment	-	-
Leave Travel Concession	11,69,156.00	6,69,652.00
Total	**14,08,07,033.00**	**12,87,10,551.00**
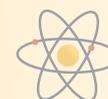
Science and Engineering Research Board

<div align="right">Amount in Rs.</div>

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 21 - Other Administrative Expenses

Particulars	Current Year	Previous Year
a) Bank Charges	3,048.32	13,682.80
b) Car Hire Charges	49,15,193.00	49,62,515.00
c) Professional Fees	28,67,774.00	37,75,799.00
d) Electricity Charges	12,19,015.00	10,34,045.00
e) Membership Fee	2,94,528.00	91,450.00
f) Meeting Expenses	1,09,42,288.00	77,69,629.00
g) Honorarium Expenses (Non- Official)	37,77,000.00	1,17,88,000.00
h) Hospitality Expenses	**22,42,818.00**	12,24,153.00
i) Printing & Stationery	84,06,160.65	64,61,164.00
j) Rent- Building	32,28,480.00	4,33,29,346.00
k) Advertisement/Publication	-	4,63,013.00
l) Courier Expenses	-	-
m) Conveyance Expenses	-	-
n) Housekeeping/Security Expenses	73,91,632.00	54,91,696.00
o) International Conference	-	-
p) Repair & Maintenance	13,74,218.00	9,89,198.00
q) Travelling Expenses (Domestic)	1,02,49,460.93	38,44,498.00
r) Travelling Expenses (International)	22,85,862.00	
s) Audit Fee	4,79,000.00	4,49,500.00
t) Accommodation Expenses (Domestic)	-	-
u) Accommodation Expenses (International)	-	-
v) Computer Hardware & Software	11,24,551.00	15,53,426.00
w) Internet Charges	49,70,313.40	9,74,198.24
x) Newspaper & Periodicals	30,830.00	25,934.00
y) Postage Expenses	30,043.00	24,372.00
z) Telephone Expenses	5,81,227.00	5,94,301.00
aa) Festival Expenses	-	26,088.00
ab) NSDL E Governance Charges	2,356.00	3,134.00
ac) Training Exenses	45,000.00	-
ad) Conference/Event Expenses	12,79,955.00	14,23,600.00
ae) AMC	81,51,748.00	57,82,557.32
af) Digitisation Cost	-	-
ag) Miscellaneous Expenses	35,08,086.95	54,18,810.26
Total	**7,94,00,588.25**	**10,75,14,109.62**

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 22 - Expenditure on Grants, Subsidies Etc

Particulars	Current Year	Previous Year
Grants given to Institutions/Organisations		
a) Grants in Aid (Capital Assets) (Ann. 29 & 29A)	2,20,00,00,000.00	2,66,76,56,214.00
b) Grant in Aid (General) (Ann. 30 & 30A)	4,95,22,94,815.26	5,34,40,82,745.18
c) Grant in Aid (Scheduled Castes - Capital) (Ann. 31 & 31A)	23,00,00,000.00	26,06,43,220.00
d) Grant in Aid (Scheduled Castes - General) (Ann. 32 & 32A)	28,73,89,098.00	36,34,28,494.00
e) Grant in Aid (Scheduled Tribe - Capital) (Ann. 33 & 33A)	6,00,00,000.00	8,19,85,394.00
f) Grant in Aid (Scheduled Tribe - General) (Ann. 34 & 34A)	8,92,51,725.00	10,43,27,780.00
Total	**7,81,89,35,638.26**	**8,82,21,23,847.18**

Schedule 23 - Interest

Particulars	Current Year	Previous Year
a) On Fixed Loans (Including Bank Charges)	-	-
b) On Other Loans (Including Bank Charges)	-	-
c) Others	-	-
Total	**-**	**-**
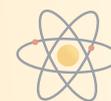
Science and Engineering Research Board

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 24 - Prior Period Income

Particulars	Current Year (H)	Previous Year (F)
A) Refund received against previous year grants		
a) Refund from Projects (Capital) FY 2011-12 (Ann.35 &35A)	48,106.00	1,323.00
b) Refund from Projects (General) FY 2011-12 (Ann. 36 & 36A)	-	65,059.00
c) Refund from Projects (Capital) FY 2012-13 (Ann. 37 & 37A)	2,56,732.00	14,18,761.00
d) Refund from Projects (General) FY 2012-13 (Ann. 38 & 38A)	-	4,37,874.00
e) Refund from Projects (Capital) FY 2013-14 (Ann. 39 & 39A)	14,08,219.43	5,04,375.00
f) Refund from Projects (General) FY 2013-14 (Ann. 40 & 40A)	3,33,438.00	5,76,260.00
g) Refund from Projects (SC-Capital) FY 2013-14 (Ann. 41 & 41A)	-	-
h) Refund from Projects (ST-Capital) FY 2013-14 (Ann.42 & 42A)	-	-
i) Refund from Projects (Capital) FY 2014-15 (Ann. 43 & 43A)	70,71,298.00	28,16,406.66
j) Refund from Projects (General) FY 2014-15 (Ann. 44 & 44A)	43,12,694.41	8,46,885.00
k) Refund from Projects (SC-Capital) FY 2014-15 (Ann. 45 & 45A)	-	13,893.00
l) Refund from Projects (ST-Capital) FY 2014-15 (Ann. 46 & 46A)	-	-
m) Refund from Projects (ST-General) FY 2014-15 (Ann. 47 & 47A)	-	-
n) Refund from Projects (Capital) FY 2015-16 (Ann. 48 & 48A)	57,75,977.02	1,22,49,848.25
o) Refund from Projects (General) FY 2015-16 (Ann. 49 & 49A)	19,73,361.34	9,56,818.00
p) Refund from Projects (SC-Capital) FY 2015-16 (Ann. 50 & 50A)	71,042.00	47,146.00
q) Refund from Projects (SC-General) FY 2015-16 (Ann. 51 & 51A)	-	5,00,000.00
r) Refund from Projects (Capital) FY 2016-17 (Ann. 52 & 52A)	1,75,05,778.37	2,58,00,127.67
s) Refund from Projects (General) FY 2016-17 (Ann. 53 & 53A)	79,72,253.13	93,75,619.14
t) Refund from Projects (SC-Capital) FY 2016-17 (Ann. 54 & 54A)	76,114.00	23,56,465.00
u) Refund from Projects (SC-General) FY 2016-17 (Ann. 55 & 55A)	22,397.00	2,01,030.00
v) Refund from Projects (ST-Capital) FY 2016-17 (Ann.56 & 56A)	7,164.00	12,91,787.00
w) Refund from Projects (Capital) FY 2017-18 (Ann. 57 & 57A)	93,20,676.84	2,47,36,819.63
x) Refund from Projects (General) FY 2017-18 (Ann. 58 & 58A)	95,89,249.00	1,24,78,671.03
y) Refund from Projects (SC-Capital) FY 2017-18 (Ann. 59 & 59A)	18,41,344.00	61,29,586.00
z) Refund from Projects (SC-General) FY 2017-18 (Ann. 60 & 60A)	1,19,388.00	11,00,081.00
aa) Refund from Projects (ST-Capital) FY 2017-18 (Ann. 61 & 61A)	1,78,886.46	3,27,824.00
ab) Refund from Projects (ST-General) FY 2017-18 (Ann. 62 & 62A)	1,41,877.47	-
ac) Refund from Projects (Capital) FY 2018-19 (Ann. 63 & 63A)	3,55,25,051.60	2,40,12,546.71
ad) Refund from Projects (General) FY 2018-19 (Ann. 64 & 64A)	3,01,63,048.04	1,91,18,759.61
ae) Refund from Projects (SC-Capital) FY 2018-19 (Ann. 65 & 65A)	70,68,345.00	3,49,312.00
af) Refund from Projects (SC-General) FY 2018-19 (Ann. 66 & 66A)	19,08,039.00	21,30,150.00
ag) Refund from Projects (ST-Capital) FY 2018-19 (Ann. 67 & 67A)	20,02,231.00	3,06,684.00
ah) Refund from Projects (ST-General) FY 2018-19 (Ann. 68 & 68A)	2,86,292.02	59,614.38
ai) Refund from Projects (Capital) FY 2019-20 (Ann. 69 & 69A)	2,81,60,688.21	91,84,556.72
aj) Refund from Projects (General) FY 2019-20 (Ann. 70 & 70A)	4,02,23,799.68	5,07,63,735.16

ak) Refund from Projects (SC-Capital) FY 2019-20 (Ann. 71 & 71A)	21,34,026.00	3,05,750.00
al) Refund from Projects (SC-General) FY 2019-20 (Ann. 72 & 72A)	14,88,070.00	26,71,640.80
am) Refund from Projects (ST-Capital) FY 2019-20 (Ann. 73 & 73A)	35,185.00	-
an) Refund from Projects (ST-General) FY 2019-20 (Ann. 74 & 74A)	1,36,110.00	6,67,519.85
ao) Refund from Projects (Capital) FY 2020-21 (Ann. 75 & 75A)	79,91,688.00	1,45,433.00
ap) Refund from Projects (General) FY 2020-21 (Ann. 76 & 76A)	5,64,79,803.03	6,44,78,124.33
aq) Refund from Projects (SC-Capital) FY 2020-21 (Ann. 77 & 77A)	830.00	11,27,130.00
ar) Refund from Projects (SC-General) FY 2020-21 (Ann. 78 & 78A)	58,34,718.00	69,05,537.95
as) Refund from Projects (ST-Capital) FY 2020-21 (Ann. 79 & 79A)	54,562.00	-
at) Refund from Projects (ST-General) FY 2020-21 (Ann. 80 & 80A)	5,99,998.00	11,02,753.50
au) Refund from Projects (Capital) FY 2021-22 (Ann. 81 & 81A)	1,48,88,817.00	
av) Refund from Projects (General) FY 2021-22 (Ann. 82 & 82A)	12,46,64,438.99	Refer Annexure 89A
aw) Refund from Projects (SC-Capital) FY 2021-22 (Ann. 83 & 83A)	35,68,764.00	
ax) Refund from Projects (SC-General) FY 2021-22 (Ann. 84 & 84A)	77,55,585.52	Refer Annexure 90A
ay) Refund from Projects (ST-Capital) FY 2021-22 (Ann. 85 & 85A)		
az) Refund from Projects (ST-General) FY 2021-22 (Ann. 86 & 86A)	8,55,765.40	Refer Annexure 91A
ba) Refund from Projects SERC (Ann. 87 & 87A)	-	-
bb) Refund from Projects PY (Ann. 88 & 88A)	-	2,74,77,946.01
B) Other income/ liabilities written back		
Excess Employee Contribution Provision Wriiten Back	2,43,288.00	-
Total A) + B)	**44,00,95,139.96**	**31,50,39,853.40**

Science and Engineering Research Board

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2023

Schedule 25 - Prior Period Expenditure

Particulars	Current Year	Previous Year
a) Professional Fees	33,309.00	-
b) Accomodation Expenses	-	-
c) International Conference	-	-
d) Travelling Expenses (Domestic)	3,59,818.00	10,500.00
e) Advertisement Expenses	-	-
f) Grant-in-Aid (Capital)	-	-
g) Newspaper Reimbursement	32,250.00	32,900.00
h) Medical Expenses Reimbursement	62,521.00	85,460.00
i) Telephone Expenses Reimbursement	67,132.00	41,791.00
j) School Fee Reimbursement	5,13,000.00	27,000.00
k) Salary Arrear (Regular Employees)	2,67,423.00	-
l) Salary Arrear (Contract Employees)	-	-
m) AMC Computers & Printers	-	-
n) AMC Photocopier	6,039.00	4,734.68
o) AMC Biometric Attendance System	-	-
p) AMC MIS System (PRISM)	21,84,770.00	-
q) Newspaper & Periodicals	-	-
r) Bank Charges	-	-
s) Digitisation Cost	-	-
t) New Pension Scheme Employer Contribution	30,978.00	-
u) Honorarium Expenses (Non-Official)	26,16,000.00	2,44,000.00
v) Leave Encashment	1,47,803.00	-
w) Depreciation A/c	-	-
x) Meeting Expenses	-	-
y) IMPRINT_II Expenses	-	-
z) AMC SERB Website	-	17,80,227.00
aa) Electricity Charges	5,60,747.00	2,13,977.00
ab) Leave Salary Contribution	1,48,251.00	2,99,727.00
ac) Pension Contribution	2,79,613.00	3,69,512.00
ad) Leave Travel Concession	4,83,047.00	
ad) Water Charges	34,550.00	2,68,054.00
ae) Printing and Stationary	-	2,700.00
Total	**78,27,251.00**	**33,80,582.68**
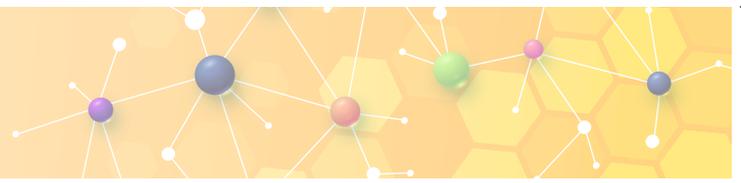
Science and Engineering Research Board

Amount in Rs.

Receipts & Payments for the Year Ended 31.03.2023

	Receipts	Current Year	Previous Year		Payments	Current Year	Previous Year
1	**Opening Balances**			**1**	**Expenses**		
a)	Cash in hand	95,000.00	20,000.00	**a)**	Establishment Expenses (corresponding to Schedule 20)	13,77,28,750.00	12,28,76,106.00
b)	Bank balances			**b)**	Administrative Expenses (corresponding to Schedule 21)	8,60,35,665.67	10,91,72,214.30
	i) In Current Accounts	-	-	**2**	Payments made against funds for various projects		
	ii) In Deposit Accounts	-	-		Grants given to Institutions/Organisations		
	iii) Savings Accounts : SERB UBI	28,96,60,216.10	40,03,80,278.40	a)	Grants in Aid (Capital Assets)	2,20,00,00,000.00	2,66,76,56,214.00
	: SERB RTI	890.00	855.00	b)	Grant in Aid (General)	4,95,22,94,815.26	5,34,40,82,745.18
	: SERB EPFO	3,27,072.02	1,688.26	c)	Grant in Aid (Scheduled Castes - Capital)	23,00,00,000.00	26,06,43,220.00
	: IMPRINT-II UBI	1,30,69,000.00	11,00,71,396.00	d)	Grant in Aid (Scheduled Castes - General)	28,73,89,098.00	36,34,28,494.00
	: SERB NM ICPS (UBI)	80,97,481.00	78,61,004.00	e)	Grant in Aid (Scheduled Tribe - Capital)	6,00,00,000.00	8,19,85,394.00
	: SERB FSER II UBI	3,93,27,848.44		f)	Grant in Aid (Scheduled Tribe - General)	8,92,51,725.00	10,43,27,780.00
	: SERB Intel FIRE(UBI)	63,00,000.00		**3**	**Investments & Deposits made**		
	: AISTDF (UBI)	13,46,40,971.09	14,70,08,636.11	a)	Out of Earmarked/Endowment Funds	-	-
				b)	Out of Own Funds (Investments-Others)	-	-
2	**Grants Received**			**4**	**Expenditure on Fixed Assets & Capital Work-in Progress**		
a)	From Government of India			a)	Purchase of Fixed Assets	1,18,71,860.01	1,48,84,090.00
	Grant in Aid (General)	5,10,00,00,000.00	5,50,00,00,000.00	b)	Expenditure on Capital Work-in Progress	3,19,64,028.00	3,24,16,931.00
	Grant in Aid (Capital)	2,20,00,00,000.00	2,66,00,00,000.00	**5**	**Refund of surplus money/loans**		
	Grant in Aid (Scheduled Castes - General)	29,00,00,000.00	35,00,00,000.00	a)	To the Government of India, Consolidated Fund	34,54,69,815.00	32,55,30,701.66
	Grant in Aid (Scheduled Castes - Capital)	23,00,00,000.00	25,00,00,000.00	b)	To the State Government	-	-
	Grant in Aid (Scheduled Tribe - General)	9,00,00,000.00	10,00,00,000.00	c)	To other providers of Funds	-	-
	Grant in Aid (Scheduled Tribe - Capital)	6,00,00,000.00	8,00,00,000.00	**6**	**Finance Charges (Interest)**	-	-
	Grant in Aid (Salaries)	6,00,00,000.00	6,00,00,000.00	**7**	**Other Payments (Specify)**		
	Grant in Aid (IMPRINT II)	-	92,00,000.00	a)	MFPI Earmarked Payment	-	-
	Grant in Aid (FIRE)	7,00,000.00	63,00,000.00	b)	AMAT Fire Earmarked Payment	25,61,690.00	-
	Grant in Aid (ITDDF)	6,80,43,13,676.39		c)	ICPS Earmarked Payment	-	-
	Grant in Aid (RAD)	6,76,96,50,642.45		d)	IMPRINT-II Earmarked Payment	1,19,60,000.00	11,06,80,000.00
	Grant in Aid (AMAT FIRE)	25,61,690.00		e)	DOT Earmarked Payment	-	-
	Grant in Aid (AISTDF)	15,30,00,000.00		f)	ITDDF Fund Earrmarked Payment	1,98,66,03,625.49	-
b)	From State Government	-	-	g)	RAD Fund Earmarked Payment	1,21,67,65,216.86	
					AISTDF Fund Earmark Payment	8,76,45,804.00	3,23,46,310.00
c)	From Other Sources (details)	-	-	h)	Bureau of Outreach & Communication, New Delhi (DAVP)	-	-
3	**Income on Investments from**			i)	Mahanagar Telephone Nigam Limited, Delhi	-	-
a)	Earmarked/Endowment Funds	-	-	j)	Centre for Development of Advanced Computing, Noida	-	-
b)	Own Funds			k)	PrePaid Internet Charges	-	45,50,080.00
4	**Interest Received**			l)	MHRD Expenditure by SERB		
a)	On Bank Deposits	6,83,82,632.00	2,63,01,963.00	**8**	**Closing Balances**		
b)	Loans Advances	-	-	a)	Cash in hand	-	95,000.00
c)	Interest on Refund	5,08,36,961.47	2,03,77,505.17	b)	Bank balances		
5	**Other Income**	10.00	10.00		i) In Current Accounts	-	-
6	**Amount Borrowed**	-	-		ii) In Deposit Accounts	-	-
7	**Any Other Receipts**				iii) Savings Accounts : SERB UBI	16,58,713.30	28,96,60,216.10
					: IMPRINT-II UBI	1,42,24,325.00	1,30,69,000.00
a)	Refunds Received Against Previous Year Grant	45,90,00,486.56	33,37,30,894.38		: SERB RTI	924.00	890.00
b)	MFPI Earmarked Receipt	-	-		: SERB EPFO	2,14,385.62	3,27,072.02
c)	S & T Earmarked Receipt	38,51,514.00	21,41,117.47		: SERB NM ICPS (UBI)	83,34,856.00	80,97,481.00
d)	ICPS Earmarked Receipt	-	-		: SERB FSER II UBI	43,55,96,534.13	3,93,27,848.44
e)	IMPRINT-II Earmarked Receipt	1,07,16,183.00	24,46,891.00		: SERB Intel FIRE(UBI)	64,58,087.00	63,00,000.00
f)	DOT Earmarked Receipts	-	-		: SERB ITDDF(UBI)	4,82,95,73,214.90	
g)	Proceed from Sale of Assets	32,400.00	2,56,520.00		: SERB RAD Bank of	5,59,20,57,695.59	
					: SERB AMAT FIRE(UBI)	13,163.00	
					: AISTDF(UBI)	21,88,90,682.69	13,46,40,971.09
	Total	**22,84,45,64,674.52**	**10,06,60,98,758.79**		**Total**	**22,84,45,64,674.52**	**10,06,60,98,758.79**

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

CA Pulkit Agrawal
(Partner)
M. No. 431102
Date : 15.05.2023
Place : New Delhi
UDIN: 23431102BGVWAV9099

For Science and Engineering Research Board

Secretary
SERB

Director-Finance
SERB
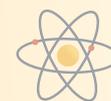
Date :
Place : New Delhi

_____

SCHEDULE FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31.03.2023

SCHEDULE 26

SIGNIFICANT ACCOUNTING POLICIES

1. **Basis of Preparation of Financial Statements**

   These financial statements have been prepared on the accrual basis of accounting, under historical cost convention, in accordance with the accounting principles generally accepted in India.

2. **Fixed Assets**

   Fixed assets are stated at cost of acquisition less accumulated depreciation and impairment losses, if any. Cost of fixed assets comprises purchase price, duties, levies and other directly attributable costs of bringing the assets to its working conditions for the intended use.

3. **Capital Work in Progress**

   Expenditure incurred on construction of assets which are not ready for their intended use are carried at cost less impairment (if any), under Capital work-in-progress.

4. **Depreciation**

   Depreciation on fixed assets is computed on the written down value (WDV) method at the rates and in the manner prescribed under the Provisions of Income Tax Act.

   In respect of additions to/deductions from fixed assets during the year, depreciation is considered on pro-rata basis, as per the provision of Income Tax Act. Assets costing Rs.5,000/- each or less are fully provided.

5. **Grant/ Subsidies Received**

   Grants, subsidies or similar assistance received for the general purposes and objectives of the Entity, on an irrevocable basis, be treated as income on receipt basis.

6. **Expenditure on Grants, Subsidies etc.**

   Grants, subsidies or other similar assistance given to the Institutions/Organisations for general purposes and objectives of the Entity, on an irrevocable basis, be treated as expenditure when they are released.
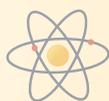
7. Interest Income of SERB

Interest income accrued/arising from various saving bank accounts maintained and also interest on refunds of Grants-in Aid given in earlier years under various schemes. As per directions of CAG and DST, these interest incomes are transferred to Consolidated Fund of India at the end of the year.

As on 31st March, 2023, total interest of Rs. 5,68,53,165.47 (for details Refer Schedule no 17) earned during the current FY 2022-23 has been transferred to Consolidated Fund of India and shown as payable in Schedule 7 - Current Liabilities and Provisions.

8. Prior period Income/Expenditure

Income/expenditure relating to previous Financial Years has been booked as Prior Period Income/Expenditure in the Income and Expenditure Account.

9. Refund from beneficiaries:

a) Refund/repayment of grant/assistance received by SERB from the beneficiaries as per the conditions stipulated in the sanction document is accounted for on receipt basis.

b) Refund/repayment of grant/assistance given and received back in the same financial year has been netted off with Grant-in-Aid (expenditure) in the Income and Expenditure Account.

c) Refund/repayment of grant/assistance given in previous years and received back in later years (i.e. not in same financial year) has been shown as "Refund received against Previous Year Grant" in the Income and Expenditure Account under "Prior Period Income".

d) Refund/repayment of grant/assistance given in previous years and received back during the year through NEFT without any supporting documents or any communication from the grantee institutions and the details of which are not traceable till the finalization of Annual Accounts has been shown as "Refund from projects Previous Year" in the Income and Expenditure Account under "Prior Period Income".

10. Unspent balances of Grants received from DST:

Treasury Single Accounts (**TSA**) System of RBI, is operational for more than 2 years and under the TSA, balance on 31st March of every year automatically lapsed and reverted to Government account, irrespective of expenditure and budgeted grants allocation. The expenditure / amount utilized, is considered as Grants- in-Aid and unutilized grants limits get lapsed. Accordingly, there is no unspent balance of Grants received at the end of financial year.

11. Time barred cheques

All cheques issued by SERB during the FY 2022-23 have been cashed within its validity period of 3 months from the date of the issue of Cheque, if any.

12. Government Grant for Fixed assets of SERB

In order to comply with AS-12 Accounting for Government Grants under direction of C&AG, amount equivalent to cost of acquisition of fixed assets out of Grants in Aid (General) has been shown as Corpus Fixed Assets. Depreciation for the year amounting Rs. 3,40,19,792/- is being credited to Income & Expenditure A/c as Deferred Revenue Grant as per para 8 of AS 12.

13. Retirement Benefits

SERB makes provision for liability towards encashment of leave lying to the credit of employees as on the last day of current financial year subject to the maximum period of leave allowable as per extant rules and retirement benefits shall be governed by the National Pension System (NPS) as applicable to the officers of equivalent rank of the Central Government as amended from time to time.

SERB makes provision for Gratuity as on the last day of the financial year subject to the maximum limit as per extant orders of retirement benefits as applicable to the officers of equivalent rank of the Central Government as amended from time to time.

14. Surplus/Deficit in Income & Expenditure A/c

Surplus/Deficit in Income & Expenditure Account at the year-end has been transferred to Corpus/Capital Account.

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

For Science and Engineering Research Board

CA Pulkit Agrawal
M. No. 431102
(Partner)

Secretary
SERB

Director-Finance
SERB

Date: 15.05.2022
Place: New Delhi
UDIN: 23431102BGVWAV9099

Date: ....
Place: New Delhi

SCHEDULE FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31.03.2022

SHCEDULE- 27 CONTINGENT LIABILITIES AND NOTES TO ACCOUNTS

1. **CONTINGENT LIABILITIES**

    1.1 Claims against the Entity not acknowledged as debts **Rs. NIL** (Previous year **Rs. NIL**)

    1.2 In respect of

    - Bank Guarantees given by/on behalf of the Entity **Rs. NIL** (Previous year **Rs. NIL**)
    - Letters of Credit opened by Bank on behalf of the Entity **Rs. NIL** (Previous year **Rs. NIL**)
    - Bills discounted with banks **Rs. NIL** (Previous year **Rs. NIL**)

    1.3 Disputed demands in respect of:

    - Income tax **Rs. NIL** (Previous year **Rs. NIL**)
    - Sales Tax **Rs. NIL** (Previous year **Rs. NIL**)
    - Municipal Taxes **Rs. NIL** (Previous year **Rs. NIL**)
    - In respect of claims from parties for non-execution of orders but contested by the Entity **Rs. NIL** (Previous year **Rs. NIL**)

    1.4 For Income Tax *(Refer Para 6 below)*
    - Current Year – Rs 12,12,88,862/-   Previous year – Rs 12,12,88,862/-

	Current Year	Previous Year
FY 2011-12	Rs. 9,43,38,079/-	Rs. 9,43,38,079/-
FY 2012-13	Rs. 2,69,50,783/-	Rs. 2,69,50,783/-
FY 2013-14	Nil	Nil
FY 2014-15	Nil	Nil
FY 2015-16	Nil	Nil
FY 2016-17	Nil	Nil
FY 2017-18	Nil	Nil
FY 2018-19	Nil	Nil
FY 2019-20	Nil	Nil
FY 2020-21	Nil	Nil
FY 2021-22	Nil	Nil
FY 2022-23	Nil	Nil
Total	**Rs. 12,12,88,862/-**	**Rs. 12,12,88,862/-**

2. **CAPITAL COMMITMENTS**

    - Estimated value of contracts remaining to be executed on capital account and not provided for (net of advances) **Rs. NIL** (Previous year **Rs. NIL**)
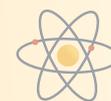
3. **LEASE OBLIGATIONS**
   - Future obligations for rentals under finance lease arrangements for plant and machinery amount to **Rs. NIL** (Previous year **Rs. NIL**)

4. **CURRENT ASSETS, LOANS AND ADVANCES**

   - In the opinion of the Management, the current assets, loans and advances have a value on realization in the ordinary course of business, at least equal to the amount at which they are stated in the Balance Sheet.

5. **Net Profit/Loss in Current FY 2022-23**

   Total Income of Current FY 2022-23 is Rs. 8,02,02,23,613.99 whereas Total Expenditure of Current FY is Rs. 8,07,31,63,051.51.

   In Income & Expenditure A/c excess of Expenditure over Income shows a difference of Rs. 5,29,39,437.52 as Gross Excess of Expenditure.

   SERB is having Net surplus of Rs. 37,93,28,451.44 in FY 2022-23 after considering Prior Period Income of Rs. 44,00,95,139.96 and Prior Period Expenditure of Rs. 78,27,251/-.

6. **TAXATION**

   our original application for exemption u/s 10(46) was from inception of SERB, somehow tax department has granted exemption effective FY 2013-14. Hence, the matter has been taken up again with CBDT to grant us exemption for FY 2011-12 and FY 2012-13 also. Hence, There is Contingent Liability shown for Income Tax at point 1.4.

   SERB is registered as charitable organization u/s 12A of the Income Tax Act, 1961 from AY 2017-18 and eligible for exemption from Income Tax u/s 11 of the Income Tax Act, 1961. Registration u/s 12A is renewed for next 5 years from AY 2022-23 to AY 2026-27.

7. **FOREIGN CURRENCY TRANSACTIONS**

   (Amount Rs.)

7.1 Value of Imports Calculated on C.I.F. Basis:	Current Year	Previous Year
Purchase of finished Goods	Nil	Nil
Raw Materials & Components (Including in transit)	Nil	Nil
Capital Goods	Nil	Nil
Stores, Spares & Consumables		
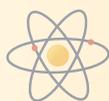
7.2 Expenditure in foreign currency:

a)	Travel	Nil	Nil
b)	Remittances and Interest Payment to Financial Institutions/ Banks in Foreign Currency	Nil	Nil
c)	Other expenditure:		
	- Commission on Sale	Nil	Nil
	- Legal and Professional Expenses	Nil	Nil
	- Miscellaneous Expenses	Nil	Nil
	- Grant-in-Aid (General)	Rs.1,65,02,588/-	Rs.6,79,01,370/-

7.3 Earning:

Value of Exports on FOB basis	Nil	Nil

7.4 Remuneration to Auditors:

-	Auditors Fee (CAG)	Rs. 1,25,000/-	Rs. 1,25,000/-
-	Auditors Fee (CA)	Rs. 3,54,000/-	Rs. 3,24,500/-
-	Taxation matters	……..	………
-	For management services	……….	………
-	For certificate	……….	…….
-	Others	…………	………

8. Absorption of expenses incurred on IMPRIMT-II scheme from SERB Fund

SERB has been funding various schemes since November 2011 as per the objectives stated in SERB Act, 2008. As a part of various scheme SERB has funded IMPRINT-I Scheme and IMPRINT-II. Now as per the directions of Secretary, DST , The IMPRINT-II Scheme has been transferred to SERB and it is conveyed that SERB shall manage IMPRINT-II out of its budget allocation of Funds and no separate grants would be released for IMPRINT-II.

9. During the year under review, SERB has purchased new printers under buy-back scheme in replacement of old printers. The resultant profit of Rs. 31,830.71, due to above transactions, being difference in exchange price/transfer price and depreciated value of fixed assets, is being transfer to Corpus for fixed asset.

10. ASEAN-India S&T Development Fund (AISTDF) was established jointly by the Ministry of External Affairs (MEA) and DST to support R&D projects and associated project development activities. The transactions for the said AISTDF are being undertaken through bank accounts that have been opened with SERB credentials (PAN, etc.) and are being accounted in SERB's books of accounts as earmarked funds. SERB provides financial and secretarial support for this scheme which is operated by the International Cooperation Division of DST. Accordingly, details of beneficiaries, resources, and usage of funds are available with DST only.

11. Government of India has directed SERB to be the Central Nodal Agency (CNA) for two Central Sector Schemes (CSS) of the Department of Science & Technology (DST), viz, Innovation Technology Development and Deployment Fund and Research and Development Fund (R&D). The transactions for the said CNA schemes are being undertaken through bank accounts that have been opened with SERB credentials (PAN, etc.) and are being accounted in SERB's books of accounts as earmarked funds. However, these two Central Sector Schemes are being operated, controlled, and monitored by Department of Science and Technology, Govt of India. Accordingly, details of beneficiaries, resources, and usage of funds are available with DST only.

12. Treasury Single Accounts (**TSA**) System of RBI, is operational for more than 2 years and under TSA, balance on 31st March of every year automatically lapsed reverted to Government account, irrespective of expenditure and budgeted grants allocation. The expenditure / amount utilized, is considered as Grants- in-Aid and unutilized grants limits get lapsed.

13. SERB had opened a separate UBI Bank account for GE-FIRE (Fund for Industrial Research) public private partnership scheme for the purpose of promotion of science and technology. However, there was no activity in this account and hence, no balance, as it was opened as a Zero Balance account.

14. During the year, SERB has capitalized intellectual property (Intangible Assets) in respect of E-PPMs System, Retired Scientist Portal and SERB website on successful completion and implementation amounting to Rs.8,36,01,182/-.

15. Previous Year figures have been regrouped /recasted wherever found necessary.

16. Schedules 1 to 27 are annexed to and form an integral part of the Balance Sheet as at 31.03.2023 and the Income and Expenditure Account for the year ended on that date.

Compiled on the basis of data and information
provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

For Science and Engineering Research Board

CA Pulkit Agrawal
M. No. 431102
(Partner)

Secretary
SERB

Director-Finance
SERB

Date: 15.05.2022
Place: New Delhi
UDIN: 23431102BGVWAV9099

Date: ....
Place: New Delhi

गुरवीन सिधु, भा.ले.प. & ले.से.

Gurveen Sidhu, IA&AS

महानिदेशक लेखापरीक्षा
पर्यावरण एवं वैज्ञानिक विभाग
ए.जी.सी.आर. भवन, इन्द्रप्रस्थ एस्टेट,
नई दिल्ली–110 002

DIRECTOR GENERAL OF AUDIT
ENVIRONMENT & SCIENTIFIC DEPARTMENTS
A.G.C.R. BUILDING, I.P. ESTATE
NEW DELHI-110 002

D.O. No. DGA (ESD)/Inspection/2(52)/SAR-SERB/2023-24/398   Dated: 18-10-2023

Dear Dr. Gupta,

    I have audited the Annual Accounts of the Science and Engineering Research Board (SERB), New Delhi for the year 2022-23 and have issued the Audit Report thereon. During the course of audit, some deficiencies were noticed which were of a relatively minor nature and were, therefore, not included in the Audit Report and are now enclosed in the Annexure. These are being brought to your notice for remedial and corrective action.

With regards,

Yours sincerely,

Enclosure: Annexure

Dr. Akhilesh Gupta
Secretary – SERB,
3rd & 4th Floor, Block II,
Technology Bhawan,
New Mehrauli Road
New Delhi - 110016

Ph. : 91-11-23702348
Fax : 91-11-23702353

E-mail : pdaesd@cag.gov.in
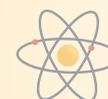
Annexure – Management Letter

1. Annual Accounts of SERB for the year 2022-23 were not approved and adopted by the Board.

2. **Understatement of Current Liabilities**

   An amount of Rs. 99519/- shown as receivable against 'AISTDF Expenditure by SERB' under Current Assets as well as 'Expense Payable to SERB out of AISTDF' under Current Liabilities was omitted to be depicted in the annual accounts, despite getting actual payment/ reimbursement from AISTDF during the next year (in April 2023). This had resulted in understatement of Current Liabilities as well as Current Assets by the same amount.

3. **Fixed asset – Rs.12.88 crore (Schedule 8)**

   The 'Intangible Asset' of Rs. 67.52 lakh on account of 'Retired Scientist Portal' operational from April/May 2022 was taken into account only in March 2023 which resulted in charging less depreciation (i.e., 12.5 percent for half year only). Due to which, the fixed asset was overstated by 8.74 lakh besides understatement of expenditure by the same amount.

4. **Diversion of refundable Unspent Grant towards Office Expenses**

   As per Schedule–24 related to 'Prior Period Income', SERB received Rs. 31.50 crore against 'Refunds from Projects' awarded during 2011-12 to 2020-21 or unidentified period during 2021-22 liable for refund to DST during 2022-23 was found diverted for the establishment and administrative expenditure of the Board and an amount of only Rs. 22.65 crore could be transferred to the GoI-Consolidated Fund (as per Schedule-1 'Corpus/Capital Fund' related to the Balance Sheet).

5. **Misclassification of Administrative Expenditure as Establishment Expenses**

   The 'Establishment Expenses" of Rs. 1408.07 lakh under Schedule-20 related to Income & Expenditure Account included "Administrative Expenses" of Rs. 699.82 lakh incurred on account of payments made to the contractor (M/s Sai Techno), contractual employees and wages to Gardner/Network cable service which resulted in misclassification of the administrative expenses as establishment expenditure.

6. **Schedule-27: Contingent Liabilities and Notes to Accounts**

   An amount of Rs 4.79 was lakh persistently disclosed under foreign currency transactions "Remuneration to Auditors" from 2018-19 to 2022-23 without involvement of any foreign currency transaction for the same.

7. **Monitoring of Utilization Certificates (UCs)**

Rule 238 of GFRs 2017 provided that a certificate of actual utilization of the grant received for the purpose for which it was sanction in form GFR 12-A should be insisted upon, which should be submitted within twelve months of the closure of the financial year by the institution/organization concerned. It was, however, noticed that 26286 number of Utilization Certificates (UCs) against release of Rs. 2546.46 crore from 2011-12 to 2021-22 were still outstanding as of 31st March 2023 which included 15189 overdue UCs of Rs. 1336.96 crore released by the Board up to 2019-20.

Remedial measures on the above would, therefore, be taken under intimation to audit.

Deputy Director (Inspection)

स.म.नि.ले.प.(पर्या.एवं वै.वि)/नि./2 (66)/SERB/SAR/2023-24/396   दिनांकः 18-10-2023

सेवा में,

The Secretary

Science and Engineering Research Board,

3rd & 4th Floor, Block II, Technology Bhawan,

New Mehrauli Road, New Delhi - 110 016

विषयः विज्ञान और इंजीनियरिंग अनुसंधान बोर्ड (SERB), नई दिल्ली के वर्ष 2022-23 के लेखों पर पृथक ऑडिट रिपोर्ट।

महोदय,

मुझे विज्ञान और इंजीनियरिंग अनुसंधान बोर्ड के वर्ष 2022-23 के लेखों पर पृथक ऑडिट रिपोर्ट अग्रेषित करने का निर्देश हुआ है।

संसद के दोनों सदनों में प्रस्तुत करने से पहले वर्ष 2022-23 के वार्षिक लेखों को विज्ञान और इंजीनियरिंग अनुसंधान बोर्ड द्वारा अपनाया जाए। प्रत्येक दस्तावेज जो संसद में प्रस्तुत किया जाए उसकी तीन प्रतियां इस कार्यालय तथा दो प्रतियां भारत के नियंत्रक एवम् महालेखापरीक्षक को अग्रेषित की जाए। संसद के दोनों सदनों में प्रस्तुत करने की तिथि (या) भी इस कार्यालय को सूचित की जाए।

आपसे अनुरोध है कि पृथक ऑडिट रिपोर्ट का हिन्दी अनुवाद अपने कार्यालय में कराने के पश्चात सॉफ्ट कॉपी तथा हार्ड कापी दोनों में हमें भेज दें ताकि हिन्दी प्रति को शीघ्र अग्रेषित किया जा सके।

यह महानिदेशक द्वारा अनुमोदित है।

भवदीय,

संलग्कः यथोपरि।

उप-निदेशक (निरीक्षण)
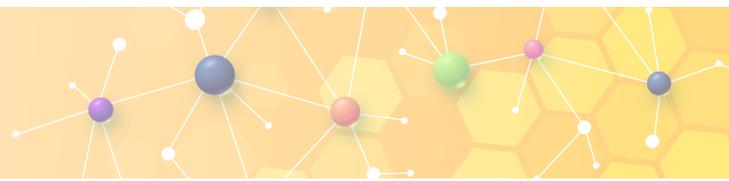
SEPARATE AUDIT REPORT ON ACCOUNTS OF SCIENCE AND ENGINEERING RESEARCH BOARD, NEW DELHI FOR THE YEAR 2022-23

We have audited the Balance Sheet of the Science & Engineering Research Board (SERB), New Delhi as of 31st March 2023 and the Income & Expenditure Account/Receipt & Payment Account for the year ended on that date under Section 19(2) of the Comptroller and Auditor General's (Duties, Power and Condition of Service) Act, 1971 read with Section 13(3) of SERB Act, 2008. These financial statements are the responsibility of the Board's management. Our responsibility is to express our opinion on these financial statements based on our report.

2. This report contains the comments on accounting treatment only with regard to classification, conformity with the best accounting practices, accounting standard and disclosure norms etc. Audit observations (Propriety and Regularity) and efficiency–cum–performance aspects, etc., if any, are reported through Inspection Reports/Comptroller and Auditor General's Audit Report separately.

3. We have conducted our audit in accordance with auditing standards generally accepted in India. These standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatements. An audit includes examining, on a test basis, evidence supporting the amounting and disclosure in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of financial statements. We believe that our audit provides a reasonable basis for our opinion.

4. Based on our audit, we report that –

   (i)   We have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit,

   (ii) The Balance Sheet, Income and Expenditure Account and Receipts and Payments account dealt with by this report have been drawn up in the format approved by the Government of India,

   (iii) In our opinion, proper books of accounts and other relevant records have been maintained by the Board, as required, in so far as it appears from our examination of such books.

   (iv) We further report that:

A. **Balance Sheet**

A.1 **Liabilities**

A.1.1 **Current Liabilities and provisions – Rs. 1.59 crore (Schedule 7)**

A.1.1.1 **Understatement of Current Liabilities**

After setting-off the administrative/establishment expenditure against the Prior Period Income of Rs. 44.01 crore shown below Income & Expenditure Account against previous years' unspent project-grant, an amount of Rs. 37.93 crore was wrongly transferred to Schedule–1 'Capital Fund/Reserve' instead of showing the same as 'Unspent Grant' under Schedule-7 "Current Liabilities" which resulted in understatement of Current Liabilities besides overstatement of Capital Fund/Reserve to the extent of Rs. 44.01 crore (including amount of expenditure in excess of income). Moreover, previous year's record also revealed that complete refund of funds out of unspent balances was not affected while diverting the remaining part for Administrative/Establishment/Other expenditure by the Board in violation of GFRs.

A.1.1.2 **Overstatement of Current Liabilities**

Schedule–7 "Current Liabilities and Provisions" pertaining to the Balance Sheet of the Board for the year as on 31st March 2023 revealed a provision of Rs. 155.43 lakh on account of 'Accumulated Leave Encashment' and Rs. 107.65 lakh towards 'Gratuity'. Since the amount included Rs. 60 lakhs (i.e., Rs. 37.12 lakh towards Accumulated Leave Encashment and Rs. 22.88 lakh for Gratuity) against the personnel re-employed/absorbed after retirement from the Govt. service, which was inadmissible as liability without taking into account the encashment of leaves/gratuity by these employees during previous service, the excess provisions made on this account had led to overstatement of liabilities towards provisions for Leave Encashment and Gratuity besides overstatement of expenditure/prior period expenditure, both by Rs. 60 lakhs.

A. **2. Assets**

A.2.1 **Current Assets, Loan, Advances etc.–Rs. 1115.18 Crore (Sch. 11)**

An amount of Rs. 24.67 lakh, including unspent grant and interest thereon, recoverable from the grantee institutions (could not be materialized due to cheque returns) was not included under Schedule 11-Current Assets, Loans, Advances etc. as receivables. On the contrary, the prior period income/liability on this account was also reversed in the accounts. This resulted in understatement of current assets as well as corresponding liabilities/prior period income on this account by Rs. 24.67 lakh.

B. **Income & Expenditure Account**

B.1 **Expenditure**

B.1.1 **Understatement of Expenditure (Schedule 20 & 21)**

(i) No provision was made in the accounts towards outstanding expenditure of Rs. 61.98 lakh for Maintenance Charges of Web-Portals, Legal Advice, stationary, air-tickets purchase, honorarium, medical bill payment(s) and telephone charges to vendors, staff/officers of SERB and others pertaining
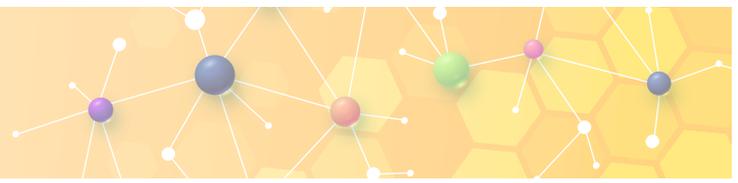
to the period 2022-23 or before (Annexure-X). This had resulted in understatement of expenditure and current liabilities on account of outstanding expenses both by Rs. 61.98 lakh.

(ii) An amount of Rs. 150.54 lakh paid to M/s C-DAC (in December 2022) as advance for e-PPMS portal included an amount of Rs. 121.81 lakh on account of 50 percent cost of manpower towards maintenance of existing software and IT-Cell for the period from June 2022 to March 2023. This had resulted in understatement of expenditure besides overstatement of 'Fixed Assets' on account of 'Work-in-Progress' while booking the same as advance instead of expenditure, both by Rs. 121.81 lakh.

(iii) No provision was made for the proportionate outstanding payment of Rs. 81.20 lakh to M/s C-DAC towards maintenance of existing e-PPMS portal, Data Centre Hosting, IT Cell, local travel, safety certification etc. pertaining to the period from December 2022 to March 2023. This had resulted in understatement of expenditure as well as 'Outstanding Expenses' under Schedule–7 'Current Liabilities' in the accounts, both by Rs. 81.20 lakh.

C.   General

C.1   Diversion of Grants-in-Aid (General) for purchase of Fixed Assets

The board had diverted an amount of Rs. 437.96 lakh provided towards 'Grants-in-Aid (General)' for procurement of Fixed Assets instead of using the funds provided against 'Grants-in-Aid (Capital)' in violation of the GOI guidelines for booking of grant on creation of capital assets.

C.2   Non-reporting of Interest accrued on Grants-in-aid projects

SERB did not report the interest accrued on Grants-in-aid projects, refundable to the GoI in terms of GFRs 2017, despite having complete information in this regard in its e-PPMS Portal System. On the contrary, the sanctions issued by SERB allow adjustment of the interest so earned towards further installment of the grant under these projects in violation of Rule 230(8) of the GFRs.

C.3   No Actuarial valuation of Gratuity and Leave Encashment

As per Schedule–7 "Current Liabilities and Provisions", SERB depicted the provisions of Rs 107.65 lakh and Rs 155.43 lakh under Gratuity and Accumulated Leave Encashment respectively at the end of 2022-23. However, in the absence of any actuarial valuation for ascertaining the liability towards Gratuity and Leave Encashment, the adequacy of such liability as on 31st March 2023 could not be ascertained in audit.

C.4   non-disclosure of the additional liability towards GST in SERB projects

As per the minutes of 38th meeting of the Board, in December 2022, it was decided to provide additional 18 percent GST in SERB projects for procurement of equipment's/consumables. However, no disclosure of the same was made in the Notes to Accounts despite resulting in additional liability on this account.

C.5   Schedule-27: Contingent Liabilities and Notes to Accounts

A static amount of Rs 12.13 crore was persistently disclosed as contingent liability toward Income Tax department for the period 2011-12 & 2012-13.

D.   Grants-in-aid

Besides opening balance of ₹ 49.15 crore, SERB had received a grant of ₹ 2176. crore from the DST during 2022-23, ₹ 52.44 crore as other receipts towards 'Refund received against previous year grants/Earmarked Funds/interest thereon' and ₹6.84 crore towards 'Interest on bank deposits and other receipts. After disbursement from the fund, refund to GOI and other expenditure of ₹ 1173.75 crore, the board was left with the balance of ₹ 1110.70 crore.

(v)   Subject to our observations in the preceding paragraphs, we report that the Balance Sheet, Income & Expenditure Account and Receipts & payments Account dealt with by this report are in agreement with the books of accounts.

(vi) In our opinion and to the best of our information and according to the explanations given to us, the financial statements read together with the Accounting Policies and Notes on Accounts and subject to the significant matters stated above and other matters mentioned in Annexure to the Audit Report give a true and fair view in conformity with accounting principles generally accepted in India.

   a)   In so far as it relates to the Balance Sheet of the State-of-affairs of the SERB as of 31st March 2023.

   b)   In so far as it relates to the Income and Expenditure Account of the *surplus* for the year ended on that date.

For and on behalf C&AG of India

Director General of Audit
(Environment and Scientific Departments)

Place: New Delhi
Date:

Annexure–I to Separate Audit Report

1. Adequacy of Internal Audit System

Internal audit of SERB for the period from 2019-20 to 2021-22 was carried out in August 2022 and a total number of 42 paras (30 pertained from 2014-15 to 2018-19) found outstanding till date (July 2023).

2. Adequacy of Internal Control Systems –

During the audit of SERB, the following deficiencies in relation to internal control system were observed:

2.1 Non-disclosure and maintenance of records of assets created out of Grants for Creation of Capital Assets

As per GFR 233, assets created out of Grants-in-aid for creation of capital assets can be retained or disposed-off by the grantee institution with the prior approval of the Board.

As per Schedule 22 of the Annual Accounts for the financial year 2022-23, the Board released ₹ 249 crores to 579 institutes as Grants for Creation of Capital Assets (399), Grant in Aid (Scheduled Caste-Capital (131) and Grants in Aid (Scheduled Tribe- Capital (49). Besides that huge amount(s) were released by the Board on this account since its establishment in November 2011.

However, the Board did not maintain any record of the assets created out of grants provided for creation of capital assets to various grantee institutions for disclosure in its Notes to accounts annexed with the Balance Sheet.

2.2 Non maintenance of Register of Grants released by the board.

Register of Grants in Form GFR-21 need to be maintained by the Board as per Rule 234, GFRs 2017, the same was not being done.

2.3. Non-utilization of Gem Portal for goods and services procurement

Rule 149 of the General Financial Rules, 2017 made it mandatory for the Government buyers to procure Goods and Services from Government e-marketplace. It was however observed that the Board was not using the GeM portal for procurement of the goods and/or services.

3. System of Physical Verification of fixed assets/Inventory

No discrepancy was reported in the physical verification of fixed assers/ consumables/inventory carried out for the financial year 2022-23.

4. Bank Reconciliation Statement

SERB had furnished the bank reconciliation statement for the month of March 2023 which shows no outstanding cheque(s) prior to March 2023.

5. Regularity in payment of statutory dues

Though the Board had no undisputed statutory dues outstanding for more than six months from the date of becoming due during 2022-23, an amount of ₹ 12.13 crore was disclosed as contingent liability towards income tax department for the period 2011-12 & 2012-13 against which the board had applied for exemption u/s 10(46) of the Income Tax Act 1961.

Deputy Director (Inspection)

Annexure – X

Sl. No	Sanction/ Bill Details	Date	Brief Description	Period belongs to	Amount (in Rs.)	Remarks
1.	J/106/2023-24	22.05.2023	DC hosting services charge for the period from 26.02.2021 to 31.10.2022	26.02.2021 to 31.10.2022	3127111.00	Invoices dated 18.01.2023 from C-DAC amounting to Rs. 1197811.00 for 2021-22 and Rs. 1929300.00 for 2022-23.
2.	J/117/2023-24	24.05.2023	Maintenance of e-PPMS System & Knowledge Portal for IMPRINT-2 with applicable GST @ 18%	2022-23	1107000.00	50 percent of the value of contract paid to C-DAC after completion of the maintenance period.
				GST (18%)	199260.00	
3.	J/178/2023-24	16.06.2023	Maintenance of COVID-19 diagnostic portal (https://www.covidnidan.in)	17.10.2022 to 31.03.2023	840737.00	Out of total value of 922760/-, proportionate amount of Rs. 840737 (164 days till March 2023) paid to C-DAC.
4.	J/83/2023-24	16.05.2023	Legal advice regarding NRF Bill 2023 from M/s Clarus Law Associates	March 2023	284000.00	Payment of professional charges for providing legal advice against invoice dated 23rd March 2023
5.	J/187/2023-24	21.06.2023	Maintenance Charges for SERB Website	November 2022 to March 2023	97597.00	Out of total Rs. 117116/- for November to April 2023, proportionate charges of Rs. 97597/- for the period from Nov'22 to March'23.
6.	J/78/2023-24	15.05.2023	Service charges to M/s Protean e-GOV Technologies Ltd for CRA-NPS.	January to March 2023	726.00	Quarterly service charges for January to March 2023.
7.	J/16/2023-24	12.04.2023	Supply of stationary/housekeeping items from M/s NCCF	March 2023	33725.00	Vide M/s NCCF invoice dated 6th March 2023.
8.	J/55/2023-24	02.05.2023	Honorarium to expert committee members for PCR evaluation.	March 2023	160000.00	For Evaluation Committee meeting dated 2nd & 3rd March 2023
9.	J/54/2023-24	02.05.2023	TA/DA and Honorarium to committee members for pre-screening of new proposals & annual progress monitoring.	September 2022	87665.00	For committee meeting dated 5th to 6th September 2022
10.	J/150/2023-24	08.06.2023	Payment to M/s Balmer Lawrie & Co. for air tickets	August to September 2022	26313.00	For official air tickets towards tour in September 2022.
11.	J/124/2023-24	29.05.2023	Payment to M/s Balmer Lawrie & Co. for air tickets	September 2022 to March 2023	131186.00	For official air tickets towards tours in October 2022 to March 2023
12.	J/107/2023-24	22.05.2023	TA Bill of consultant for monitoring meeting at Bangalore	March 20223	1200.00	Tour bill for monitoring meeting at NIMHANS, Bangalore during March 2023.
13.	J/192/2023-24	26.06.2023	Medical Bills Staff & family members	January to March 2023	5748.00	Reimbursement of Rs. 5748/- out of total Rs. 8009/- towards medical expenditure (outdoor treatment)

14.	J/42/2023-24	27.04.2023	Medical Bills Staff & family members	February to March 2023	10599.00	Reimbursement of Rs. 10599/- out of total Rs. 13169/- towards medical expenditure (outdoor treatment)
15.	J/40/2023-24	27.04.2023	Medical Bills Staff & family members	February to March 2023	20684.00	Reimbursement of Rs. 20684/- out of total Rs. 23530/- towards medical expenditure (outdoor treatment)
16.	J/39/2023-24	27.04.2023	Reimbursement of monthly mobile/ telephone/ internet charges to officers	May 2022 to March 2023	64143.00	Reimbursement of mobile/telephone/ internet charges to 11 officers of SERB for the period from May 2022 to March 2023
				Grand Total = Rs.	6197694.00	
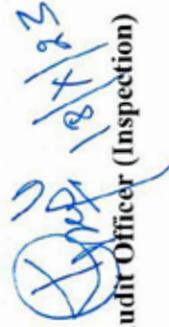
Sr. Audit Officer (Inspection)

Notes

About SERB

Set up through an Act of Parliament, viz. the Science and Engineering Research Board Act, 2008, SERB serves as the national premier funding agency for planning, promoting and steering internationally competitive research in science and engineering. The mandate is to promote basic research in frontier areas of Science and Engineering and provide financial assistance to persons engaged in such research, academic institutions, research and development laboratories, and other agencies. This is achieved through various schemes like extramural research funding fellowships, grants, awards, scholarships and joint industrial relevant collaborations.

Science and Engineering Research Board

Submit R&D proposals online at: www.serbonline.in

3rd and 4th Floor, Block-II, Technology Bhawan, New Mehrauli Road, New Delhi-110016 Telefax: 011-26511094

For General & Programme related Enquiries: 011-26511173
E-mail: info@serbonline.in Website: www.serb.gov.in