सत्यमेव जयते

Annual Report
2019-20

विज्ञान और
इंजीनियरी
अनुसंधान बोर्ड

Science and
Engineering
Research Board

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Science and
Engineering
Research Board

वार्षिक रिपोर्ट 2019-20 **Annual Report**

From the Secretary's Desk

I feel privileged to present the 9th Annual Report of the Science and Engineering Research Board (SERB), illustrating a comprehensive overview of our activities and achievements in the year 2019-2020. In this year, SERB saw the launch of several new R&D programs that offers a wider landscape for Indian researchers to seek outstanding scientific breakthroughs, making impactful contributions to our fundamental understanding and offer disruptive technologies at the cutting edge.

New programs such as SERB-SUPRA (Scientific and Useful Profound Research Advancement) and SERB-Exponential Technologies intend to challenge the Indian researchers to evolve transformative concepts based on original and creative research problems, opening up newer opportunities in national S&T landscape and create the right visibility on the global stage. With ever-increasing outreach, we are at the forefront of developing a right ecosystem to crowd-source outstanding research problems, and delivery of equally unique solutions and knowledge creation. SERB is also on the forefront in bringing wider platforms for multiple players in research and development. SERB-FIRE (Fund for Industrial Research Engagement) is a new model of public-private partnership, put in motion in the reporting period, to serve as a new framework for industry-oriented research, along with capital contributions from industries.

SERB-STAR (Science and Technology Award for Research) program was instituted to recognize and reward outstanding research performance in frontier areas of science and engineering. It is envisaged that SERB-STAR will be an appropriate recognition for investigators, by acknowledging their exemplary contributions in research and sustain their motivation for to undertake pioneering research.

It is important for the country to keep pace with technological advances and encourage its researchers to compete at the world stage and vie for due visibility through breakthrough research and achievements. With the mission of being the premier research funding agency involved in raising the footprint, quality, and output in the niche areas of science and engineering, SERB remains committed to accelerate research support to all levels of investigators infused through calibrated R&D support.

I wish to extend our gratitude and appreciation to the numerous colleagues who partake in Program Advisory Committees, Expert Committees and in project review, ensuring that the processes enshrined in the governance of SERB programs are adhered to the highest levels of quality assessment, transparency, and integrity.

Our activities of the past year truly reflect the spirit of innovation, inclusion, and collaboration that we are cultivating in Indian Science, reaffirming our commitment to the nation's development. We believe that best of our R&D efforts in S&T will continue to emerge as we build upon our past successes and judicious investments in supporting high quality research breakthroughs in Indian science.

Jai Hind!

Sandeep Verma
Secretary, SERB

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1 THE ORGANIZATION

The Department of Science and Technology has established Science and Engineering Research Board (SERB), as a Statutory body in the year 2011 for planning, promoting and funding of internationally competitive research in emerging areas; and identify major inter-disciplinary research areas, and individuals, groups or institutions and funding them for undertaking research. The Board (SERB), since its inception is instrumental in inculcating scientific pursuit in the country by supporting state of the art research infrastructure and research projects in academic and research institutions. Apart from this the Board also provides assistance to scientific fraternity in their capacity building and recognizes the significant contributions of individuals through meritorious awards. In order to guide and advise the Board from time to time an Oversight Committee has been constituted under the provisions of the SERB Act.

Figure 1.1 : SERB Office at Vasant Kunj, New Delhi.

1.1 VISION, MISSION & GOALS

To better focus in its energies and resources on 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.

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.

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 pro-actively have mechanism 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.

1.2 ORGANIZATION AND PROGRAMMATIC CHART

a) Organizational Chart

The organization structure of SERB is given in Figure 1.2

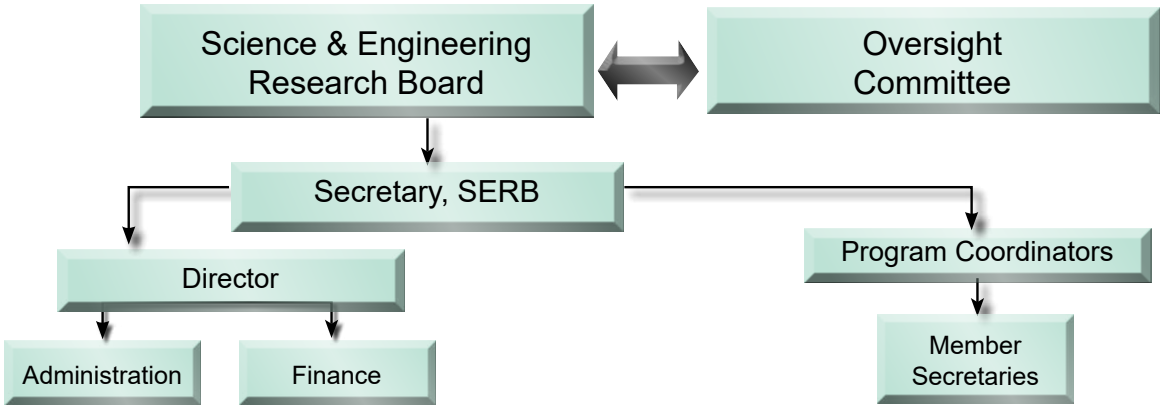


Figure 1.2 Broad Working Organization Chart of SERB

b) Programmatic Chart

The various scientific programs and schemes handled by SERB are given below (Figure 1.3)

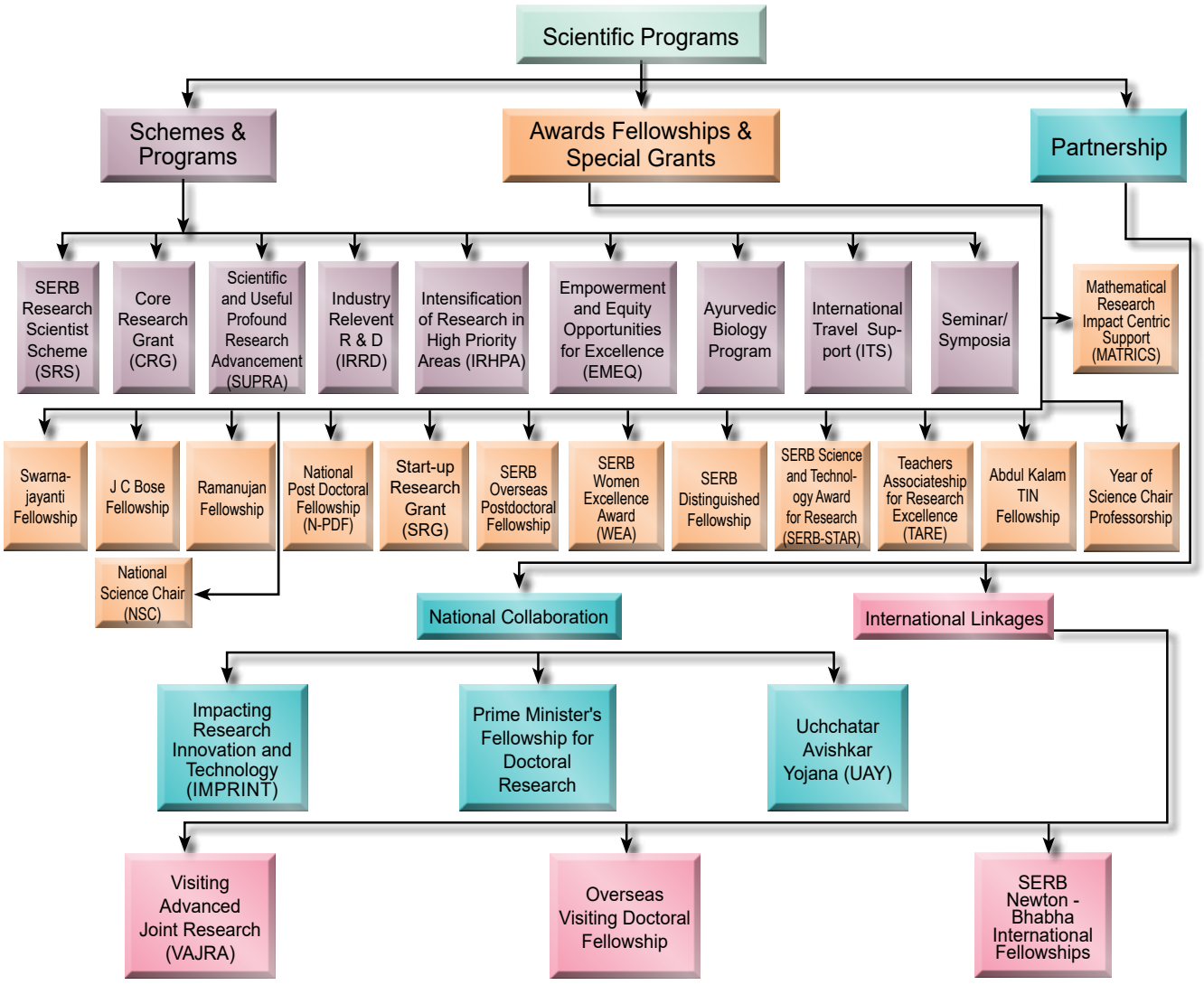


Figure 1.3 : Flowchart depicting programs handled by SERB

1.3 BOARD & OVERSIGHT COMMITTEE

a) The Board

The Board, chaired by Secretary, Department of Science and Technology (DST), is comprised of 16 members including a few eminent Indian Scientists and six Secretaries to the Government of India. Following are the Members of the Board as depicting in the Flowchart (Figure 1.4)

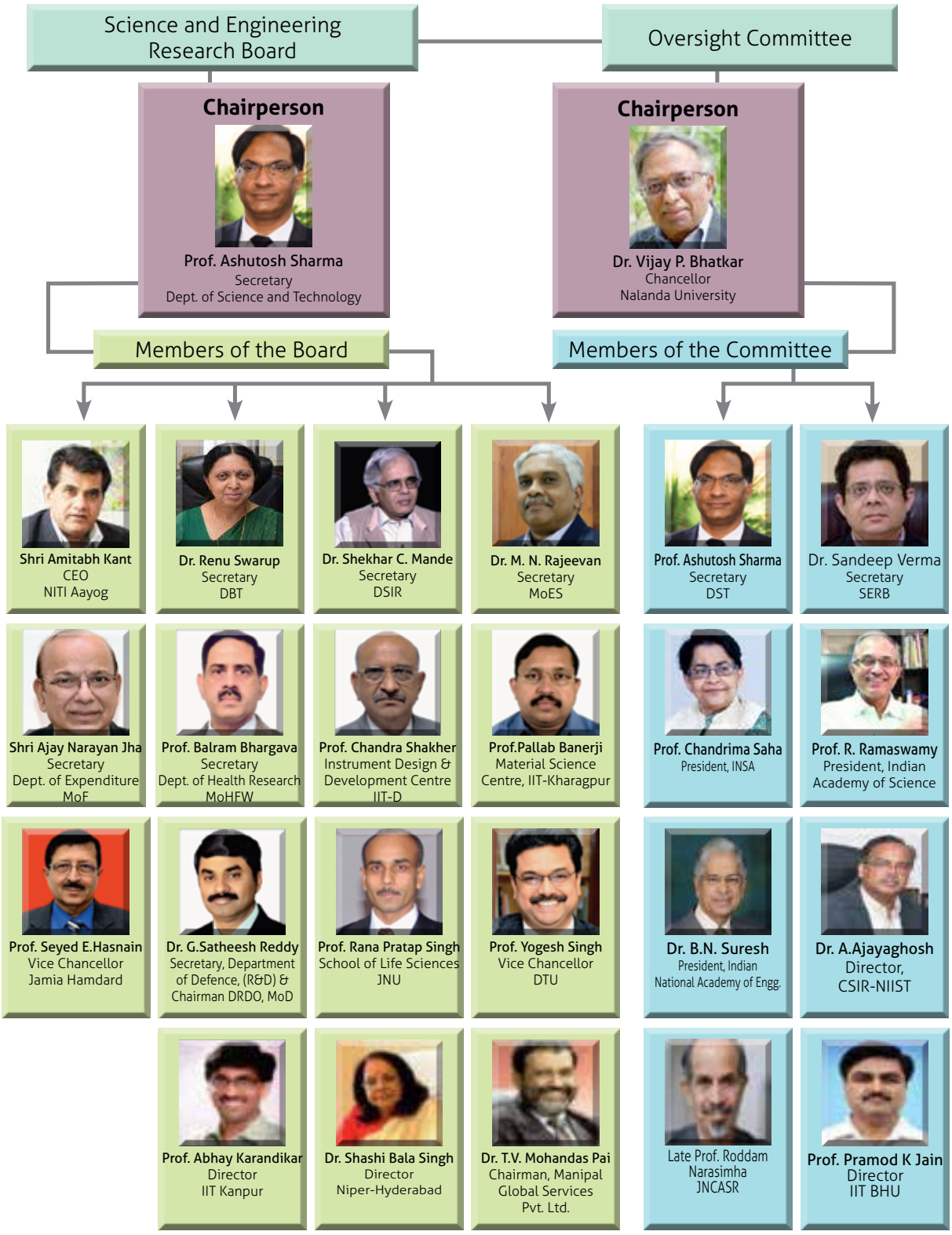


Figure1.4 : Members of the Board and Oversight Committee.

b) The Oversight Committee

The SERB Act provides for constitution of an Oversight Committee to advise and assist the Board. A scientist of eminence and international repute chairs the Oversight Committee with Secretary to the Government of India in DST as Vice Chairperson and a few distinguished experts, Secretary to the Board and Presidents of 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 1.4.

1.4 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. At first stage, the proposals are sent to domain experts for their comments. At second stage, the proposals are generally evaluated for funding by specific Committees. 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:

1.4.A Programme Advisory Committee (PAC)

Programme Advisory Committee (PAC) is the first level peer review committee in the system. Fourteen 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. The members were drawn from Universities / National Labs / IITs/ IISc. PACs role is critical in taking decision on R&D proposals submitted to the Board.

1.4.B Empowered Committee

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

1.4.C Expert Committees / Task Force

Five Expert Committees are helping the Board in taking funding decision on Start-Up Research Grant (SRG) and National Postdoctoral Fellowship (NPDF) proposals. A Task Force constituted under the Board takes decision on proposals received under EMEQ Scheme.

2 OVERVIEW

SERB in its span, has glided as a premier funding agency for planning, promoting and funding of internationally competitive research in budding areas. It has encouraged prominent research areas and potential scientists and funding them for undertaking competitive research. The SERB support schemes has taken shape into elaborated research infrastructure of academic and research institutions across the country and enabled synergy between academic institutions, research and development laboratories and industry for promoting basic research in science and engineering. SERB has a progressive management system, which is founded on modern management practices, techniques for delivery of time bound funding decisions and monitoring of ongoing schemes.

2.1 GROWTH PROFILE

The Board has brought forth with several innovative programmes and schemes to identify potential scientists and support them for 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.

2011
- Transition from SERC to SERB

2013-14
- Online submission of proposals, review and decision marking process

2015
- Adaptation of "Code of conduct" and "Conflict of interest" policy

2016
- Global Research Council Annual Meeting in India

2018
- Adaptation of "Scientific Social Responsibility" policy

Figure 2.1: Key Milestones of SERB since inception

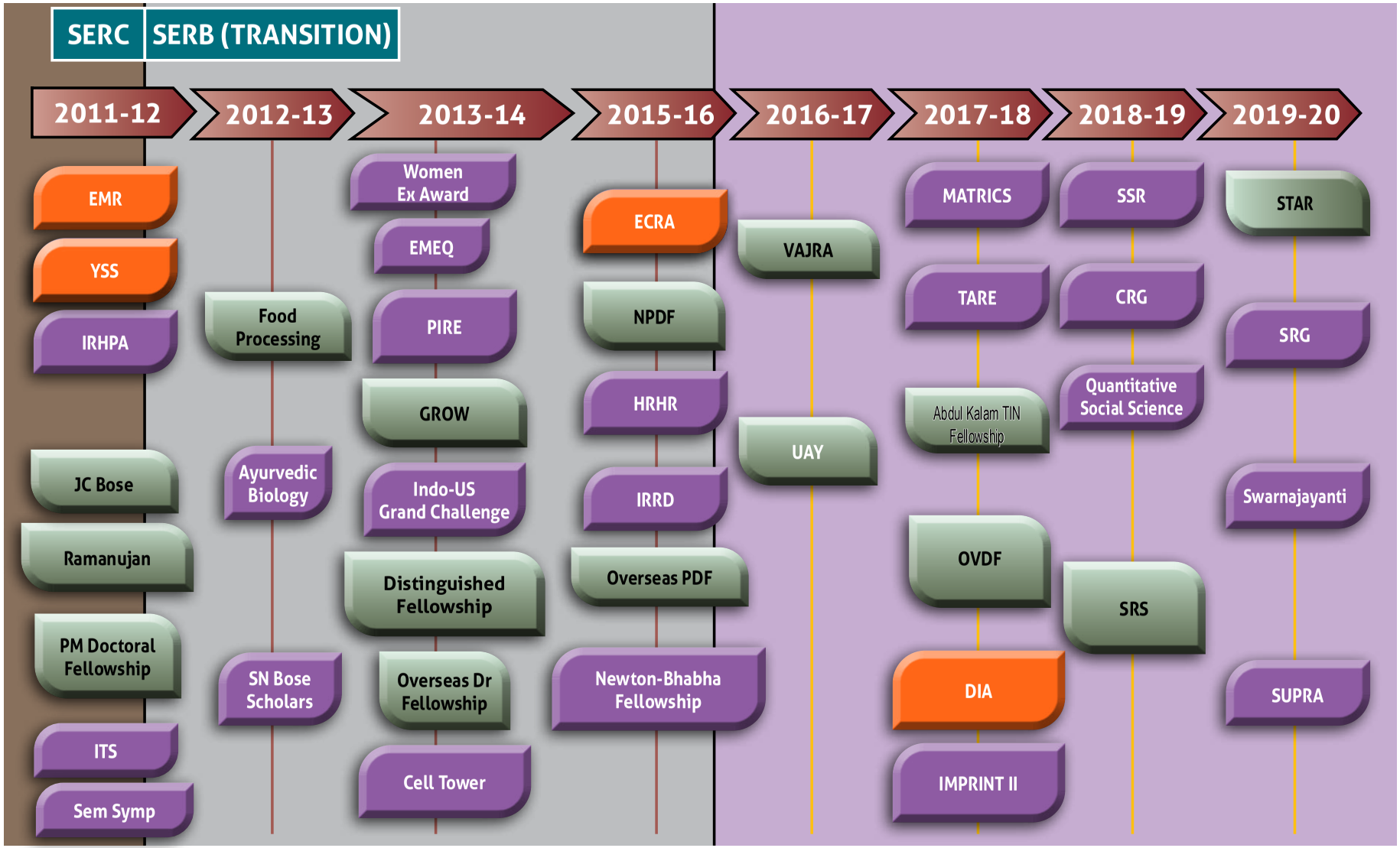


Figure 2.2: The growth profile of SERB Programmes since inception

2.1.1 Milestones

The Board has come a long way in its journey from the erstwhile SERC to its current profile as depicted. Some of the major milestones over the years are shown in Figure 2.1

2.1.2 Adaptability

The Board, since inception had introduced several schemes and programmes to cater various segments of the scientific community. Its adaptability to suit the changing S&T needs of the country is depicted in Figure 2.2

2.1.3 Budget

A steady growth in terms of the budgetary allocation for SERB was observed over the past many years. The allocation for SERB since inception is shown in Figure 2.3.

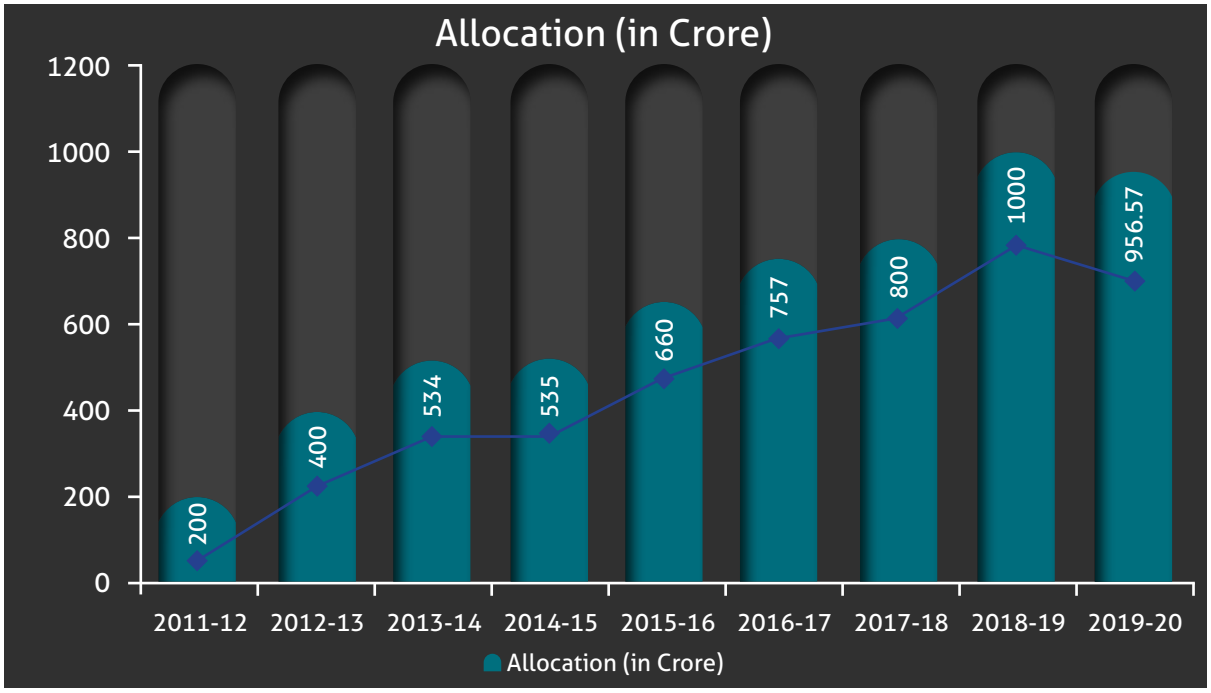


Figure 2.3 : Budget allocation

2.2 SCHEMES AND PROGRAMMES

SERB seeks to achieve its mandated objectives through activities built around programmatic themes as described below:

2.2.1 Support for Core Research & Innovations

The activities are broadly centered on following components:

2.2.1.1 Core Research Grant (CRG)

Individual centric competitive mode of funding is provided under CRG. The Board supports potential scientists for undertaking research in frontier areas of S&T. There is no upper limit to the funding. The grant is provided for manpower, equipment, consumables, national travel, contingencies and overheads. One call for proposals was solicited and 13189 grant applications were received. A total of 1038 projects were sanctioned in frontier areas of Science and Engineering.

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

The scheme is instituted to ensure enhanced participation of weaker sections of the society in research and development. The applicant should be an active researcher belonging to the

Schedule Caste and Schedule Tribe category working in academic institutions/ national labs or any other recognized R&D institutions in the field of Science and Engineering. The call for applications is made once a year. A total of 761 proposals were received, and 199 proposals were sanctioned for the reporting period.

2.2.1.3 Scientific Useful Research Advancement (SUPRA)

The scheme is aimed at supporting proposals that are new, challenge existing hypothesis, and provide 'out of box' on important problems. It should contain significant risk elements but promise of high reward if the difficulties could be circumvented. It is expected that the success of such proposals will have far reaching implication in S&T. Outcome could be new and significant theoretical or experimental advances, formulation of new hypothesis, or breakthrough science, which will lead to new technologies. The funding is provided normally for a period of three years. The proposals can be submitted by an individual or by a team of investigators. In the reporting period a total of 1593 proposals were received and two proposals were sanctioned.

2.2.1.4 Industry Relevant R & D (IRRD)

The scheme is aimed at supporting ideas that address a well-defined problem of industrial relevance. The proposal shall be jointly designed and implemented by the academic partner (which includes a partner from national laboratories/ recognized R&D institutions as the case may be) and industry. The participating industry should ensure that the objectives are industrially relevant. The funding is shared between SERB and industry. The support from SERB is extended only to the academic partner and not to the industry. The industry share should not be less than 50% of the total budget. The funding can be provided for a maximum period of three years. Eight projects were funded in partnership with Industry.

2.2.1.5 Intensification of Research in High Priority Areas (IRHPA)

The IRHPA programme supports proposals in high priority areas where multi-disciplinary/ multi-institutional expertise is required which will put our nation in international science map in that particular discipline. The Board identified priority areas in consultation with stake holders and made national call for proposals in the following: (a). 3-D bioprinting (b). Emergent properties of Nanoscale Matter (c). Drug discovery for neglected diseases. A total of 36 proposals were received and seven proposals were recommended for funding.

2.2.1.6 Mathematical Research Impact Centric Support (MATRICS)

The scope of the MATRICS Scheme, which provides a fixed grant to active researchers pursuing Mathematical Sciences, has been expanded to include other Theoretical Sciences. The Scheme name has also been modified as: MATRICS/CREST (Catalytic Research Support for Theoretical Sciences) including economics & other social sciences involving quantitative analysis, mathematical modelling & use of physico - chemical or mathematical sciences. Two call for proposals were solicited and 2300 proposals were received. 245 projects were sanctioned in the reporting period.

2.2.1.7 Teachers Associateship for Research Excellence (TARE)

The scheme aims to facilitate mobility of faculty members working in a regular capacity in state universities / colleges and in private academic institutions to carry out research work in an established public funded institution such as IITs, IISc, IISERs, NITs, CSIR, ICAR, ICMR labs and other central institutions and central universities, located preferably closer to the institution where the faculty member is working. Research work will be carried out to ensure that the principal investigator continues to work in the host institute as well as his / her parent institute on mutually agreed terms between the PI and the mentor. One call for applications was solicited and 391 applications were considered. A total of 91 applications were recommended for support.

2.2.2 Fostering the Young Researchers

Young researchers in the country are supported through the following schemes:

2.2.2.1. Start-up Research Grant (SRG)

The Early Career Research Award (ECRA) was restructured and inducted as the Start-up Research Grant (SRG) scheme. This program helps researchers to initiate their research career in a new institution. The scheme enables researchers enable to establish themselves and work in frontier areas of science and engineering and provides a platform to move on to the mainstream core research grant. Criteria for selection would be based on the track record of the applicant and the proposed research plan. Research grant of Rs. 30 lakh plus overheads for a period of two years will be provided to the awardees. One call for proposals was solicited and 4508 grant applications were received. A total of 403 projects were recommended to young scientists in frontier areas of Science and Engineering.

2.2.2.2. National Post-Doctoral Fellowship (N-PDF)

The SERB-National Post-Doctoral Fellowship (N-PDF) is aimed to identify motivated young researchers and provide them support for doing research in frontier areas of science and engineering. The fellows are to work under a mentor, and this training is to provide them a platform to develop as an independent researcher. The fellowship is purely a temporary assignment and is tenable for a period of 2 years. The upper age limit for the fellowship is 35 years at the time of the submission of application. Age relaxation of 5 years is given to candidates belonging to SC/ST/OBC/Physically Challenged & Women candidates. The call for applications for SERB-N PDF is notified once in a year through the website. One call for applications was solicited and 3426 grant applications were considered. A total of 239 Fellowships were sanctioned to budding scientists in frontier areas of Science and Engineering.

2.2.2.3 Ramanujan Fellowship

Ramanujan National Fellowships are offered to brilliant scientists returning from all over the world to take up scientific research positions in India. It is directed to scientists and engineers below the age of 40 years, who want to return to India from abroad. The Ramanujan Fellows can work in any of the scientific institutions and universities in the country. The duration of Ramanujan Fellowships is five years. 9 Fellowships were awarded.

2.2.3 Building Research Networks

SERB has built strong domestic and international partnership with several agencies. The details are given below:

2.2.3.1 Partnership Programmes – National

2.2.3.1.1 IMPRINT (Impacting Research Innovation and Technology)

IMPRINT (Impacting Research Innovation and Technology), is a program piloted by the Ministry of Human Resource Development (MHRD) which aims to address and provide solutions to the most relevant engineering challenges faced by our nation by translating knowledge into viable technology (product and processes) in selected technology domains. IMPRINT2, a new and revised edition of Impacting Research Innovation and Technology (IMPRINT) Programme, has been launched to streamline and simplify the processes and sharpen the focus on translational research and also to attract wider participation of stakeholders including industry. IMPRINT – 2 is sourced on a corpus set up jointly by the Ministry of Human Resource Development (MHRD) and DST and it also intends to derive contribution from various participating Ministries. SERB has been entrusted for the implementation of IMPRINT projects. 57 proposals were recommended for support for funding in the reporting period.

2.2.3.1.2 PM Doctoral Fellowship

The Prime Minister's Fellowships for Doctoral Research is a Public-Private Partnership (PPP) Programme developed in partnership with Confederation of India Industry (CII) and Federation of Indian Chambers of Commerce and Industry (FICCI). The scheme is for supporting aspiring PhD. Scholars with double scholarship, 50% of which is provided by government (SERB) and balance 50% by a sponsoring industry for doing industrial research for a period of four years. 47 Fellowships were awarded in the reporting period.

2.2.3.2 Partnership Programmes – International

2.2.3.2.1 Newton – Bhabha International Fellowships

It is a joint initiative with the Royal Society of the United Kingdom to enhance capacity in the area of research and innovation. A MoU has been signed between The Royal Society and SERB to institute 15 Newton – Bhabha International Fellowships per year to the Indian research community, covering fields of Science, Technology, Engineering and Mathematics (STEM). Applicants must hold regular positions in institutions based in India or should have completed PhD degree in science, engineering and mathematics. The awards are given up to two consecutive years in length spent in the UK, undertaking research at a host university or research institute. The awards provide a stipend, research expenses and one-off relocation expenses and provide up to an amount of £99,000for two years. All applicants must identify a UK co-applicant who will host them whilst they are in the UK. 15 researchers have been offered the fellowship in the reporting period.

2.2.3.2.2 Overseas Doctoral Fellowship Scheme

The Board offers Overseas Doctoral Fellowship to build national capacity where the talent supply of researchers in areas of interest to the country is sub-critical. The applicant should be an Indian and have got admission into doctoral research programme in specified areas in collaborating overseas universities. The Scheme is limited to only specified Universities namely, Cambridge University, Stanford University, University of Southern California, Carnegie Mellon University, University of California, Rice University and University at Buffalo, The State University of New York and University of British Columbia, Canada with which SERB had entered a MoU. The MoU ensures that each and every SERB Overseas Doctoral Fellow will be getting tuition fee waiver / support from the University concerned. Selected fellows are provided US $24,000 per annum for a period of 4 years. In addition, one-time Contingency/ Preparatory allowance of Rs. 60,000/- and to & fro Airfare (Economy) is given to the fellows. 13 students have been awarded the fellowship in the reporting period.

2.2.3.2.3 Overseas Visiting Doctoral Fellowship Scheme

The Scheme is designed with a primary objective to offer opportunities for PhD students admitted in the Indian institutions for gaining exposure and training in overseas universities / institutions of repute and areas of importance to country for period up to 12 months. The first call for application under the scheme was announced in the year 2018-19 and 40 researchers have been selected for the fellowship to pursue their short-term doctoral research in 24 different countries around the world under renowned guides of various Institutions/ Universities. Under the SERB-Purdue University OVDF program 25 students were selected. Under the SERB-UAlberta OVDF scheme 10 students were selected.

2.2.3.2.4 Visiting Advanced Joint Research (VAJRA) Faculty Scheme

The Scheme aims to tap the expertise of Overseas Faculty / scientists including Non-resident Indians (NRIs) & OCIs. Itoffers adjunct / visiting faculty positions to overseas scientist / faculty / R&D professional to undertake high quality collaborative research in public funded academic and research Institutions in India. The Scheme facilitate 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 stimulate the latent potential of our academic and research sector.The VAJRA Faculty will reside in India up to 3 months in a year and they will be provided a lump-sum amount of US $ 15000 in the first month of residence and US $ 10000 p.m. after that. The faculty would be physically available for 1-3 months in Indian institutions but maintain an adjunct faculty/ scientist status round the year and keep the collaborative lab and co-guided Ph.D. students in India for the whole term providing round the year mentoring and support to students and other researchers. During the reporting period

8 accomplished scientists have been offered VAJRA Facultyship. From the earlier batch, 9 scientists had made their collaborative research visits.

2.2.4 Awards & Recognitions

2.2.4.1 J C Bose Fellowship

J C Bose Fellowship is instituted to recognize and support active Indian scientists and engineers for their outstanding performance in R&D and significant contribution towards scientific research. The fellowship is scientist-specific and very selective. 31 Fellowships were awarded in the reporting period.

2.2.4.2 SERB Distinguished Fellowship

SERB Distinguished Fellowship Scheme is meant for eminent and performing senior scientists to continue active research even beyond their superannuation. 6 Fellowships were sanctioned in the reporting period.

2.2.4.3 Year of Science Chair Professorship

The Chair Professorship is presented as benchmark of performance, stature, value and eminence in the national and international arena. The Awardee should be a distinguished Indian Scientist who has made outstanding contributions in any one or more areas of Science & Technology, Engineering and Mathematics and should have proven track record of exceptional research achievements during last 10 years, including continued excellent research output in the last 5 years preceding the year of consideration, mentoring young researchers and involved in policy making. The tenure of YoSCP would be for a period of five years initially and extendable through assessment based on performance. 1 award was conferred in the reporting period.

2.2.4.4 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 outstanding performance of Principal Investigators (PIs) of SERB Projects. SERB-STAR is an initiative to acknowledge exemplary contributions in research and to motivate the PIs of ongoing projects for outstanding performance. 7 Awards were given in the reporting period.

2.2.4.5 SERB Women Excellence Award

SERB Women Excellence Award is a one-time award given to women scientists below 40 years of age and who have received recognition from any one or more of the following national academies such as Young Scientist Medal, Young Associate etc.

a. Indian National Science Academy, New Delhi
b. Indian Academy of Science, Bangalore
c. National Academy of Sciences, Allahabad
d. Indian National Academy of Engineering, New Delhi
e. National Academy of Medical Sciences, New Delhi
f. National Academy of Agricultural Sciences, New Delhi

9 Awards were sanctioned to women scientists in the reporting period.

2.2.5 Support for Science and Technology Events

2.2.5.1 Assistance to Professional Bodies & Seminar/Symposia

The program extends partial support for organizing seminar/symposia/training program/workshop/ conferences at national as well as international level. The support is provided to Research Institutes/ Universities/ Medical and Engineering collages and other Academic Institutes/ Professional bodies who organize such events for the scientific community to keep them abreast of the latest developments in their specific areas. It is generally given for encouraging participation of young scientist and research workers in such events and publication of proceedings and

abstract for wider dissemination. The program also supports S&T professional bodies. 533 events were partially supported in the reporting period.

2.2.5.2 International Travel Support Scheme (ITS)

ITS scheme is designed to provide financial assistance for presenting a research paper or chairing a session or delivering a keynote address in an international scientific event (conference/ seminar/symposium/ workshop etc.) held abroad. In addition, support is also provided to young scientists (age limit 35 years as on date of conference) for attending training programs and short-term schools/workshop/courses. Economy class airfare by shortest route, airport taxi and visa fees are provided under the scheme. Registration fee is also provided to young scientists in addition to the above support. A total of 1353 researchers were supported.

2.3 NEW INITIATIVES

2.3.1 SERB-TETRA (Technology Translation Award)

The Board approved to launch the programme. SERB-TETRA will challenge scientists executing SERB grants, such as Core Research Grant, 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.

TETRA Support will help entities having successful ideas to kickstart new venture processes. With a seed capital, flexible working spaces and interaction between mentor and start-up entrepreneurs, the SERB-TETRA will expand the scope by providing numerous networking opportunities, followed by presenting the finished prototype to an audience of large investors, established MSMEs and private companies, and public sector enterprises.

2.3.2 SERB-FIRE (Fund for Industrial Research Engagement)

The Board signed Letter of Intent (LoI) with a group of industries to institute a new programme "Fund for Industrial Research Engagement (FIRE)" to stimulate industry-relevant research in the country. The new Initiative, SERB-FIRE, under Industry Relevant R&D (IRRD)scheme of SERB, aims to utilize the expertise available in academic institutions and national laboratories to solve industry-specific problems for the larger benefit of society. The scheme supports ideas that address a well-defined problem of industrial relevance, defined jointly with concerned industries, in a project mode through an open call at the national level by SERB.

The LoI was signed by SERB with Intel Technology India Private Limited, Applied Materials India Private Limited, Texas Instruments (India) Private Limited, Mentor Graphics (Sales & Services) Private Limited, and NXP India Private Limited.

2.3.3 COVID 19 Specific R&D Initiatives

COVID-19 virus has spread rapidly throughout the world bringing a pandemic situation. Given the lack of an efficacious vaccine and lack of availability of suitable chemotherapeutic interventions, the global population has been hit hard with utmost vulnerability to the current coronavirus outbreak. Thus, there is an urgent need to ramp up national R&D efforts for new antivirals, vaccines, and affordable diagnostics. It is desirable to bring technical partnerships and collaborative know-how from biotech and pharmaceutical companies. SERB is committed for strategic investments to accelerate antiviral research in this area. With this background, SERB announced following special calls:

(i) COVID-19 and related respiratory viral infections

- New or repurposed antivirals against valid viral targets; viricidal coatings; etc.
- Affordable diagnostics for symptomatic and asymptomatic respiratory viral infections
- Investigational vaccines against respiratory viruses
- Development of disease models for respiratory viral infections
- Studies on immune response and immunity during respiratory viral infections
- Epidemiology of COVID and other respiratory viral infections

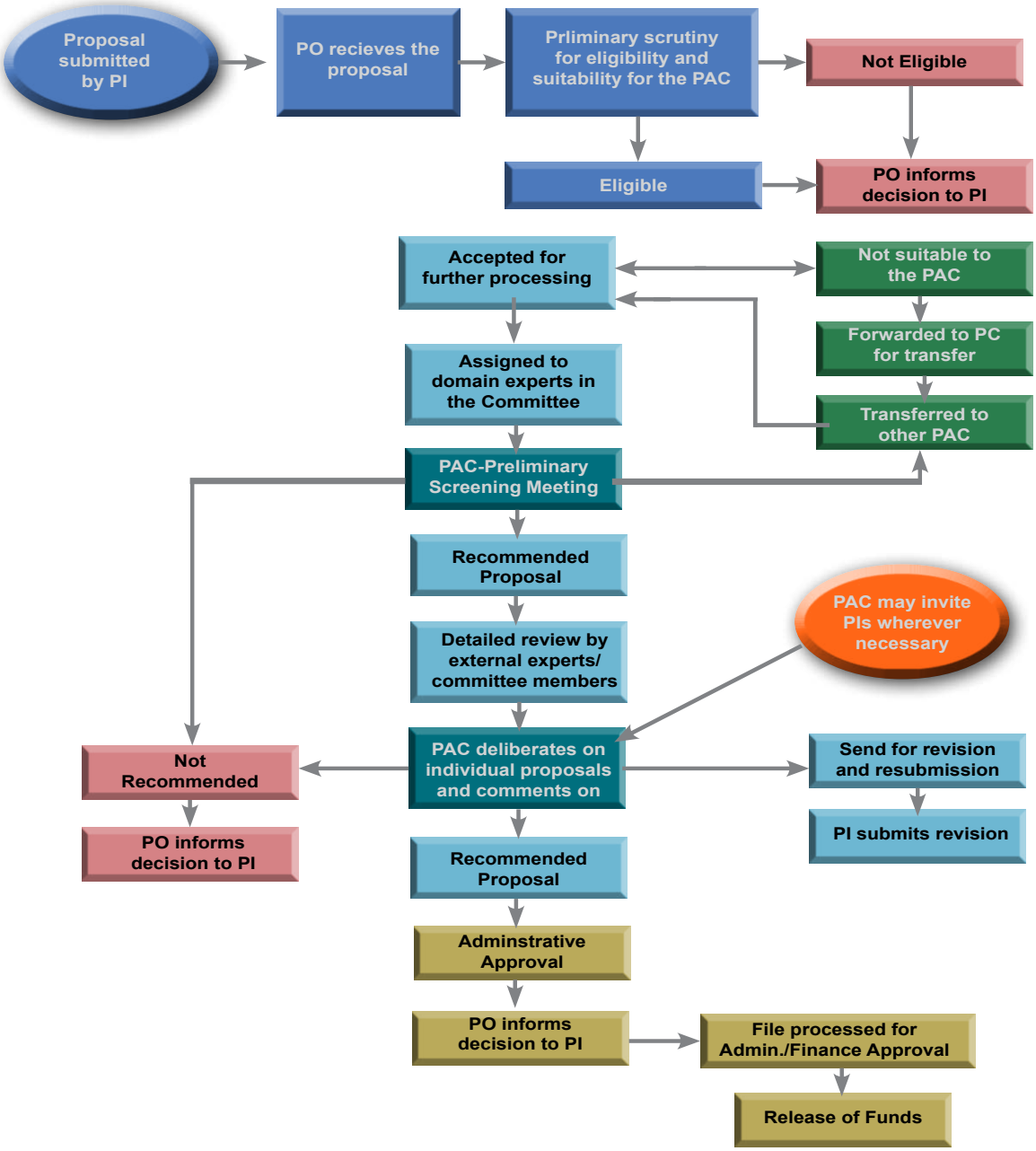
(ii) Preventive Chemical Approaches

SERB solicited one-year project proposals from Institutions for preventive chemical approaches as antivirals, repurposed drugs against COVID-19, and new methods to sanitize inanimate surfaces. It is also applicable to antivirals to be incorporated in cost-effective breathing masks.

2.4 PROCESS AND PROCEDURAL FLOWS

The applications from the researchers in majority of the online programmes undergo the following process of scrutiny, selection and recommendation, prior to the funds are disbursed. (Figure 2.4)

EVALUATION & APPROVAL



***PI** = Principal Investigator; **PO** = Programme Officer; **PC** = Programme Coordinator; **PAC** = Programme Advisory Committee*

Figure 2.4 : Acceptance of proposal for final evaluation

2.5 VITAL STATISTICS

2.5.1 Sanctioned Proposals During the Last seven Years

The number of sanctioned projects/ fellowships under major schemes namely CRG/EMR, YSS, ECRA and NPDF are given below

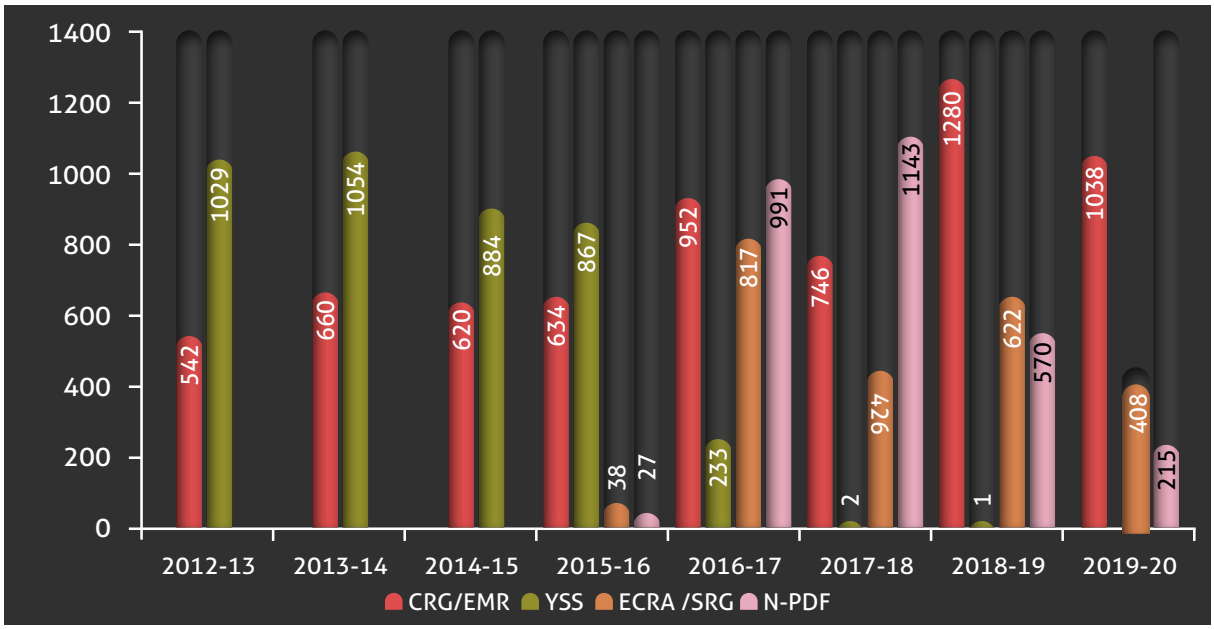


Figure 2.5 : Number of sanctioned projects fellowship under major schemes during last few years.

2.5.2 Total Expenditure for the Year 2019-20

The below chart depicts the total expenditure of Rs. 873.29 crore in the year 2019-20 under different schemes and administrative heads.

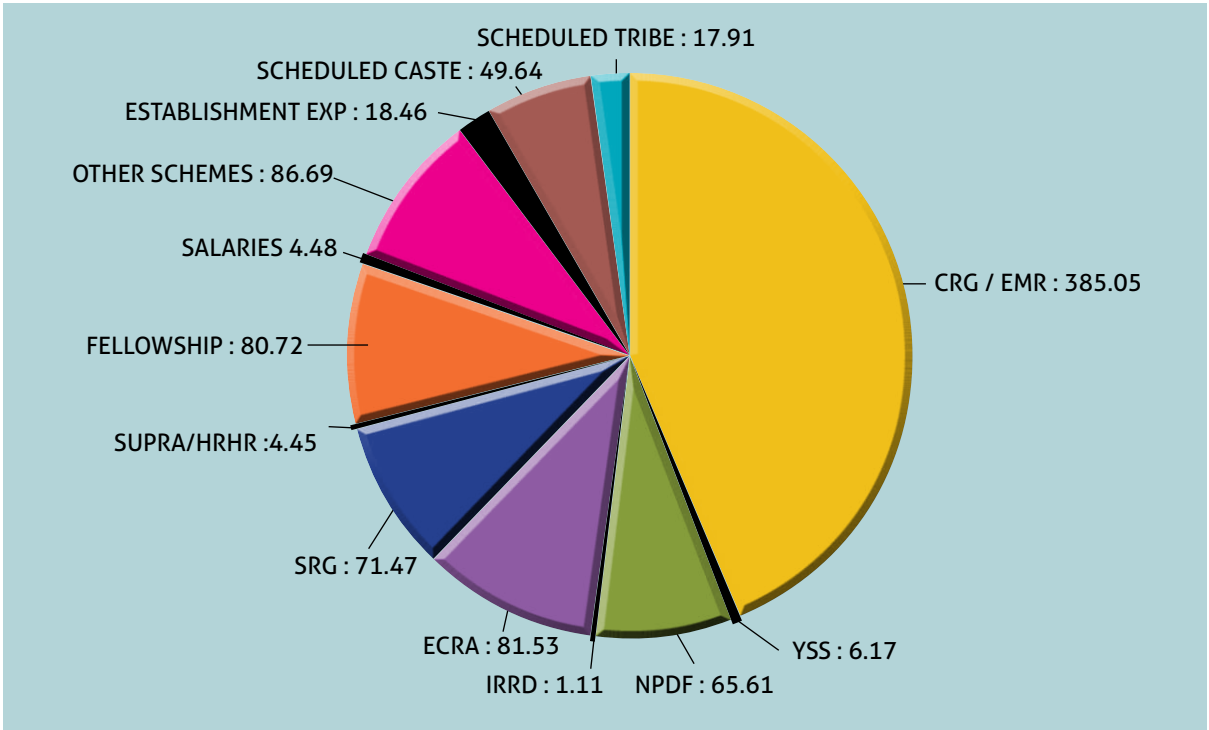


Figure 2.6 : The total Expenditure in the year 2019-20 under different heads (In crore)

2.5.3 New Proposals Sanctioned During the Year 2019-20

New projects numbering a totalof 1038 sanctioned in the year 2019-20 under CRG scheme, distributed in sub-disciplines as given below:

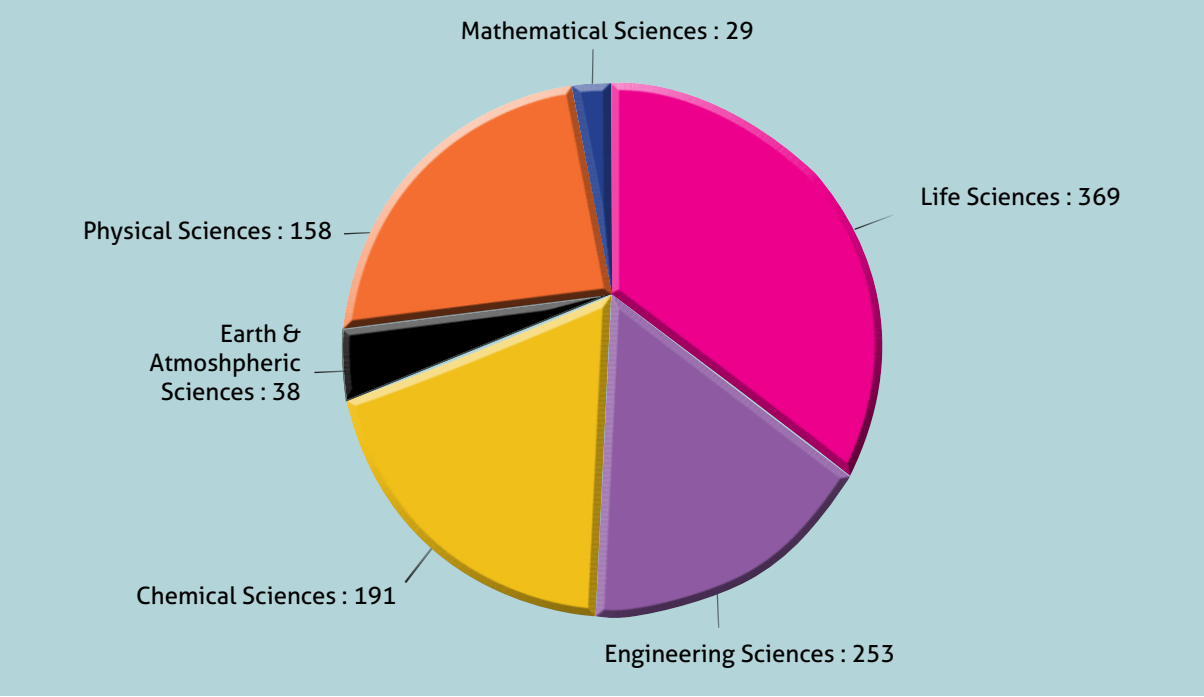


Figure 2.7 : New projects sanctioned under CRG Scheme in the financial year 2019-20

As seen from the figures, it is evident that Life Sciences form a major part of the funding under CRG scheme.

The number of new proposals sanctioned in the year 2019-20 under SRG and N-PDF scheme distributed sub-discipline wise is given below in Figures 2.8 (i) and 2.8 (ii)

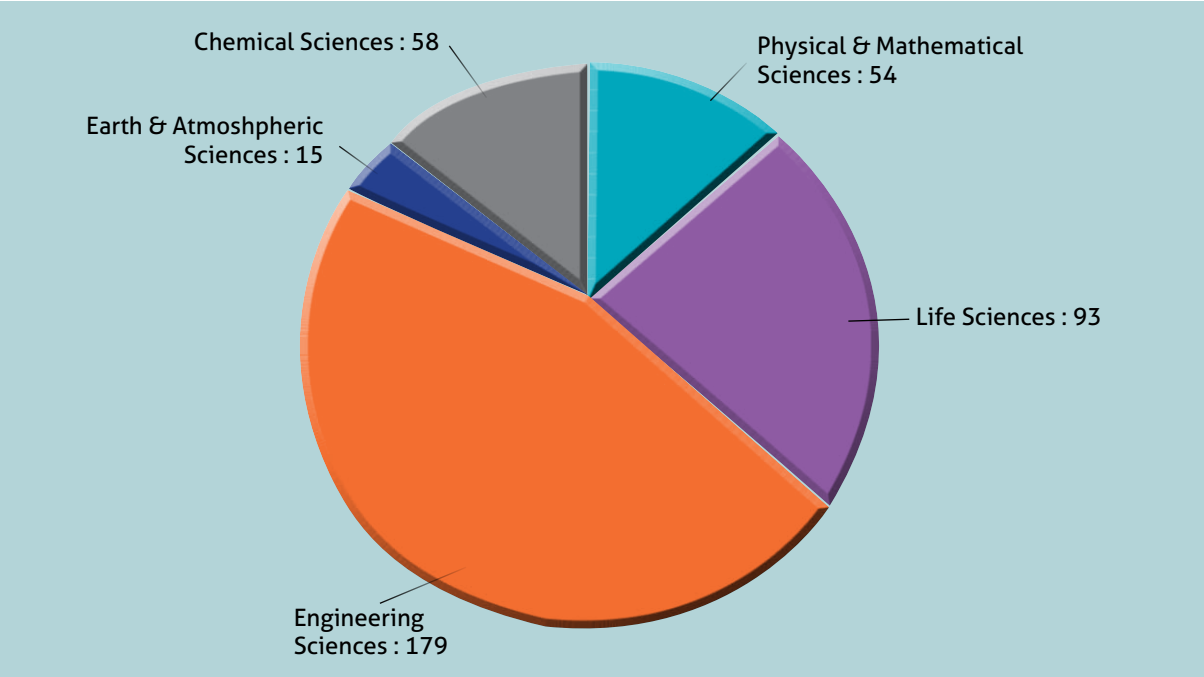


Figure 2.8 (i) : New projects (399) sanctioned under SRG schemes in the financial year 2019-20

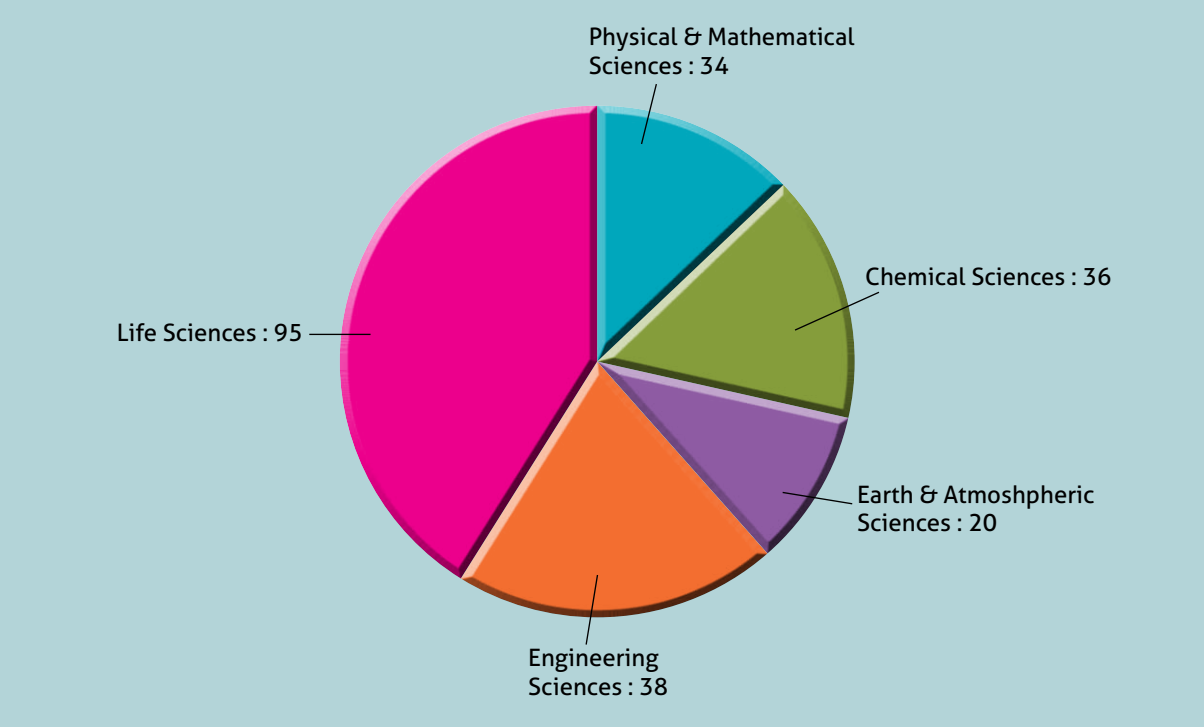


Figure 2.8 (ii) : New fellowships (223) sanctioned under N-PDF scheme in the financial year 2019-20

Again as per the figures, Life Sciences form a major part of funding under all the schemes followed by Engineering Sciences and Physical and Mathematical Sciences.

3 SUPPORTING CORE RESEARCH & INNOVATION

The scientific eco system which is created by SERB through various programmes viz., CRG,MATRICS, EMEQ, IRRD, IRHPA etc. has shown great focus on translation of research while extending support for excellence in research in the basic and applied sciences.

3.1 CORE RESEARCH GRANT (CRG)

Objective	Features
To provide research support to individual or group of researchers to undertake cutting edge research.	This is the flagship scheme of the Board accounting to almost one-third of SERB' s budget. The scheme is for those who are holding a regular academic/ research position in a recognized academic institution or national laboratory or in any other recognized R & D institution in India. INSPIRE Faculty, Ramanujan and Ramalingaswamy fellows are also eligible to apply provided they have at least three and half years of tenure remaining at the time of submission of application. The grant covers equipment, manpower, consumables, travel and contingency. Normal duration of the project is three years.

Website links
http://serb.gov.in/jcbn.php

3.1.1 CHEMICAL SCIENCES

3.1.1.1 Organic Chemistry

A total of 337 proposals were received out of which 48 were sanctioned during the year. Sub discipline wise distribution of the projects is given in the figure 3.1.

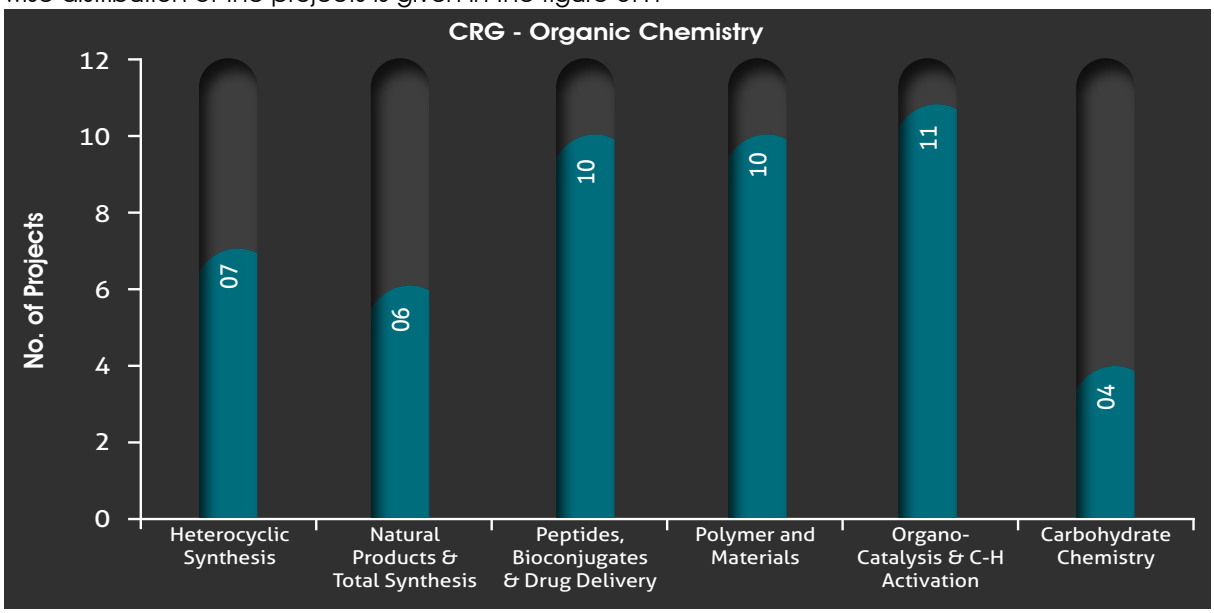


Figure 3.1 : Projects sanctioned in different sub-disciplines of organic chemistry

Research Highlights

i. Development of Anti-alzheimer Peptide from Taxol Binding Pocket of β-Tubulin

Alzheimer's disease (AD) is associated with progressive damage of brain cells that causes memory loss and confusion. During progression of AD, Amyloid-beta (Aβ) peptide misfolds into fibrillary aggregates (β-sheet) and deposited as amyloid plaques in the cellular environment, which severely damages intra-neuronal connections. Furthermore, neurons are rich in tubulin/microtubule and the intracellular network of microtubules also gets disrupted by the accumulation of Aβ fiber in brain. Hence, development of new potent molecules, which can simultaneously inhibit Aβ fibrillations and stabilize microtubules, is particularly needed for the efficient therapeutic application in AD.

These issues have been successfully addressed through adopting an innovative fusion strategy to design and develop next generation peptide and peptoid based anti-AD therapeutic leads. In brief, lead molecules have been identified and validated their potential as anti-AD molecules by various *in vitro* assays. The effect of these lead molecules have also tested in various *in vitro* cellular models of AD. These newly designed anti-AD leads are nontoxic in nature, shows excellent neuroprotection in the PC12 derived neurons and stabilizes the intracellular microtubule network without causing neural toxicity. All the lead molecules have been tested for their potential in in vivo system such as blood brain barrier (BBB) crossing ability and toxicity in mice model.

As a future prospective of this work, a new neurosphere model system as drug screening platform has developed and established traumatic brain injury model system (Figure 3.2).

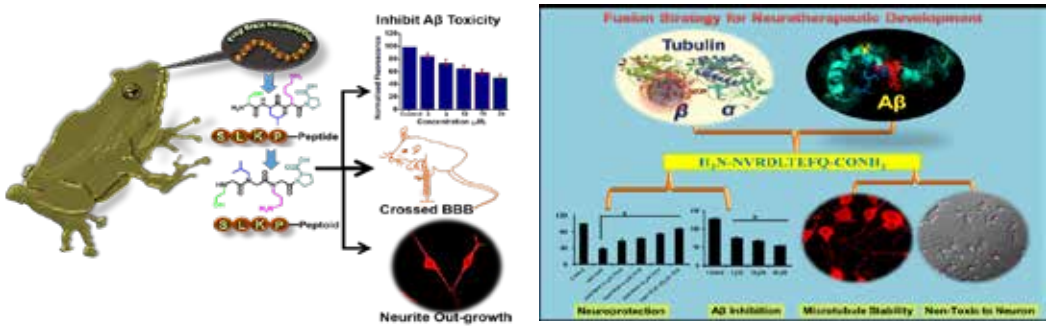


Figure 3.2 : (A) A potential neuroprotective peptide evolved from dual neurotherapeutic targets. (B) Cartoon represents discovery of neuro-regenerative peptoid from amphibian neuropeptide inhibits Aβ toxicity and Crossed BBB

3.1.1.2 Inorganic and Physical Chemistry

A total of 531 proposals were received out of which 102 were sanctioned during the year. Sub discipline wise distribution of projects is given in Figure 3.3.

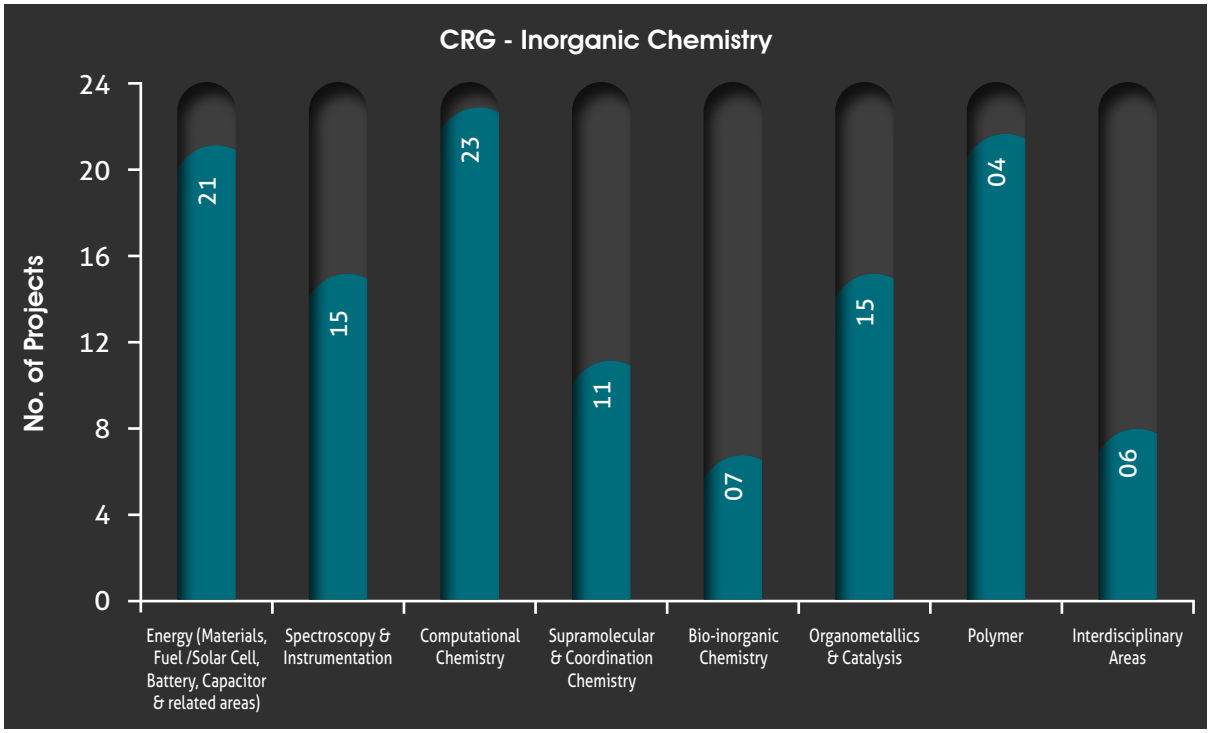


Figure 3.3 : Projects sanctioned in different sub-discipline of Inorganic & Physical Chemistry

Research Highlights

i.Pb-free thermoelectric energy conversion: Enhancement of thermoelectric performance of SnTe by aliovalent doping, valence band convergence and nanostructuring

Nearly 90 percent of the energy we use comes from burning of fossil fuels and natural gas reserves. Unfortunately, almost 65 percent of that precious energy gets irreversibly wasted as dissipated heat. This is an alarming scenario as the global energy crisis is looming on the society with the depleting level of fossil fuels and natural gas reserve. The miraculous sounding technology is thermoelectrics in which a material generates electrical voltage when one side of the material is heated while keeping the other side cold.

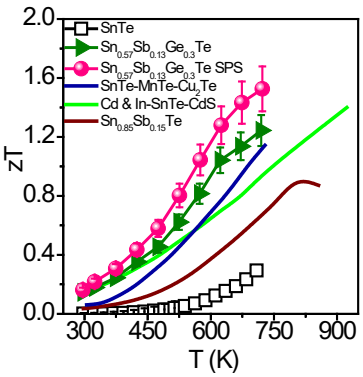


Figure 3.4 : Tailoring local structural distortions and the associated ferroelectric instability in SnTe *via* Ge alloying resulted in low lattice thermal conductivity, which boosts the thermoelectric figure of merit (*zT*) to 1.6 at 721 K (pink solid sphere;

Over the last 60 years or so, scientists have studied a number of materials and improved their thermoelectric performance – the electrical voltage generation capability from heat source. Unfortunately, to date, most of the efficient thermoelectric materials uses lead (Pb) as major constituent element, which restrict their use for mass market applications.

This work made a design breakthrough by introducing a concept called ferroelectric instability in which a material is about to experience a ferroelectric transition. They demonstrated this concept in an environment friendly material called tin telluride (SnTe). The ferroelectric instability in SnTe was tuned through germanium

(Ge) alloying. The local rhombohedral structural distortion inside a global cubic phase of SnTe gives rise to ferroelectric instability. The ferroelectric instability, in turn, generates large number of soft optical phonons which then strongly scatter the heat carrying acoustic phonons. This ultimately lowers the thermal conductivity in SnGeTe. A record thermoelectric figure of merit of 1.6 in SnTe (figure 3.4) has been observed, which corresponds to a heat to electrical conversion efficiency of nearly 12 percent in Pb-free SnTe. Along with of thermoelectric energy conversion in SnTe, the Pb-free solids such as AgCuTe, BiSe, $AgPbBiSe_3$ etc. have also been studied. In the same line, the thermoelectric figure of merit (zT) of 2.1 at 630 K in Sb doped $(GeTe)_{1-2x}(GeSe)_x(GeS)_x$ have successfully achieved which is one of the 3rd generation Pb-free materials developed from India.

3.1.2 Earth & Atmospheric Sciences

A total of 200 proposals were received out of which 38 were sanctioned during the year. Sub-discipline wise distribution of projects is given in Figure 3.5.

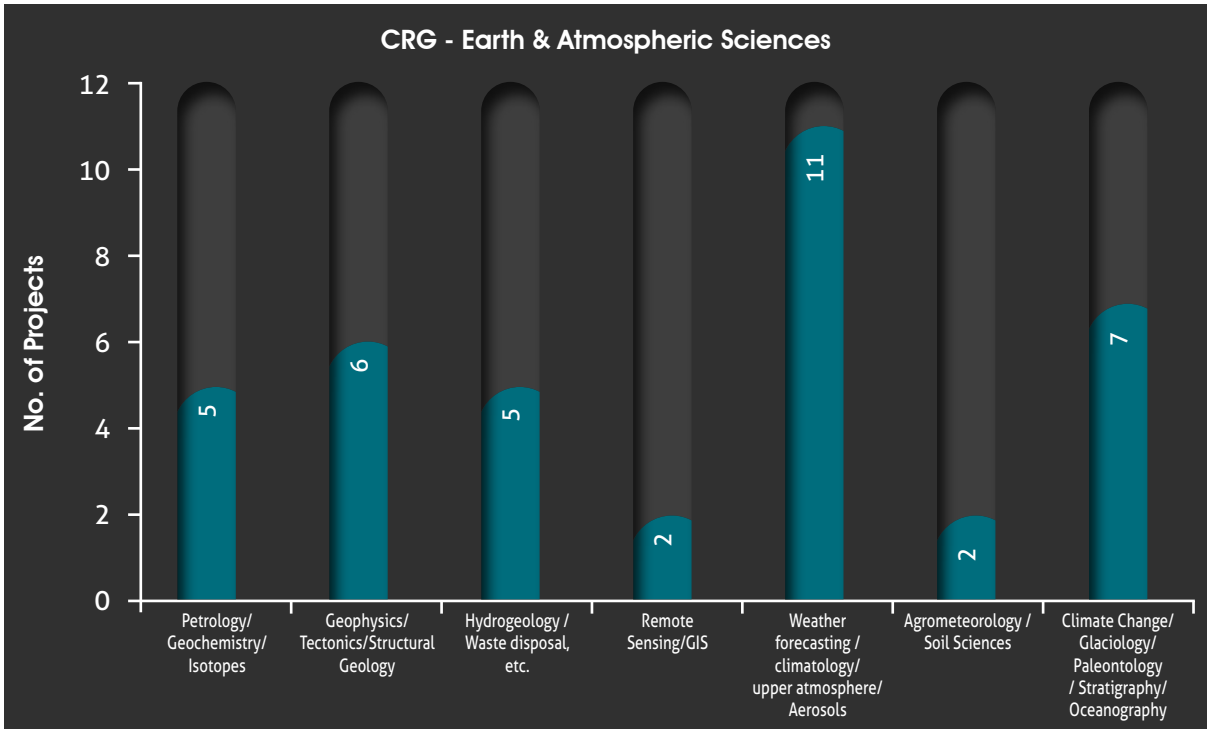


Figure 3.5 Projects sanctioned in different sub discipline of Earth & Atmospheric Sciences.

Research Highlights

Hadean & Archean Continental Crust Formation & Evolution: Constraints from U-Pb Dating & Hf Isotope Measurements from Ancient Metaigneous & Supracrustal Sequences in the Singhbhum & Western Dharwar Cratons.

(a) Detrital zircon evidence for change in geodynamic regime of continental crust formation 3.7–3.6 billion years ago:-

The nature of the early terrestrial crust and how it evolved through time remains highly controversial. Whether conventional plate tectonics operated in the Hadean and early Archean and when it came into existence remains unclear. In this study, Prof. Dewashish Upadhyay and coworkers from IIT Kharagpur, describe U-Pb ages, Hf isotopes and trace element chemistry of 3.95–3.10 Ga detrital zircons (Figure 3.6 (a)) from the Singhbhum Craton. The >3.7 Ga zircons have crust-like Hf isotope composition with strongly negative εHfi and their granitoid sources formed by intra-crustal reworking of a Hadean protolith that was extracted from primitive mantle at 4.4–

4.5 Ga (Figure 3.6 a&b). The zircons document a transition from higher Nb/Th, Nb/U, crust-like Hf isotopes, and longer crustal residence times of protoliths prior to 3.7–3.6 Ga, to lower Nb/Th, Nb/U, mantle-like Hf isotopes, and shorter protolith residence times post 3.7–3.6 Ga. The changes in the granitoid chemistry recorded by the detrital zircons document a change in the depth of melting of the protoliths as well as in the tectonic setting of continental crust formation, and we argue that it marks the transition to granitoid production from oceanic plateaus to arc-like tectonic environments.

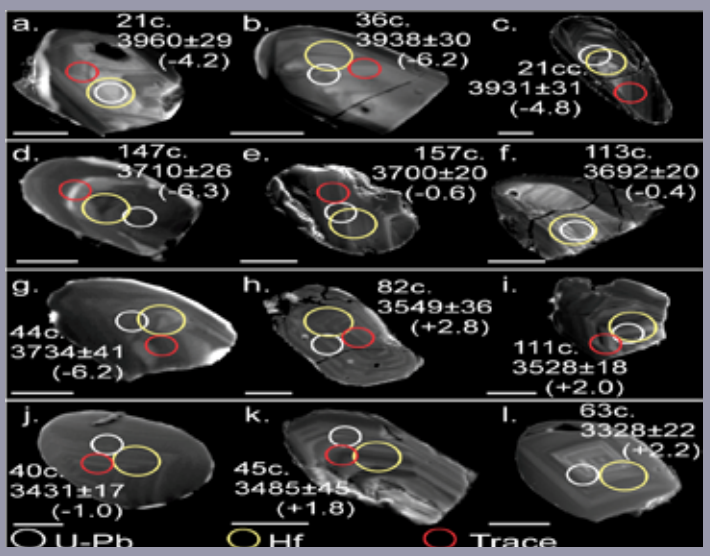


Figure 3.6(a): Cathodoluminescence images of Eoarchean to Paleoarchean detrital zircons from the Singhbhum Craton.

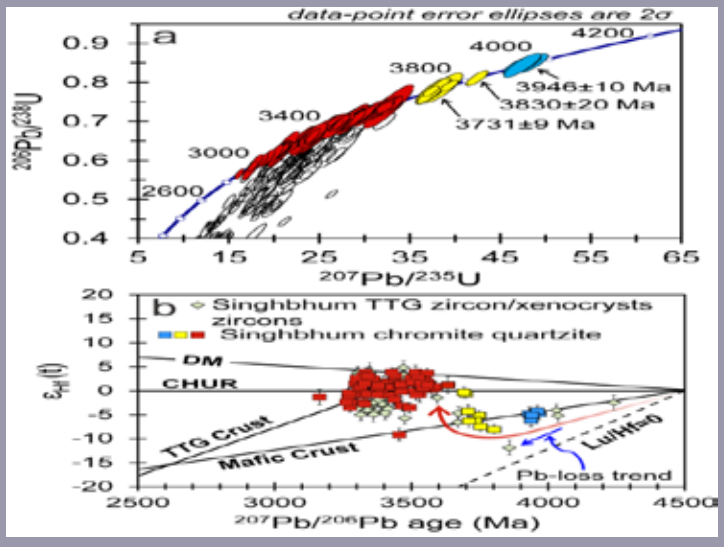


Figure 3.6(b): Concordia diagram of U-Pb ages and Hafnium isotope evolution diagram of detrital zircons. The data define εHf-time array consistent with the Eoarchean zircons having been derived by re-working of Hadean crust as old as 4.4–4.5 Ga. Arrow indicates the transition from crust-like εHf (t) to increasing juvenile values at 3.7 Ga.

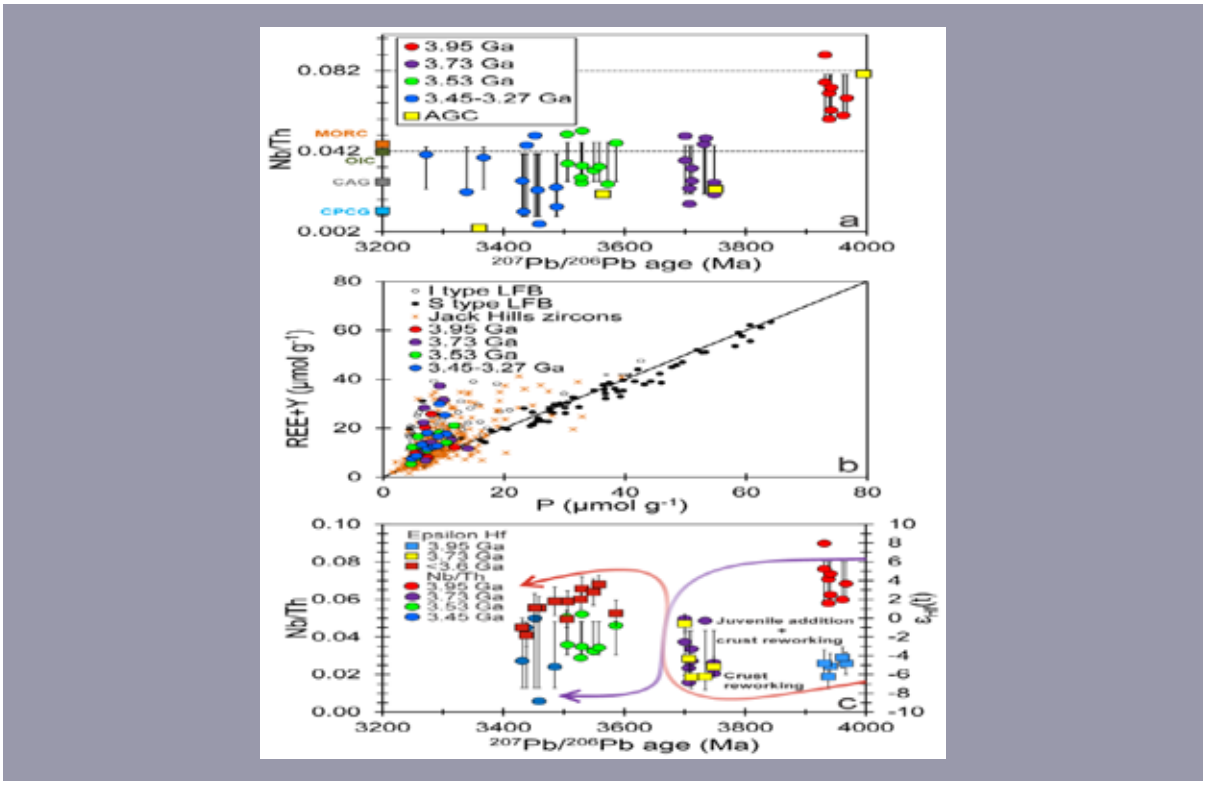
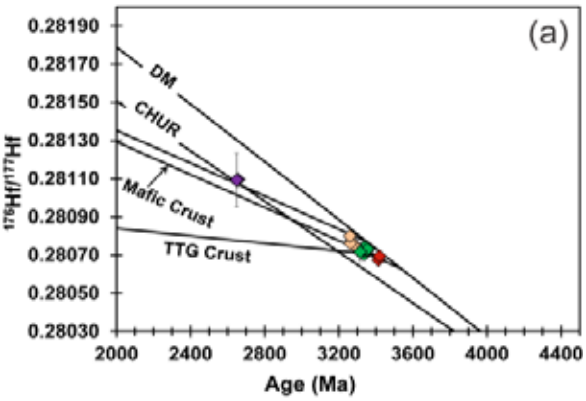


Figure 3.7: Nb/Th, REE, P, and εHf (t) of the detrital zircons from the Singhbhum Craton. The transition to lower Nb/Th between 3.9 Ga and 3.7 Ga is attributed to the initiation of crustal reworking in an arc-like tectonic setting.

(b) Petrogenesis of Paleoarchean and Neoarchean Tonalite-Trondhjemite-Granodiorite (TTGs) and granites from the Western Dharwar Craton, southern India: implications for Archean continental growth and geodynamics

In this study, zircon ages to constrain four major episodes of granitoid crust formation at 3.43–3.41 Ga, 3.36–3.34 Ga, 3.29–3.26 Ga, and 2.66–2.65 Ga in the Western Dharwar Craton. The 3.43–3.41 Ga, 3.36–3.34 Ga, and 3.29–3.25 Ga granitoid suites have positive εHfi (2.7–4.5) and were produced by repeated granitoid extraction at 3.43–3.41 Ga, 3.36–3.34 Ga, and 3.29–3.25 Ga from mafic sources that separated from depleted mantle between 3.55 Ga and 3.35 Ga (Figure 3.8). The 2.66–2.65 Ga Neoarchean granitoids involved significant crustal recycling. Uranium-Pb ages from metamorphic zircons indicate polyphase metamorphism of the granitoids at 3353–3329 Ma, 3264–3256 Ma, 3187–3141 Ma, 3083–3062 Ma, and 2574–2526 Ma. Hf-isotopic data from zircons in granitoids from several cratons indicate that prior to c. 3.5 Ga most granitoids have crust-like εHfi explained by repeated granitoid extraction from long-lived mafic crusts with limited interaction with juvenile magmas. Juvenile εHfi and short protolith residence times of the Western Dharwar Craton Paleoarchean granitoids is suggestive of a tectonic setting with rapid recycling of basalts as in subduction zones. In contrast, greater protolith residence times and crust-like signature of granitoids older than 3.5 Ga in the crustal record indicate a tectonic setting where basalts persisted for prolonged periods of times such as in an oceanic plateau.



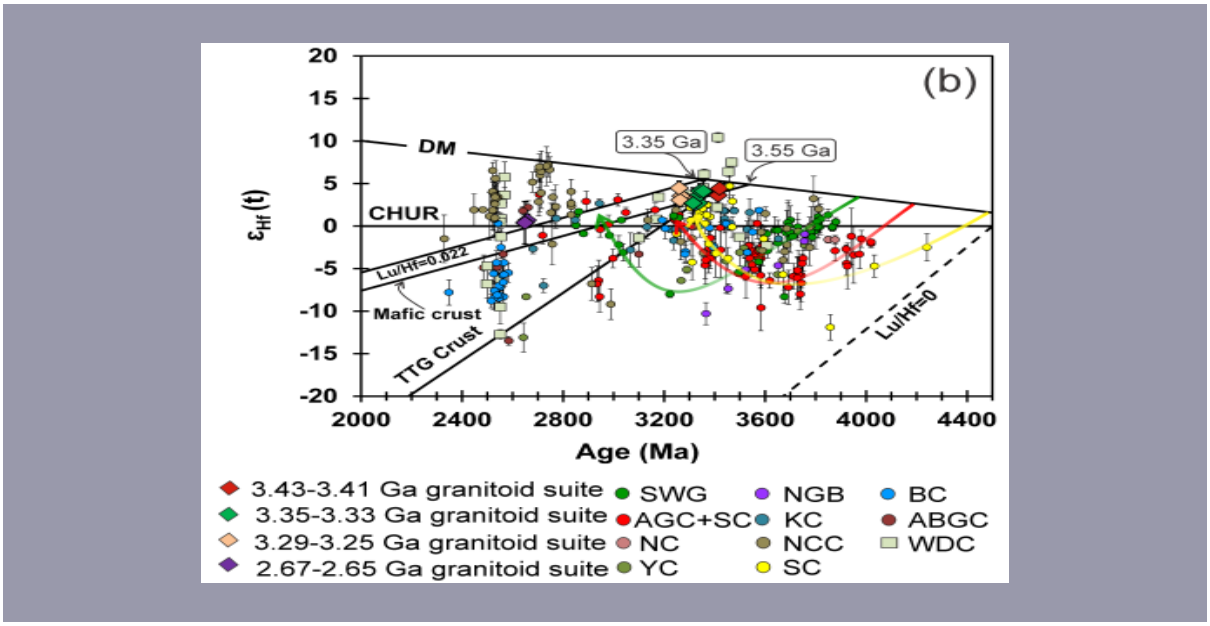


Figure 3.8: The initial 176Hf/177Hf (a) and εHfi (b) vs. age for the Western Dharwar Craton TTGs and granites. The evolution curve for model depleted mantle (DM), mafic crust and TTG crust, and εHfi values from zircons in TTGs/granites from several Archean cratons worldwide are also plotted for comparison. The yellow, red and green curves roughly mark the temporal trends in the εHfi of zircons from TTGs of the Singhbhum Craton, Acasta Gneiss Complex/Slave Craton, and the Isua region of southwest Greenland respectively. These reflect transition from crust-like to more mantle-like values in the time period between 3.7 G and 3.5 Ga.

3.1.3 Engineering Sciences

3.1.3.1 Civil and Mechanical Engineering

A total of 1398 proposals were received out of which 76 were sanctioned during the year. Projects supported in different Sub-discipline wise distribution of the project is given below (Figure 3.9) :

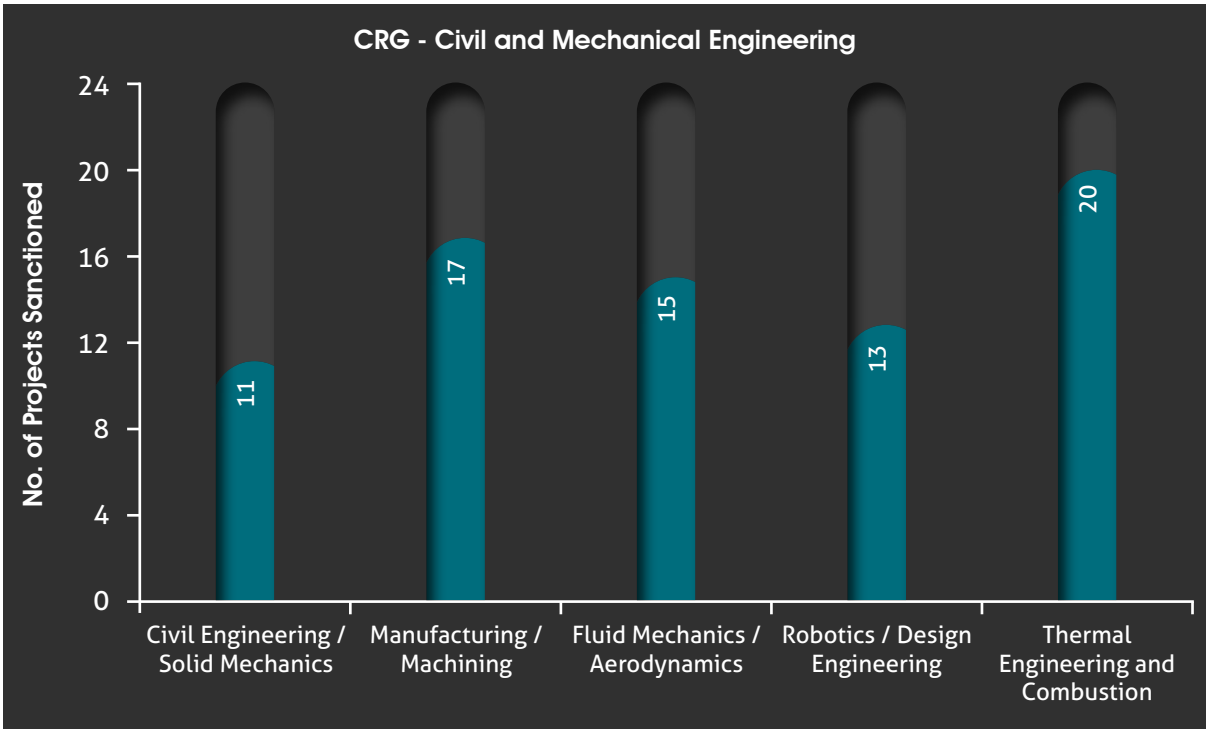


Figure 3.9 : Projects sanctioned in different Sub-discipline of Civil & Mechanical Engineering

Research Highlights

i. Microfluidic platform for identification and isolation of target cells

Single-cell analysis has emerged as a powerful technique for characterization of genomics, transcriptomics, proteomics and metabolomics at the individual cell level. The investigators developed a novel microfluidic platform for the detection and selective isolation of target cells encapsulated in microdroplets in single-cell format for downstream analysis (Figure 3.10). Sample containing a mixed population of cells with target cells fluorescently labelled, is focused using a sheath fluid to direct cells in single-file toward a droplet junction wherein the cells are encapsulated inside droplets. Encapsulation of particles/cells inside aqueous droplets was studied while operating in the different regimes, namely squeezing, dripping and jetting regimes. The study revealed that the cell encapsulating droplets can be of larger, smaller or equal size than the empty droplets depending on the operating regime, capillary number and jet width at the droplet junction.

The droplets containing the cells migrate toward the centre of the channel owing to the non-inertial lift force thus eliminating the need of two-dimensional focusing. The cells present in the droplets are interrogated and characterized based on forward scatter (FSC), side scatter (SSC) and fluorescence (FL) signals. An optofluidic detection system was developed and validated for enumeration and detection of droplets. The research group explored the use of magnetic field and electric field for selective sorting of target cells from the background cells. It is found that size based sorting of ferrofluid droplets at oil-oil interface based on magnetic fields depend on magnetic, non-inertial lift and interfacial tension forces. While sorting of cells encapsulated ferrofluid droplets was possible, the cells do not remain viable in ferrofluid beyond a few minutes and therefore this technique was not suitable for our application. Further, it was explored use of electro-coalescence technique to remove the droplets containing background cells form the oil stream into ancoflowing aqueous stream thus isolating the droplets containing the target cells. It was found that the electro-coalescence of aqueous droplets with an aqueous stream depend on the electric field, droplet diameter and velocity (i.e. the role of electrocapillary number). Moreover, the electro-coalescence technique was found to preserve cell viability. FL signals from the target cells activate the electro-coalescence module, using a suitable electronics and program to sort droplets containing the target cells in single-cell format from the droplets containing the background cells.

It was demonstrated that the detection and isolation of target cells (cancer cells – HeLa and DU145) from a mixed population of cells, peripheral blood mononuclear cells (PBMC) + cervical cancer cell (HeLa) and PBMC + human prostate cancer cell (DU145) at a concentration range - at 300 cells per second. The performance of the device is characterized in terms of sorting efficiency, enrichment, purity and recovery. The viability of the target cells was tested using trypan blue assay, which showed that the cells remain viable during the sorting process and thus the isolated target cells can be used for downstream analysis.

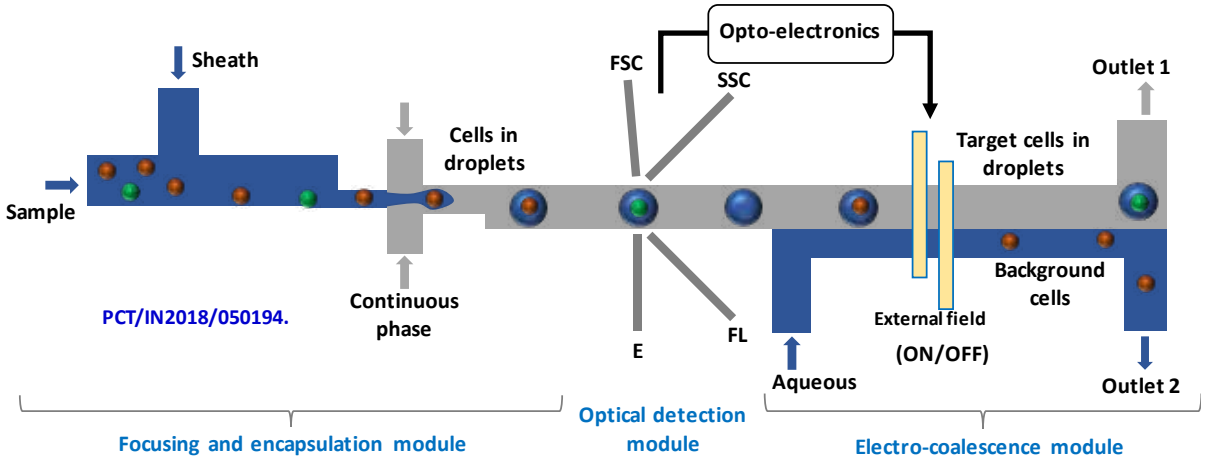


Figure 3.10. Schematic of the microfluidic platform for the detection and selective isolation of target cells encapsulated in microdroplets in single-cell format for downstream analysis

3.1.3.2 Chemical & Environmental Engineering

A total 289 number of new research proposals were considered, out of which 28 were sanctioned. Sub-discipline wise distribution of projects is given below (Figure 3.11):

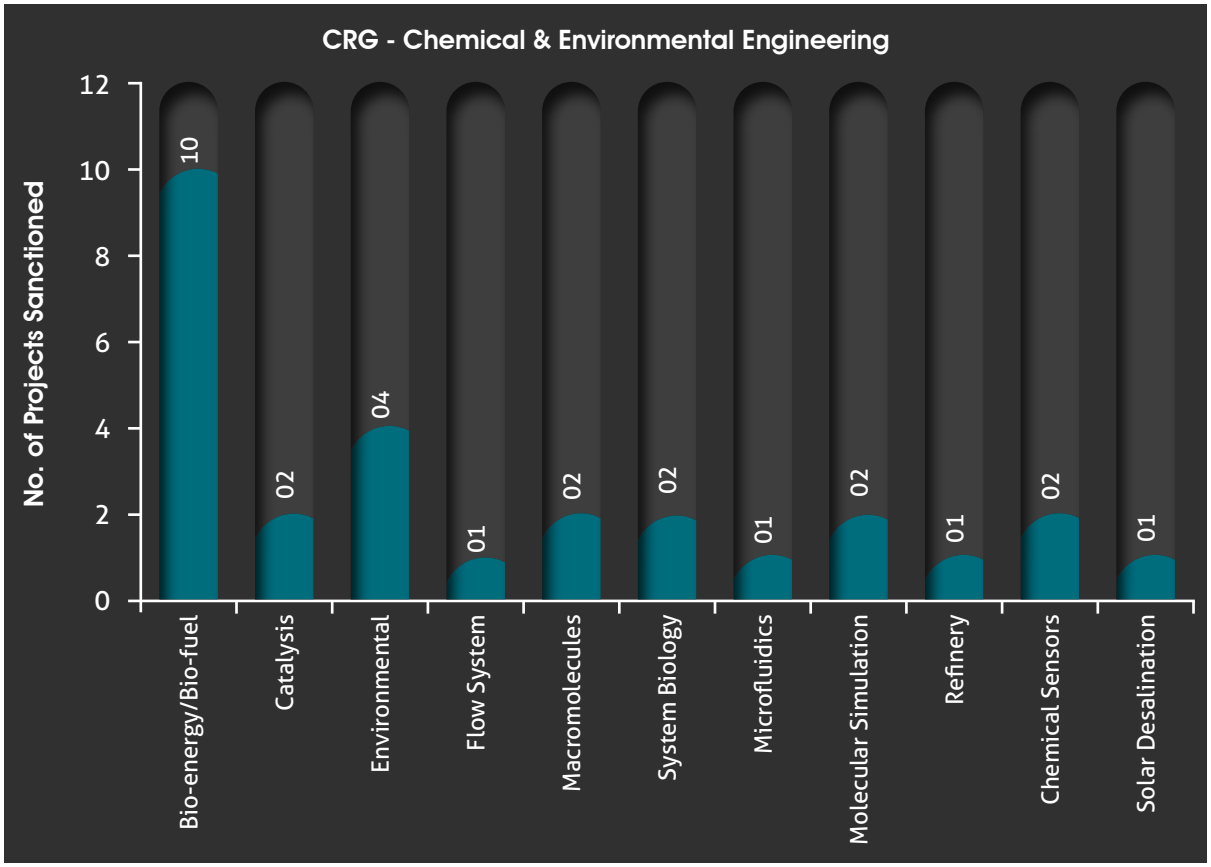


Figure 3.11 : Projects sanctioned in different sub-disciplines of Chemical & Environmental Engineering

Research Highlights

Development of Novel, Single-Step Production of Metal Oxide Based Aligned, Electrospun Core-Shell Nanofibers and Quantitative Assessment of their Gas Sensor Performance

NO_2 based Sensors have been developed

A design based on coaxial electrospinning coupled with *in-situ* UV photo-reduction facility has been successfully completed and fabricated for the development of aligned 1D core-shell heterojunction nanofibers.

Further, to Study the Structure - Property relationship of gas sensing performance, different ZnO based nanostructures were synthesized and crystallographic analysis was carried out to correlate their NO_2 sensing properties.

To understand the exact fundamental processes affecting sensor performance, metal oxide based core-shell nanofibers have been chosen as a model system, where the effect of catalytic sensitization and orientation effects can be easily achieved. Aligned metal oxide based core-shell nanofibers (ZnO@Au and SnO_2@Au) were prepared using the coaxial electrospinning with *in-situ* photoreduction method and investigation on the surface catalysis associated with the noble metal cluster shell layers was analyzed (Figure 3.12 a-f)) to study the gas/material interactions at the heterojunction interfaces to elucidate their complex gas sensing mechanism by quantitative estimation of their NO_2 gas sensing properties. The research was more focused towards the crystallographic explorations of complex gas sensing mechanism of the fabricated ZnO@Au and SnO_2@Au core-shell heterojunction nanofibers. The operating temperatures of the aligned coaxial nanofibers sensors were reduced to 100°C with enhanced sensitivity upto 198% for trace level concentration of NO_2 (500 ppb) with good selectivity as depicted in Figure 3.12(g-i).

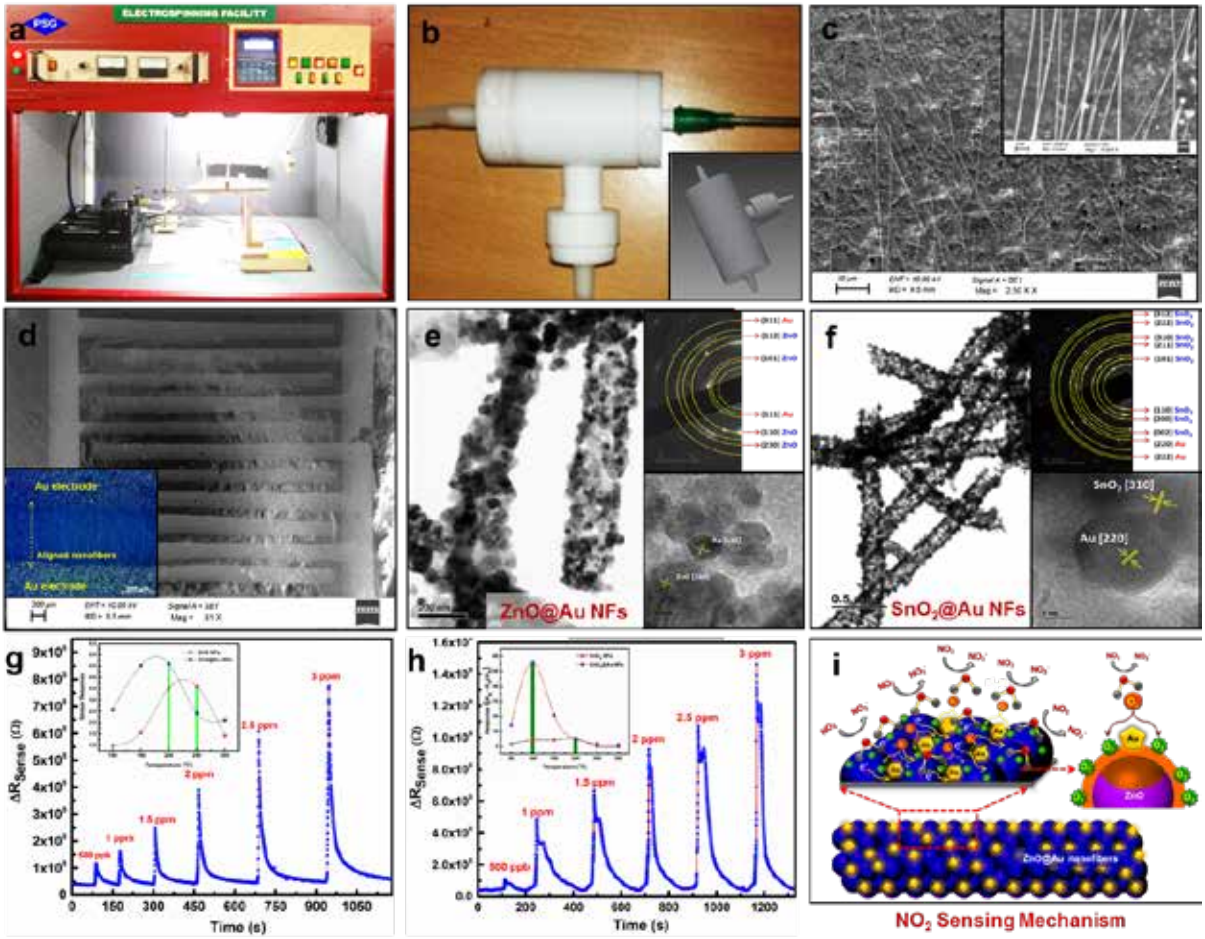


Figure 3.12(a) : Photograph of home built Electrospinning unit with independently controlled dual syringe pump also with UV irradiation facility, (b) Photographs of the fabricated co-axial spinneret components (Inset show AutoCAD images of spinneret), (c-d) SEM images of aligned of ZnO@Au/PVA nanofibers onto IDA electrode before and after heat treatment, (e-f) TEM analysis of core-shell ZnO@Au and SnO_2@Au heterojunction nanofibers, (g-h) NO_2 sensing characteristics (*inset* show determining the operating temperature of sensors) and (i) NO_2 sensing mechanism on core-shell heterojunction nanofibers.

H_2 based Sensors

Developed hybrid CNF@Pt NIs for the successful development of highly flexible and conducting carbon nanofibers with surface anchored bimetallic platinum based nanoislands (CNF@ Pt NIs, CNF@Au-Pt NIs AND CNF@Ni-Pt NIs) using a simple combination of electrospinning and chemical reduction method. The gas sensing performance of the bimetallic Ni-Pt nanoparticles onto CNF (CNF@Ni-Pt NIs) revealed higher sensing response towards H_2 than the monometallic CNF at room temperature.

Fabricated single-step production of Core shell CNF@Pt based NIs heterojunctions by incorporating polyacrylonitrile (PAN) solution as core material and metals and bimetals (Pt, Au-Pt and Ni-Pt) with polyvinyl pyrrolidone (PVP) solution as shell material. In this phase of the project, *in-situ* photo reduction method of monometallic and bimetallic in a single step approach were employed as shown in Figure 3.12(a). Morphological analysis of the core-shell nanofibers was investigated using transmission electron microscopy (TEM) shown in Figure 3.13(a-c). The gas sensing performance of the less-Pt co-axial bimetallic Ni-Pt nanoparticles onto CNF (CNF@Ni-Pt NIs) exhibited higher sensing response towards H_2 than the monometallic CNF at room temperature shown in Figure 3.13(c).

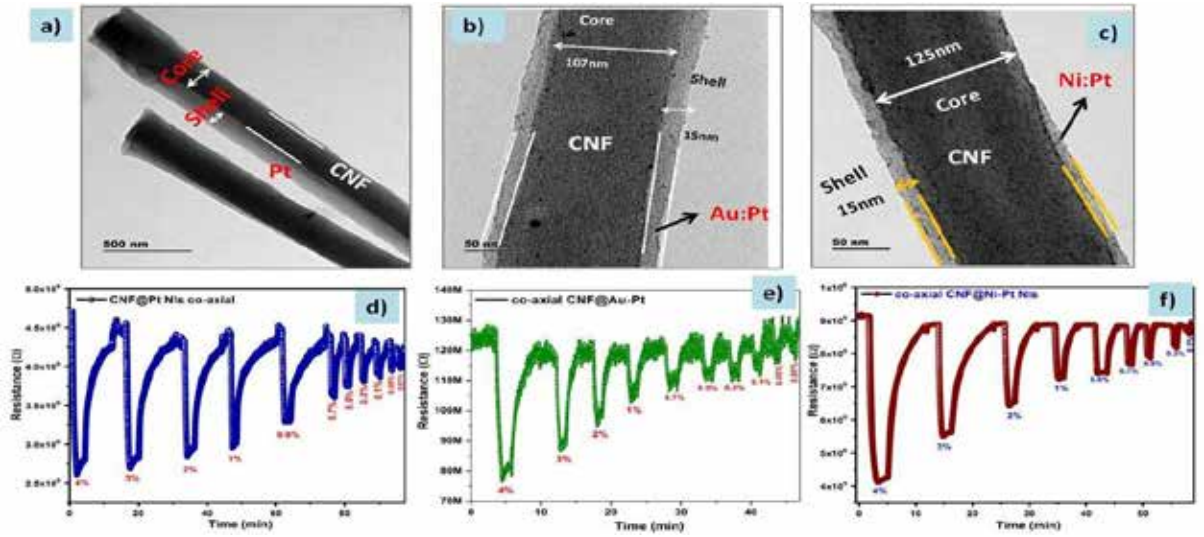


Figure 3.13 : TEM images of Co-axial **a)** CNFs@Pt NIs **b)** CNF@Au-Pt NIs and **c)** CNF@Ni-Pt NIs and Dynamic H_2 gas sensing performance of Co-axial **d)** CNFs@Pt NIs **e)** CNF@Au-Pt NIs and f) CNF@Ni-Pt NIs

In-situ Raman spectroscopy and *in-situ* electron transport studies of carbon nanofibers with surface anchored bimetallic platinum based nanoislands (CNF@ Pt NIs, CNF@Au-Pt NIs and CNF@Ni-Pt NIs) were analyzed for the first time and revealed the gas sensing mechanism of the system.

An extensive kinetic modeling on hydrogen adsorption was performed, which indicated that the adsorbed layer of hydrogen on surface alters the work function of CNFs@Pt based bimetallic systems, which consequently modify the resistance. The theoretical prediction of the model was comparable with the experimental data obtained for CNFs@Pt based systems.

3.1.3.3 Electrical, Electronics and Computer Engineering

A total of 990 proposals were received out of which 92 were sanctioned during the year. Sub discipline wise disribution of the Project is given below (Figure 3.14):

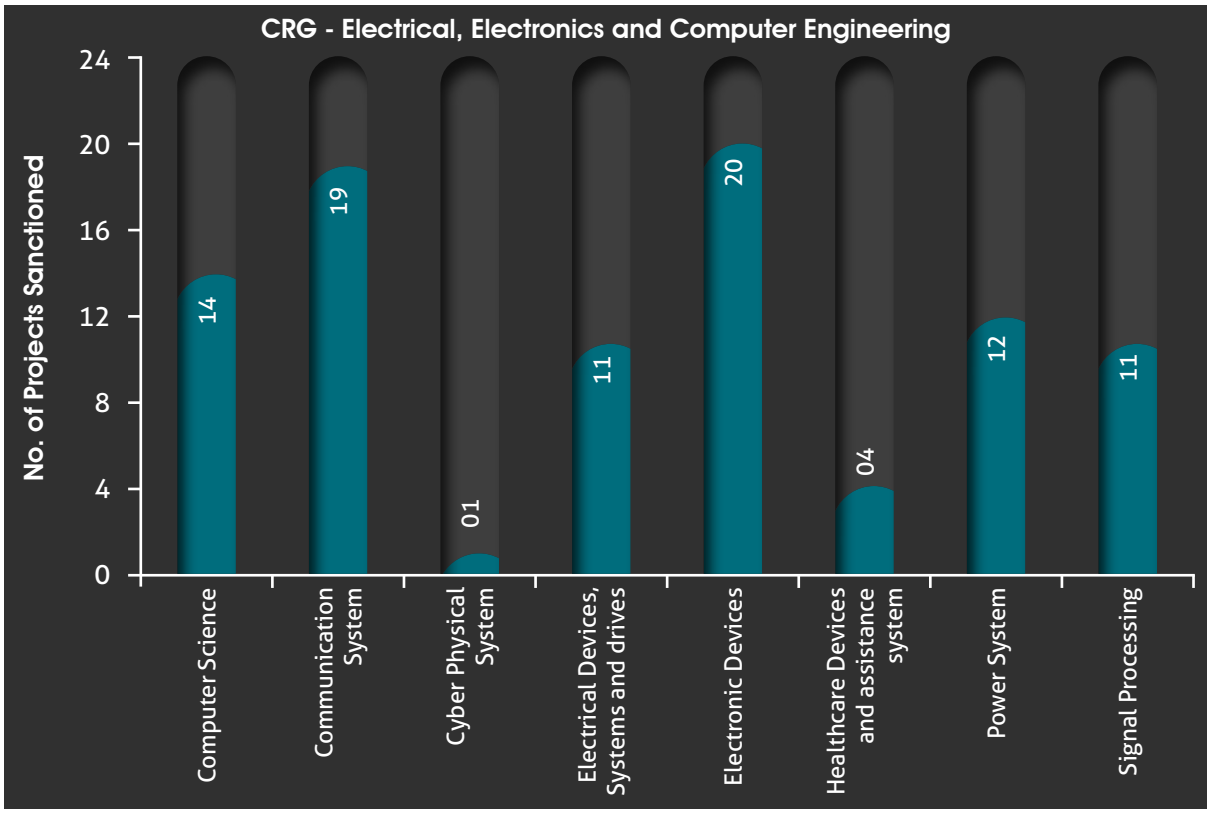


Figure 3.14 : Projects sanctioned in different sub-discipline of Electrical, Electronic & Computer Engineering

Research Highlights

Investigation on Ultra-thin Conformal Metamaterial Absorbers for Multiband Applications

Single-band, dual-band and multiband microwave metamaterial absorbers are designed on the rigid substrate like FR-4 substrate and analysed different properties e.g. absorptivity, polarization and incident angle dependency, permittivity and permeability of the absorber have been developed. After that, different microwave laminates and flexible substrate has been used to make them conformal. In this connection, single-band, dual-band, triple-band, multiband and wideband microwave metamaterial absorbers have been designed for conformal application. Experiment setup is shown in Figure 3.15. It was found that simulated result and measured result have good agreement. The developed conformal microwave absorber has also been tested on the cylindrical and curved surface. It was observed that the performance of the absorber almost similar for flat and curved surface which was the novel contribution the field of the metamaterial absorbers. Additionally wideband tuneable absorbers also designed for curved surface because they are more suitable for practical application. The research outcome of the project are written below.

Designed a flexible single band metamaterial absorber with wide incident angle insensitivity for conformal applications.

Designed a compact ultrathin conformal metamaterial dual band absorber for curved surfaces for C- and X-band application.

Developed a compact dual band ultra-thin conformal absorber for C-band application to wrap the metamaterial absorber on the curved surfaces.

Analysed polarization independent triple band ultrathin conformal metamaterial absorber for C- and X-band applications.

Investigated the quad-band absorber for S-, C- and X-band application.

For getting the wide absorption bandwidth a polarization independent conformal wideband metamaterial absorber using resistor loaded sector shaped resonators has been designed.

Wideband conformal metamaterial absorber has been design on the flexible substrate which provide more than 100% absorption band for C- and X-band application.

Metamaterial absorbers may be a possible replacement of all type of conventional microwave absorber. On the other hand active frequency selective surface (FSS) based absorbers can be used for tuning applications where the absorption bandwidth can be regulated to desired frequency band.

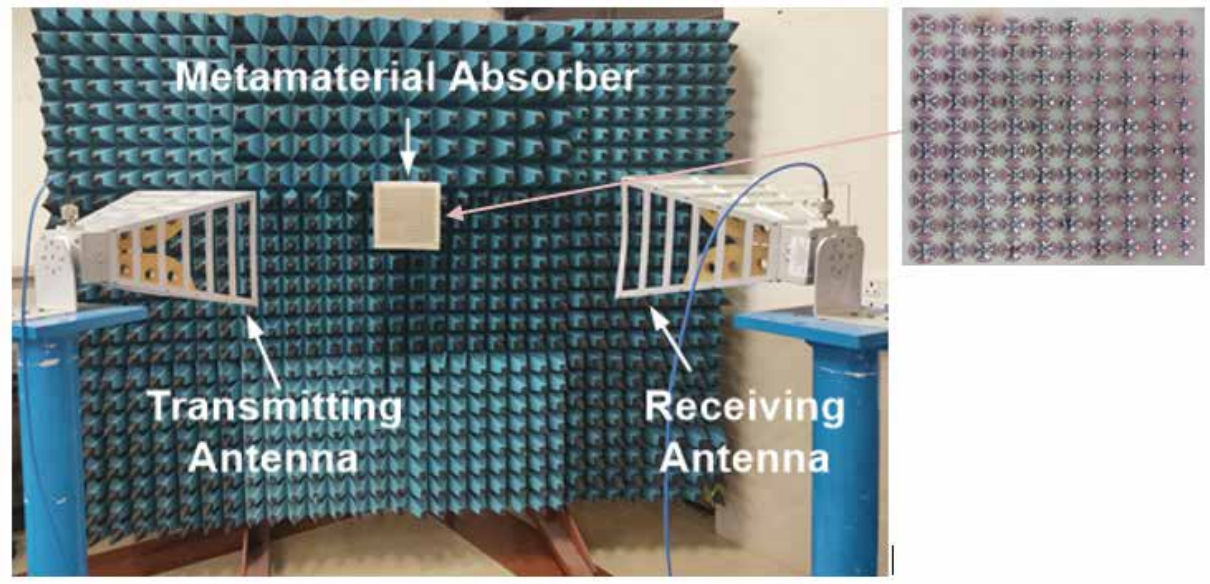
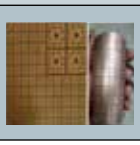
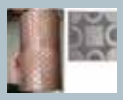
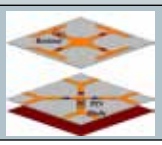


Figure 3.15 : Experiment setup to determine the absorptivity

Table: 1. Results and useful parameters of the different type of developed absorber

Properties	Single Band Absorber	Dual Band Absorber	Triple Band Absorber	Quad Band Absorber	Wideband Absorber-1	Wideband Absorber-2	Switchable Absorber
Size	$0.25\lambda_o \times \mathbf{0.25}\lambda_o$	$0.5\lambda_o \times \mathbf{0.5}\lambda_o$	$0.23\lambda_o \times \mathbf{0.23}\lambda_o$	$0.24\lambda_o \times \mathbf{0.24}\lambda_o$	$0.16\lambda_o \times \mathbf{0.16}\lambda_o$	$0.14\lambda_o \times \mathbf{0.14}\lambda_o$	$0.15\lambda_o \times \mathbf{0.15}\lambda_o$
Thickness	$0.012\lambda_o$	$0.010\lambda_o$	$0.006\lambda_o$	$0.005\lambda_o$	$0.098\lambda_o$	$0.070\lambda_o$	$0.100\lambda_o$
FWHM (MHz)	510	320, 720	160, 240 and 260	110, 230, 230, 240	6.6 GHz (-10dB)	10.23 GHz (-10dB)	6.83 GHz (-10dB)
Band	X-band	X-band	C- and X-band	S, C, and X-band	C- and X-band	C- and X-band	C- and X-band
Conformal	Yes	Yes	Yes	Yes	Yes	Yes	No
Design/ Prototype							

3.1.3.4 Materials, Mining and Minerals Engineering

A total of 381 proposals were received out of which 53 proposals were sanctioned during the year. Sub-discipline wise distribution of the project is given below (Figure 3.16) :

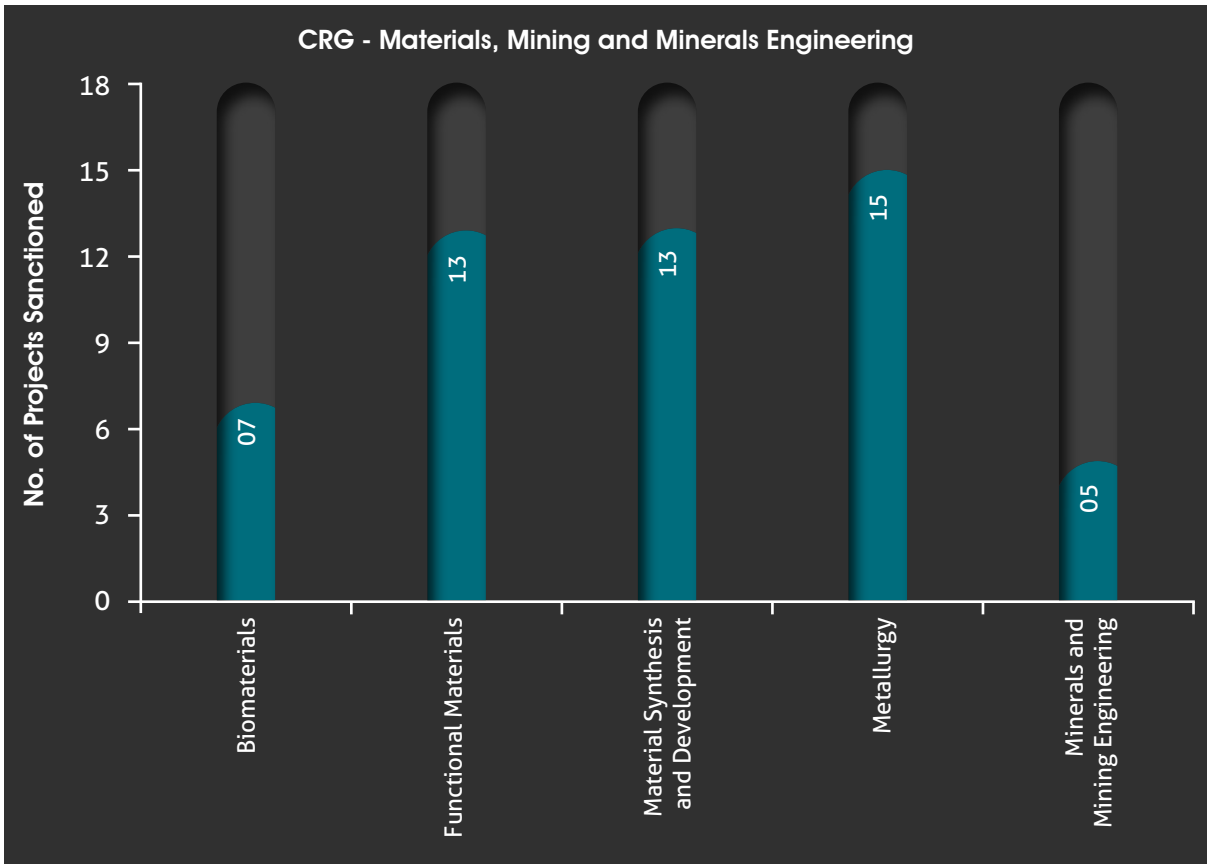


Figure 3.16 : Projects sanctioned in different sub-discipline of Materials, Mining & Minerals Engineering

Research Highlights

Development of Fibrous Filter Media to Inhibit Particle Bounce and Re-entrain in Automotive Engine Intake Air Filtration

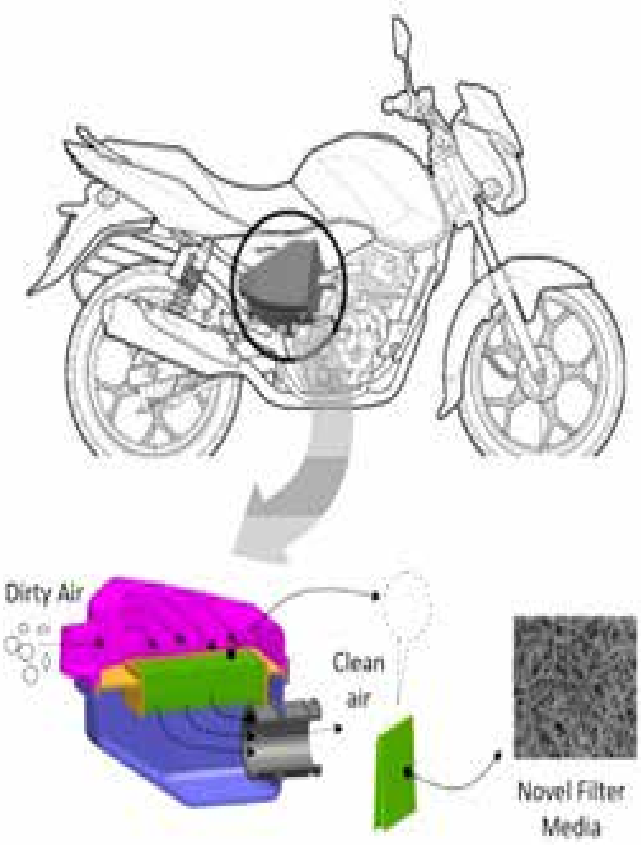


Figure 3.17 : Novel engine intake air filter for motorcycle

The current project offered an innovative and cost-effective solution for development of engine intake air filters (Figure 3.17) to obtain a fuel-efficient vehicle with increased engine life, reduced gas emission, extended filter life, and improved energy efficiency. It accomplished to deliver an indigenous technology that created an optimal impingement of a suitable viscous liquid onto air filters, thereby offering higher filtration efficiency, less air restriction, and extended service interval. The viscous film facilitated the airborne particles to dissipate kinetic energy on contact, thereby reducing particle rebound and re-entrainment into air stream. Consequently, the air filters developed in this research work offered higher filtration efficiency than their untreated counterparts. This, in turn, caused less wear and tear of automotive engines, thereby increasing engine life. Further, because of the presence of the viscous film, a large number of dust particles got accumulated onto the air filters. This resulted in higher dust holding capacity of the air filters as compared to that of the untreated ones. Thus, the air filter developed in this work offered higher service life than their untreated counterparts. Also, because of the presence of the viscous films, the dust particles got deposited quite uniformly onto the surface of chemically-treated air filters. On the contrary, the dust particles formed dendritic structures onto the surface of the untreated air filters. As a result, the pressure drop across the developed air filters was less than that across the untreated ones. Further, the air filter developed in this work offered a gradual increase of pressure drop due to delayed depth loading stage. This was in contrary to the steep rise of pressure drop, as exhibited by the untreated filter. As a consequence of this, the former offered less fuel consumption, hence less greenhouse gas emission, than the latter.

3.1.4. Life Sciences

3.1.4.1. Animal Sciences

Total of 261 proposals was received and 50 sanctioned during the financial year which including 23 projects under erstwhile PAC- Animal Sciences. Sub discipline wise distribution of project is given in Figure 3.18 :

3.1.4.1.1 Organismal and Evolutionary Biology

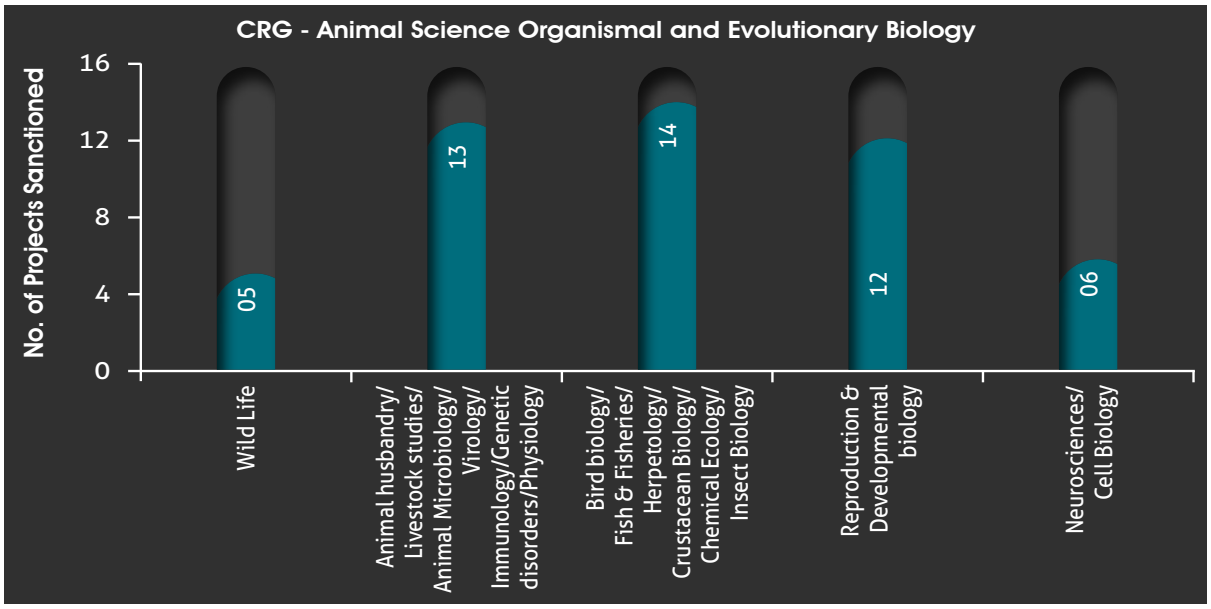


Figure 3.18 : Projects sanctioned in different sub-discipline of Animal Sciences

Research Highlights

Direct Fitness in the Primitively Eusocial Wasp *Ropalidia marginata*

Many species of insects live in colonies consisting of a single fertile queen and, several sterile workers who forgo reproduction and spend their entire lives working for the welfare of their colonies. The evolution by natural selection of such altruistic workers is a paradox.

A widely accepted theory resolves this paradox by arguing that sterile workers obtain indirect fitness by helping their close relatives. But this may be only part of the story because the group showed in this study that workers in the Indian paper wasp *Ropalidia marginata* can also obtain direct fitness by leaving their parental nests and starting their own new nests.

To study this phenomenon, the team transplanted naturally occurring nests into large laboratory cages and observed the process of new nest foundation. The study found that wasps aggregated outside their parental nests, even before founding a new nest, and interacted with each other to decide who will be the queen and who will be the workers in the new nest as per figure 3.20.

In a second study they found that many but not all the wasps in a colony were capable of starting new nests. How much food they had consumed earlier, and their age influenced the probability that they can found new nests. Most surprisingly, working hard on the parent nest did not preclude wasps from starting their own nests in the future. Thus, wasps can combine indirect fitness while first working in their parental nests and direct fitness by later working on their own nests and evolve sociality more easily.

In a third study, the group isolated 1, 2 or 3 wasps in small plastic boxes and studied the development of new colonies. These experiments revealed that just two wasps are sufficient for the emergence of cooperation and reproductive division of labour into queens and workers. Similarly, three wasps are both necessary and sufficient for the additional emergence of the division of labour among the workers such that one works at home and the other works outside. Only nests with 3 wasps harnessed the benefits of sociality by witnessing an increase in colony productivity as per figure 3.21.

The Indian paper wasp has once again yielded new insights into the evolutionary paradox of altruism.

Figure 3.19: A large colony of the Indian paper wasp *Ropalidia marginata* with the wasps, paint-marked for individual identification.

Figure 3.20 : The large laboratory cage used for studying new nest foundations

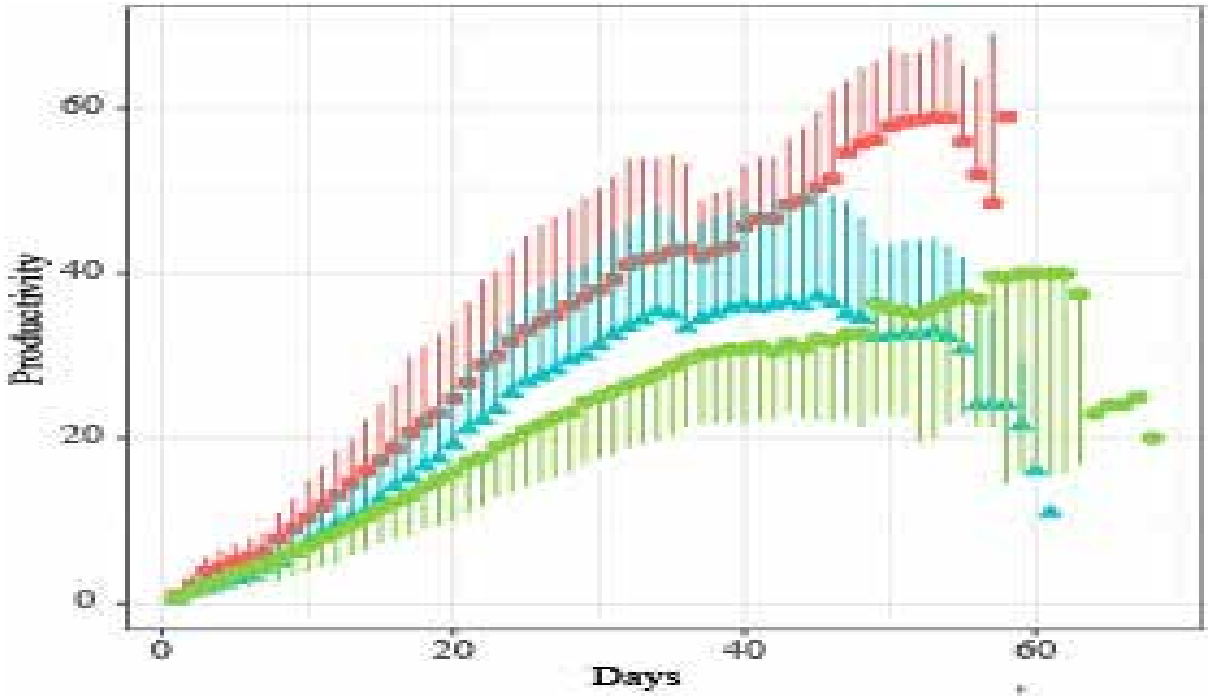


Figure 3.21 : Daily increase in colony productivity (measured as brood production) of nest with 1 (green), 2 (blue) and 3 (red) wasps

3.1.4.2. Plant Sciences

Total of 694 proposals were received and 80 sanctioned, including 33 projects from estwhile Plant Sciences, during the financial year. Sub-discipline wise distribution of project is given below (Figure 3.22) :

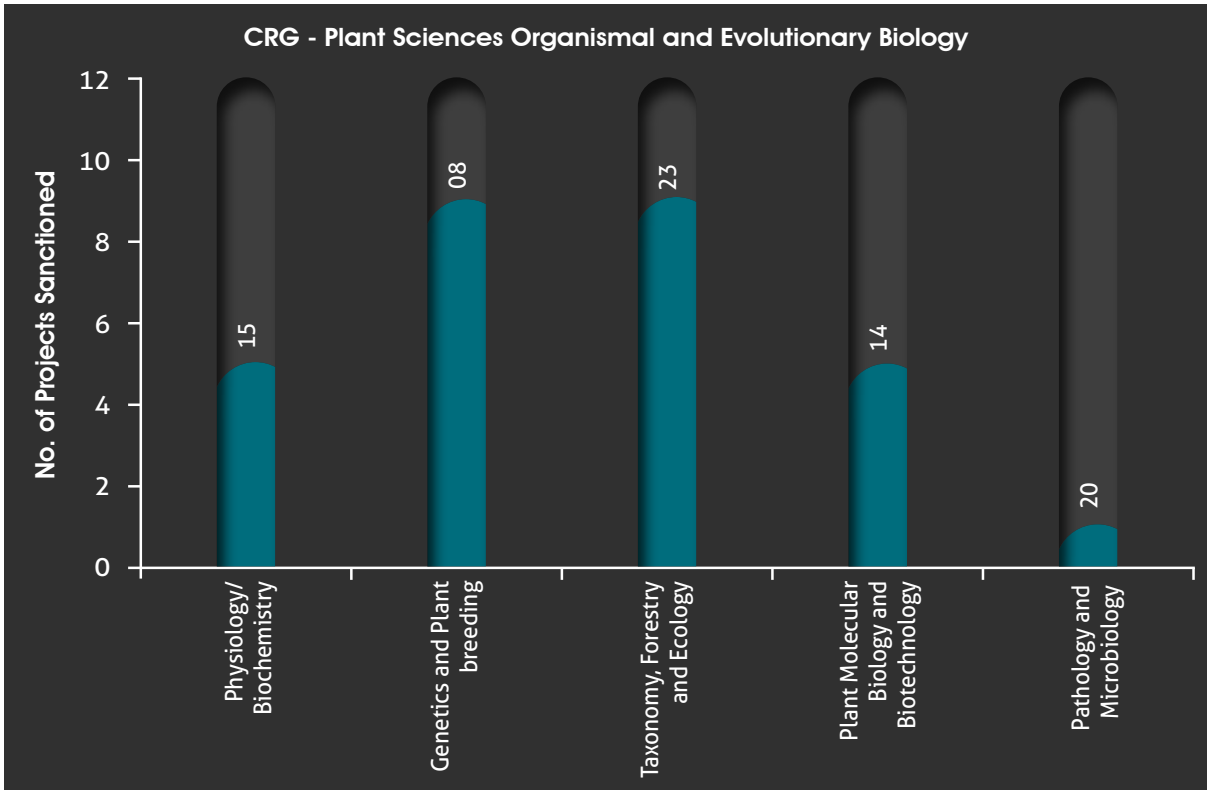


Figure 3.22 : Projects sanctioned in different sub-disciplines of Plant Sciences

Research Highlights

Vindoline enhancing strategies and relevant gene prospecting in important medicinal plant *Catharanthus roseus*

The *Catharanthus roseus* produces over 130 terpenoid indole alkaloids (TIAs) but it is significant due to the potent anticancer activities of its bisindole alkaloids, vinblastine and vincristine that are the costliest and most scarce drugs around. These alkaloids are composed of two monomeric TIA moieties, vindoline and catharanthine. The biosynthetic potential of the plant for the bisindole alkaloids is very low due to their high cytotoxicity. The best possible means to produce the bisindole alkaloids on an industrial scale is their semi-synthesis from their monomeric precursors. For this, catharanthine is sourced relatively easily as it is produced throughout the plant (aerial and underground parts) and also in cell suspension cultures. But, sourcing vindoline is the major bottlenecksince its biosynthesis is restricted to the green leaves and requires high level of differentiation (well-defined thylakoids), which precludes any production through a bioreactor mode. Even though recent attempts have been made to produce vindoline in heterologous systems like yeast, it still requires much optimization and is distant from being economically attractive. Thus, the plant retains its importance due to the localization of vindoline biosynthesis in its leaves.

Since vindoline procurement is the major bottleneck, efforts aimed at making improvement on this front would significantly reduce the exorbitant cost of the bisindoles. Here the target was to have an indigenous Indian *C. roseus* genotype that could meet the global benchmark by accumulating up to 0.2% or more vindoline. This has fructified in the form of CIM-Sushil, a new high vindoline yielding variety developed by CSIR-CIMAP through EMS-induced mutation breeding approach. Initial evaluation trial was conducted at Lucknow during 2017-18 and advanced multilocation evaluation trials were conducted at Lucknow and Bengaluru during 2018-19. CIM-Sushil has a dwarf character, spreading/bushy growth habit, wide canopy and small dark green

leaves. It has ~0.2% vindoline content and ~5% total alkaloid content in its leaves (on % dry weight basis). The estimated dry leaf yield potential is ~2418.3 kg/ha, which is achieved within a short span of ~180 days. It provides an estimated vindoline yield potential of ~4.8 kg/ha and an estimated total alkaloid yield potential of ~120.9 kg/ha. It outperformed the check varieties, Nirmal and Dhawal, in content as well as yield of vindoline and total alkaloid. Its vindoline content is comparable to the global benchmark. The advanced multilocation evaluation trial indicated that CIM-Sushil performed better at Bengaluru as compared to Lucknow, in terms of vindoline and total alkaloid content as well as yield. In future, efforts will be made to disseminate the industrial variety CIM-Sushil for commercial cultivation, mainly in South India. Additionally, CIM-Sushil will be greatly beneficial for research purpose, providing an excellent resource for prospecting genes related to the high vindoline character.

Figure 3.23 : A CIM-Sushil *Catharanthus roseus* plant

3.1.4.3 Health Sciences

A total of 1567 proposals were received out of which 156 were sanctioned during the year. Sub discipline wise distribution of the projects is given in the figure 3.24.

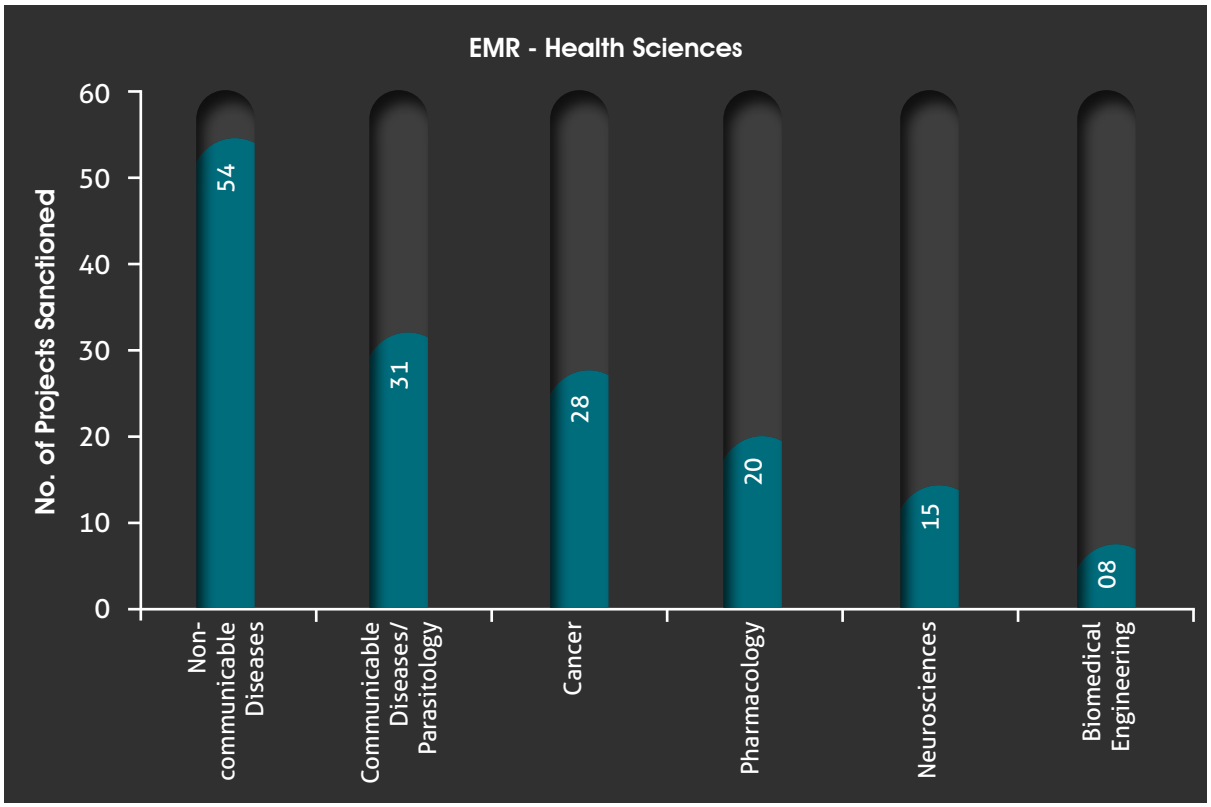


Figure 3.24 : Projects sanctioned in different sub-disciplines of Health Sciences

Research Highlights

Interactions between Japanese Encephalitis Virus and host Autophagy Pathway: Implications for Pathogenesis

Japanese Encephalitis Virus (JEV) is a leading cause of viral encephalitis in Southeast Asia and India. JEV is highly neuroinvasive with symptoms ranging from mild fever to severe encephalitis and death. Investigator attempts to characterize how the host autophagy cellular mechanism responds to infection by JEV and its role in pathogenesis.

Autophagy was functional during early stages of infection however it becomes dysfunctional as infection progressed resulting in accumulation of misfolded proteins. Autophagy deficient cells were highly susceptible to virus-induced cell death. In the present study, investigators characterized the interaction between the cellular autophagy machinery and innate immune response in the context of JEV infection. They used WT and autophagic deficient (atg5-/-) MEFs along with neuronal cells and microglial cells model system to study the mechanism. The investigators inferred that JEV infection lead to activation of innate immune sensors (RLRs and TLRs). How-ever for virus replication autophagy induction through activation of the unfolded protein response (UPR) leading to Endoplasmic Reticulum (ER) and oxidative stress is found to be essential. Using appropriate molecular techniques such as qPCR and western blotting investigator confirmed that transcriptional activation of several innate immune related genes during JEV infection was autophagy-dependent. Further, to study the impact of dysfunctional autophagy on the cellular proteome during JEV infection, they performed TMT based mass spectrometry and compared the level of protein abundance between WT and atg5-/- MEFs, in the context of mock and JEV infection. Pathway enrichment analysis was done to discover the up and down-regulated pathways in context to JEV infection and observed that the level of proteins related to cell adhesion, metabolic processes, transport, cell differentiation and immune pathways were highly affected upon autophagy deficiency.

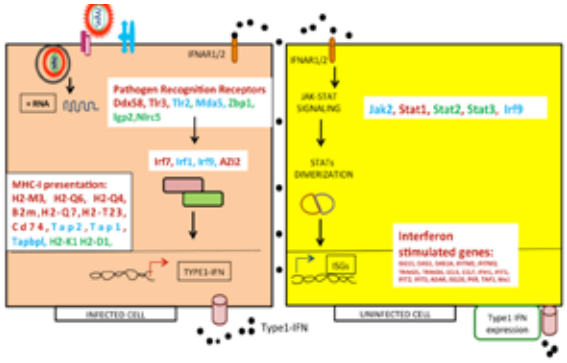


Figure 3.25 : Flow chart

JEV infection lead to the up-regulation of various immune related pathways like cytosolic DNA sensing, TLR, RIG-1, JAK-STAT signaling pathways, etc and also the levels of various Pathogen Recognition Receptors Interferon Regulatory Factors and Interferon Stimulated Genes interferon gamma and various cytokine proteins were also increased upon JEV infection (Figure 3.25).

The observation of the current study might be help to design the drug target to against JEV infection.

3.1.4.4. Biochemistry, Biophysics, Molecular Biology and Microbiology

A total of 9 proposals were sanctioned during the year. Sub-discipline wise distribution of Projects are given below (Figure 3.26) :

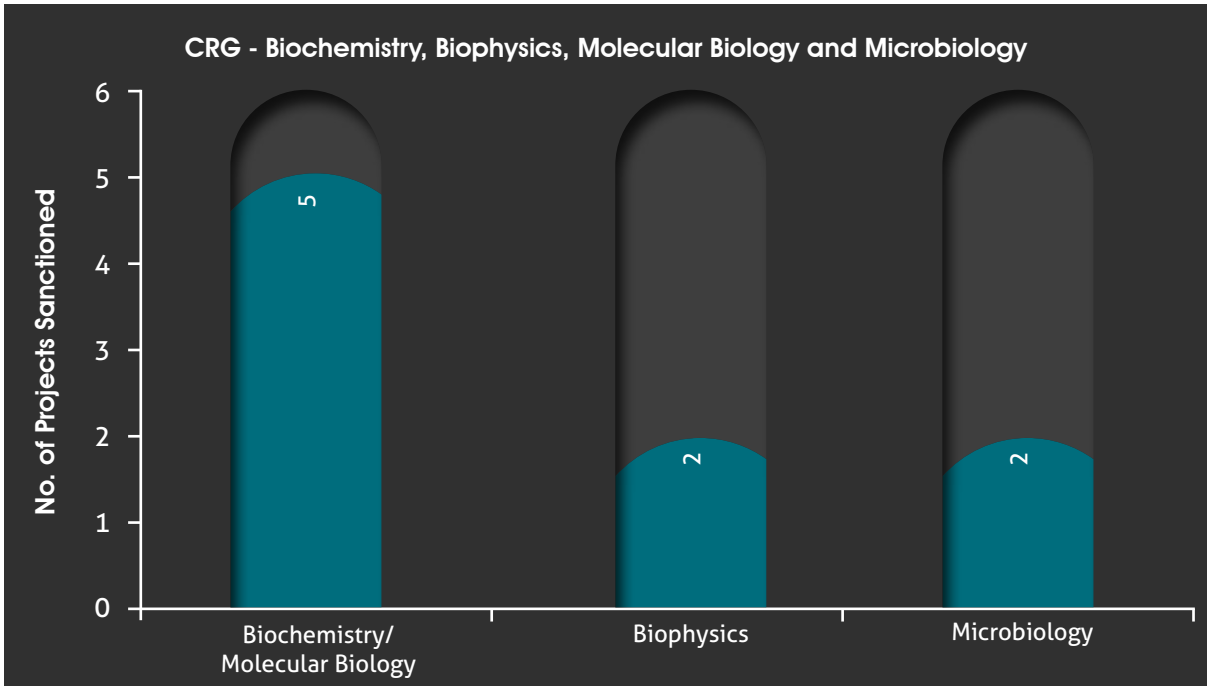


Figure 3.26 : Projects sanctioned in different sub-disciplines of Biochemistry, Biophysics, Molecular Biology and Micro biology

Research Highlights

Understanding the assembly and conformational features of the Staphylococcal degradosome

The bacterial degradosome is a multi-protein RNA complex. Ribonuclease activity catalyzed by enzymes that are components of the degradosome is essential for efficient RNA recycling. The rationale for the assembly of multiple enzymes to form a multi-protein-RNA complex as well as the role of these enzymes in modulating RNA-dependent signal transduction is poorly understood. In this project, the focus was to understand structural and biochemical features of different degradosome components. In particular, the observation that this multi-enzyme RNA recycling machinery influences the phenotype in *Staphylococci* suggested that the biochemical characterization of these enzymes could provide insights into biofilm forming (persistent) as well as virulent phenotypes in *Staphylococci*. One highlight of this study was the observations on two *S. epidermidis* RNase J paralogues- RNase J1 and RNAse J2 (Figure 3.27 a, b& c).

RNase J enzymes are involved in RNA maturation, RNA recycling and govern gene expression. These metallo-hydrolases catalyze both exo-nuclease and endo-nuclease activity. The catalytic activity of RNase J is regulated by multiple mechanisms which include oligomerization, conformational changes to aid recruitment of RNA substrates and the metal cofactor at the active site. Structural and biochemical studies on two *Staphylococcal* RNase J paralogues- RNase J1 and RNase J2- suggested significant differences that were hitherto unanticipated. We note that RNase J1 is a homo-dimer with exo-nuclease activity aided by two metal co-factors at the active site. RNase J2, on the other hand, is an endo-nuclease with one metal ion at the active site and is predominantly a monomer. Furthermore, we found that the expression levels of these enzymes vary across *Staphylococcal* strains. Together, these observations suggest that multiple interacting RNase J paralogues represent an evolutionary strategy for functional improvisation combining features of both- the 5′ base specific and the base-bypass routes adopted by metallo-ribonucleases. These studies provide a basis to understand the role of these enzymes in the degradosome (Figure 3.28).

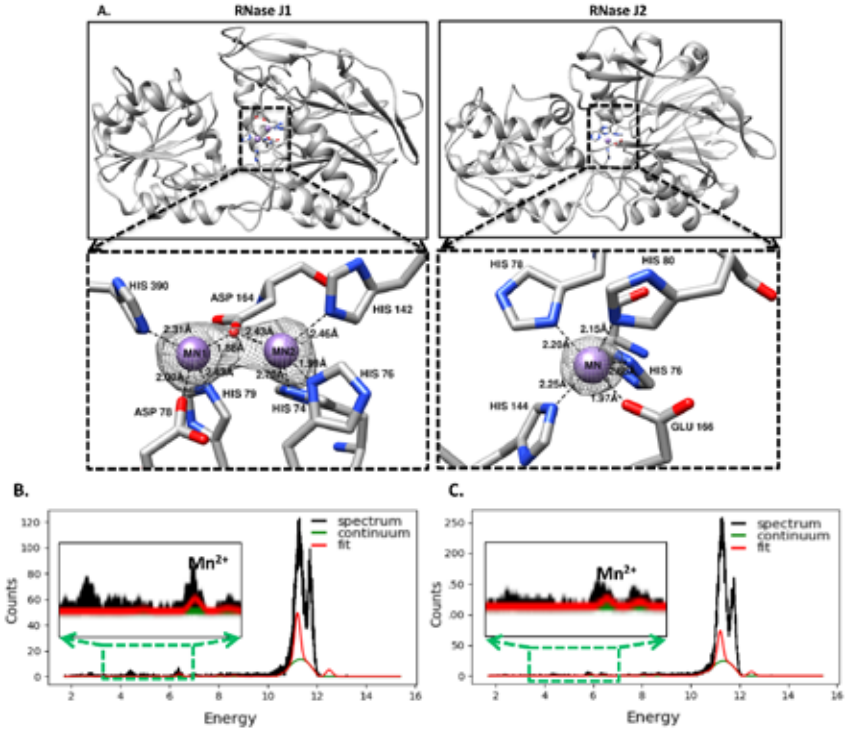


Figure 3.27 : Both *S. epidermidis* **RNase J paralogues require a metal co-factor for catalysis. A.** RNase J1 has two metal ions at the active site. These bound metal ions could be modelled in the (2mFo-DFc) experimental electron density map at 5 σ level. Only one metal ion could be modelled at the active site of RNase J2. Modelling of these metal ions in the experimental electron density maps was guided by anomalous difference density calculations. **B.** The X-ray fluorescence scan of a RNase J1 crystal and **(C)** a RNase J2 crystal confirms the presence of Mn^{2+} as the bound metal cofactor.

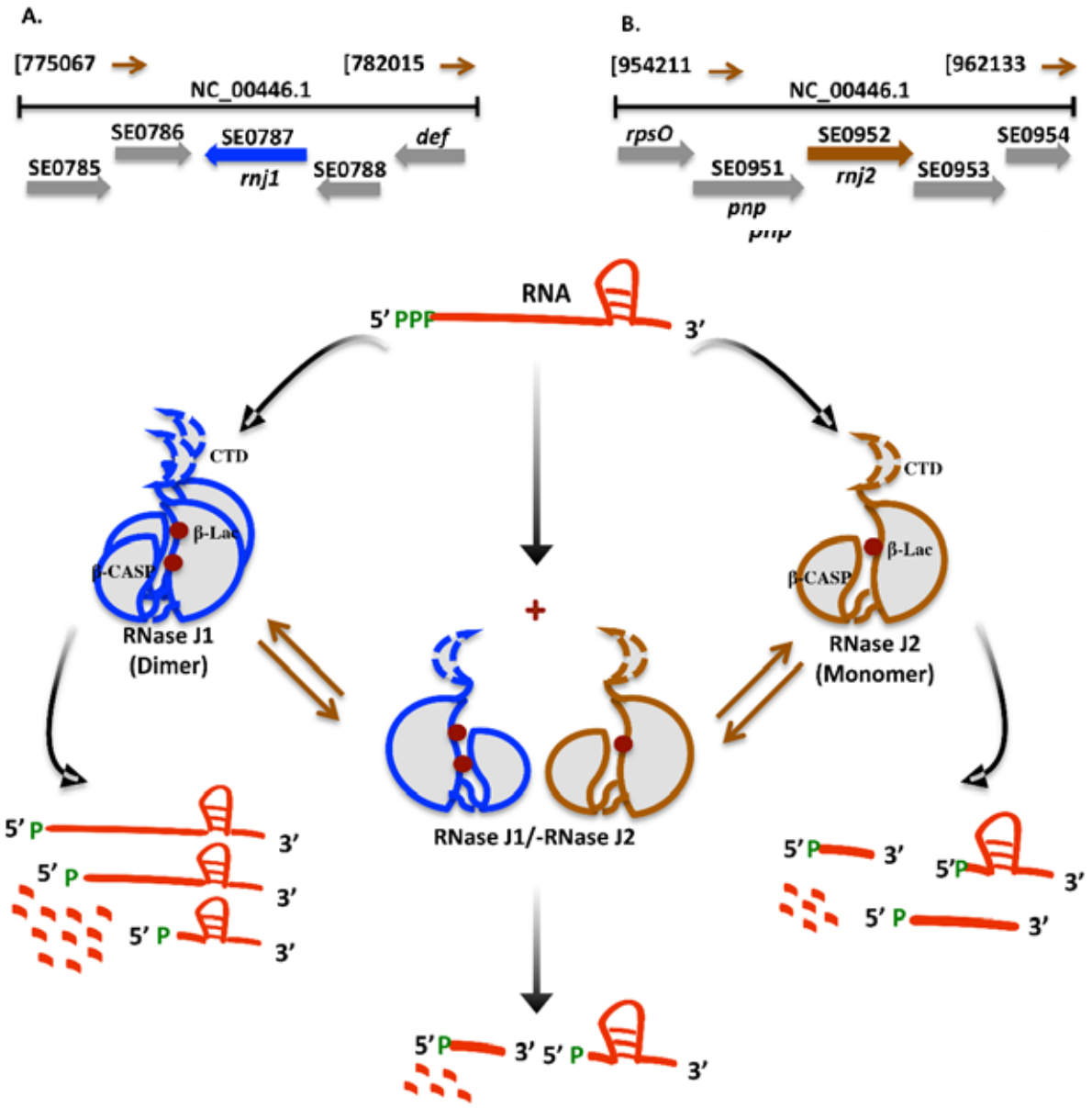


Figure 3.28A : A Mechanistic model for the activity of ***Staphylococcal* RNase J paralogues.** The *rnj1* gene (encoding RNase J1) and *rnj2* (encoding RNase J2) lie in different operons. **A.** A schematic describing the gene ontology of *rnj1* (Gene ID: 1057330, locus tag: SE0787) alongside neighboring genes, locus tag- SE0785 (encodes cytochrome d-ubiquinol oxidase subunit-II-like protein), SE0786 (hypothetical protein), SE0788 (hypothetical protein) and gene *def* (encodes peptide deformylase). **B.** The gene encoding RNase J2 (*rnj2*, Gene ID: 1057661, locus tag: SE0952) alongside neighboring genes - *rpsO* (30S ribosomal protein S15) and *pnp* (Polynucleotide phosphorylase), SE0953 (SpoIIIE- protein) and SE0954 (GntR family transcriptional regulator). **C.** A mechanistic model wherein context dependent oligomerization could modulate the catalytic activity of the RNase J1/RNase J2 complex. The experimental observation supporting this model is that interaction between the paralogues influences both catalytic efficiency and substrate specificity. This, alongside the finding that the expression levels of *rnj*1 and *rnj*2 can vary across *Staphylococcal* strains suggests that interactions between RNase J paralogues is, in effect, a regulatory mechanism to modulate ribonuclease activity.

3.1.5 Physical & Mathematical Sciences

3.1.5.1 Mathematical Sciences

A total of 304 proposals were received out of which 29 were sanctioned during the year. Sub-discipline wise distribution of Project is given below (Figure 3.29) :

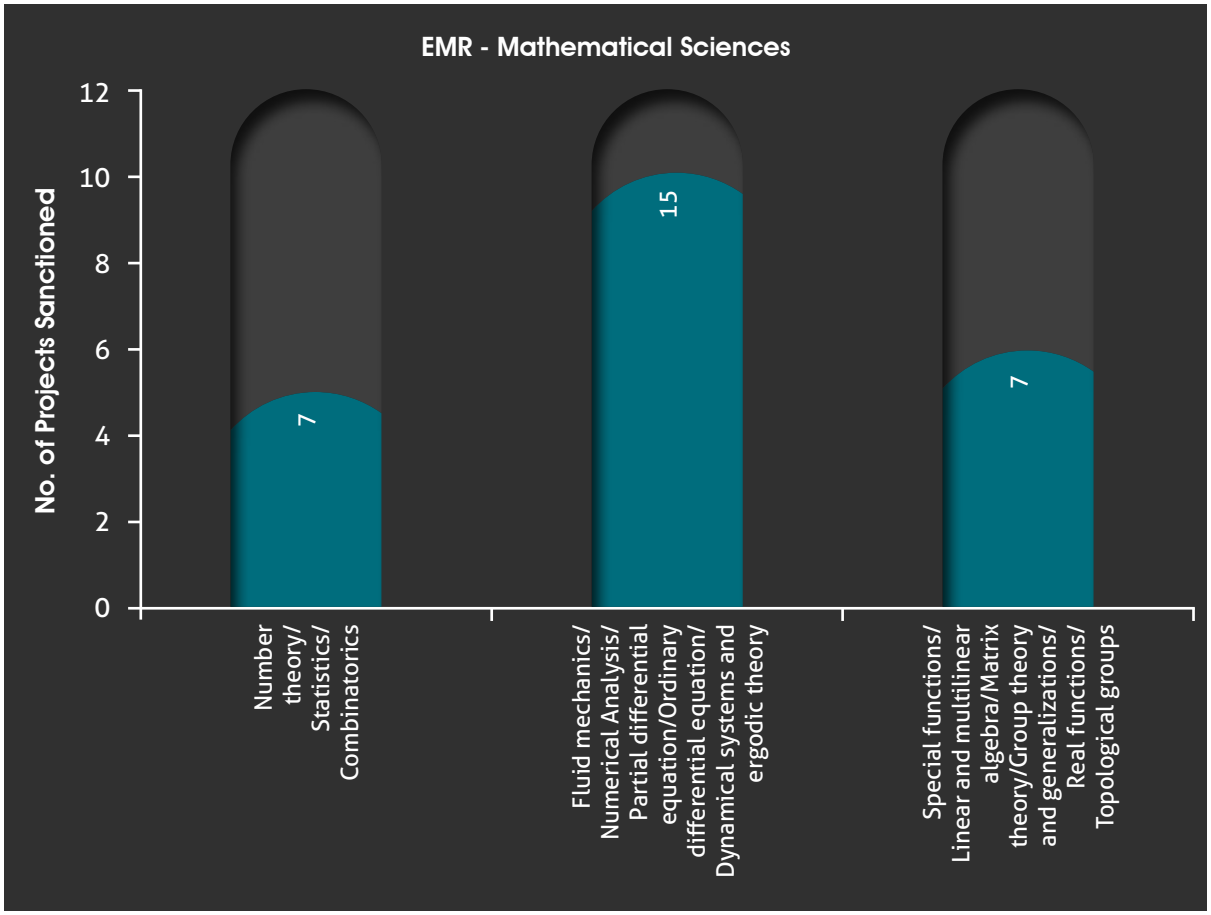


Figure 3.29 : Projects sanctioned in different sub-disciplines of Mathematical Sciences

Research Highlights

Emergent dynamics in ecological networks: Spreading of disease and its control

In ecological landscapes, species tend to migrate between nearby patches in search of a better survivability condition. By this dispersal process, they form connectivity between the patches and thereby may develop various correlated or partially correlated population dynamics among species living in the patches. In this project, various possible emergent collective population patterns have been explored using a simple ecological network model ofall-to-all connected patches where a particular type of dispersal process that is controlled by a weighted mean-field diffusion is used to include the failed migrationbetween the interacting patches.

The population dynamics of both the and prey and predator in every patch is represented modified Rosenzweig-MacArthur (mRM) model that incorporates an additional effect of habitat complexity. The model is extended to N all-to-all connected network of patches, where the local dynamics of each patch is governed by the mRM model. Dispersal of both the prey and predator between the patches is considered to be diffusive type, but the diffusion process is governed by the mean-field density of both the specieswith a weighing factor 'q'. The theoretical investigationson the network dynamics, using numerical and to some extent analytical techniques, show various complex patterns, namely, 2-cluster, 3-cluster and multicluster states, andchimera states (where coherent and incoherent subgroups coexist), besides synchrony (1-cluster) and homogeneous steady states (HSS) in amigrating metapopulation.

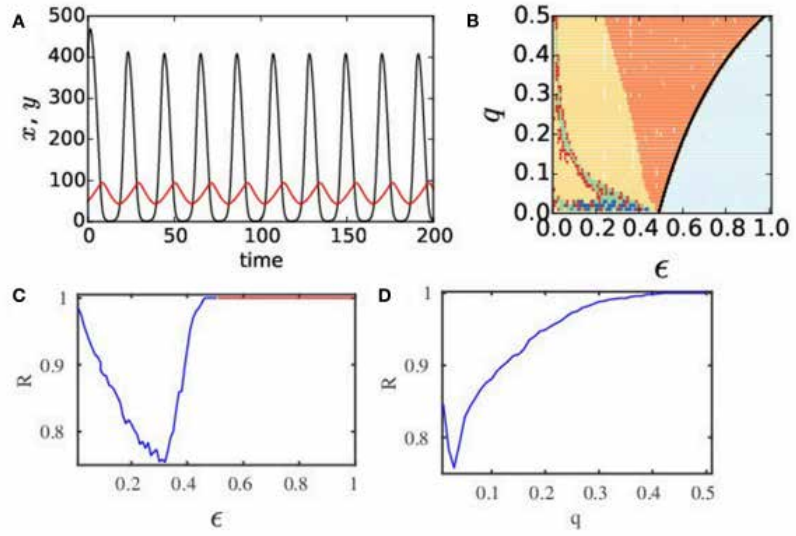


Figure 3.30: (A) Temporal dynamics of an isolated patch. It is governed by the modified RM model where black and red lines denote prey and predator populations, respectively. The intrinsic dynamics of an isolated patch is relaxation type (x > 0 and y > 0) for the choice of parameters: $r = 2.65, K = 898, h = 0.0437, \theta = 0.215, d = 0.12, \alpha = 0.045, c_1 = 0.01, c_2 = 0.1$. (B) Phase diagram in $q - \epsilon$ plane of the ecological network of N = 100 nodes, where $\epsilon_1 = \epsilon_2 = \epsilon$. Different colors depict diverse collective states: light blue for HSS, orange for global synchrony (1-cluster), yellow for 2-cluster states; red indicates 3-cluster; green represents higher cluster states; blue for chimera state. (C) R vs. ϵ plot (q = 0.02) shows global synchrony (R = 1, blue line) for $0.45 < \epsilon \leq 0.5$, HSS for $\epsilon > 0.5$ (R = 1, red line). For $\epsilon < 0.45$ $(R < 1)$, partial synchronization, clustering, or chimera states are observed. (D) R vs. q plot shows effect of q on synchrony ($\epsilon = 0.31$).

An important observation is that addition of habitat complexityin the Rosenzweig-MacArthur (RM) model makes qualitative changes in the collectivebehaviors. Specially to mention that it shrinks the region of synchrony and broadens theregion of HSS in parameter space and thereby leads to better survival probabilities andincreased population persistence in a natural ecosystem. Figure 3.30A shows that the dynamics of an isolated patch exhibits relaxation type oscillation. Figure 3.30B gives an overview of different collective states represented by colors. A unique state of complete coherence (1-cluster) is seen (orange) in a large region of parameter space, where populations of both species in all patches oscillate in a common rhythm and the population densities in all patches are identical in time. The parameter region of complete coherence (orange) is seen to form a typical arnold-toungue-like structure. This coherent state (1-cluster) represents a globally synchronous state.

If population in any one of the patches goes extinct at any arbitrary instant of time then all other patches will follow the same trend, and thus enhances the possibility of a global extinction. We notice complex patterns such as chimera states (blue) for low q and a range of values. The complexity in collective behavior is clearly visible in the lower range of q value.

In the HSS (homogeneous steady states) region, both species reach a constant density in all the patches; they coexist with non-zero identical population density in each patch and they are safe. In dynamical sense, a stable steady state has the ability to return to its original stable state after a transient time under a perturbation and thus HSS signifies robustness of a population to external attacks. Besides these coherent oscillatory states (synchrony) and HSS, the regions of 2-cluster (yellow), 3-cluster (red), and multi-cluster (green) states can be found.

For global coherence (1-cluster), or synchrony measure, the complex Kuramoto order parameter (R) is used. The plot R against (Figure 3.30C) decreases first, indicating a decreasing level of coherence with higher clusters and emergence of chimera states. Then R increases for increasing, indicating a decrease in cluster size, but finally R = 1 when the network transits to synchrony (blue line) at = 0.45 and it continues until = 0.5. Similar study was done with respect to the variation of qfor a fixed dispersal rate = 0.31, as shown in Figure 3.30D. It follows a monotonic increase to R = 1, indicating existence of clustered and chimera states before reaching synchrony.

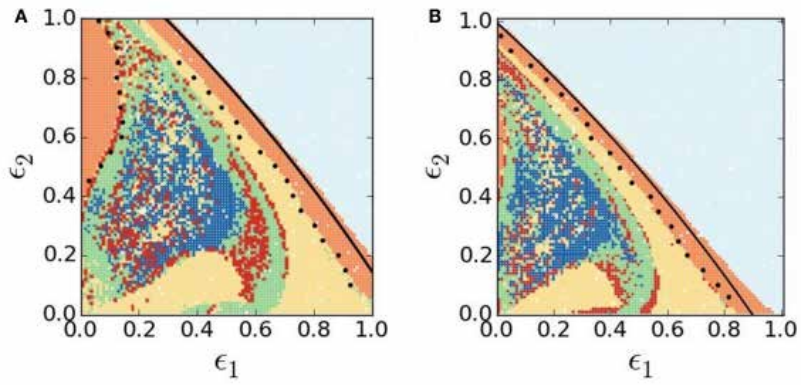


Figure 3.31: Collective dynamical states in $\epsilon_1 - \epsilon_2$ parameter plane. (A) Original RM network model ($c_1 = c_2 = 0$). (B) Modified RM network model ($c_1 = 0.01, c_2 = 0.1$). Different colours depict various collective states. HSS (light blue) global synchrony (orange), 2-cluster (yellow), 3-cluster (red dots), higher cluster (green) and chimera states (blue). Black circles on both phase diagrams denote the symmetry-breaking line from synchrony (1-cluster) to 2-cluster state as obtained from numerical simulations of a reduced 2-patch model. Other system parameters are same for both the models: $r = 2.65, K = 898, h = 0.0437, \theta = 0.215, d = 0.12, q = 0.02$ *and* $N = 100$.

Furthermore, in the absence of habitat complexity, a region of synchrony that existed for lower rates of dispersal of prey and higher dispersal of predator, disseminated into larger varieties of complex patterns in presence of habitat complexity.

Figure 3.31 shows a comparative understanding of the collective dynamics in presence and absence of habitat complexity. The region of HSS had been enlarged significantly, in parameter space, by the addition of habitat complexity in our proposed mRM model, indicating an increased parameter region of dispersal rates that provided an improved condition of persistence.

3.1.5.2. Physical Sciences

A total of 1231 proposals were received out of which 158 were sanctioned during the year. Sub-discipline wise distribution of Project is given below (Figure 3.34) :

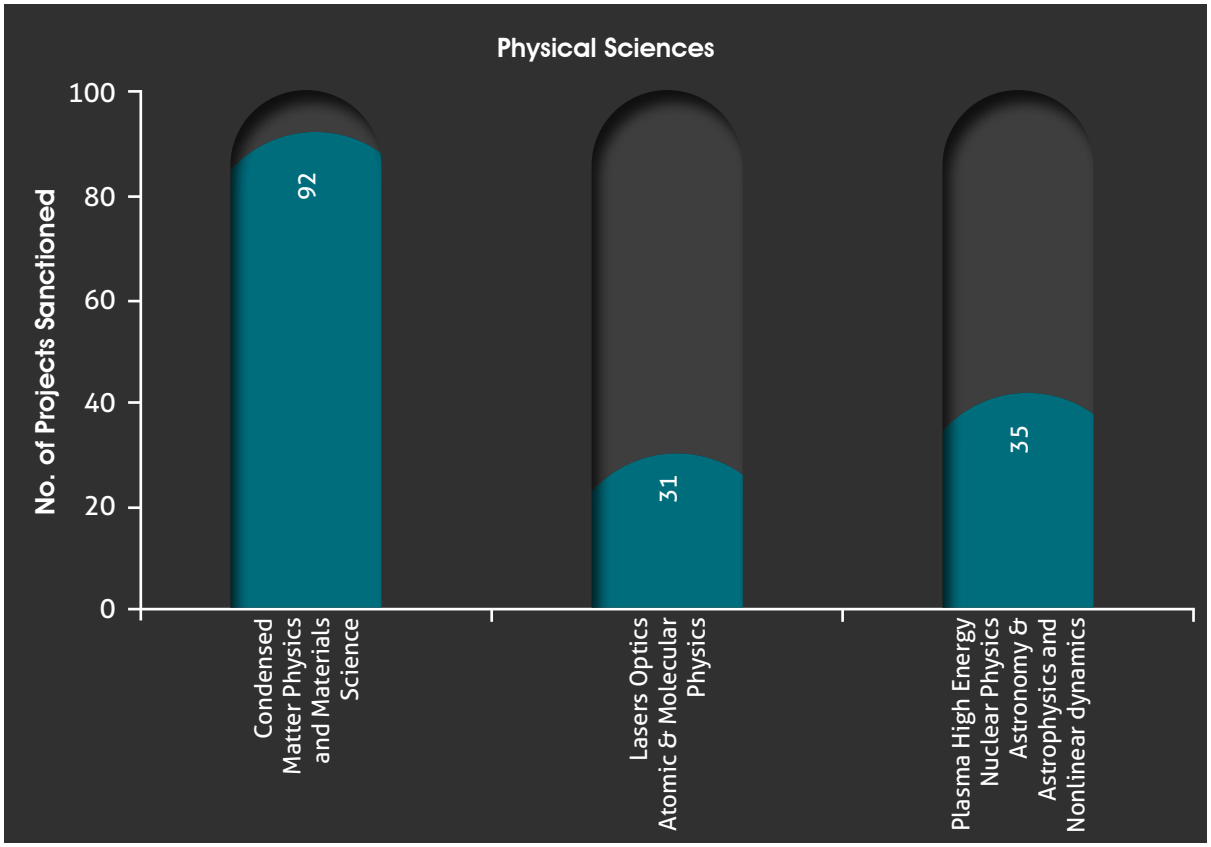


Figure 3.32 : Projects sanctioned in different sub-disciplines of Physical Sciences

Research Highlights

Effect of Crystal Symmetry and d/f –orbitals on the Electronic Properties of Strongly Correlated Oxides and their Interfaces

(I) Band Topology and Topological Phase transition in Halide Perovskites

Model Hamiltonian studies and ab initio electronic structure calculations are carried out on Halide perovskites to examine the symmetry driven band structure and plausible ways to induce topological phase transition in this family of compounds which are promising for optoelectronic applications and have appropriate crystal symmetry to exhibit non-trivial band topology. Though the calculations are primarily done on the prototype compound CsSnI3, the inferences are universal for every member of the halide perovskite family. The significant outcomes of our studies are as follows.

a) **Strain is the appropriate external stimuli to induce a continuous phase transition from normal to topological insulating (TI) state.** While for the cubic phase both compressive and tensile strains can create the phase transition (see Figure 3.33), for the tetragonal phase only tensile strain can do it (see Figure 3.34). The orthorhombic phase cannot establish a topological insulating state in halide perovskites.

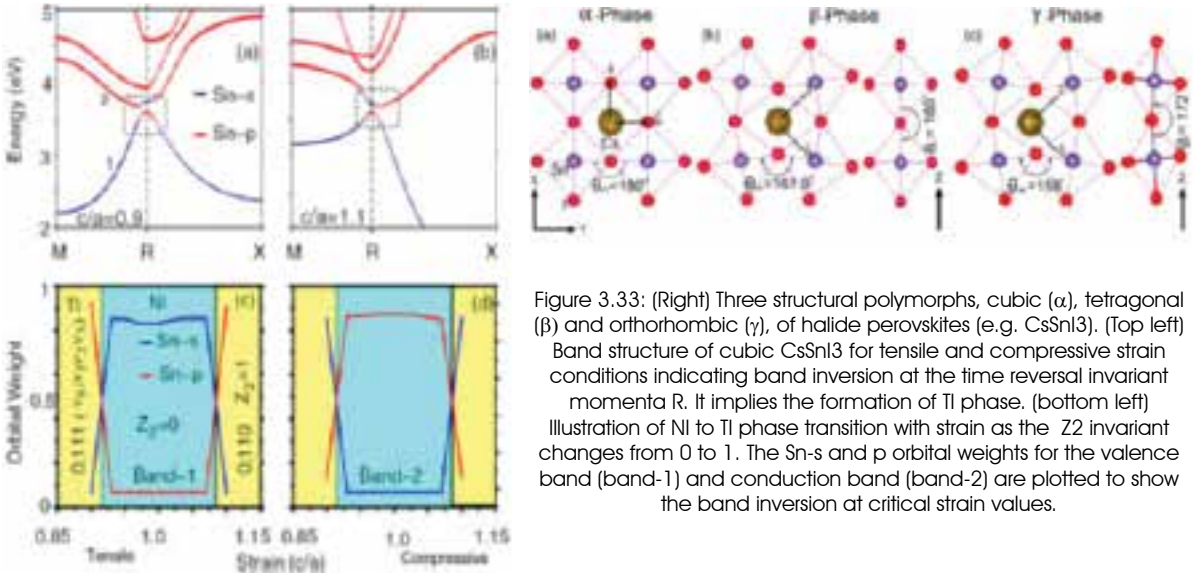


Figure 3.33: (Right) Three structural polymorphs, cubic (α), tetragonal (β) and orthorhombic (γ), of halide perovskites (e.g. CsSnI3). (Top left) Band structure of cubic CsSnI3 for tensile and compressive strain conditions indicating band inversion at the time reversal invariant momenta R. It implies the formation of TI phase. (bottom left) Illustration of NI to TI phase transition with strain as the Z2 invariant changes from 0 to 1. The Sn-s and p orbital weights for the valence band (band-1) and conduction band (band-2) are plotted to show the band inversion at critical strain values.

(b) As shown in Figure 3.34, we explored **a stability plateau** in the tetragonal phase where the total energy of the system varies slowly while the band gap can be tuned in a window of 0.7 eV and hence provides a significant tool to engineer optoelectronic properties.

(c) **A minimal basis set based common tight-binding Model Hamiltonian which can appropriately describe the band topology of all the three phases (cubic, tetragonal and orthorhombic).** This is a significant methodological advancement for analyzing the electronic structure of *sp*-element based halide and oxide perovskites.

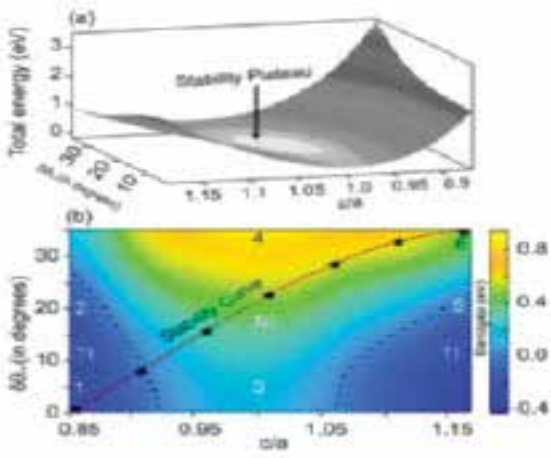


Figure 3.34: (Top) Map of total energy (top) and bandgap (bottom) in the space spanned by strain (c/a) and angle between the neighboring octahedra (δθ). The dotted curve distinguishes the TI phase from the NI phase for the tetragonal CsSnI3. The stability curve (measure of relative energy) shows that compressive strain cannot induce TI phase.

(d) **A new set of parameters, called topological influencers, are designed to examine and predict the band topology of any crystalline solids.** This provides a quantitative measure of the influence of a particular chemical bonding (electron-electron hopping interaction) on the band topology of a given compound.

(e) Our investigations show if Halide perovskite loses its inversion symmetry, the new internal electric field (known as inversion symmetry breaking (ISB field)) is created. **The ISB field introduces a pressure driven unique first order normal to topological phase transition in halide perovskites** (see Figure 3.35). Such type of phase transition was earlier observed only in two compounds, Pb1-xSnxSe and TlBiS1-xSex so far.

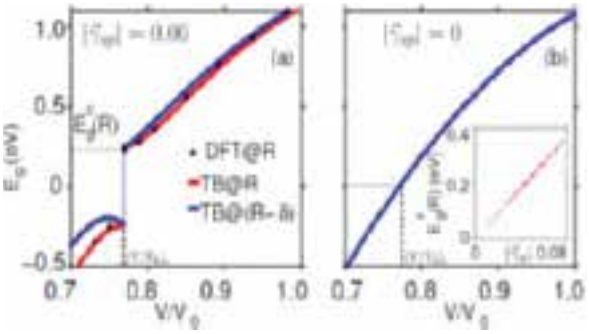


Figure 3.35 : The band gap as a function of volume compression (V/V0) with (left) and without (right) the ISB field (γsp). The discontinuity in the bandgap at a critical compression indicates first-order phase transition. The results are shown for the compound $CH_3NH_3PbI_3$.

(f) With ISB field, the surface band structure produces a time reversal symmetry protected a novel topological quantum state in the form of a Dirac Circle (see Figure 3.36). This is observed for the first time in a 3D topological material.

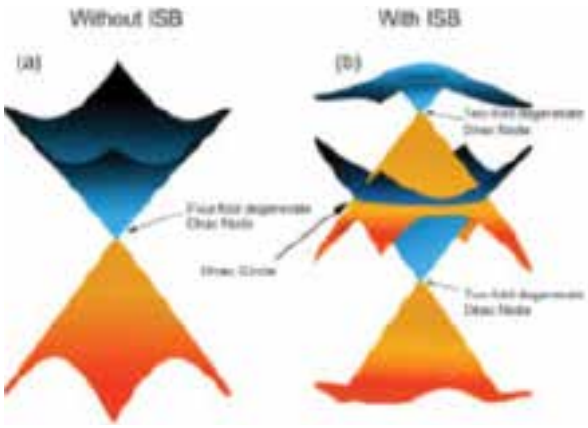


Figure 3.36 : Surface electronic structure (a) in the absence of ISB field and (b) in the presence of ISB field. With ISB field, two Dirac cones interpenetrate to form a Dirac circle. This is very much similar to the electronic structure of hexagonal stacked bilayer graphene. So far it had not been observed in 3D materials.

(II) Photoresponse studies in the doped perovskite $Bi_{1-x}Ca_xFe_{1-y}Ti_yO_{3-\delta}$

In a collaborative experimental and theoretical study, we examined the defect states emerging out of the 3d transition metal based perovskite $Bi_{1-x}Ca_xFe_{1-y}Ti_yO_{3-\delta}$ (BCFTO). The formation of the defect states in the original band gap of BiFeO3 and tuning them is crucial to enhance its photovoltaic efficiencies. The evolution of defect states is schematically shown in Figure 3.37. The mid-bandgap defect states are attributed only to the unsaturated bonds and oxygen vacancies (OV) at the grain boundary in BCFTO. These studies manifest a critical role of OV residing at the grain boundaries in tuning the photoconductivity and, hence, the photoresponse of BCFTO. The defect states arising from Ca and Ti do not contribute to the photoresponse as they are buried inside valence and conduction bands respectively.

In this joint work, we show that there can be a four order increase in the photocurrent due to the oxygen vacancies at the at the GB can increase the photocurrent in BFO.

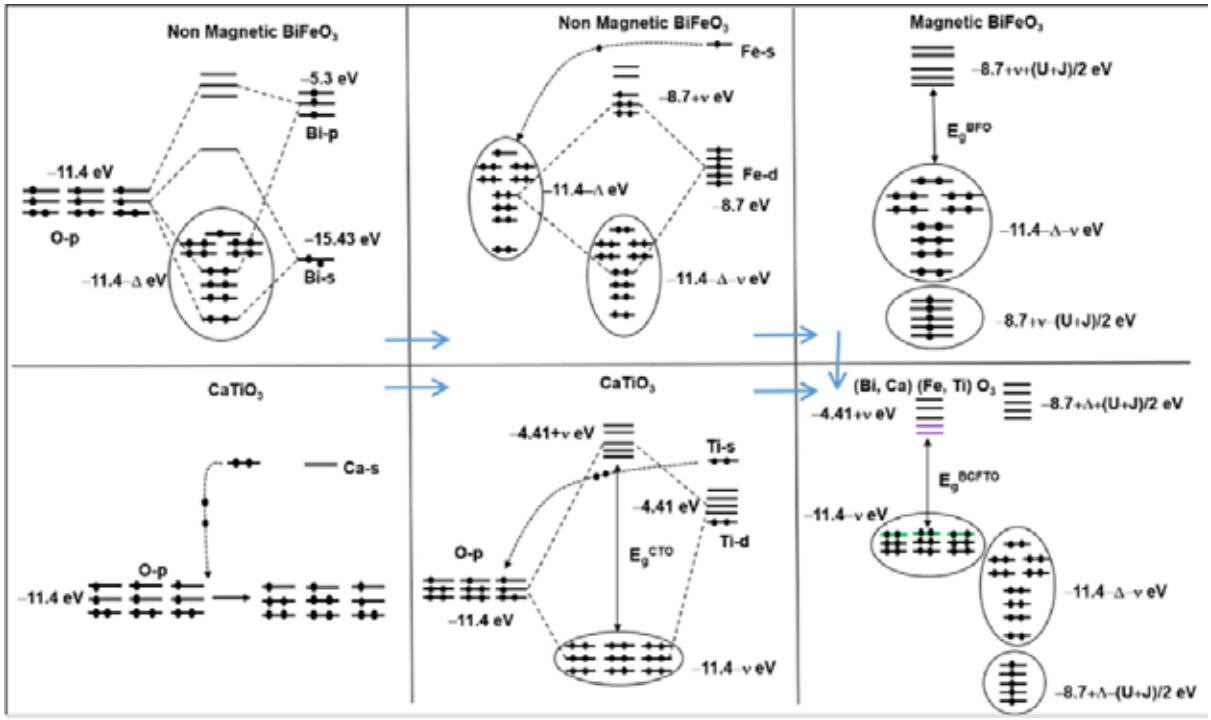


Figure 3.37: Schematic illustration of the mechanism, using the empirical molecular orbital picture that leads to the formation of defect bands in the Ca and Ti co-doped bulk BiFeO3. Follow the arrows to gain an insight into the step-by-step process. The molecular orbital picture is obtained after a thorough analysis of the density of states over the full Brillouin zone and the real space charge distribution as calculated with the aid of density functional theory.

From this study four publications and one patent have been filed.

3.2 EMPOWERMENT AND EQUITY OPPORTUNITIES FOR EXCELLENCE IN SCIENCE (EMEQ)

Objective	Features
To provide research support to scientists belonging to the Scheduled Caste and Scheduled Tribe category in undertaking research in newly emerging and frontier areas of science and engineering and thus to involve them in the National Science and Technology development process.	The applicant(s) who are an active researcher belonging to the Scheduled Caste and Scheduled Tribe category working on regular basis in academic institutions/national labs or any other recognized R&D institutions in the field of Science and Engineering. Tenure of a project is 3 years and ceiling amount is Rs. 50 lakh.

Website links
http://serbonline.in/SERB/Weaker_section
http://www.serb.gov.in/emeq-php

A total of 761 proposals were received against the call for application in the month of April-May, 2019 of which 711 were accepted for evaluation. A total of 158 proposals were recommended for support.

Table 2 : Sanctioned Projects under EMEQ Scheme during 2019-2020

Sl. No.	Broad Area	Sub Area	Number of Projects Sanctioned (Online)
1	Chemical Sciences (28)	Inorganic Chemistry	6
		Organic Chemistry	12
		Physical Chemistry	10
2	Physical Sciences (13)	Condensed Matter Physics & Materials Science	12
		Laser, Optics, Atomic and Molecular Physics	-
		Plasma, High Energy, Nuclear Physics, Astronomy & Astrophysics and Nonlinear Dynamics	1
3	Life Sciences (86)	Animal Sciences	13
		Plant Sciences	27
		Health Sciences	24
		Biophysics, Biochemistry, Molecular Biology and Microbiology	22
4	Engineering Sciences (58)	Chemical Engineering	7
		Electrical, Electronics & Computer	26
		Mining, Mineral & Materials	4
		Mechanical & Manufacturing Engineering and Robotics	16
		Civil & Environmental Engineering	5
5	Earth & Atmospheric Sciences (9)	Earth Sciences	8
		Atmospheric Sciences	1
6	Mathematical Sciences (5)	Mathematical Sciences	5
Total			199

Research Highlights

I. **Investigations on high mobility III-V, Ge and GeSn nano CMOS devices including radiation effects for analog/RF and logic applications**

Investigator developed a 2-D surface-potential-based sub-threshold analytical model for GeSn-on-insulator (GeSnOI) MOSFETs taking into account the interface-trapped and fixed-oxide charge densities, and also quantum effects. Using this model important device parameters such as threshold voltage, sub-threshold swing, DIBL of GeSnOI MOSFETs are calculated for various channel lengths down to 14nm, and Sn concentrations ranging 0-6%. For instance, Figure 3.38 shows that with reducing channel length the threshold voltage rolls-up for all Sn concentrations in the GeSn channel.

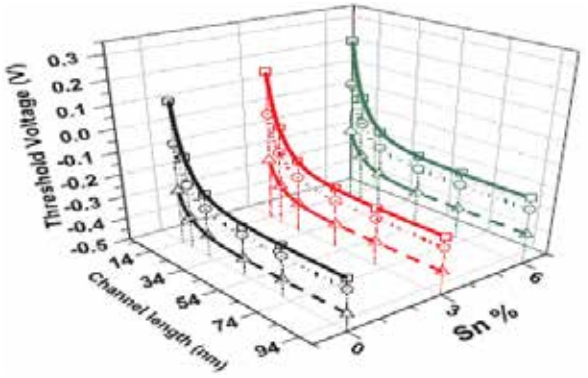


Figure 3.38 : Variation of threshold voltage of GeSnOI MOSFETs with Sn (%) and channel length.

The effects of thickness as well as dielectric constant of buried oxide on the digital performance such as threshold voltage, subthresholdswing,DIBLure, I_{ON}, I_{OFF} and delay of 30-nm Germanium-on-insulator (GeOI) MOSFETs were investigated. For a GeOIpMOSFET having 10-nm thick channel lowest value of subthreshold slope, OFF-current, and the highest value of threshold voltage and ON-to-OFF current ratio using 20-nm thick channel is obtained whereas the lowest intrinsic delay of 5.79 ns is obtained using HfO_2 BOX thickness of 200 nm as shown in Figure 3.39.

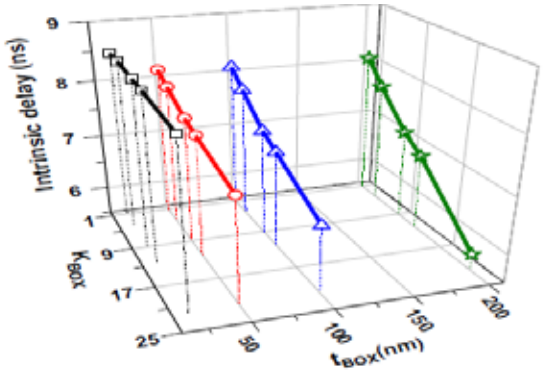


Figure 3.39 : Variation of intrinsic delay of GeOI pMOSFETs with channel thickness and BOX dielectric constant.

Findings revealed that various digital device metrics of nanoscaleGeOI MOSFETs may be improved significantly by adjusting thickness and dielectric constant of BOX insulator, and also channel thickness.

3.3 AYURVEDIC BIOLOGY (AB)

Objective	Features
To promote resource development & collaborative research in Ayurveda Biology and related areas by offering fellowships, training opportunities, providing support to scientific meetings and workshops.	Project proposals should emanate from the concepts, procedures or products of Ayurveda. The project should be a joint effort of scientists and Ayurvedic experts.

Website links
http://www.serb.gov.in/ayurved.php

Ayurveda transcends the practice of medicine and is identified with India's traditional system of medicine in vogue since the Buddhist era. It continues to serve 70% of India's rural population. AB Programme is designed to highlight scientific underpinnings of concepts, procedures and products of Ayurveda in terms of modern sciences such as Molecular biology, Immunology and Chemistry.

Research Highlights

Evaluation of Patterns of Inheritence of Phenotypes in defined Human Dosha Prakriti

Advancement in genetic research established tools to understand the genetic basis, physiological and biochemical mechanisms implicated in diseases and also the classical inheritance patterns. The multifarious modes of control of gene expression and phenotype categories provide a standardized methodology to study different types of human constitutions described in Ayurveda, known as Prakriti. The prakriti-phenotype studies in the context of contemporary knowledge is quintessential. The study seeks the list of phenotypes in individuals of different dosha prakritis and to trace them through generations, to find distribution of patterns of inheritance of phenotypes within a family. The present investigations focus on understanding of inheritance patterns of prakriti and anthropometric parameters from generation to generation. The study also provides a qualitative and quantitative trait distribution and understanding of different human constitutions described in Ayurveda which can be implemented for prakriti-based health profiling and counselling.

In the present investigations, individuals belonging to three or more generations of a family were selected for the assessment. For the study 20 families were identified. A total of 274 individuals belonging to seventeen different families with three or more generations were recruited upon consenting. About 98 individuals belonging to these families are being assessed for various parameters. Among them, 19 (7 males and 12 females) were first-generation individuals, 44 (20 males and 24 females) were second-generation individuals and 32 (10 males and 22 females) were third-generation individuals and 03 (3 males) were fourth-generation individuals. Assessment of anthropometric features, Prakriti by Ayusoft and PTC was carried out for a total of ten families (Fig 3.40A).

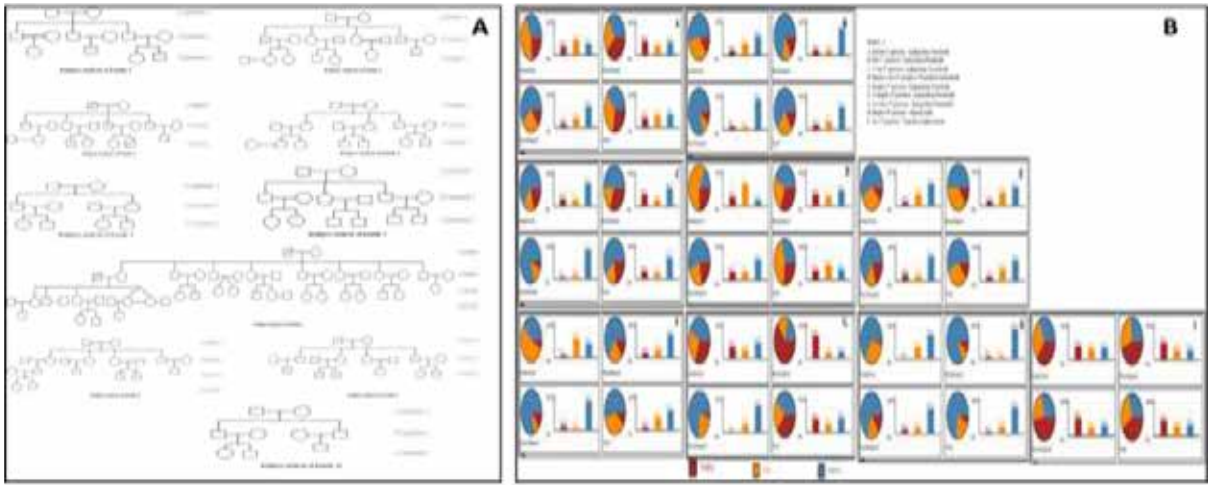


Figure 3.40: Pedigree of the selected families (A) and Prakriti assessment of the members of the family (B)

A total of ten families were assessed for prakriti, anthropometric parameters and genetic trait of PTC test. The preliminary data indicates that the inheritance of prakriti through generations. The anthropometric parameters also follow the inheritance pattern linked to prakriti. The genetic trait analyzed by PTC test also explaining the association with prakriti and all of which needs to be assessed further. Hence in the current study proves that human prakriti is determined at conception, by the influence of one or more dominating doshas at the time. The prakriti formed is thus stable throughout the lifetime. Many features describe therein converge with the phenotypes described in current biology. Thus this study provides a wider qualitative and quantitative understanding of different human constitutions described by Ayurveda.

3.4 MATHEMATICAL RESEARCH IMPACT-CENTRIC SUPPORT (MATRICS)

Objective	Features
To provide fixed grant support to active researchers with good credentials in Mathematical Sciences, Theoretical Sciences and Quantitative Social Sciences. The aim is to undertake research in these fields which have observed dwindling rate during last few years on numerous factors.	The applicant should be an active researcher in the field of (i) Mathematical Sciences and allied areas; (ii) Science and Engineering (excluding mathematical sciences) or (iii) Social Sciences. The applicant should hold a Ph.D. or M.D./M.S./M.D. S/M.V.Sc degree and must be working on regular basis in academic institutions/national labs or any other recognized R& D institutions. The applicant should have at least four years of service remaining before superannuation as on the date of submission of proposal. Research grant of Rs. 2.00 lakh p.a. for a period of three years.

Website links
http://serb.gov.in/jcbn.php

A total of 2300 proposals wise received out of which 245 were sanctioned during the year. Sub discipline wise distribution of the project is given below (Figure 3.41) :

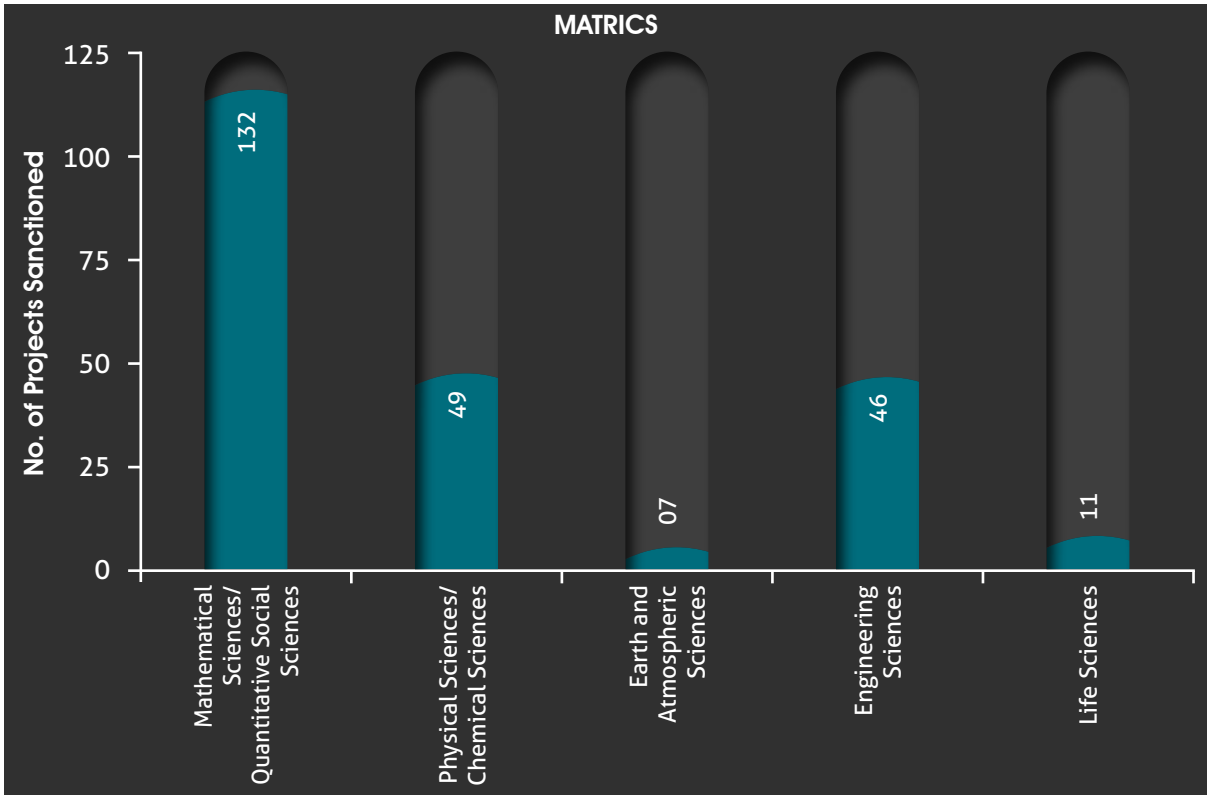


Figure 3.41 : Projects sanctioned in different sub-disciplines of MATRICS

Research Highlights

Development of Heuristic and Metaheuristic Techniques for Some Emerging Problems in Manufacturing and Logistics

The field of addressing combinatorial optimization problems through metaheuristic approaches has been advanced to a level where any new approach for a problem has to utilize the knowledge particular to that problem in an appropriate manner in order to be competitive with respect to the state-of-the-art approaches for that problem. As the problems considered were NP-hard combinatorial optimization problems, it has been dealt through various metaheuristic techniques, viz. artificial bee colony algorithm, genetic algorithm, hyper-heuristic and differential evolution. All the approaches developed makes use of problem specific knowledge wherever appropriate.

Initial work was focused on covering salesman problem (CSP), which is an extension of the classical traveling salesman problem (TSP). CSP seeks a Hamiltonian cycle over a subset of cities such that each city not in the subset is within the coverage radius of at least one city in the subset and that has minimum length among all Hamiltonian cycles over such subsets. The applications of CSP arises in emergency & disaster management and rural healthcare. Two hybrid metaheuristic approaches for the CSP have been developed. The first approach is based on the artificial bee colony algorithm, whereas the latter approach is based on the genetic algorithm. Both the approaches make use of several first improvement or best improvement based local search strategies defined over various neighborhood structures.

Generalized covering traveling salesman problem (GCTSP) is a recently introduced variant of the covering salesman problem. Given a demand D and a set of cities that includes depot, facilities and customer cities, the objective of the GCTSP is to find a minimum length tour over a subset of facilities so that the sum total of demands of customers covered by this subset of facilities is at least D. A customer is said to be covered by a subset of facilities if it is within the coverage radius of one or more facilities. The study finds important applications in humanitarian relief transportation and telecommunication networks. An artificial bee colony algorithm have been developed with variable degree of perturbation for the GCTSP where the degree to which a solution is perturbed for generating its neighboring solution is reduced over iterations.

Family traveling salesman problem (FTSP) is a recently introduced variant of the generalized traveling salesman problem (GTSP). The FTSP finds a tour visiting a pre-specified number of cities from each of these families in such a manner that the total distance traveled is minimized. The FTSP finds application in order picking in modern warehouses, where similar items can be stored at different places as the latest technologies like radio frequency identification (RFID) facilitate item localization.

Anti-covering location problem (ACLP) also called as a facility location problem locates a maximum weighted set of facilities such that no two facilities are closer than a given distance from each other. For this reason ACLP, is also known as r-separation problem, where r is the given distance. This NPhard problem has several important real world applications such as telecommunications equipment siting, locating military units, locating franchise outlets, locating obnoxious facilities, forest management and DNA sequence matching. A hybrid genetic algorithm and discrete differential evolution algorithm have been developed for both weighted and unweighted version.

3.5 INDUSTRY RELEVANT R&D (IRRD)

Objective	Features
To support ideas that address a well-defined problem of industrial relevance in the country. The proposal, therefore, shall be jointly designed and implemented by the academic partner and industry.	Routine proposals that address conventional problems and those not related to industry, or with already established approaches are not encouraged. The academic partner must hold a regular academic/ research position in an academic institution or national laboratories or recognized R&D institutions. For Industry Partner, all industries (including MSME & Industrial R&D Centres) are eligible. More than one Industry and/or more than one Investigator can apply. The funding is shared between SERB and Industry. The Industry share should not be less than 50% of the total budget. The funding can be provided for a maximum period of three years. The support from SERB shall be extended only to the academic partner.

Website links
http://serbonline.in/SERB/IRR
http://www.serb.gov.in/irrd.php

IThe Scheme for Funding Industry Relevant R&D (IRRD) aims to utilize the expertise available in academic institutions and national laboratories to solve industry specific problems for the larger benefit of society. The scheme supports ideas that address a well-defined problem of industrial relevance in a project mode. The project proposal shall be jointly designed and implemented by the academic partner (which includes a partner from national laboratories/recognized R&D institutions as the case may be) and industry. The participating industry should ensure that the objectives are industrially relevant.

The support from SERB shall be extended only to the academic partner. Projects are jointly designed and implemented by the academic partner and industry, and the cost is shared between SERB and Industry with industry share should not be less than 50 % of the total budget. All industries (including MSME & industrial R&D Centres) are welcome to participate in this scheme.

During the reporting period, eight new projects have been funded by the SERB. Some of these projects were looking at designing and development of CO_2 based secondary loop systems for cold storage applications; develop and establish medicine printing technology for printing of medicines on oral thin films; performance assessment of a reflux classifier in coal preparation etc.

Research highlights of some of the ongoing projects are given below:

Title of the project	Institution	Industry Partner
Design and Development of Energy Efficient Permanent Magnet Assisted Reluctance Motor Drives for Pump Application	Electrical and Electronics, SSN College of Engineering College of Engineering, Kalavakkam, Kanchipuram, Tamil Nadu.	Euro Process Automatik, Chennai.

Salient Features

The project aims to Design and Develop a robust controller for reluctance motor drive in order to test the Performance of fabricated Permanent Magnet Assisted Reluctance Machines and to compare the results with conventional configuration.

The reseach work undertaken involves the Electromagnetic analysis of different Permanent Magnet assisted Synchronous Reluctance motor configurations and their comparison with conventional motor drives.Operating point establishment of Permanent magnet Assisted Synchronous Reluctance and conventional motor with respect to pump characteristics. Simulation of suitable controller for variable speed operation.

The experimental setup for carrying out the study consists of prototype ferrite assisted synchronous reluctance motor with a controller, coupled to loads with respect to specific application requirements by means of a torque sensor (Figure 3.42). The prototype would be manufactured by Wire-Cut Electrical Discharge Machining (EDM) process. The thermal sensors would be placed in the winding and body of the motor. The vibration sensors are placed at specific locations in the enclosure of the motor.

Figure 3.42 : Pump setup with conventional drive

The testing of prototype ferrite assisted synchronous reluctance motor for specific operating points will be visualized by torque and speed response curves obtained from electromagnetic analysis and torque and speed sensors interfaced by power converter circuits and controlled by controller implemented using DSP processors. The output from electromagnetic analysis and torque and speed sensors would be used for efficiency analysis. The temperature response from thermal analysis and thermal sensors provide the necessary temperature response curves for deciding the requirements of cooling. The analysis results from vibration study from modal and deformation analysis and vibration sensors would provide data for safe operation of motor for specific load requirements.

Title of the project	Instituion	Industry Partner
Synthesis and Characterization of High Strength Manganese Bronzes with Silicon Additions	Dayananda Sagar College of Engineering, Bangalore	Rapsri Engg Products Limited, Ramnagar

Salient Features

The formation of manganese silicide particles (Mn_5Si_3) in a matrix of $\alpha+\beta$ composition in the alloys made in this study has resulted in a high hardness ratio of 10:1 between silicon and manganese. This high hardness ratio along with low coefficient of dry friction is the reason for excellent wear resistance of the alloys. This alloy that can withstand loading pressures up to 200MPa and are highly wear resistant and can be subjected to high shock loading. The wear test results obtained in this investigation using pin on disc machine with a 52100 steel counterface are very indicative of the high wear resisting ability of the alloys made and their excellent tribological characteristics.

The rapid freezing rate and the chilling effect in permanent moulds cause the formation of fine grained solid skin on the casting causing no defects in the castings.

The permanent moulded castings of manganese bronzes in the present investigations have high mechanical and tensile properties and cost effective than the sand casting.

In the design of marine propellers for coastal and arctic services, reliability and durability are often more critical considerations than speed and efficiency. The alloy should posses toughness and ductility such that impact loading produces plastic deformation rather than unstable crack propagation and failure of the blade. Another important aspect to be considered in the design of warships is the ability of the equipment to withstand collision and shock. It is a vital part of the naval designers business with the help of the metallurgist to recognize, adopt for naval purposes and exploit the growing field of materials available today for the benefit of future ships. Therefore, the high impact strength values achieved for the alloys developed in this study is a step towards this direction. Similarly the number of cycles the material has withstood before failing in a fatigue test is appreciable.

The research work has immediate and long term application potential-

Immediate - Detailed corrosion and erosion –corrosion /cavitation behaviour of developed alloys for ascertaining suitability of them in manufacturing various engineering components (small size) and defect free castings.
Exploiting the economic advantages of manganese bronzes compared to NAB (AB2) Rs.230 per kg versus 330 per kg (NAB).

Long Term - The synthesized alloy can be used for ship propellers, rudder, pump housings, gun mountings, sea water fittings, gear segments for armaments, electrical contact support for low tension air circuit breakers, pivot bushings in the lift cylinders of the hydraulic exca

Figure 3.43 : Microhardness Tester

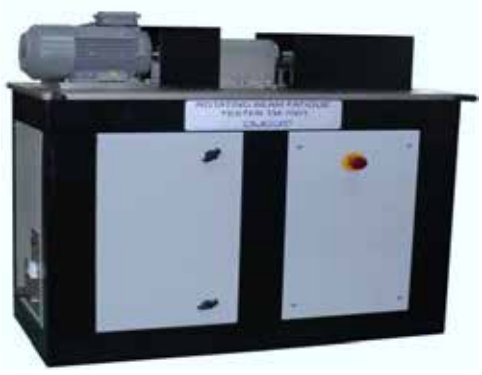


Figure 3.44 : Rotating Beam Fatigue Tester

Figure 3.43 and 3.44 show the equipment used for testing microhardness and fatigue of the material developed.

3.5.1 Fund for Industrial Research Engagement (FIRE)

SERB intensely pursued different means to engage with industry to address the widening gap between the knowledge economy that is driven by fundamental research and commercial economy driven by the marketplace. This led to initiation of a programme called FIRE under IRRD. The program "Fund for Industrial Research Engagement (FIRE)", 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.

SERB signed a Letter of Intent (LoI) with a group of semiconductor industries, namely, Applied Materials India Private Limited, Intel Technology India Private Limited, Mentor Graphics (Sales & Services) Private Limited, NXP India Private Limited, Texas Instruments (India) Private Limited to create a 'Research Fund' with the objective to collaborate on research problems that can have a ground-breaking impact at a large scale over the next five years. The partnership focuses on national and global problems, and fund top high-quality research with maximum industry impact potential, at a national scale with 50:50 monetary fund sharing.

Web links
http://www.serbonline.in/SERB/IRR
http://www.serb.gov.in/irrd.php

3.6 INTENSIFICATION OF RESEARCH IN HIGH PRIORITY AREA (IRHPA)

Objective	Features
To support proposals in high priority areas where multidisciplinary/ expertise may be required and which will put our nation in international science map in that particular discipline.	Identification, formulation and implementation of national R&D Programmes through involvement of scientists from different agencies & institutions is encouraged. The amount of grant is slightly higher than regular projects, since in order to set up core groups or units/facilities under this scheme, existing infrastructural facilities of the institutions needs to be strengthened. The duration of these type of Projects is 5 years. A Core Group/Unit is set up for a period of five years so that it can serve as focal point for a national programme. The parent institute is asked to take over the unit after five years.

Website links
http://serbonline.in/SERB/irhpa
http://www.serb.gov.in/irhpa.php

The scheme has contributed significantly to augment general R&D capabilities in academic institutions and national laboratories by setting up of Core Groups, Centers of Excellence and National Facilities in frontline and emerging fields of science & engineering. Several IRHPA Projects had been sanctioned in the past.

Title of the project	Institution
National Interdisciplinary Center for Cyber Security and Cyber Defense of Critical Infrastructures	Indian Institute of Technology, Kanpur

This project is one of the impact making projects supported under the Intensification of Research in High Priority Areas (IRHPA). The details are given below:

The center has several deliverables namely (i) a national scale SCADA/ICS test-bed for cyber security studies (ii) developing tools and techniques for malware collection, benchmarking of malware detection and classification algorithms; (iii) developing tools and techniques

for vulnerability and penetration testing and discovery of yet to be uncovered vulnerabilities in ICS software; (iv) developing tools and techniques for insider-threat proofing; (v) working with power utilities to develop data analytic techniques on PMU data to detect on-going cyber-attacks; (vi) creating at least one start-up on the developed technologies; (vii) developing mobile malware and their analysis techniques.

In the last one year, the test-bed creation in the various critical infrastructure sectors has been accelerated and at this time, except for the power transmission test-bed – all other testbeds have been installed. Power distribution, solar and diesel generation and synchronization, water treatment plant, industrial manufacturing test-beds have all been installed in the lab. The C3I center also moved to a new building constructed by IIT Kanpur where the test beds have been installed. Power Transmission testbed is being commissioned.

The C3I center researchers installed honeypots to collect malware, and also worked with various researchers around the world to collect sizable repositories of windows, Linux, Android malware for applying machine learning based malware detection and classification tools. The students and engineers at the center published 3 papers in International conferences on malware and bot-net detection. 3 more papers are under review. Adversarial training techniques to defeat malware that evade machine learning based detection by adversarial design have been developed.

In the vulnerability and penetration testing, the reporting year had been quite successful. 5 CVE (Common Vulnerabilities and Exposures) numbers have been assigned to vulnerabilities discovered and disclosed by C3I center. Security advisories attributed to C3I center has been made world-wide by the vendors. 2 more CVEs have been assigned but until the vendor sends out security advisories, they will not be put in the NVD database. More than 15 vulnerabilities have been disclosed by C3I center and are being validated by the vendors upon completion of which CVEs will be assigned. Overall, C3I has now made into the league of organizations that contribute to common vulnerabilities and exposures database. Several penetration testing, industrial network traffic capture and analysis tools have been developed which are being further developed.

In the context of insider-threats, a block-chain based solution to detecting any tampering in a data-base by privileged administrators have been developed, implemented and put to use in a project on block-chain based land-record management. This technique called "Verity" has been demonstrated at various block-chain forums. Further, work on insider threat detection was planned.

Several techniques have been developed and implemented to detect false data injection and data tampering in the industrial control networks. On the PLC side, due to resource constraint, an invariant failure based monitoring has been tested and implemented. On the SCADA side, singular spectrum analysis of sensor measurement time series has been implemented. It has been also demonstrated that previous work on singular spectrum analysis has lesser accuracy than our new method.

A start-up development is under discussion at the moment, and we hope by next year, a start-up would be spawned by C3I. We already signed MoU with Tech-Mahindra to develop our Malware-Analysis tool, the Web-application firewall, and Honeypot technology to the market. We are in the process of signing anMoU with BEL for similar cooperation. Schneider Electric has signed anMoU with us to help develop vulnerability discovery tools.

Mobile malware analysis work has progressed and C3i has developed a tool for android malware detection. An instrumented sandbox for dynamic analysis of Android has also been developed.

A lot of interactions with government agencies such as National Cyber Security Coordinator, Central Electric Authority, National Thermal Power Corporation are on-going. Several industries such as Schneider, Siemens, Tech-Mahindra have been interacting quite often. Disclosures of vulnerabilities have been made to many ICS vendors – Schneider and Rockwell in particular.

C3I center also promotes awareness and education in cyber-security. Yearly cyber-security competition event CSAW in cooperation with New York University has been an on-going activity every year. C3I center organized India's first ever Capture-the-flag for SCADA (SCADA-CTF) at Nullcon in 2018. C3I also hosted 20+ summer interns during the summer who worked for 2 months on various cyber security projects. C3I also conducted two courses – each of 2 weeks duration, for engineers from various Asian and

African countries on the behest of the Ministry of External affairs. A few other training sessions have been organized for various government agencies (not to be named) and students.

The research work has resulted 3 SCI journals & also 1 patent was filled during 2019-20. C3i center, in association with TalentSprint has designed an Advanced Certification Program in Cyber Security and Cyber Defense for current and aspiring professionals who are keen to explore and exploit the latest trends in Cyber Security Technologies.

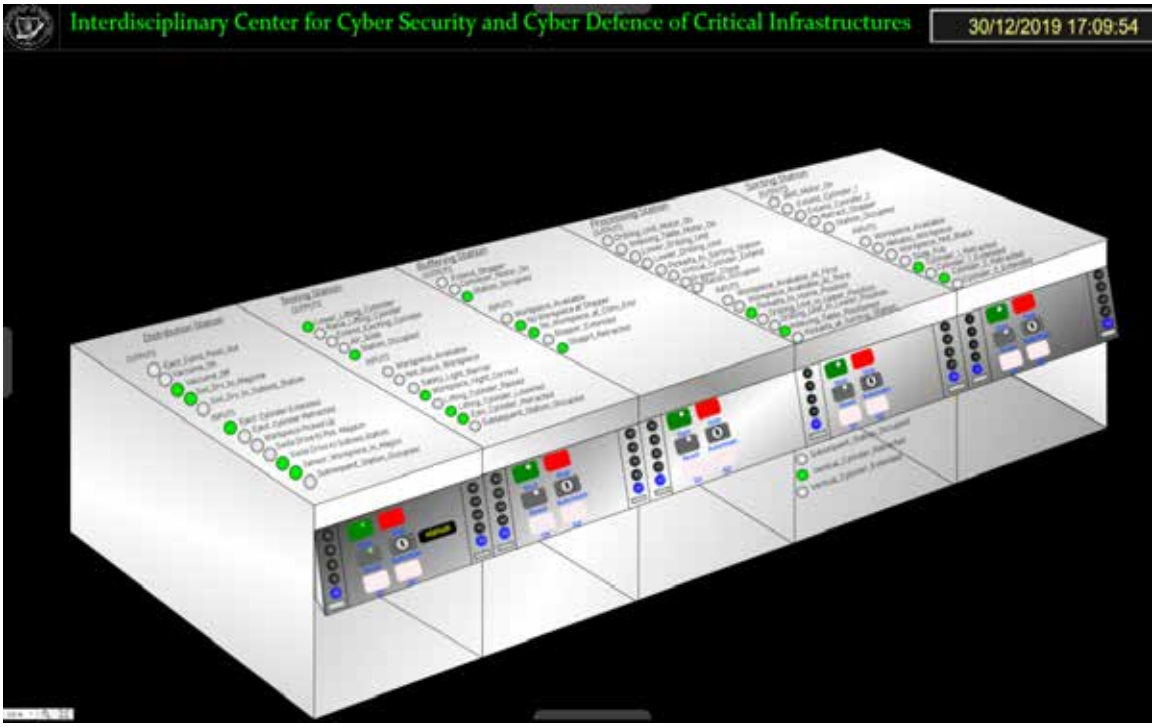


Figure 3.45 : Modular Manufacturing Plant SCADA Screen

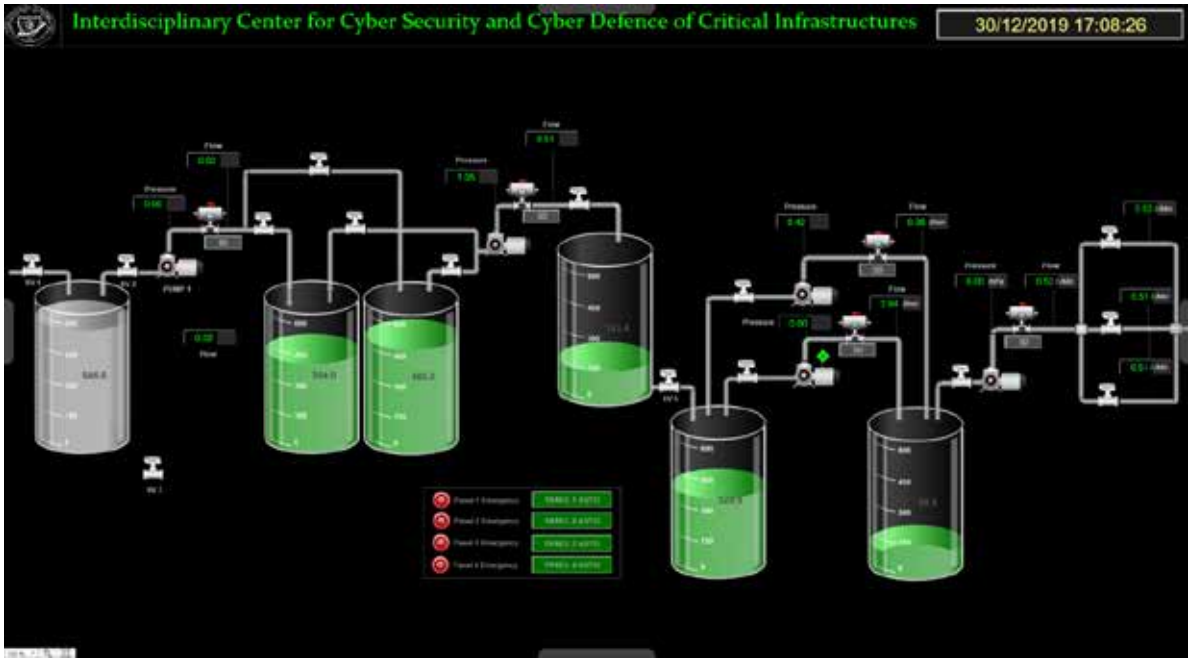


Figure 3.46 : Modular Manufacturing Plant SCADA Screen

Title of the project	Institution
Straw Management System for Combine Harvesters	Centre for Precision & Conservation Farming Machinery (CPCFM) at CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana

Salient Features

The major goal of the "Centre for Precision & Conservation Farming Machinery (CPCFM)" is: Accelerated R&D efforts to enhance agricultural productivity through development of agricultural machinery in selected areas to bridge the existing mechanization gaps to facilitate precision & conservation farming.

Rice–wheat (RW) cropping systems are practiced on around 10 Million Hectares across the Indo-Gangetic alluvial plains in India. In major rice growing states like Punjab, Haryana and Uttar Pradesh, rice straw has no economic use, remains unutilized and burnt by farmers to prepare the field for wheat sowing. Even spread of loose residues in the field is a prerequisite for smooth operation of straw management machines like Happy seeder or Zero-till drill. The combine harvester along with Straw Management System (SMS) is required to cut and spread the straw residues from straw walkers in the center of the harvested area. The SMS for Combine Harvesters developed at the centre is shown in Figure 3.47. Efficient chopping of straw and its distribution is the primary concern with minimum power use. Therefore, the design of blades (rotary and stationary) and its positioning along the rotor is being carried out and exhaustive field testing is completed in terms of power on the combine harvester, threshing efficiency, cleaning efficiency and germination of wheat crop sown. Multi-location trials with farmer participatory evaluation of the refined SMS system and its large-scale adoption are progressing.

Figure 3.47 : Straw Management System for Combine Harvesters

Title of the project	Institution
Evolution of Indian Sub-continental Lithospheric Mantle: Insights from mineral chemistry of kimberlites, lamproites, lamprophyres, their entrained xenoliths/xenocrysts, mafic dykes and dyke swarms from Bastar and Eastern Dharwar Cratons.	Centre of Advanced Study in Geology, Institute of Science, Banaras Hindu University, Varanasi-221005, India.

Electron Probe Micro Analyser (EPMA) (Figure 3.48) and Scanning Electron Microscope (SEM) (Figure 3.49) are successfully installed and have been extensively utilized by more than 150 researchers from ~100 institutions across the country. These facilities cater to the physico-chemical characterization of the minerals and materials (including the extra terrestrial) by the way of elemental analysis and high magnification imaging. More than 50 research papers in SCI journals have been published by the PIs and the other users so far. Some major highlights of researches during the year 2019-2020 are provided herewith:

- Protocols for monazite chemical dating and for measurement of Boron in tourmaline (Figure 3.50) have been established and results published in SCI journals.
- Depth of post-Deccan lithosphere-asthenosphere boundary in NW India is estimated to be ~100 km at 65 Ma
- An extremely heterogeneous and layered lithospheric mantle has been inferred from the study of lamprophyres from the Korakkodu, Eastern Dharwarcraton (Figure 3.51).
- A long-lived major subduction system inferred in the easterDharwarcraton from the study of pyroxenites at Gurramkonda, Dharwarcraton.

Figure 3.48 : CAMECA-SXFive EPMA

Figure 3.49 : CARL ZEISS EVO-18 SEM

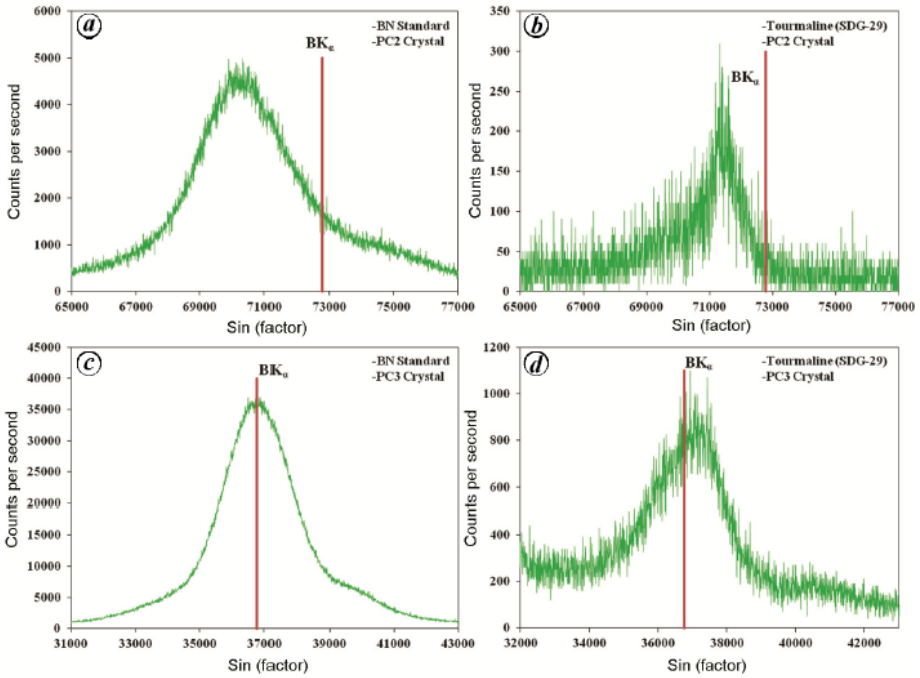


Figure 3.50 : WDS spectra of boron generated by CAMECA SXFive EPMA at 15 kV and 100 nA at (a) BN standard using PC2 crystal; (b) tourmaline sample using PC2 crystal; (c) BN standard using PC3 crystal and (d) tourmaline sample using PC3 crystal

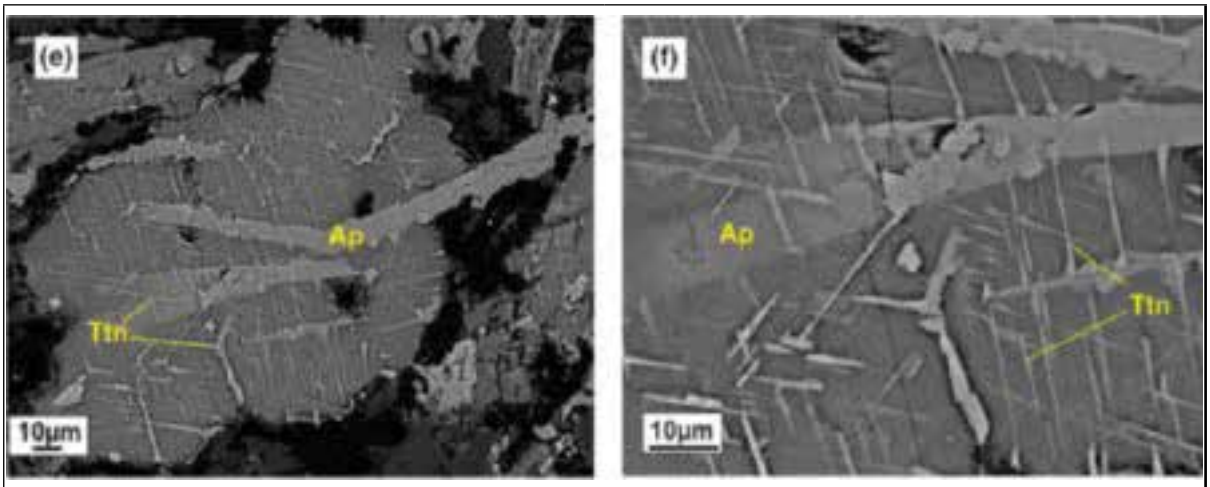


Figure 3.51 : (e) and (f) are the high-resolution SEM-based BSE images showing titanite needles exsolved in biotite at ~1200. Abbreviations: Ap- Apatite, Bt- Biotite, Ttn- Titanite.

Title of the project	Institution
Atmospheric Studies in the Geophysically sensitive Tropical to Sub-tropical transition region with ST Radar Facilities at Calcutta University.	Institute of Radio Physics and Electronics, University of Calcutta, Kolkata-700009.

Salient Features

An indigenously developed, state-of-the-art 53 MHz VHF ST Radar is being established at Ionosphere Field Station, Haringhata of University of Calcutta, and when commissioned, will be the first radar at this frequency in an Indian University. Once established, this Radar would become a unique facility in the entire eastern and north-east parts of the country as well as the South-East Asian longitudes. This radar is located in the transition region from the tropics to the sub-tropics and proximity of land and sea. It will facilitate research on Stratosphere-Troposphere Exchange processes, atmospheric dynamics, turbulence, development of models for forecasting severe weather events, role of atmospheric gravity waves in development of weather systems and ionospheric effects on radio signal propagation. Data analyses and interpretation using a Pilot version (Fig. 3.52) of the main array (Fig. 3.53) in collaboration with other national laboratories were carried out. This project is at a very advanced stage with civil and electrical work at the radar site being underway following which installation and commissioning of the radar will take place.

Figure 3.52 : University of Calcutta ST Radar Pilot Array

Figure 3.53 : University of ST Radar Main Array Kolkatta

Title of the project	Institution
Interdisciplinary forays into human-environment interactions: an integrative research initiative in energy, ecology and nonlinear modelling	National Institute of Advanced Studies, NIAS- Bangalore

Salient Features

This perhaps is the being first multidisciplinary proposal where studies on various issues on energy, human- animal conflicts and modelling of environment assessment near coal mining areas. The study area proposed is Ramagundam area, Karim Nagar District of Telengana state. Major objective is to conceptualize self-sustaining ecosystem, develop suitable regulatory mechanism for pre- and post-mining land usage and ecological impact of coal mining. The study sites of this component are Singareni Collieries Co. Ltd (SCCL) and Western Coalfields Ltd. (WCL) region (Ramagundam area, Karim Nagar District of Telangana state). These individual areas have specific characters (WCL has water management system. In SCCL, there will be no void left at the end of the mining operations. The land after mining shall be restored for agriculture purpose). The analysis of available data for PM 10 and PM 2.5 and other parameters collected from coal mining areas and same have been for modelling studies. These two aspects of "Energy utilisation" and "Human- Animal Concepts" will be handled for better understanding of the process as well as look into the predictability.

3.7 TEACHERS ASSOCIATESHIP FOR RESEARCH EXCELLENCE (TARE)

Objective	Features
To provide an avenue to those academician(s) cum researcher(s) working in State Universities / Colleges and in private Academic Institutions who are eager to learn new vistas of S&T by carrying out their research work in an established public funded institution 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.	The applicant(s) must have a regular academic / research position in a State Universities / Colleges and in private Academic Institutions. Research fellowship of Rs. 60,000/- per year (in addition to the researcher's own salary) will be provided subject to completion of minimum 90 days research work per year in the host institution. Research grant of Rs. 5 lakhs per annum (50% each to host and parent institution) and overheads (as per SERB norms) will be provided.

Website links
http://serbonline.in/SERB/Tare

A total of 391 proposals were considered by the Expert Committee during this period and 91 proposals were recommended for TARE awards. This includes 13 proposals in Chemistry, 3 in earth & atmospheric sciences. 13 proposals in physics & mathematical sciences, 33 in life sciences and 29 proposals in engineering sciences.

Table 3: Projects supported in TARE Scheme

Subject Area	Recommendation
Chemical Sciences	13
Earth and Atmospheric sciences	3
Physical and mathematical sciences	13
Life Sciences	33
Engineering sciences	29

Research Highlights

Development of a novel synthetic protocol in designing a new class of 3d-4f complex salts with (n,n) ligands and evaluation of their structural aspects.

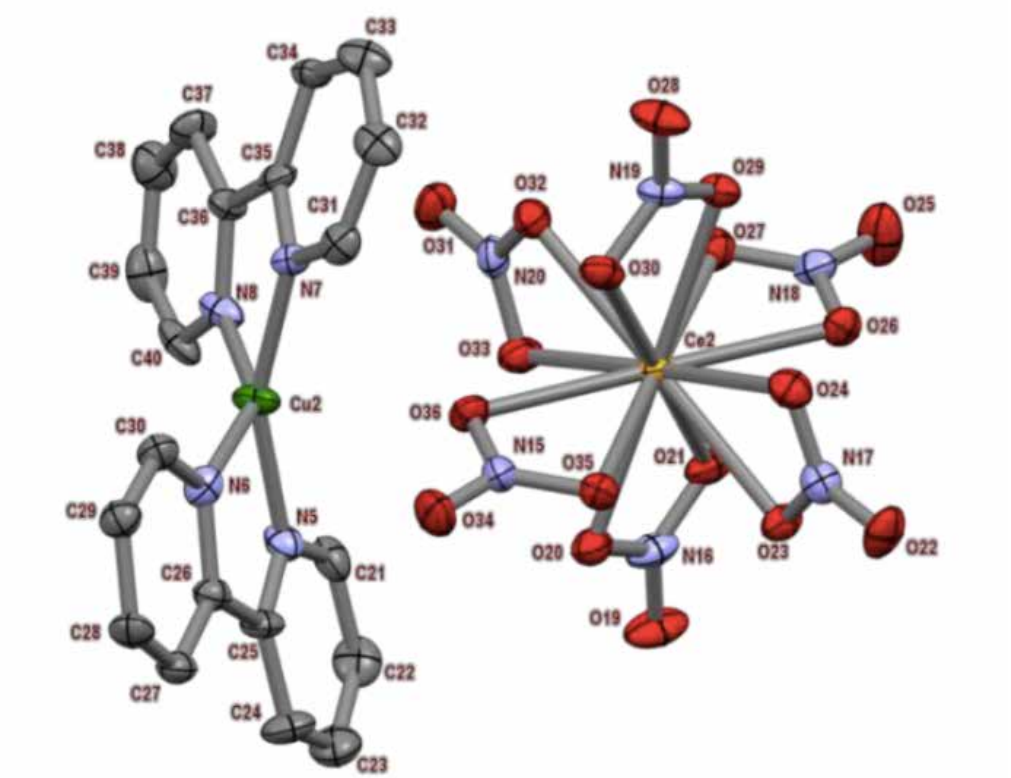


Figure 3.54: An ORTEP diagram of 1 (30% ellipsoid probability) with atom numbering scheme, H atoms are deleted for clarity (one unit is cited here)

The proposed synthetic route has been applied to isolate hetero-metallic ion pairs as complex salts. Study resulted in two Cu(II)-Ce(IV) complex salts and two Ni(II)-Ce(IV) complex salts with structural characterization and X-ray structures. This proposed synthetic route attested the development of synthetic protocol in isolating 3d-4f complex salts in crystalline phase. (ii) Two new unique copper(II)-cerium(IV) complex salts, [Cu(bpy)2]2[Ce(NO3)6]2 (1) and [Cu(phen)2(NO3)]2[Ce(NO3)6](HNO3) (2); [bpy = 2,2'-bipyridine; phen = 1,10-phenanthroline] have been synthesized and structurally characterized by different spectroscopic techniques and single crystal X-ray diffraction analysis. X-ray structural analysis reveals that the copper(II) centres in 1 adopt distorted tetrahedral geometry and copper(II) centres in 2 adopt bicapped square pyramidal geometry while the anionic cerium(IV) units exist in dodecahedral geometry in both 1 and 2. The bimetallic (3d-4f) molecular complex salt 1 crystallizes in monoclinic crystal system with P21/c space group and complex salt 2 crystallizes in triclinic crystal system with P`1 space group. The crystal structure of 1 shows that two cationic copper(II) units, [Cu(bpy)2]2+ are of slight different conformations and adopting a distorted tetrahedral geometry, and the cationic charges are counterbalanced by the anionic charges of two anionic cerium(IV) units, [Ce(NO3)6]2- which are in dodecahedral geometry. The crystal structure of the compound 2 shows the similar features about Cu(II)-Ce(IV) system except the geometry of copper centre. The compound crystallized in triclinic crystal system with P`1 space group. The compound 2 can also be assumed as a complex salt of 3d-4f class, in which the unit cell contains two isostructuralmonocopper(II) units, [Cu(phen)2(NO3)]+, and one ceric nitrate unit with one nitric acid molecule. The cationic charges of the two [Cu(phen)2(NO3)]+ units fully counterbalance one cerium(IV) unit, [Ce(NO3)6]2-. In 2, Cu(II) centres are in bicapped square pyramidal geometry, which also resembles to a previously reported bicapped square pyramidal chromophore, [Cu(bpy)2(O2NO)](NO3) and this structure is also known as a rare geometry in scientific literature. The square plane contains N3,N4 (phen), N1(other phen) atoms and O1 atom of nitrate ligand [Cu1-N1, 1.99Å; Cu1-N3,

2.06 Å; Cu1-N4, 1.98 Å;Cu1-O1, 2.10Å] while N2 (other phen) and O2(nitrate) atoms occupy the apical position [Cu1-N2, 2.09Å; Cu1-O2, 2.55Å]. Though there are two Cu-O bonds (axial and equatorial) around the Cu centre in 2 but one of the Cu1-O2 (Cu1-O2, 2.55Å; O atoms of chelating nitrate) bond gets axially elongated due to Jahn Teller distortion. The Ce ion of [Ce(NO3)6]2- unit in 2 also exists as dodecahedron geometry and acts as a centre of inversion. (iii) The solution phase conductivity for Cu(II)-Ce(IV) complex salts was measured which exhibits good conducting property in solution phase. Study is continuing to understand the charge transport property of the synthesized compounds in solid state.

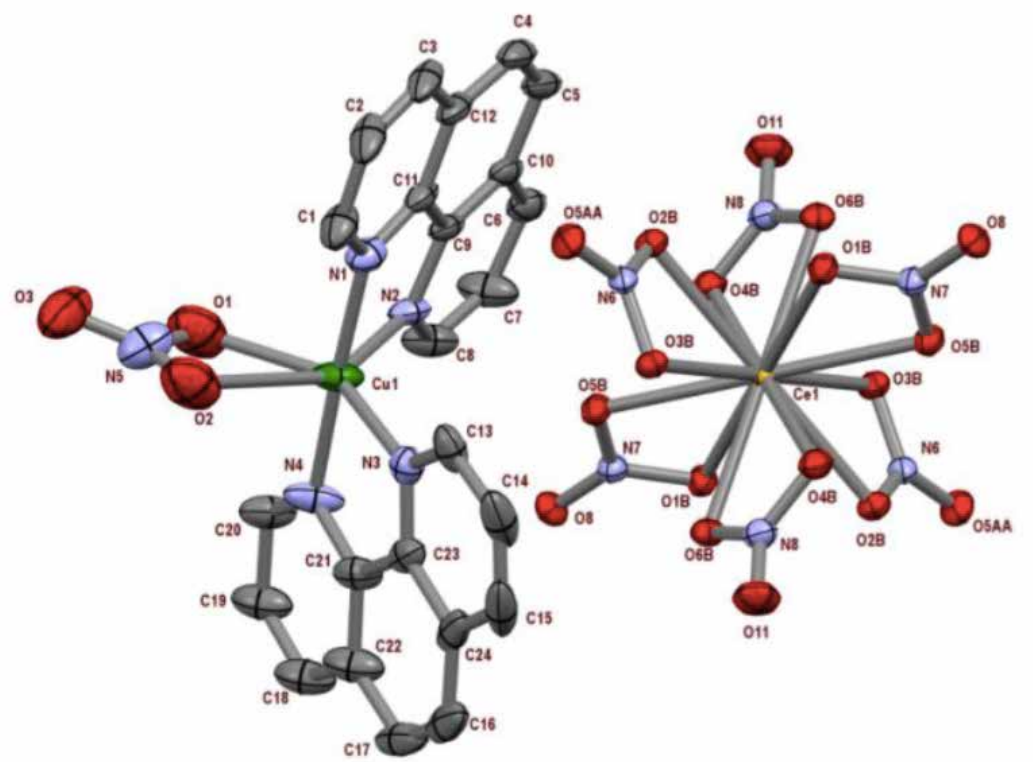


Figure 3.55: An ORTEP diagram of 2+ (30% ellipsoid probability) with atom numbering scheme, H atoms are deleted for clarity.

4 FOSTERING THE YOUNG RESEARCHERS

It is of paramount importance to offer opportunities to the young researchers to pursue exciting and innovative research in frontier areas of science and technology SERB has created R&D platforms for young researchers to build their research career.

Young Scientist Scheme (YSS)

The Start-up Grant is an important element in the career of a young scientist. In recent times, the YSS (erstwhile) has been restructured into two parts – **National Post-Doctoral Fellowship(N-PDF)** and the **Early Career Research Award (ECRA)**. In recent past Early Career Research Award scheme has been reformulated to **Start-up Research Grant.** The N-PDF aims to provide opportunities for young PhDs to avail post-doctoral research fellowships in academic institutions and research laboratories of the country. The Start-up Research Grant (SRG) scheme aims to assist researchers to initiate their research career in a new institution. The erstwhile YSS continue to be in existence w.r.t ongoing approved projects in most of the disciplines.

4.1 START-UP RESEARCH GRANT (SRG)

Objective	Features
To assist researchers to initiate their research career in a new institution. It is a two-year grant meant to enable researchers working in frontier areas of science and engineering to establish themselves and move on to the mainstream core research grant. Criteria for selection would be based on the track record of the applicant and the proposed research plan.	Research grant of Rs. 30 lakh plus overheads for a period of two years. The research grant will cover equipment, manpower, consumables, travel and contingency apart from overheads. There is a standard cap for travel, contingency and overheads. SRG would be a one-time career grant.

Website links

http://www.serb.gov.in/srgg.php

A national call for proposals was solicited in April 2019. The number of proposals under different disciplines and the number of awards offered are listed in table 4.1

Table 4.1: The number of SRG awards offered in the reporting period

PAC	Total Proposals received	No. of proposals Recommended
Chemical Sciences	329	59
Earth & Atmospheric Sciences	161	15
Engineering Sciences	2068	178
Life Sciences	1314	93
Physical & Mathematical Sciences	636	58

4.1.1 Chemical Sciences

A total of 59 projects were recommended under different sub disciplines as given in the Figure 4.1

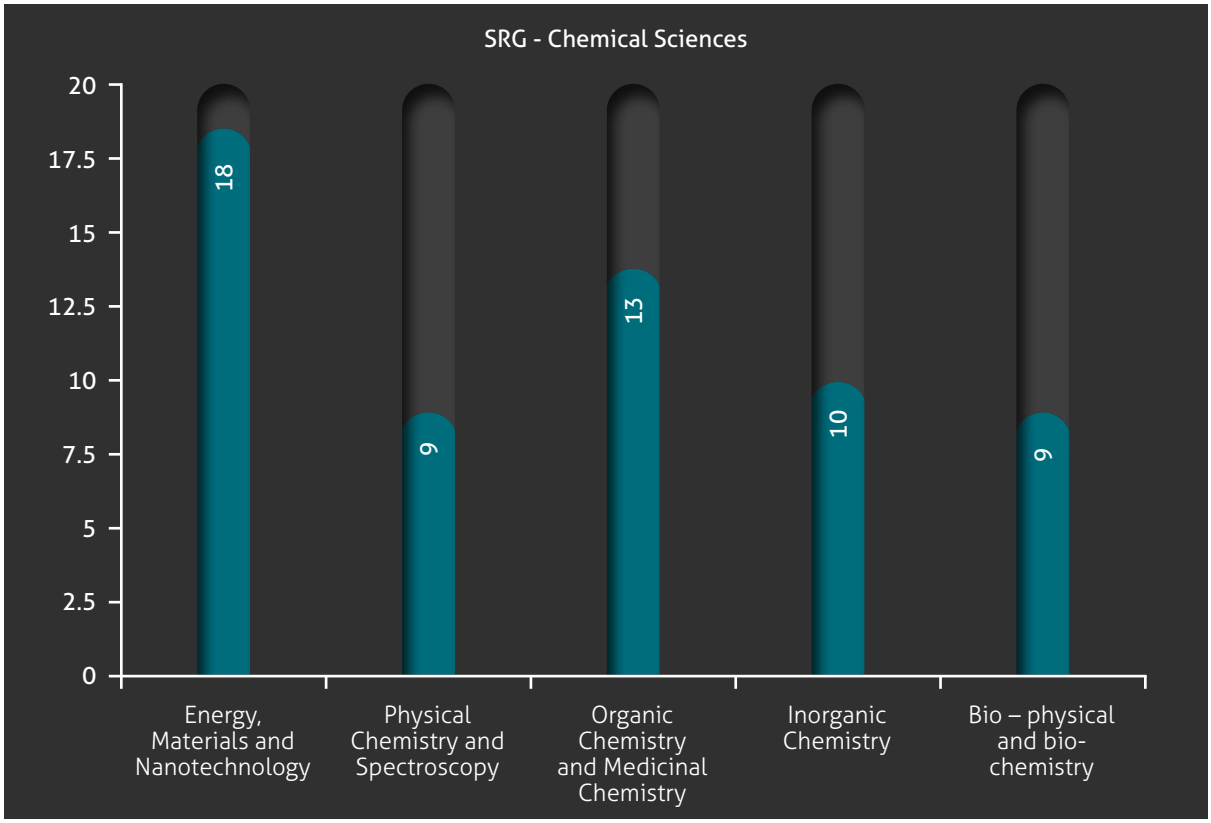


Figure 4.1 : Projects recommended in Chemical Sciences

4.1.2 Earth and Atmosphere Sciences

A total of 15 projects were recommended under different sub disciplines as given in figure 4.2.

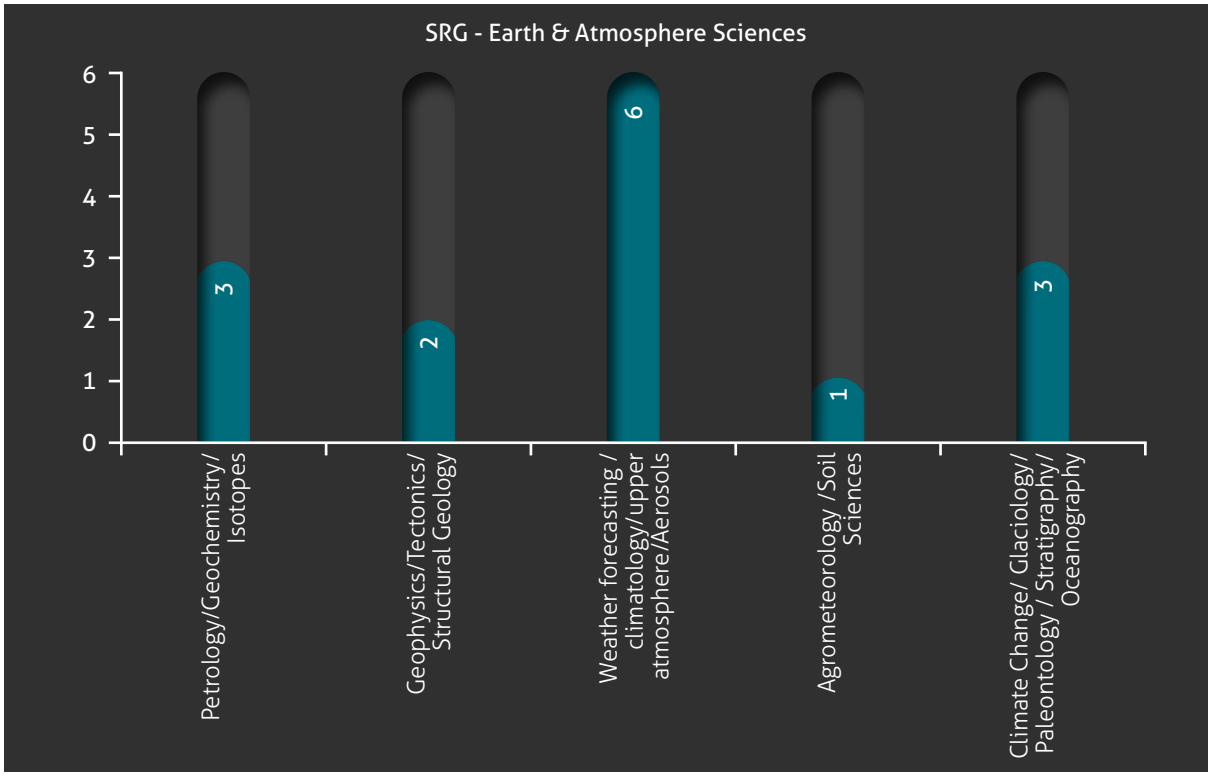


Figure 4.2 : Projects recommended in Earth and Atmospheric Sciences

4.1.3 Engineering Sciences

A total of 178 projects were recommended under different sub disciplines as given in Figure 4.3.

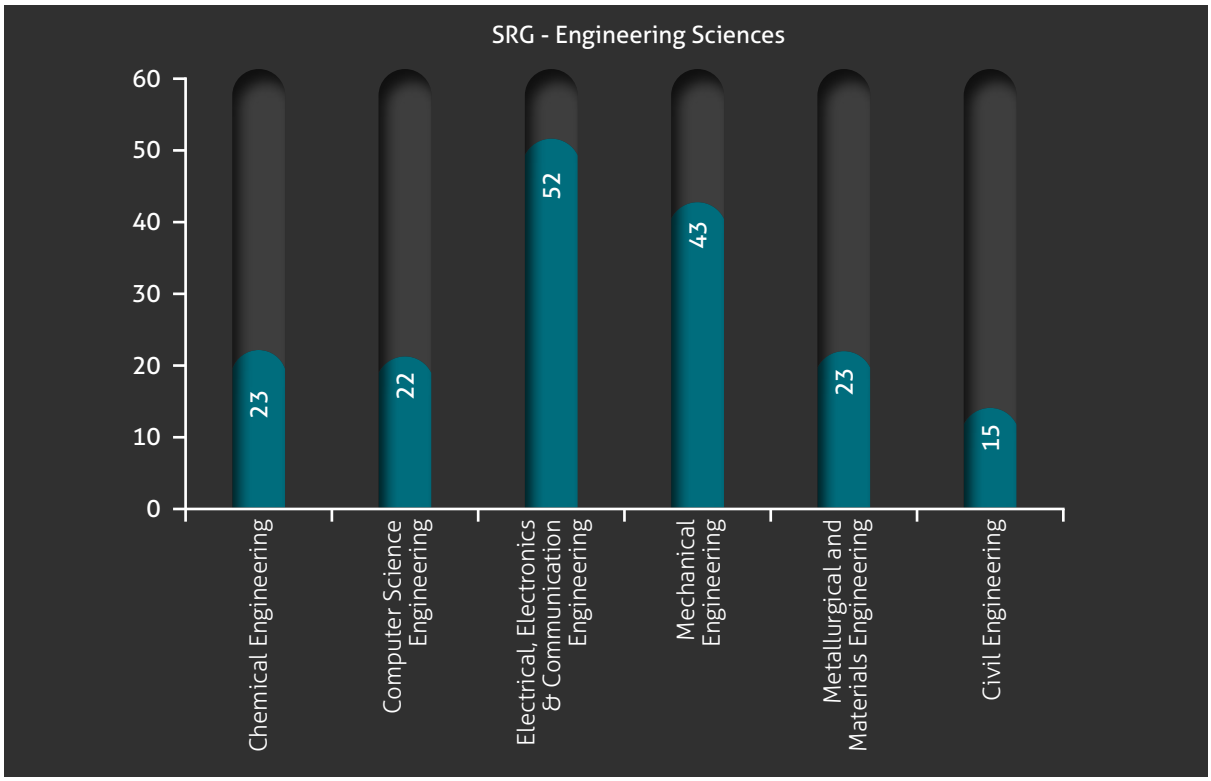


Figure 4.3 : Projects recommended in Engineering Sciences

4.1.4 Life Sciences

A total of 93 projects were recommended under different sub disciplines as given in Figure 4.4.

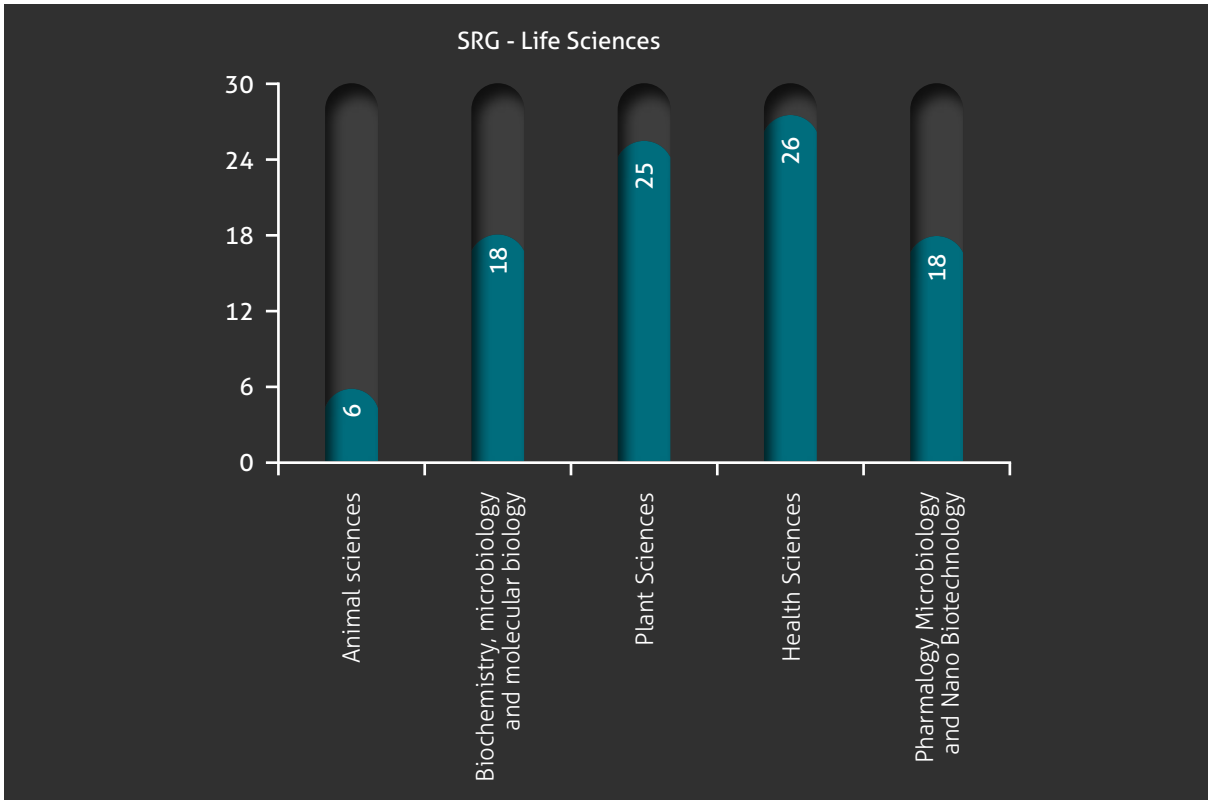


Figure 4.4 : Projects recommended in Life Sciences

4.1.5 Physical and Mathematical Sciences

A total of 58 projects were recommended under different sub disciplines as depicted in the Figure 4.5.

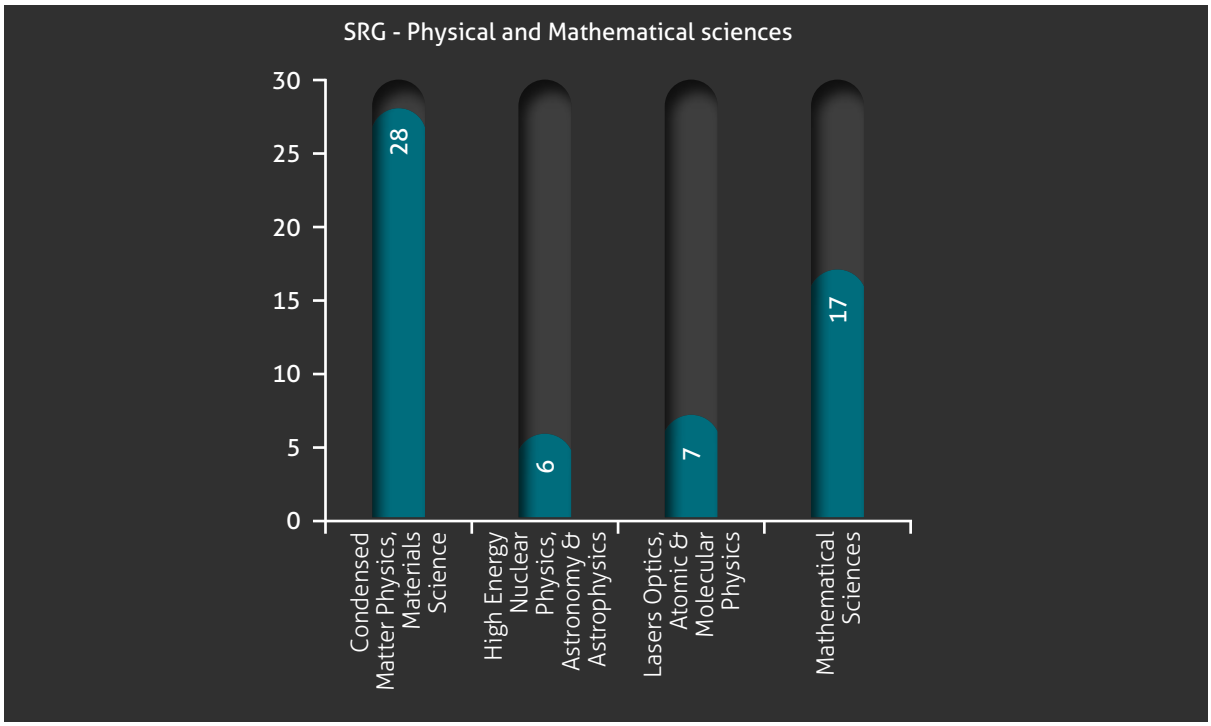


Figure 4.5 : Projects recommended in Physical & Mathematics Sciences

4.2 NATIONAL POST-DOCTORAL FELLOWSHIPS

Objective	Features
To identify motivated young Indian researchers and provide them support for undertaking post-doctoral research.	Fellows availing NPDF are required to work under a mentor so that the training provided to them act as a platform to develop them as an Independent researcher. NPDFs are open to the applicants who have obtained Ph.D degree in Science, Engineering and Medicine. The fellowship is a temporary assignment and provide a sum of Rs. 55,000 per month for the period of 2 years with research grants of Rs.2,00,000 per annum to each awardee.

Website links
http://serbonline.in/SERB/npdf?HomePage=New
http://www.serb.gov.in/npdf.php

Call for NPDF applications were solicited in May 2019. A total of 3426 applications were considered by the designated Expert Committees under different disciplines. A total of 239 Fellowships were sanctioned/awarded. The number of applications considered in different disciplines and the number of fellowship offered are given in Table 4.2.

Table 4.2 : The number of NPDF awards sanctioned during the reporting period.

Subject Area	Total No. of proposals considered	Number of Fellowships Sanctioned
Chemical Sciences	780	41
Earth and Atmospheric Sciences	189	20
Engineering Sciences	485	39
Life Sciences	1511	104
Physical and Mathematical Sciences	461	35
Total	3426	239

4.2.1 Chemical Sciences

A total of 57 fellowships were recommended under different sub-disciplines (figure 4.6) and 41 sanctions were issued during this period.

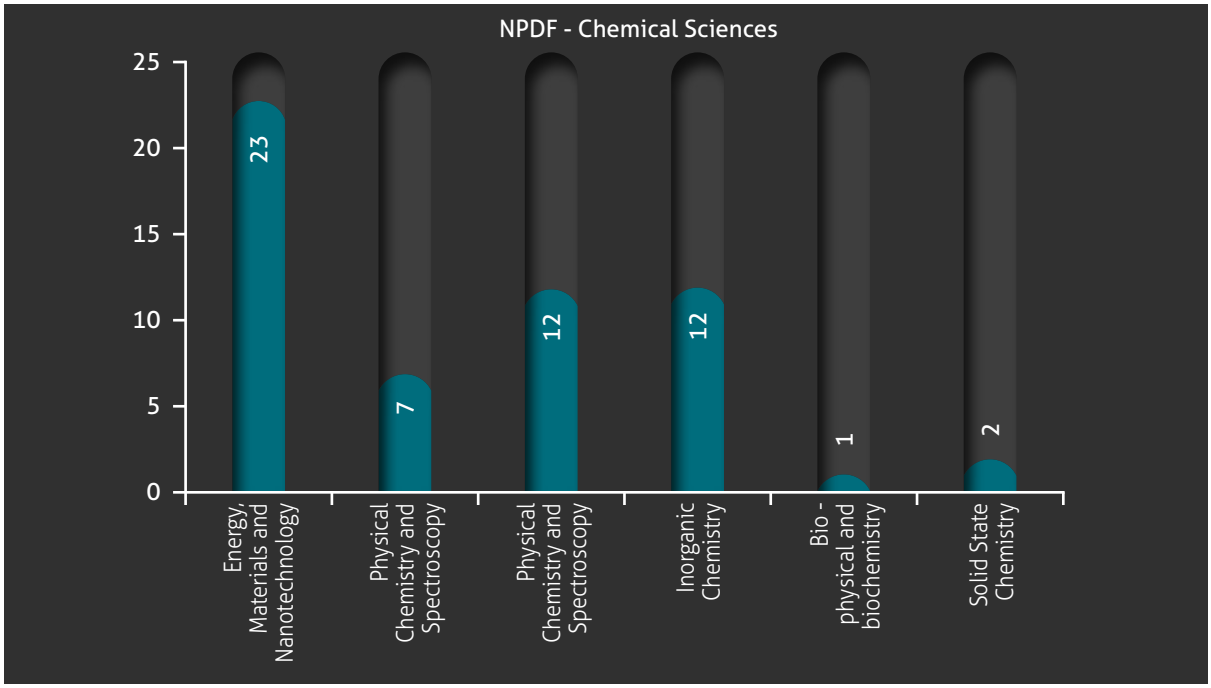


Figure 4.6 : Fellowships recommended in Chemical Sciences

4.2.2 Earth and Atmospheric Sciences

During the reporting period, fifteen Young Scientists were endowed with an opportunity to establish themselves as an independent researcher to cater the national requirement in the area of Earth, Atmospheric Sciences and Glaciology. The funded research proposals were in the area of tectonic evolution of Indian landmass and sedimentary basins, River System and Oceanography, Atmospheric Sciences, Agro-meteorology and Climate Change, Paleobotany/ Paleontology and Paleo-ecology.

A total of 15 fellowships were recommended under different sub-disciplines (figure 4.7) and 20 sanctions were issued during this period.

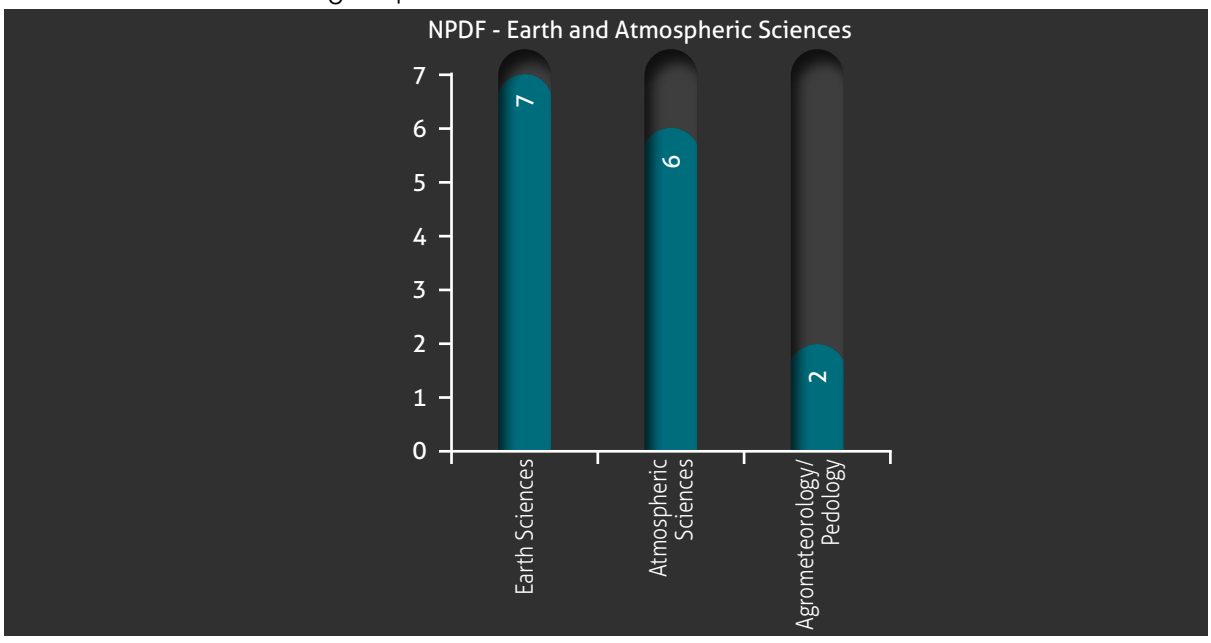


Figure 4.7 : Fellowships recommended in Earth and Atomospheric Sciences

4.2.3 Engineering Sciences

A total of 39 fellowships were recommended under different sub disciplines as depicted in the Figure 4.8 and the same has been sanctioned during this period.

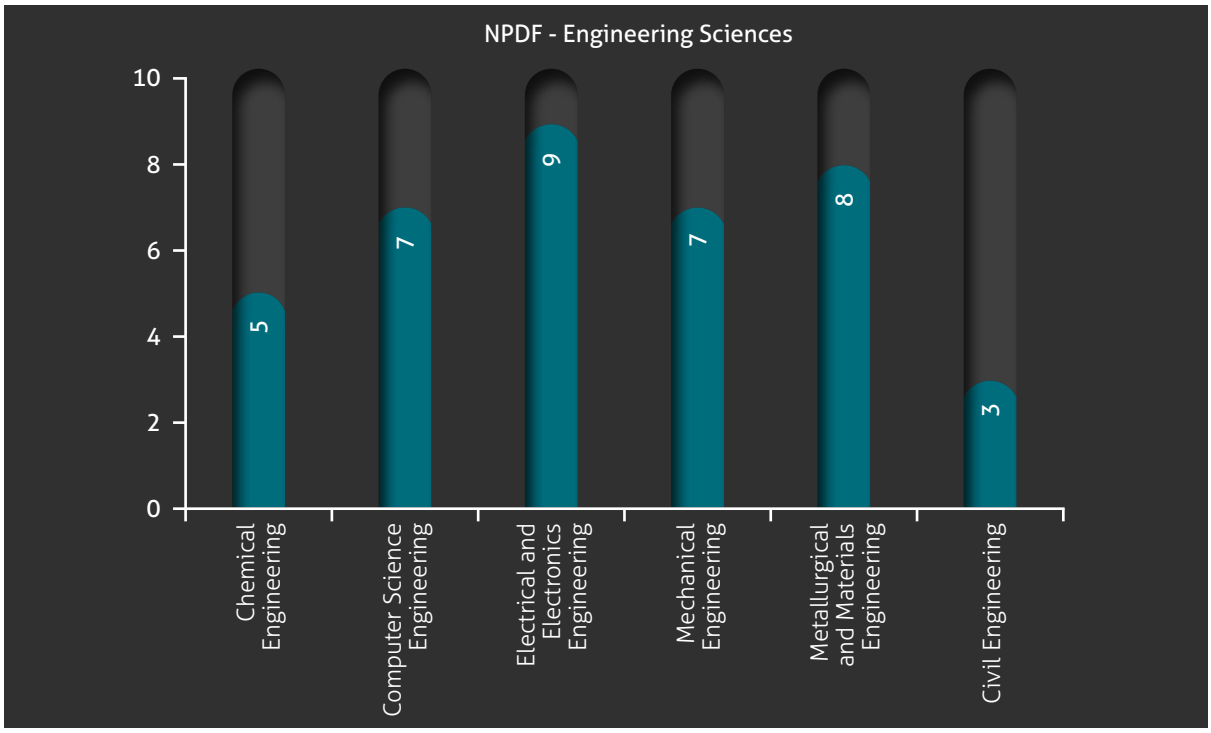


Figure 4.8 : Fellowships recommended in Engineering Sciences

4.2.4 Life Sciences

A total of 103 fellowships were recommended under different sub disciplines as depicted in the Figure 4.9 and 104 sanctions were issued during this period.

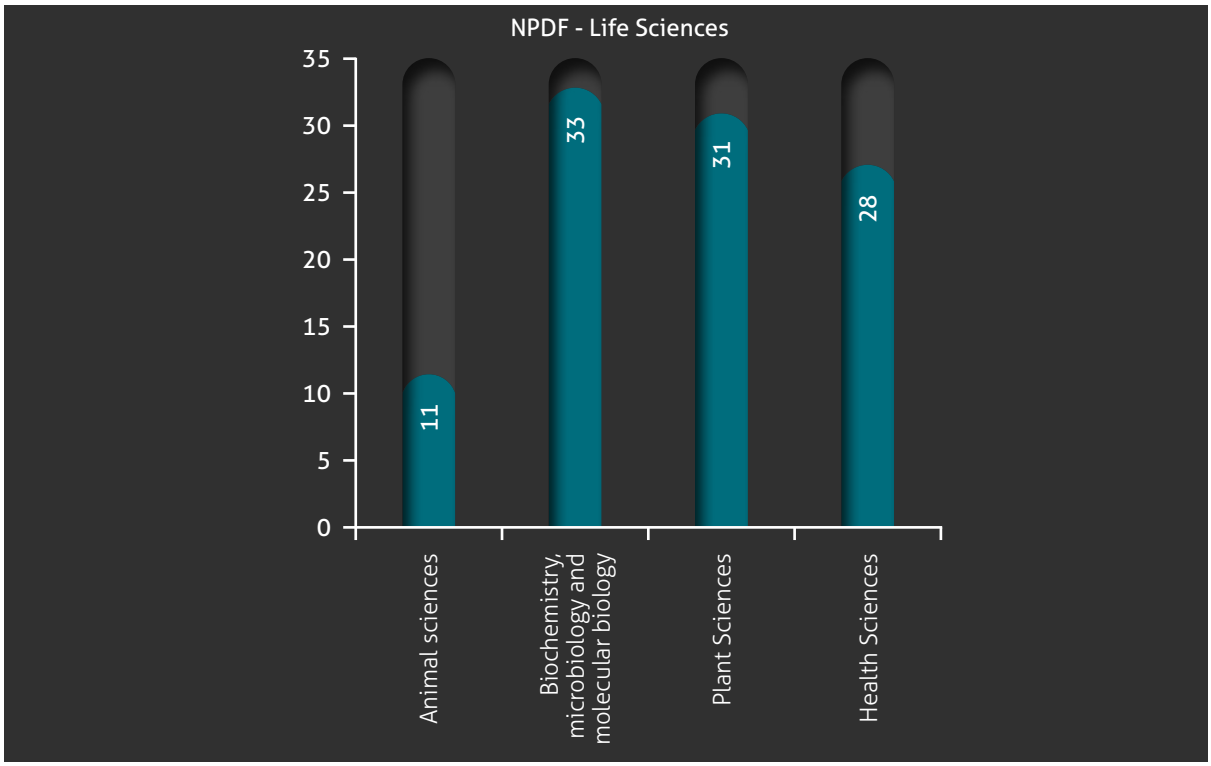


Figure 4.9 : Fellowships recommended in Life Sciences

4.2.5 Physical and Mathematical Sciences

A total of 36 fellowships were recommended under different sub disciplines as depicted in Figure 4.10 and 35 sanctions were issued during this period.

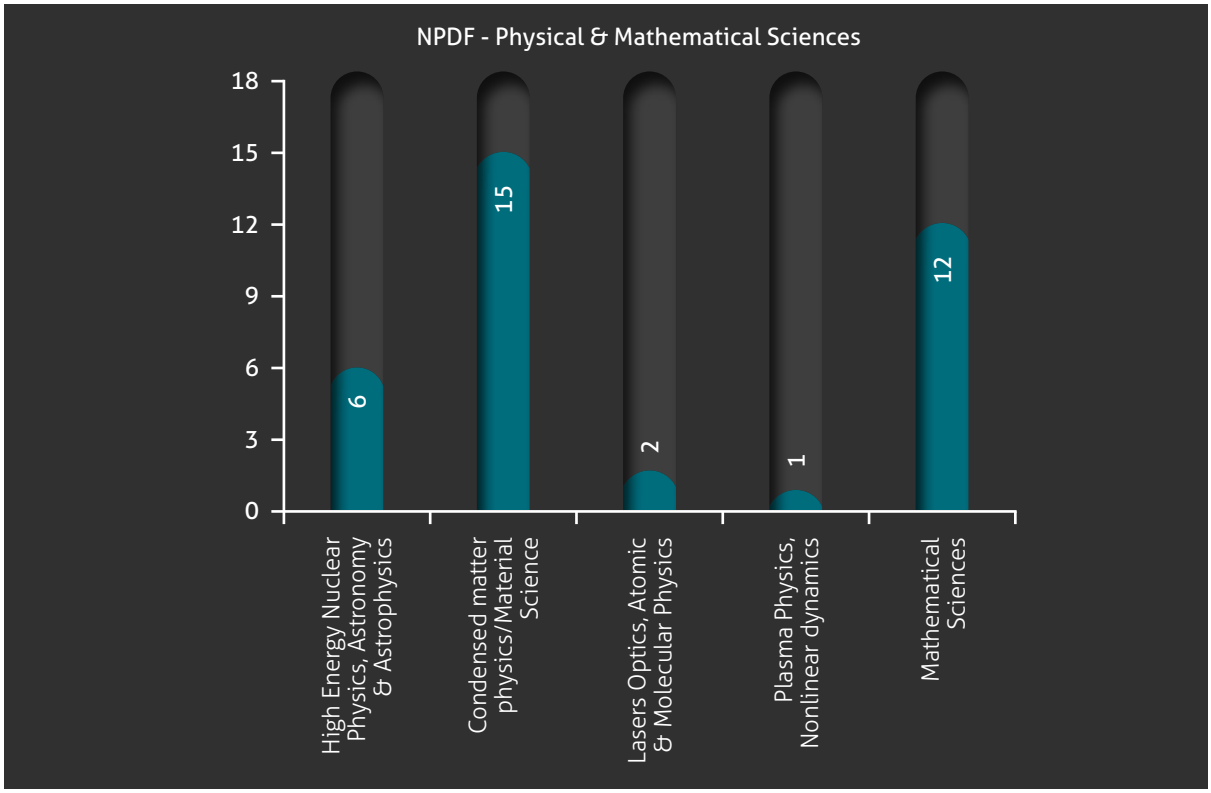


Figure 4.10 : Fellowships recommended in Physical Mathematical Sciences

SIGNIFICANT RESEARCH HIGHLIGHTS

Several young researchers are awarded under the programs, NPDF and ECRA every year. For the purpose of brevity, only one research from each discipline of YSS/ ECRA/SRG/NPDF has been included in the document here.

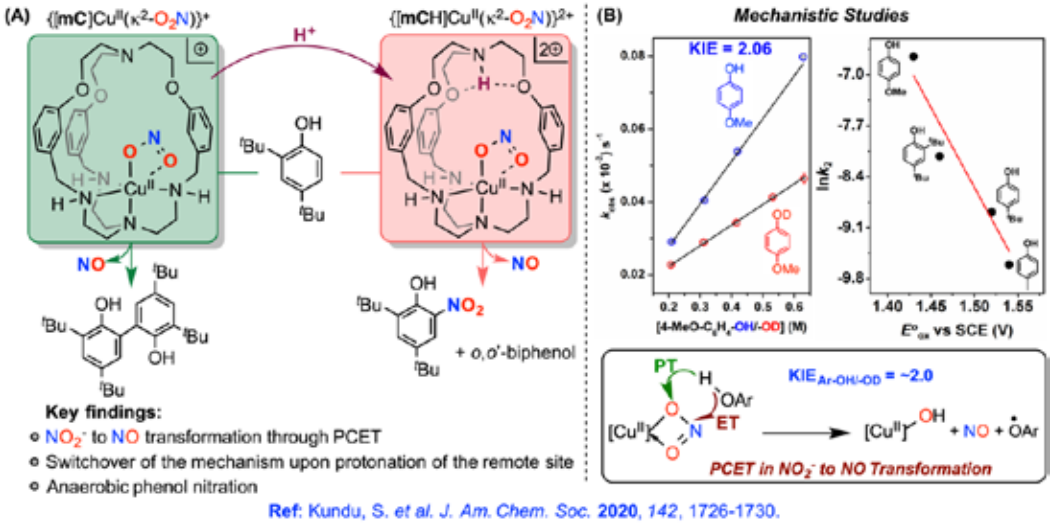
(a) Chemical Sciences

Insights into the Interplay of H_2S and NO at Redox Active Metal sites

Hydrogen sulfide (H_2S) and nitric oxide (NO) have recently gained remarkable research interests due to their involvement as gasotransmitters in a diverse array of physiological processes such as vasodilation, immune response, and neurotransmission. Notably, the generation and utilization of H_2S and NO in the biological milieu are very tightly controlled due to their potent toxicity at higher concentrations. This project (Dr. Subrata Kundu, IISER Thiruvananthapuram) studies the molecular mechanisms involving reactive sulfur, oxygen, and nitrogen species (RSONs) in the biologically-relevant H2S and NO generating routes.

Owing to the interest in revealing the molecular pathways for NO generation from NO2-, a pair of nitrito-copper (II) cryptate models {[mC]Cu^{II}(K^2-O_2N)}(ClO_4) and {[mCH]Cu^{II}(K^2-O_2N)}(ClO_4)2 were employed with different protonation states of the outer-coordination sphere (Figure 4.11). {[mC]Cu^{II}(K^2-O_2N)}(ClO_4) oxidizes substituted phenols with concomitant reduction of NO_2- to NO. Detailed kinetic studies on the reactions of {[mC]Cu^{II}(K^2-O_2N)}(ClO_4) with phenols outline that both proton and electron transfers are involved in the rate-limiting step (Figure 4.11 B). This study reveals that a phenolic moiety may serve as a competent reductant for reducing NO2- to NO through a proton-coupled-electron-transfer (PCET) pathway. The discovery resembles the interactions between NO2- and polyphenols originating from the dietary sources and resulting in the elevation of NO concentration in the stomach.

Intriguingly, the reaction of {[mCH]Cu^{II}(K^2-O_2N)}$(ClO_4)_2$ with the substituted phenols proceeds through a primary electron-transfer. Consequently, the alternative mechanism involving the nitrito-copper (II) cryptate with the protonated outer-coordination sphere facilitates an unusual anaerobic route for phenol nitration (Figure 4.11A). The findings illustrate the role of a proton-responsive outer-coordination sphere in the mechanistic switchover during the phenol-nitrite interaction at copper (II). The recognition of these new pathways may provide a lens to view the potential oxidizing routes involved in tyrosine modifications in the presence of an alternative oxidative stress condition, particularly under hypoxia. The gained insights may guide the development of therapeutics related to NO and H2S signalling processes in mammalian biology.



Ref: Kundu, S. *et al. J. Am. Chem. Soc.* **2020**, *142*, 1726-1730.

Figure 4.11 : (A) Anaerobic oxidative transformations of substituted phenol mediated by nitrito-copper (II) cryptates {[mC]Cu^{II}(κ^2-O_2N)}(ClO_4) and {[mCH]Cu^{II}(κ^2-O_2N)}$(ClO_4)_2$. (B) Mechanistic studies revealing phenol mediated nitrite reduction at copper(II).

(b) Earth and Atmospheric Sciences

An Insight through Indian Ocean Geoid Low using Seismic Data and computing models to predict the Geoid and its Origin

The research was carried out at Institute of Seismological Research (ISR), Gandhinagar, Gujarat. to study the detailed mantle structure beneath Indian Ocean Geoid Low using seismic data compute models to predict geoid and investigate its origin.

The existing global tomographic models (e.g., SB4L18, TX2005, S20RTS etc.,) were evaluated depth-wise with specific focus on preciseness in predicting the IOGL. The tectonic regionalization of the tomographic models provided several insights into the probable sources of the Indian Ocean Geoid Low. The cluster analysis of the lithosphere showed that the divergent boundary between the Indo-Australian Plate and the African Plate, that between the Indian and the Arabian Plate and volcanic arcs near the Sumatra Fault, Japan Trench etc., were sampled by low velocity profiles, the India-Eurasia collision zone, orogenies in the Central Asia and the South Indian shield by high velocity profiles and the oceanic part of the African and Indo- Australian Plate by intermediate velocity profiles for most tomographic models. The Indian shield is sampled by very high velocity (4% for S velocity and 2% for P velocity perturbations) structure within the lithosphere.

By cluster analysis of global tomographic models, the study has pinpoint the location of the source of the Indian Ocean Geoid Low (IOGL) and also able to explain the shape of the Indian IGOL (Figure 4.12). The IOGL is caused by the combination of a low velocity material rising from the African LLSVP and trapped within the transition zone (440 km – 660 km) surrounded by a lesser magnitude low velocity material extending from the Indian Shield to the southern Australian Plate. The lesser magnitude low velocity material is caused by the secondary convection of the mantle known to exist parallel to the Indo-Australian Plate. The low velocity material beneath the center of the IOGL and the lesser magnitude low velocity envelop can explain the maximum geoid low beneath the north Indian Ocean and the elongated low amplitude geoid of 30-60 m surrounding it upto the Australian Plate respectively. The role of the high density material in the lowermost mantle

in generating the large amplitude of the geoid low at the IOGL center seems unimportant as the other regions (east Africa and IOGL tail) has higher density material than IOGL center, yet exhibit low amplitude geoid. The low velocity material present in the East African Rift Zone (EARZ) has lesser magnitude than the low velocity material in the center of the IOGL. Therefore, we do not see such a large amplitude geoid in the EARZ. The low velocity material beneath the Indian Shield is negated by the high velocity material within the lithosphere and the mid mantle. The high velocity materials are due to the Indian Craton in the lithosphere and remnants of the Tethys slab in the mid mantle, respectively. In the absence of these high velocity materials, the amplitude of the geoid above the Indian Shield could have larger negative amplitude. The low observed in the Central Asia is caused by the negative gravitational effect of the high velocity material.

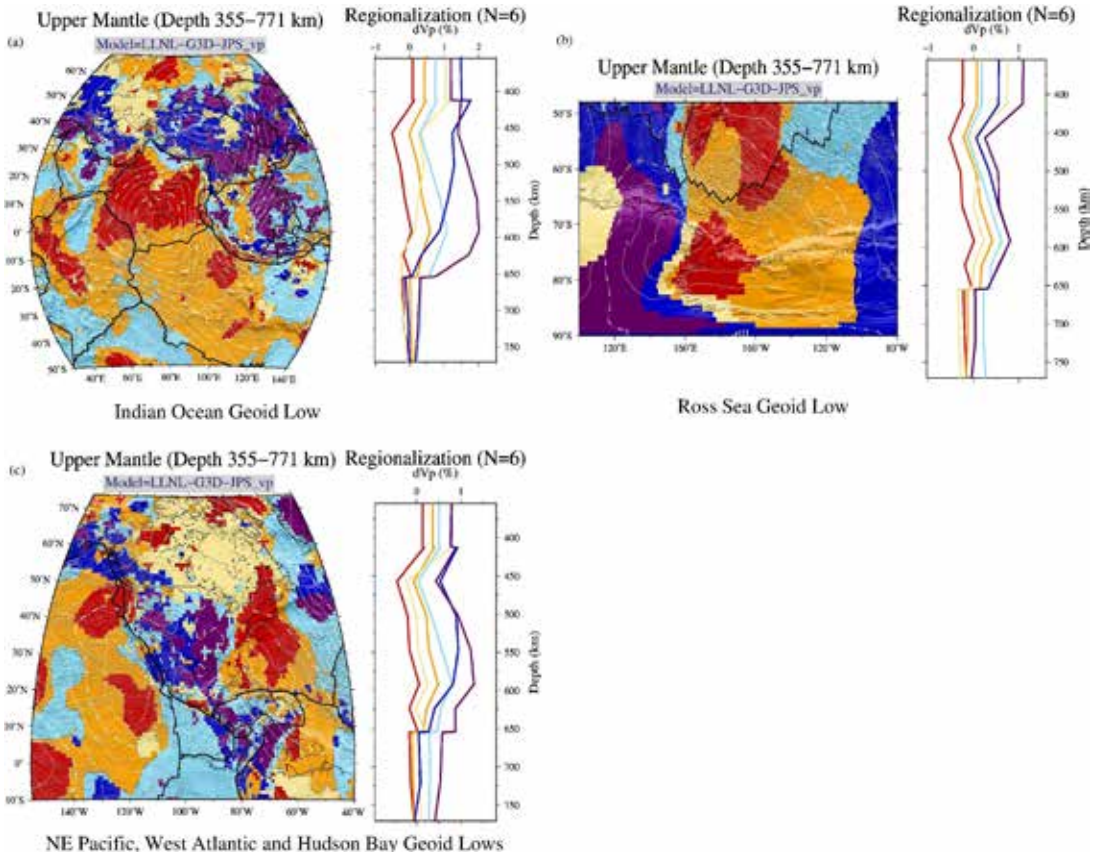


Figure 4.12 : Tectonic Regionalization of the upper mantle (350-800 km) beneath (a) Indian Ocean geoid low (b) Ross Sea geoid low, (c) NE Pacific, West Atlantic and Hudson Bay geoid low for the model LLNL-G3D-JPS. The regionalization of the lowest velocity is shown as red while highest velocity regionalization is shown as purple. The velocity profiles are shown on the right of the regionalization map.

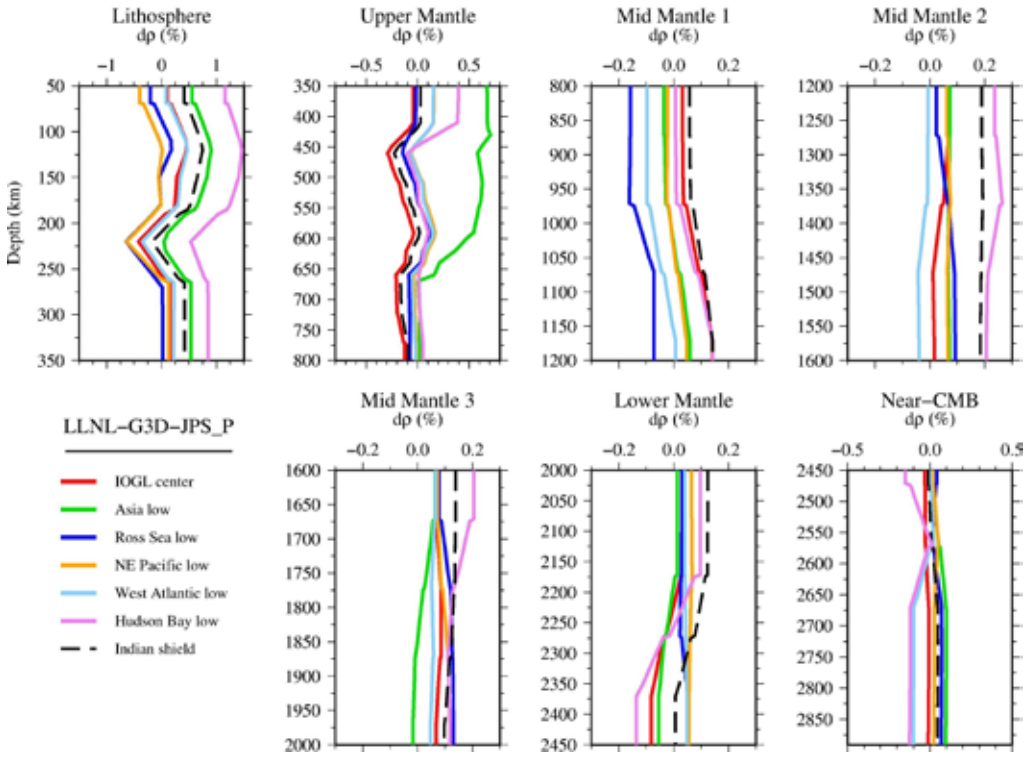


Figure 4.13 : Comparison of density profiles of the model LLNL-G3D-JPS through different geoid lows.

The salient observations of the study includes: In the upper mantle (depth 350–800 km) beneath IOGL, a combination of two different low velocity materials are observed. One has a Vs perturbations of -0.3 to -0.5% while the other has a velocity perturbations of -0.7% to -1.0%. The large negative velocity structure resides beneath the Indian Shield and the north Indian Ocean. The smaller negative magnitude velocity surrounds the large negative velocity structure and extends upto the Australian Plate (Figure 4.13). The large negative velocity structure is seen in the mid-mantle and lower mantle and is tracked to be originating from the African Large Low Shear Velocity Province (LLSVP) in the Core Mantle boundary The small magnitude negative velocity structure matches with the characteristics of mantle upwellings which were created during the Mesozoicsubduction. The presence of mantle upwellings in the upper mantle beneath Ross Sea, Northeast Pacific and West Atlantic geoid lows but not beneath Hudson Bay geoid low and Asia geoid low. The presence of high velocity structure corresponding to subducted slabs at mid, lower and lowermost mantle (1600-2891 km) beneath all geoid lows. These slabsbear evidence of subduction of the Tethys Plate (IOGL region), Phoenix Plate (Ross Sea region) and Farallon Plate (Pacific-Atlanticregion). Beneath Indian Shield there is the presence of Ceno-Tethys Plate at a depth of 800-1600 km which masks the effect of low velocity material in the upper mantle. As a result, the extreme geoid low is not seen above the Indian Shield but is seen above the north Indian Ocean only. The Asia low and Hudson Bay geoid low are caused by the deformation of the free surfacedue to the presence of the Himalaya and the pastice-sheets.

(c) Engineering Sciences

Nano Optoelectronic Sensing Platform based on Slot-waveguide for Fast and Efficient Lab-on-chip Applications: Nanophotonic on-chip slot waveguide based biosensing device is proposed. The initially proposed device consists of gold underneath the slotted silicon region and gratings over the silicon slot, which has improved the optical confinement in slot region which in turn increase the interaction of light with bio-sample. Hepatitis B surface antigen (HBsAg) is the principal marker for the diagnosis. The HBsAg is the first protein that appears in the serum after the incubation period, which confirms acute HBV infection. The device shows high sensitivity of 1200 nm/RIU for the detection of surface antigen HBsAg, with a very small FWHM of 4 nm. The engineered device is also tested for different analytes and proven its capability in

detection of analyte with RI ranging from 1.2 to 2, which covers many biosensing analytes. The proposed designs of the device consist of grating in the propagation direction which leads to a resonance a useful criterion for on-chip sensing. By measuring shift in the resonance, the analyte is detected. However, the grating-based design of the device is sensitive to fabrication errors. To overcome this issue, a new method of bio-sensing is proposed, which do not include grating structure and output is measured in terms of photocurrent instead of output wavelength spectrum resonance peak. The design of the sensor provides large fabrication tolerance with easy-to-implement sensing mechanism and a faster way of measuring the change in output sensing parameter. The experimentally tested results shows successfully detection of the E.coil bacteria in the LB media. The device can further be optimized to detect other bacteria such as Viberocholera and ShingellaFlexiniri. The materials used has such photocatalytic property which can be used for water splitting and Hydrogen reduction for cleaning of the water. The proposed device and the adopted sensing mechanism carry the potential for lab-on-chip applications in wide wavelength range of 300 nm to 500 nm with a very large difference in dark and photo currents paving a way for efficient label-free (optical) detection of various diseases. The proposed device designs can also be used for other applications e.g. optical resistive memory and modulation which are added outcomes of the present work.

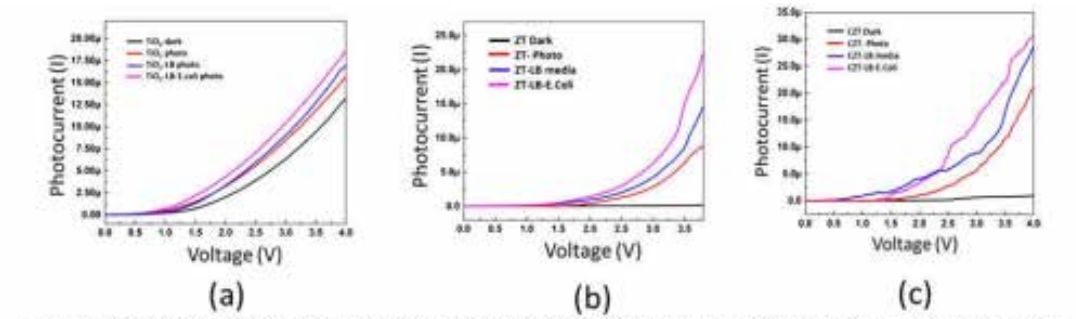


Figure 4.14 : Sensing Mechanism

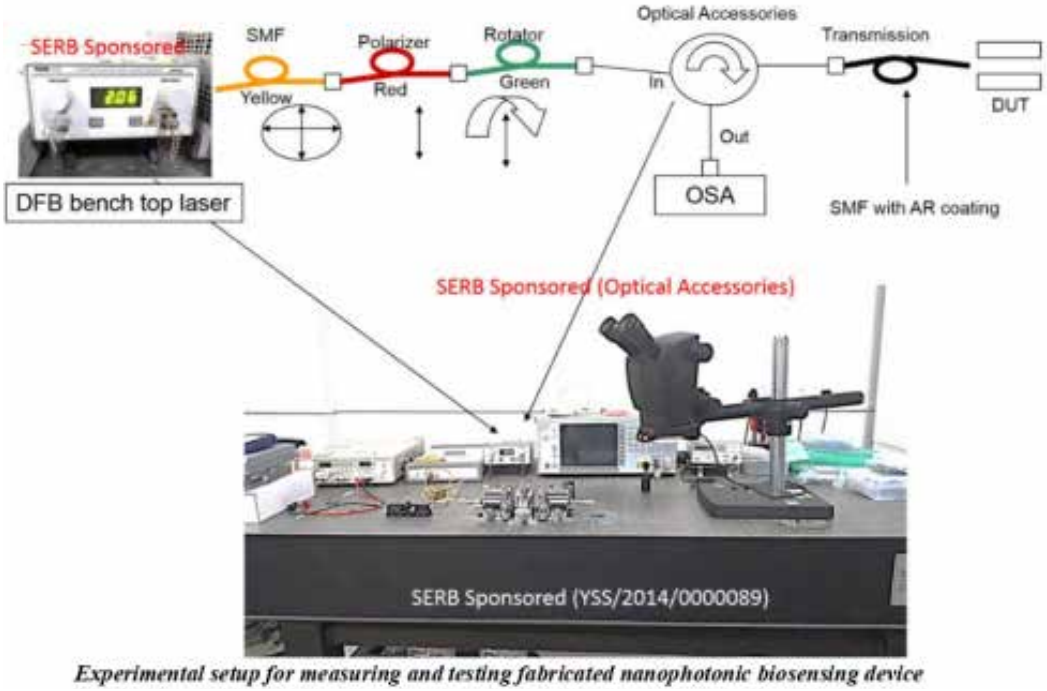


Figure 4.15 : Experimental set up for measuring and testing fabricated nanophotonic bio sensor

(d) Life Sciences

Fronto-parietal mechanisms of top-down and bottom-up visual attention : Study developed a psychophysical model for analysing behaviour in attention tasks. Human observers (n=30 subjects) performed in a multi-alternative visuospatial attention task with a "top-down" cue and behavioural choices were analysed with m-ADC model (as per Figure 4.16). The model effectively decoupled attention's effects on perceptual sensitivity from those on decisional bias, and revealed striking dissociations between. Followed to this, to test the generality of these findings across different types of attention cueing, replicated the same finding with an attention task with bottom-up cueing (n=45 subjects). Together with the results of the previous study, this study also showed that bottom-up control of attention could be subdivided into component sensory and decisional mechanisms. Study completed acquiring and analysing diffusion imaging (dMRI) data from n=22 subjects at IISc and n=60 subjects from the Human Connectome Project (HCP). Diffusion imaging (dMRI) measures the diffusion of water molecules in the brain's white matter, and with tractography, permits inferring structural connections between different brain regions. We discovered a striking relationship between SC connectivity with various cortical brain regions, including the PPC, and showed that white matter connectivity of the SC correlated with asymmetry in decisional components of attention. New methods were applied for simultaneously smoothing and reducing the dimensionality of functional MRI (fMRI) data, analysing data from 1000 subjects of the HCP database. Results showed that very slow dynamics in the fMRI data can be used to reliably infer cognitive states, and can provide putative markers for cognitive decline in patients with mild cognitive impairment and Alzheimers disease (AD) (Figure 4.17 and 4.18).

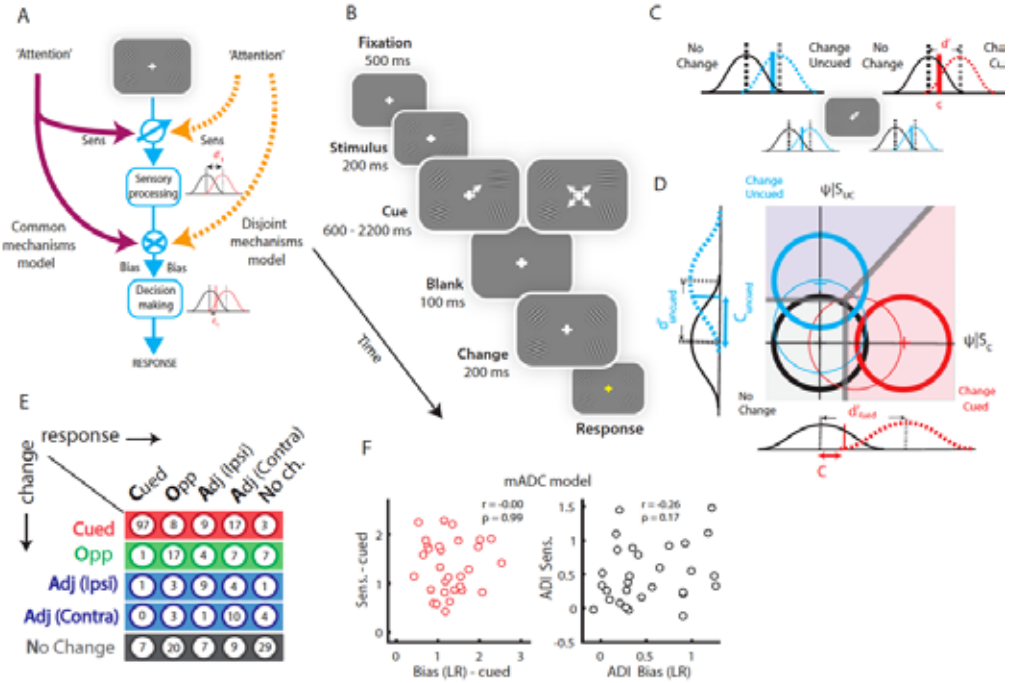


Figure 4.16 : Analysis of behavioral choices with m-ADC model

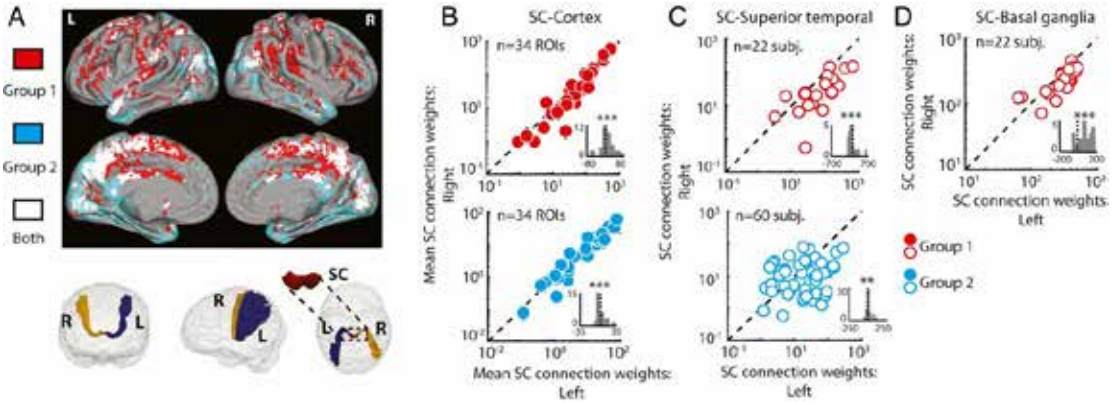


Figure 4.17 : Aratomical Connectivity of the superior colliculus with other regions of the neocorier

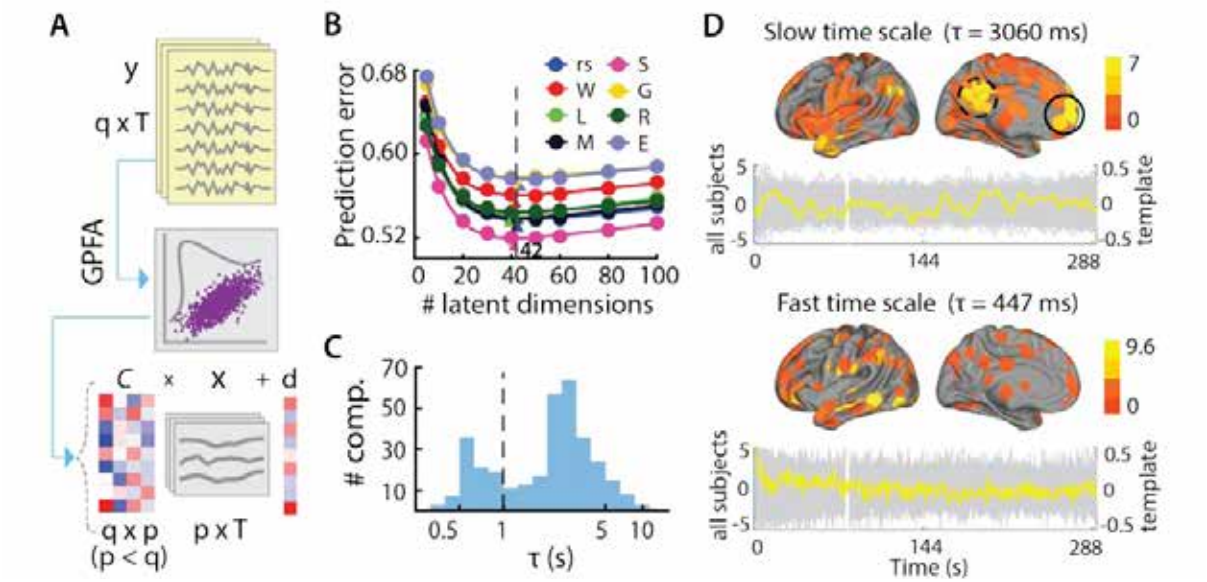


Figure 4.18 : Infra-slow dynamics Characterizing functional networks of brain regions

(e) Physical and Mathematical sciences:

Experimental investigation of polarization features of electromagnetic optical fields: In this project the study deals with probing the polarization features of electromagnetic optical fields. The effect of phase conjugation on electromagnetic fields has been studied, and found that the coherence properties start decreasing on propagation even in free space. This effect can found applications in coherence control.

Several experiments have been conducted to investigate polarization property of the electromagnetic fields. Polarization coherence theorem has been used for optical coherence engineering in the polarization and spatial degrees of freedom. Further, statistically stationary, quasi-monochromatic, partially polarized, partially spatially and temporally coherent optical beams in an intensity interferometer has been considered. A tunable degree of polarization source has been constructed using a filtered white light LED

Using intensity interferometry, it has been demonstrated that the degree of polarization, temporal electromagnetic degree of coherence and degree of cross polarization can be determined using intensity correlation method. Since an intensity interferometer is not affected by the phase variations of light fields, this interferometric method provided an easy, fast and alignment robust method for determining coherence polarization features of electromagnetic light fields.

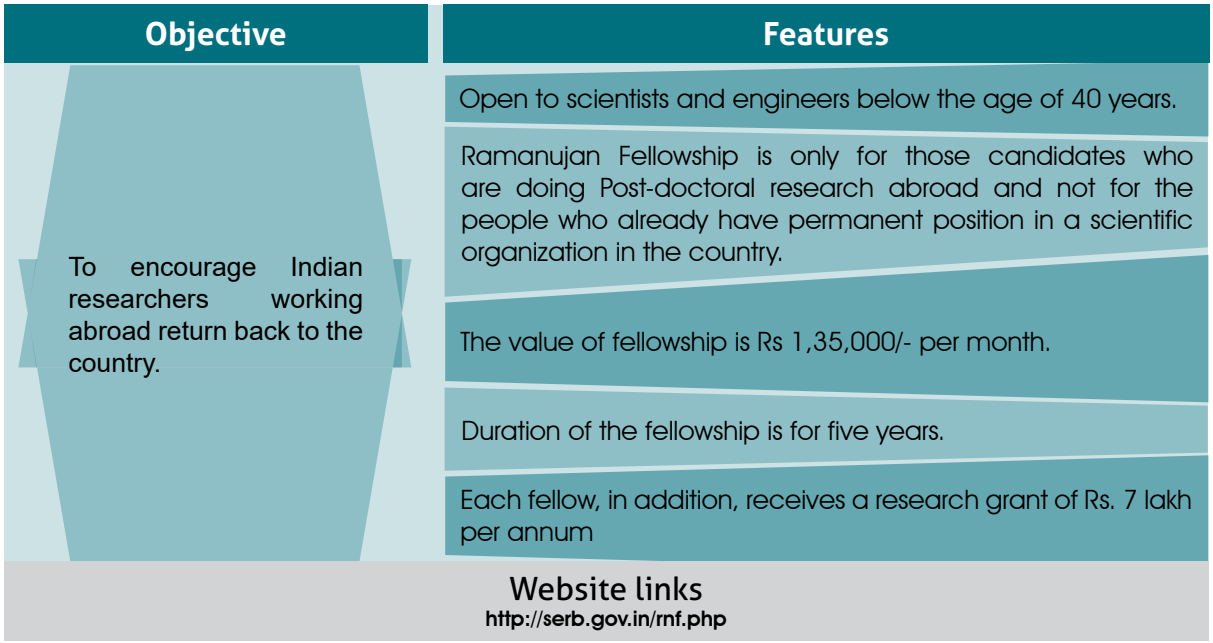
An experiment for constructing a tunable spatial coherence and polarisation source has been performed. Such source can found applications in generating arbitrary polarisation and spatial

coherence features for propagation studies in free space and turbulent atmosphere. The role of polarization manipulations has been tested experimentally in spectral shaping and switching of input spectra. For this, a nematic liquid crystal has been used, which is birefringent in nature. By controlling various degree of freedoms, which include polarization, thickness and applied voltage, it has been demonstrated that the shape of the output spectrum can be controlled. One can also achieve spectral switching (both red shift and blue shift) by controlling the applied voltage. Such spectral manipulation and switching may find applications in spectral shaping of given light fields by making variable spectral filters, and in spectral switching based data communication schemes.

The study has also been focussed to investigate hidden polarization features of unpolarized and partially polarized light fields. Using a Stokes measurement setup, variance in first and second orders of intensity has been measured. Non-zero value of variance in second order of intensity which is different for different Stokes parameters reveals the hidden polarization of such source.

4.3 RAMANUJAN FELLOWSHIP

Ramanujan Fellowship is meant for profound scientists and engineers from all over the world who return back to the country and take up scientific research positions in India.



During the year, a total of 22 Ramanujan fellowships were recommended. The awarded fellows have published several research articles in the peer-reviewed journals of high repute. Nine young sanction orders have been issued during the reporting period (Table 4.3).

Table 4.3: Summary of Ramanujan Fellowship

Broad subject area	Number of Ongoing awards	Number of awards sanctioned during 2019-20	Number of projects completed during 2019-20
Chemical sciences	35	2	3
Life Sciences	49	4	1
Phyiscal sciences	51	2	2
Mathematical sciences	8	0	0
Engineering Sciences	20	0	1
Earth & Atmospheric Sciences	7	1	1

Research Highlights

Salient research outputs emanated out one of the ongoing Ramanujan Fellow projects is summarized here under

Supernova Neutrinos: Unveiled the importance of temporal instabilities in flavor evolution, clarified conceptual issues about fast instabilities and their dispersion relations, and identified model-independent experimental tests. Most recently, gave the first self-consistent treatment of collisions and fast flavor oscillations.

Dark Matter: Discovered a helicity selection rule for the non-perturbative Sommerfeld factor for multi-state dark matter annihilation, its origin in particle exchange symmetry and phenomenological signatures, role in astrophysical dissipation, etc. Recently, proposed the paradigm of ballistic dark matter, which can show stronger clustering on small scales than even cold dark matter due to nontrivial velocity perturbations. Provided the strongest constraints on low-mass WIMPs.

Neutrino Cosmology: Gave the most detailed treatment, including all relevant interactions, quantum Zeno effect, three-flavor effect, etc., of whether secret interactions can reconcile eV-scale large-mixing sterile neutrinos with null evidence for sterile neutrinos in cosmological data.

4.4 SERB RESEARCH SCIENTISTS (SRS)

In 2018-19, a scheme called SERB Research Scientists (SRS) was originated from SERB, aiming to provide a platform for sustainment of research careers of INSPIRE Faculty and Ramanujan Fellows for an additional period of two years. The scheme is open only to INSPIRE Faculty and Ramanujan Fellows, wherein the applicants should have completed the tenure of INSPIRE Faculty Award/ Ramanujan Fellowship or nearing its completion. 5 awards were conferred in the reporting period.

Some of the key findings from a project that was supported under the SERB Research Scientists (SRS) Scheme:

Porphyrazine-sensitized solar cells - Rational Molecular Design, Photoinduced Processes, Panchromatic Sensitization and Devices:

Zinc titanates (especially $ZnTiO_3$) are intriguing materials that are used as catalysts, pigments and dielectric materials. However, the utilization of $ZnTiO_3$ in solar energy conversion is relatively less studied. In this SRS project (PI Dr. A. Kathiravan), photoinduced electron injection dynamics of porphyrin dye with cubic $ZnTiO_3$ was studied. The electron injection rate is substantially higher for $ZnTiO_3$ nanomaterials than TiO_2 due to better electron–hole separation in $ZnTiO_3$. This provides an impetus to further explore $ZnTiO_3$ nanoparticles as possible semiconductors of choice for dye sensitized solar cells (DSC) applications.

The group has developed D-D'-A structured dye that consists of N-aryl-substituted imidazole as donor (D) with N-alkylated carbazole as auxiliary donor (D') and cyanoacrylic acid as an acceptor (A). The DSCs based on the dye demonstrates a significantly high cell performance of without any co-adsorbents. Notably, the overall conversion efficiency of D-D'-A dye reached 50% with respect to that of N719-based device (4.12%) under the identical experimental conditions (Figure 4.19).

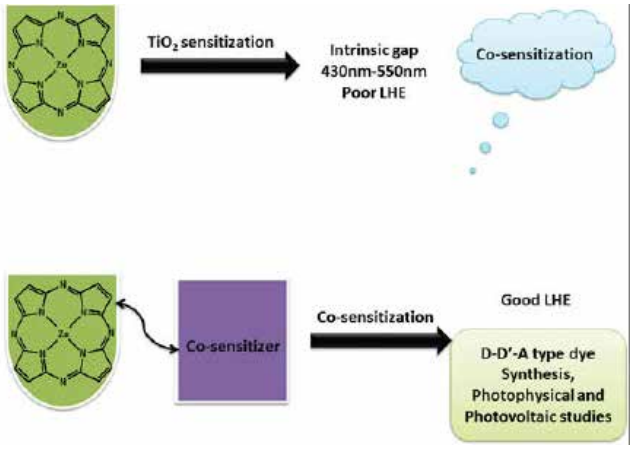


Figure 4.19 : Photo induced electron injection dynamics of porphyrin dye with cubic $ZnTiO_3$

5 BUILDING RESEARCH NETWORKS

With an intention of building more opportunities for research collaboration and advance training SERB has developed various domestic and overseas research networks for several segments of research fraternity. It encompasses doctoral and postdoctoral training programmes, industry-oriented projects, sectoral intensive schemes etc.

5.1 NATIONAL COLLABORATIONS

5.1.1 IMPacting Research INnovation and Technology (IMPRINT-II) Programme

Objective	Features
To address major engineering challenges that our country must address and champion to enable, empower and embolden the nation for inclusive growth and self-dependent. This novel initiative with a two-fold mandate is aimed at: Developing new engineering education policy and creating a road map to pursue engineering challenges. IMPRINT provides the overarching vision that guides research into areas that are predominantly socially relevant.	IMPRINT-II is a joint initiative by Ministry of Human Resource Development (MHRD) and Department of Science and Technology (DST) which is being implemented by SERB The principal objective of the scheme is to translate knowledge into a viable technology MHRD and DST/SERB are equal partners to steer the scheme IMPRINT is open to all MHRD funded Higher Educational Institutions (HEIs) / Centrally Funded Technical Institutions (CFTIs) Industry support and partnership is mandatory

Website links

http://www.serb.gov.in/irit.php
https://www.serbonline.in/SERB/IMPRINT2C
https://imprint-india.org/imprint-2

A unique national initiative called Impacting Research, Innovation and Technology (IMPRINT) has been launched by the Ministry of Human Resource Development (MHRD), Government of India (GoI) to address all major engineering challenges relevant to India through an inclusive and sustainable mode of translational research steered by the top engineering institutions in the country. Ten technology domains have been identified under IMPRINT that could substantially impact the quality, safety and security of life both in urban and rural areas, namely: (1)

Healthcare, (2) Energy, (3) Sustainable Habitat, (4) Nano Technology hardware, (5) Water resources and river systems, (6) Advanced materials, (7) Information and Communication Technology, (8) Manufacturing, (9) Security and Defence, and (10) Environmental Science and Climate change. IMPRINT-II with a revised strategy has been initiated by MHRD in partnership with DST/ SERB. The principal objective of IMPRINT-II is to address all major engineering challenges faced by the nation by translating knowledge into viable technology (product/process). An announcement was made for inviting preliminary proposals on March 2018. A total no of 2145 proposals was received (IMPRINT – II A&B) out of which 126 proposals were recommended.

The next round of IMPRINT-II, called IMPRINT IIC-1 (Societal Mission Projects) was launched aiming to seek proposals related to 20 highly specific technology development themes of major societal relevance/benefit, selected from the areas identified by various ministries. In these projects, at least 25% of the project cost should be supported by the industry out of which at least 10 % of the project cost should be in cash. An announcement on IMPRINT-IIC-1 was made for inviting preliminary proposals in December 2018. A total of 499 proposals were received and after first screening 144 detailed proposals have been received. The detailed proposals were again considered by the Expert Committee and finally, 57 proposals were recommended for financial support and out of these 51 proposals have already been sanctioned in the reporting financial year (Table 5.1).

Table 5.1 : Domain wise proposals submitted and sanctioned in IMPRINT-IIC-1

S. No.	Domain name	No. of Proposals Submitted	No. of proposals approved	No. of proposals sanctioned
1.	Environmental Science & Climate Change	50	1	1
2.	Energy Security	77	14	14
3.	Healthcare Technology	113	4	4
4.	Sustainable Habitat	15	2	2
5.	Water Resources & River Systems	18	3	3
6.	Advanced Materials	40	7	6
7.	Information & Communication Technology	73	14	13
8.	Manufacturing	52	5	2
9.	Nano Technology Hardware	28	5	4
10.	Security & Defence	33	2	2
Total		499	57	51

A modified consortium approach is proposed in the IMPRINT IIC (IMPRINT-IIC-2) programme to include strong and complementary expertise from across different disciplines to address major technological breakthrough in designated areas of societal/industrial importance. It is expected that the consortium upholds Inter-disciplinarily that brings the power of togetherness from diverse knowledge and competence; complementarity that brings the uniqueness of the partners for collective benefit and is ready to work under one leader as PI. **There should be at least two Institutes / Universities and two Industries involved in the Consortia.** SERB has announced the themes and challenge the scientific community to undertake major challenges concerning the society. The lead institute should also illustrate a sustainability plan in the proposal beyond the approved duration for the long-term impact of the consortium. A call for proposal has been announced in the last week of March 2020.

This is also to be noted that a complete IMPRINT-II program has been implemented online. A Knowledge Portal for IMPRINT-II program has also been created and available in the public domain http://www.imprint-2.in/Imprint-II/HomePage.

5.1.2 Prime Minister's Fellowship Programme for Doctoral Research

Objective	Features
To steer talent for doctoral research, and encourage industrial research in academic institutions. The scheme ensures highest exposure to industry relevant research for doctoral students and also provides mentoring through industry and academic experts.	The applicant should be a full-time PhD scholar in any recognized Indian university / institute / research laboratory. The applicant should have a valid industry partner who should be ready to support the research project financially as well as provide guidance and mentorship. The mutually agreed topic of research, between the applicant and the supporting company, should be innovative, have practical relevance and industrial application. The scheme has the provision to award up to 100 new scholarships every year, of up to Rs 8.7 lakh per annum per candidate. 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. The scheme is being implemented in partnership with CII and FICCI.

Website links

http://serb.gov.in/pmfdr.php
www.serbficci-iirrada.in
www.primeministerfellowshipscheme.in

A total of 47 Fellowships awarded in the reporting period. In addition, 122 fellows are pursuing research under the scheme.

Table 5.2 : Summary of Prime Minister's Fellowship for Doctoral Research

Broad subject area	Number of Ongoing Fellowship	Number of Fellowships sanctioned during 2019-20	Number of Fellowships completed during 2019-20
Chemical sciences	16	6	0
Life Sciences	47	18	7
Physical sciences	2	2	0
Mathematical sciences	-	-	0
Engineering Sciences	56	20	7
Earth and Atmospheric Sciences	1	1	0

Research Highlights

An On-Chip NEMS Switch Integration with CMOS for reducing the stand-by leakage for Mobile applications

The stand-*by* leakage power has become comparable to the average ON-state power in nano-scale low power electronic applications such as battery-operated mobile applications, power management circuits and wireless sensor nodes. The static energy dissipation amounts to significant percentage of the total energy consumed in a digital chip. Therefore, continuous innovation in the device is needed to address the concerns of static energy consumption in the future.

Power gating is a common circuit technique used to reduce the leakage power by inserting an additional switch in series with the digital circuit block and is turned OFF during the idle time. However, it is very difficult to achieve lower leakage with existing devices rather it keeps on increasing with the improvement in technology. The leakage path between supply and ground will be completely eliminated only with an ideal switch. One of the drawbacks of power gating is the reduced effective supply voltage across the digital block due to drop across the power gated switch resistance, which in turn increases the circuit delay of the logic block. The power gating technique entails a tradeoff between the incurred delay and saving in the leakage power. The former needs a larger width transistor in the ON-state to reduce the drop across the switch, while the later needs a shorter width transistor in the OFF-state so, as to have a low leakage current.

With the conventional transistor, it is easy to reduce the ON-state resistance by adding multiple units in parallel, but the OFF-state leakage in turn increases a lot. Nano-electro-mechanical switches (NEMS) in principal can offer close to infinite resistance in the OFF-state. So with NEMS power gating switches, the ON-state performance can be improved without increasing the leakage current during the OFF-state, which eventually breaks the tradeoff mentioned earlier.

5.1.3 R&D Scheme of Ministry of Food Processing Industries in partnership with MoFPI

Objective	Features
	Ministry of Food Processing Industries has approached Science & Engineering Research Board (SERB) In order to implement its Research & Development Scheme in the area of food processing. Subsequently SERB started handling the R&D scheme of MoFPI from the financial year, 2012-13 through its effective functional mechanisms. However, currently, no new proposals are being accepted under this scheme.

Website links

http://serb.gov.in/pdi.php

Research Highlights

Intensified Recovery of Valuable Products from Whey using Ultrasound (SERB/MOFPI/056/2015)

A researcher from IIT Mumbai, implemented the above project. Recovery of valuable products such as proteins and lactose from dairy industry effluents offers promise due to the value addition and reduction in the environmental concerns. The project includes the effect of pretreatment of whey, enhanced recovery of whey proteins, Lactose sonocrystallization and value addition, ultrasound assisted ultrafiltration and reconstituted lactose sonocrystallization for intensified recovery of lactose and enhanced recovery of whey proteins. For pretreatment study, Ultrasonic horn (20 kHz) with varying power levels over the range of 100 W to 250 W has been used at 80 % duty cycle and three different levels of ultrasonic exposure as 5, 10 and 15min. Combined pretreatment using ultrasound and heating i.e. thermosonication resulted in maximum recovery as 94.6%. Detailed understanding into the effect of different pretreatment conditions allowed for maximizing the recovery of lactose. Fractionation of whey into permeates stream containing lactose and retentate stream containing proteins and the subsequent recovery as WPC using spray drying was investigated in the present work. It was observed that about 80% fouling was reduced with the use of ultrasound. 10 KDa hydrosart membrane showed maximum recovery of the proteins and lactose. Optimization of spray drying was performed under different conditions and it was observed that lowest aspirator RPM (1350) and highest protein concentration gave best results at pressure of 3 bar. Spray drying was also performed with ultrasonic nozzle showing better uniform particle size distribution. Overall it was clearly established that optimization of all the processing steps gave better yield and concentration in the final WPC. Ultrasonic horn (22 kHz) with varying power levels over the range of 40 W to 120 W has been used for experiments at 100 % duty cycle and two different levels of ultrasonic exposure for 10 min and 20 min. It was established that the maximum lactose recovery obtained was ~98% using ultrasonic horn while the maximum lactose purity was ~97%. The work has enabled to understand the optimized application of ultrasound so as to maximize both the lactose yield and purity from whey. It was observed that the maximum process intensification obtained by introduction of ultrasound in the lactose hydrolysis process performed at 70 °C and 3 N HCl was reduction in the required time for ~90% hydrolysis from 4 h (without ultrasound) to 3 h. The work has established that use of recovered lactose from whey samples instead of pure lactose did not result in any significant changes in the progress of hydrolysis, confirming the efficacy of the selected approach. Comparison using different US approach and effect of Dual frequency reactor and US probe system was investigated. It has been established that better membrane cleaning and reduced fouling was obtained using US reactor compared to US probe system. Similarly, Dual frequency US Produced higher cavitational activity (due to mutual influence of frequencies) as compared to single frequency US and thus, enhanced permeate flux was obtained using dual frequency US with 300 W being the optimal power level corresponding to higher lactose recovery (Figure 5.1). Further, Reconstituted Lactose Sonocrystallization was studied for optimization of the process for further scale up aspects. Comparison using different US approach such as US probe, US single frequency bath and US dual frequency reactor system was studied for maximizing the recovery of lactose and understanding the effect of frequency mode on lactose recovery. Dual frequency US produces more cavitational activity compared to single frequency US thus, intensifying the lactose recovery process even at low energy densities. The salient outcomes of the project are summarized here under;

- The possible benefits of application of ultrasound were established as reduced treatment times, better quality products as well as reduced requirement of chemicals.
- For spray drying, particle size increased with an increase in the aspirator RPM. Thus, lowest aspirator RPM of 1350 was optimum with respect to yield and particle size.
- Final samples of WPC gave best results with the use of ultrasound during ultrafiltration with 10 KDa hydrosart membrane at 1.2 TMPs as 45.36 % protein content (Figure 5.2).
- For lactose sonocrystallization, Lactose recovery as well as purity increased with an increase in ultrasonic power levels from 40 W to 120 W for 10 min while it decreased for 20 min of ultrasonic horn exposure, which might be due to degradation of lactose by prolonged exposure to the ultrasonic cavitation.

- Ultrasound assisted ultrafiltration showed maximum permeate recovery of 95.99 % at 300W as optimized power level using dual frequency ultrasound reactor.
- For higher scale experiments, reconstituted lactose sonocrystallization recovery of 87.87 % has been obtained using US bath (25 kHz) while recovery of 91.35 % has been obtained using dual frequency (22+44 kHz) US bath at lower energy density compared to single frequency US bath.
- Better energy distribution with transducers mounted on the four walls of US bath (as in case of dual frequency US bath) compared to transducers at the bottom of the bath (as in US bath, 25 kHz) might be the reason for higher lactose recovery at dual frequency US.

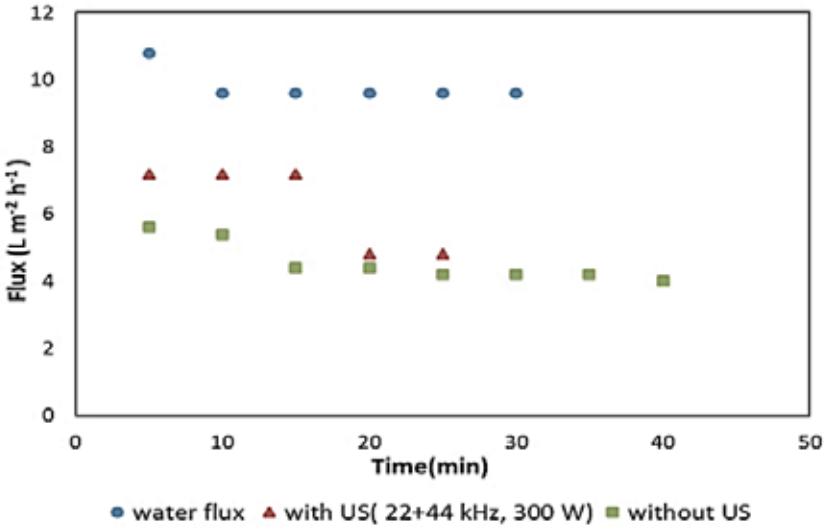


Figure 5.1 : Effect of dual frequency ultrasound on permeate flux for whey ultrafiltration. *Water flux for initial 30 min water wash, **US +UF using dual frequency US and without US results for 100 ml sample filtration

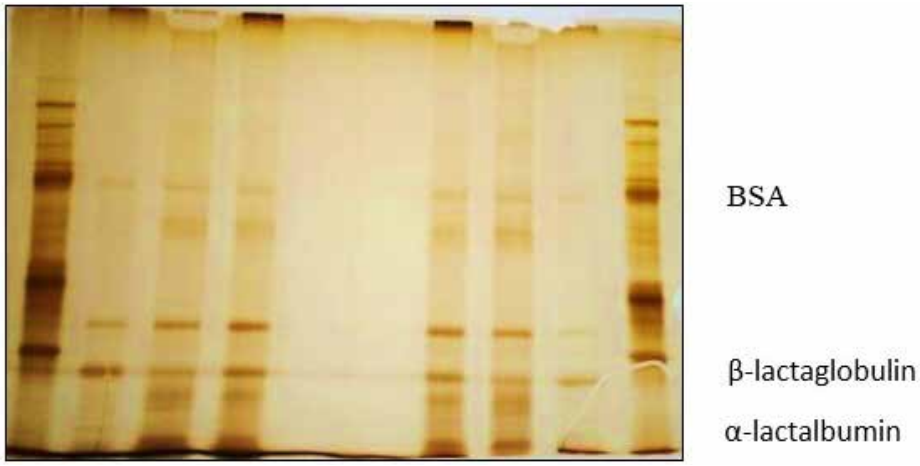


Figure 5.2 : SDS-PAGE of spray dried whey protein confirming presence of all whey protein constituents.

Innovations

- Developed enhanced process for recovery of proteins based on the use of ultrasound as a process intensification approach and spray drying using ultrasonic nozzle.
- Developed pretreatment process for whey to maximize the permeate flux and demonstration of ultrasound intensified recovery of lactose with maintenance of the required purity levels.

Potential Outcome/Deliverables/ Achievements

- Improved pretreatment processes for enhancing the stability of whey and avoiding fouling in the membrane separations

for intensified recovery of lactose from whey using the anti-solvent assisted sonocrystallization.

- Improved ultrafiltration using ultrasound for enhanced permeate flux, reduced fouling and maximum lactose recovery.

5.1.4 UCHHATAR AVISHKAR YOJANA (UAY)

The Uchhatar Avishkar Yojana (UAY) has been launched by the Ministry of Human Resource Development (MHRD) with a view to promote 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 are funded. While MHRD funds 50% of the project cost, industry and other participating Ministries share the balance project cost (25% each). SERB is partnering with MHRD in funding UAY projects. Financial sanctions issued to total 40 projects under UAY-Phase-I and Phase-II during the financial year.

5.2 INTERNATIONAL COLLABORATIONS

5.2.1 SERB NEWTON - BHABHA INTERNATIONAL FELLOWSHIPS

Objective

The Scheme encourages and support increased research capacity in the area of research and innovation at the postdoctoral level under the People strand of Newton Bhabha Programme.

Features

The Royal Society of the United Kingdom and SERB signed a MoU to encourage and support increased research capacity in the area of research and innovation.The resulted scheme known as Newton - Bhabha International Fellowships which cover fields of Science, Technology, Engineering and Mathematics (STEM) was welcomed extensively by the Indian research community.

As per the MoU, SERB along with the Royal Society supports 15 fellowships per year.

The awards are given up to two consecutive years in length spent in the UK, undertaking research at a host university or research institute. The awards provide a stipend, research expenses and one-off relocation expenses and provide up to an amount of £99,000 for two years.

All applicants must identify a UK co-applicant who will host them whilst they are in the UK.

Website links

http://www.serb.gov.in/snbi.php

Fifteen researchers have been offered the fellowship in the reporting period (Table 5.3).

Table 5.3 : Summary of SERB Newton - Bhabha International Fellowships

S. No.	Number of Ongoing awards	Number of awards sanctioned during 2019-20	Number of projects completed during 2019-20
1	15	15	14

5.2.2 SERB OVERSEAS DOCTORAL FELLOWSHIP

Objective	Features
The Scheme aims to build national capacity in frontier areas of Science and Engineering by giving opportunities to Indian students to undertake doctoral research in specific overseas institutions with which SERB had signed an agreement.	The applicant should be an Indian and have completed eligible degree in India (Bachelor/Postgraduate) in Science or Engineering (including Medicine, Pharma, Agriculture and related S&T areas) not earlier than preceding two years. Selected fellows are provided US $24,000 per annum for a period of 4 years. One-time Contingency/Preparatory allowance of Rs. 60,000/- and to &fro Airfare (Economy) is also given to the fellows. SERB has entered MoU with Cambridge University, United Kingdom and The University of British Columbia, Canada, and US Universities: Stanford University, University of Southern California, Carnegie MellonUniversity, University of California, Rice University and University at Buffalo, The State University of New York. The hallmark of the alliance is that through the MoU it is ensured that each and every SERB Overseas Doctoral Fellow will be getting tuition fee support / waiver from the University concerned. The selected candidate is required to execute a bond on a non-judicial stamp paper of Rs.100/- before a notary-public/ Oath of Commissioner as per specimen bond of SERB. The candidates are required to return to India after completion of their Ph.D.

Website links

http://www.serb.gov.in/odf.php

7 fellowships have been sacntioned during the reporting period (Table 5.4).

Table 5.4 : Summary of SERB Overseas Doctoral Fellowship

S. No.	Program	Number of Ongoing awards	Number of awards sanctioned during 2019-20	Number of projects completed during 2019-20
1	SERB – UBC ODF	15	3	0

S. No.	Program	Number of Ongoing awards	Number of awards sanctioned during 2019-20	Number of projects completed during 2019-20
2	Cambridge India Ramanujan Scholarship	14	3	0
3	SERB- RICE University ODF	5	1	0
4	SERB – UCI ODF	3	0	0
5	SERB – CMU ODF	1	0	0

5.2.3 SERB OVERSEAS VISITING DOCTORAL FELLOWSHIP

Objective

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

Features

The applicant should have registered for full-time Ph.D. Degree in any of the recognized Institutions / Universities in India in Science, Technology, Engineering and Mathematics (including Medicine, Pharma, Agriculture and related S&T areas) disciplines.

The scholars should apply directly to universities with which SERB has signed MoU for Overseas Visiting Doctoral fellowship i.e University of Purdue, USA and University of Alberta, Canada.

Website links

https://www.serbonline.in/SERB/ovdf

(i) Under the SERB-Purdue University OVDF program 25 students were selected.
(ii) Under the SERB-UAlberta OVDF scheme 10 students were selected.

5.2.4 VAJRA (Visiting Advanced Joint Research) Faculty Scheme

Objective	Features
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 professional to undertake high quality collaborative research in public funded academic and research Institutions in India. The Scheme facilitate 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 stimulate the latent potential of our academic and research sector.	The scheme is open to overseas scientists, faculty members and R&D professionals including Non-resident Indians (NRI) and Overseas Citizen of India (OCI). The overseas scientist or faculty should be an active researcher working in a leading academic / research / industrial organization with significant accomplishments in research and development. Indian Collaborator(s) should be a regular faculty/researcher in public-funded academic/research institutions with significant ongoing research in the area of VAJRA Faculty. The initial assignment will be for a period of one year extendable to subsequent years based on the collaborative outcome and interest. The residency period of VAJRA Faculty in the host institution would be for a minimum of 1 month and a maximum of 3 months every year. VAJRA Faculty will be provided US$15000 in the first month of residence and US$10000 in each of the subsequent month. No separate support is provided for travel, accommodation, medical / personal insurance etc. However, the host institution may consider providing additional support for e.g. highly subsidised on-campus / nearby off-campus accommodation.

Website links

http://www.serb.gov.in/vajra.php
https://www.serbonline.in/SERB/vajra
http://www.vajra-india.in

During the reporting period 8 accomplished scientists have been offered VAJRA Facultyship. From the earlier batch, 9 scientists had made their collaborative research visits. Taking note of the value of ongoing engagement of the VAJRA Faculty with the Indian scientists, SERB has approved 27 renewal applications for second term for a period of one year (Table 5.5).

Table 5.5 : Summary of VAJRA Faculty Scheme

S. No.	Number of Ongoing awards	Number of awards approved during 2019-20	Number of visits made by the awardees during 2019-20
1	46	8	9 VAJRA Faculty made multiple visits

Some of the significant research leads out of the engagements are given below:

- Under the supervision of the VAJRA Faculty, the group at IIT Bombay had developed the set-up for recording transmission, Raman and PI spectra through individual nano-gaps. The group could learn novel fabrication technique and light-matter interactions on nanoscale.
- The Finite Element biomechanical models of the total hip replacement (THR) developed in the collaboration of the VAJRA Faculty and the group at IISc, Bengaluru have provided key insights for guiding the design of the prosthetic attributes of hip implants. It was found that the acetabular liner exhibited the highest probability for mechanical failure. This study established the biomechanical effects of pre-clinically tested acetabular liners of various compositions and femoral head size/properties and interfacial friction on stress/deformation response at the bearing surfaces in case of cemented THR, for different subject weights.
- The TIFR Group at Mumbai with the VAJRA Faculty explored the Raman spectra of protein within the evanescent plasmonic field of illuminated metal nanoparticles and observed field-induced enhanced scattering. It was probed whether specific types of neurotransmitters make the cell membrane more vulnerable to amyloid attacks. The observations are very significant in the context of cell-type specific nature of amyloid diseases such as Alzheimer's disease.
- As a direct result of the VAJRA collaboration undertaken at Indian Institute of Technology Gandhinagar, the VAJRA faculty and Indian lead collaborator together made a potentially profound discovery. Working on the Dual Origins of Gravity the researchers discovered a new equation that was a hybrid of the traditional first law of thermodynamics and the black hole-like first law in that it was locally valid and yet included gravitational entropy.
- Working on Quantum Metrology, Open Quantum Systems and Quantum Information Systems, the VAJRA group at The Institute of Mathematical Sciences, Chennai has put forward a novel estimation scheme for the coin parameter and evaluated the ultimate quantum limits to precision for the class of estimation protocols.
- For water-cooled single-phase flow heat-sink designs, a significant temperature mal-distribution cause (not related to inlet plenum) has been identified the group at IIT Indore with the VAJRA Faculty. This one is associated with approximately insulated side-edge thermal boundary conditions (where heat-sink is exposed to convection to air). This identification has led to definition of a mitigation approach that is to be deployed in the proposed new multi-channel heat-sink design approach based on Michigan Tech's new flow-boiling approach.

6 AWARD & RECOGNITIONS

One of the vital activities of SERB is to provide recognition to brilliant young scientists, active superannuated scientists, professors and engineers through several fellowships and awards for their remarkable contributions in the field of Science and Technology. The goal is to motivate the scientists to aspire for excellence in scientific R & D.

6.1 J C BOSE FELLOWSHIP

J C Bose Fellowship is instituted to recognize active scientists and engineers for their outstanding performance and contributions. These fellowships are scientist–specific, very selective and are open to Indian nationals residing in India, with upper age limit of 68 years. The value of the fellowship is Rs. 25,000/- per month in addition to the fellow's regular income. For Research grant Rs. 15 lakh per annum is provided for a period of 5 years. During this year, a total of 30 fellows were awarded with J C Bose fellowship.

Objective	Features
The JC Bose Fellowship is meant to recognize active scientists for their outstanding performance.	Fellow should be in service at the time of submission of nomination. The fellowship amount is Rs. 25,000 per month in addition to regular income. Research grant of Rs. 15.00 lakh per annum. Overhead of Rs.1.00 lakh per annum to the host institute. The duration of the fellowship will be initially for five years.

Website links
http://serb.gov.in/jcbn.php

A total of 31 eminent scientists / academicians were sanctioned with JC Bose Fellowship for the reporting period (Table 6.1).

Table 6.1 : Summary of JC Bose Fellowship

Broad subject area	Number of Ongoing awards	Number of awards sanctioned during 2019-20	Number of projects completed during 2019-20
Chemical sciences	45	6	8
Life Sciences	86	14	12
Phyiscal sciences	34	5	6
Mathematical sciences	11	-	1
Engineering Sciences	37	5	3
Earth & Atmospheric Sciences	12	1	1

Research Highlights

Salient research outputs emanated out one of the ongoing JC Bose Fellow projects is summarized here under

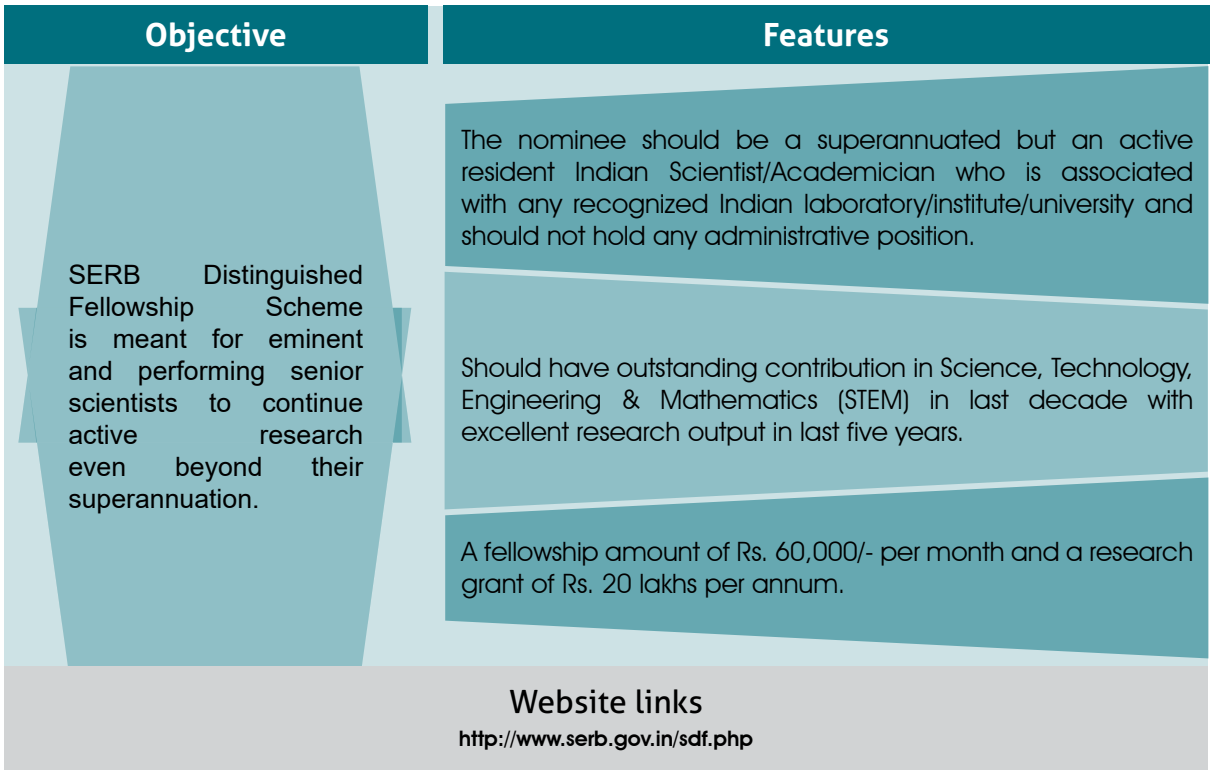
(i) PI has developed a series of In-MOFs and shown how subtle variations in the structures of the linkers leads to closely-related MOFs with different topologies and the results are published in Applied Materials Today 2020. (ii) Exemplified access to a luminescent Zn-MOF based on on a semi-rigid dibenzochrysene tetraacetic acid Linker by a Zn-MOF for sensing of herbicides in water and published in Inorganic Chemistry 2020. and iii) demonstrated how 2D metal-organic nanosheets (MONs) with redox switching capability can be engineered and the paper appeared in (Chemistry – European Journal 2019). In continuation of the latter, fellow has transitioned into developing likewise more robust and chemically-inert porous organic polymers (POPs) for application in catalysis. It is also shown that Aldol condensation can be exploited to develop covalent and porous organic polymers endowed with a, b-unsaturated carbonyl functionalities. The latter can be exploited to stabilize Pd nanoparticles such that Pd-imbedded POPs can be applied for catalysis of a number of reactions in a recyclable fashion. It is also demonstrated that Pd@POP can be applied as heterogenous catalysts for a) reductions, ii) coupling reactions, iii) hydrogenations and iv) cascade reactions in a recyclable manner (Journal of Catalysis 2020). Fellow has also demonstrated that oxidation chemistry with IBX can be extended to the synthesis of i) isatins, invaluable synthetic intermediates, starting from readily-available indoles (Tetrahedron 2019) and ii) a number of 4-carboalkoxy-Substituted Benzo[h]coumarins from α- and β-naphthols and established their excited-state properties in a comprehensive manner (ACS Omega 2020).

6.2 NATIONAL SCIENCE CHAIR

The main aim of the scheme is to reward 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. Since the selection criteria and type of awards in YoSCP and DF are somewhat similar, both the schemes have been merged, to constitute the new scheme National Science Chair (NSC). Five (5) National Chairs were awarded during the reporting time.

6.3 SERB DISTINGUISHED FELLOWSHIP (DF)

This fellowship is for active senior scientists who are passionate about research and find it extremely difficult to continue their research after superannuation and are forced to stop their research against their choice. The great amount of knowledge and more importantly the experience that they have accumulated over the years, which may be considered as a non-replaceable treasure, can be lost if some avenues are not made available to them. In order to support research of such eminent scientists, who do not hold any administrative roles and functions but are active and performing, SERB has instituted Distinguished Fellowship Award.



A total of Twelve (12) ongoing awards were supported and Six (6) new awards were sanctioned during the reporting period. This includes 1 fellowships under physical, 2 engineering, 1 earth and 2 biological sciences discipline (Table 6.2).

Table 6.2 : Summary of SERB Distinguished Fellowship

Number of Ongoing awards	Number of awards sanctioned during 19-20	Number of projects completed during 19-20
12	6	1

6.4 SERB SCIENCE AND TECHNOLOGY AWARD FOR RESEARCH (SERB-STAR)

First Call for Nominations under SERB-STAR was made during November-December, 2019. The meeting of Committee to evaluate Project Completion Reports for SERB-STAR was held on 21st January 2020 at Delhi. During the meeting, 142 Project Completion Reports (PCR) of PIs who were nominated for SERB STAR were evaluated. 40 PCRs were rated Excellent by the Committee.1st Meeting of the Award Committee for SERB Science and Technology Award for Research (SERB-STAR) was held on 29th January 2020 at Delhi. Committee deliberated and finalized the Awardees based upon a) PIs overall research accomplishments and b) Quality of Publications. 7 (Seven) Awardees were finally selected among the 40 (Forty) 'Excellent' rated projects for the year 2019 (Table 6.3).

Table 6.3 : Summary of SERB Science and Technology Award for Research

Broad Subject Area	Number of Ongoing Awards	Number of Awards Sanctioned During 2019-20	Number of Projects Completed During 2019-20
Chemical sciences	-	3	-
Life Sciences	-	1	-
Physical sciences	-	-	-

Broad Subject Area	Number of Ongoing Awards	Number of Awards Sanctioned During 2019-20	Number of Projects Completed During 2019-20
Mathematical sciences	-	-	-
Engineering Sciences	-	3	-

6.5 SERB WOMEN EXCELLENCE AWARD

Objective	Features
To recognize and honour extraordinary women of outstanding professional excellence across the country for their remarkable contribution in science and engineering.	The research grant is Rs.5.00 lakh per annum for a period of 3 years. Applicant age should be below 40 at the time of application

Website links

http://www.serb.gov.in/rnf.php

SERB Women Excellence Award is a one-time award given to women scientists below 40 years of age and who have received recognition from any one or more of the following national academies such as Young Scientist Medal, Young Associate etc.

- Indian National Science Academy, New Delhi
- Indian Academy of Science, Bangalore
- 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

During the year total 30 applications were received out of which 14 awards were conferred to the women scientists. Among them top three awardee were facilitated during National Science Day (28th February, 2020) by our Honorable President of India Shri Ram Nath Kovindji. Awardees are from Animal, Plant, Earth, Mathamatical, Physical Sciences, Environmental Engineering, Organic Chemistry and Biophysics Biochemistry and Molecular biology (Table 6.4).

Table 6.4 Summary of SERB Women Excellence Award

Number of Ongoing awards	Number of awards sanctioned during 2019-20	Number of projects completed during 2019-20
10	9	13

6.6 YEAR OF SCIENCE CHAIR PROFESSORSHIP (YoSCP)

The Year 2012 is recorded as the Year of Science, in commemoration of the outstanding scientific contribution emanating from Indian Science since the last 100 years. The beginning of Year of Science Chair Professorship (YoSCP) can be traced back and related to this cause in the year 2012 to recognize outstanding Indian Scientists. The award is given initially for a period of 5 years and is extendable through assessment based on the performance evaluation.

Objective

To recognize outstanding contributions made by any of the Indian scientists towards excellence and highest impact in R&D in sciences at the National level as well as in global context.

Features

The awardee should be a distinguished Indian scientist in any one or more areas of expertise in Science, Technology, Engineering, Mathematics, and Biomedical Research.

He/she should have an excellent track record as evidenced by the election to prestigious Science and Engineering Academics in the world, high impact publications, patents and recognition as distinguished contributor to the growth of science in the country.

Research grant of Rs. 25.0 lakhs per annum and an honorarium of Rs. 1.0 lakh per month will be given to each fellow.

A total of Six (6) ongoing awards were supported and One (1) new award was sanctioned during the reporting period in the broad subject area of chemical sciences (Table 6.5).

Table 6.5 : Summary of Year of Science Chair Professorship

Number of Ongoing awards	Number of awards sanctioned during 2019-20	Number of projects completed during 2019-20
6	1	Nil

6.7 ABDUL KALAM TECHNOLOGY INNOVATION NATIONAL FELLOWSHIP (AKTIN)

Objective	Features
Award outstanding engineers to recognize, encourage and support translational research to achieve excellence in engineering, innovation and technology development.	The scheme is applicable to Indian nationals working in India in various capacities of engineering profession in public funded institutions. The applicants should be working in India and possess adequate professional qualification and hold at least a bachelor's degree. This applicant should have a minimum of five (5) years of service left in the parent organization as on the date of the award. They should not be holding any other fellowship and in the event of selection, they will have to opt for only one of the fellowships. The fellowship amount is Rs. 25,000 per month, in addition to regular perks of these researchers in their parent organization. Research grant is Rs.15.00 lakh per annum, which can be utilized for engineering research and innovation activity including hiring of manpower, consumables, national and international travel for research purposes, chemicals, equipment, etc. An Overhead of Rs.1.00 lakh per annum is provided to the host institute. The fellow is eligible for regular research grants through the extramural and other research schemes of various S&T agencies of the Government of India.

Website links

www.serb.gov.in/kalam.php

Abdul Kalam Technology Innovation National Fellowship was launched by SERB to recognize, encourage and support translational research by Indian Nationals. Indian National Academy of Engineering (INAE) will co-ordinate and award Abdul Kalam Technology Innovation National Fellowships to outstanding engineers to recognize encourage and support translational research by individuals to achieve excellence in engineering, innovation and technology development in association with SERB. All areas of engineering, innovation and technology will be covered by this fellowship. The duration of the fellowship will be initially for three years. The nominations can be sent by the Heads of the Institutions/ organizations, Presidents/ fellows of National science/ engineering academies, SS Bhatnagar Awardees and JC Bose awardees and the same will be accepted throughout the year. Maximum of 10 Fellowships will be awarded per year. In FY 2019-2020, 7 new projects and 14 ongoing projects were supported under Abdul Kalam Technology Innovation National Fellowships.

Research Highlights

One of the Abdul Kalam Fellows has been actively working on developing processes with prototype building & field trail on fluoride removal from groundwater; removal of heavy metals from groundwater; removal of cyanide from steel plant effluent and scaling up of cold sterilization technique for storing tender coconut water with high shelf life using suitable membranes.

The highlights of the work done so far are listed below:

- **Fluoride removal from groundwater:** A novel adsorbent material (mineral rich carbon) has been developed in laboratory for removal of fluoride. Using this material, fluoride removal filters are developed in domestic scale as well as community scale. These filters are deployed in various places of the affected areas.
- **Removal of cyanide from steel plant effluent:** Cyanide contamination in steel plant effluent is a major concern. A treatment method has been developed using hydrogen peroxide in presence of air bubbling at controlled rate and exposure to UV radiation. This technology is tested in laboratory using steel plant effluent and a pilot unit of capacity 2 m3/h has been successfully tested at the site of Tata Steel, Jamshedpur.
- **Scaling up of cold sterilization technique for storing tender coconut water with high shelf life using suitable membranes:** A suitable ultrafiltration hollow fiber membrane cartridge is developed to filter tender coconut water. This technology was demonstrated in laboratory to number of interested entrepreneurs and one pilot unit was deployed in Madhura Agro Process Pvt Ltd., Coimbatore. The filtered juice stored under normal refrigeration temperature has long shelf life (18 weeks) without addition of any preservative or chemicals and retaining the original flavor, taste and nutritional profile of the juice.
- **Removal of heavy metals from groundwater:**
- **Arsenic removal filter (Domestic scale, 50 L/day):** Naturally occurring laterite-based adsorbent developed in laboratory is successfully demonstrated for its effectiveness towards arsenic removal from groundwater. A domestic scale filter is designed and developed and deployed in Kashinathpur.
- **Iron and Bacteria removal filter from groundwater:** Naturally occurring laterite based adsorbent developed has strong anti-bacterial property due to presence of iron oxides. This material is therefore used for removal of minerals as well as bacteria from groundwater. Manganese coated sand is used to remove iron by oxidizing the soluble ferrous to insoluble ferric form. Using these two methods, a filter is developed to remove iron and bacteria from groundwater and installed in various places.

6.8 SWARNAJAYANTI FELLOWSHIPS

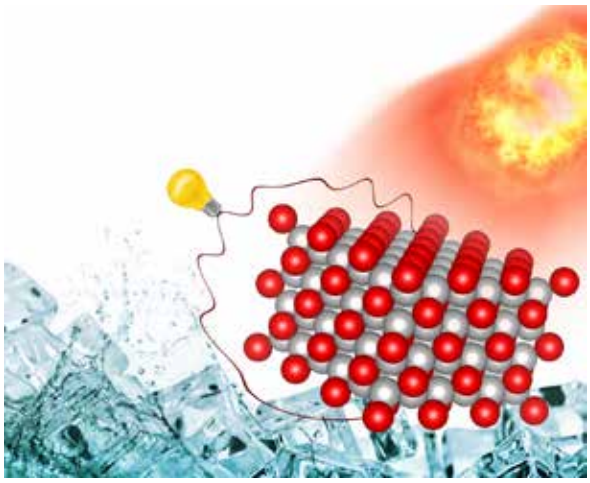
Swarnajayanti Fellowship is a flagship scheme of the Department of Science and Technology (DST) initiated in the year 1997-98, to commemorate the 50th year of India's independence. The scheme entails fellowships and research grants to young scientists in contemporary areas of science and technology. Presently, DST is implementing the scheme, and candidates are selected based on a three-tiered peer-review system. SERB will be providing additional funding to meet the required expenditures pertaining to the research objectives enumerated in the proposal submitted by the awardee. Some of the significant research projects being funded under the scheme are given below:

(A) Intrinsically Low Thermal Conductive Metal Chalcogenides for Thermoelectric "Waste Heat" to "Electrical Energy" Conversion

Nearly 65% of all utilized energy gets irreversibly dissipated as waste heat. Thermoelectric materials can directly and reversibly convert waste heat into electricity and will play a significant role in the future energy management. The grand challenge is to fit three seemingly different material properties into one single inorganic solid: high electrical conductivity of metals, high Seebeck coefficient (the magnitude of electrical voltage generated from a given temperature gradient) of semiconductors and low thermal conductivity of glasses. Conflicting interdependency among the Seebeck coefficient (S), electrical conductivity (σ) and electrical thermal conductivity (κ_{el}) leave the only choice of tuning of the lattice thermal conductivity (κ_L) independently to enhance the zT.

The above Swarnajayanti Fellowship project proposes to design new inorganic solids that will possess ultra-low lattice thermal conductivity (κ_L) and high thermoelectric performance by only tailoring the *intrinsic* parameter such as chemical bonding, lone pair, lattice anharmonicity, rattling dynamics, selective soft vibrations and liquid like

cation flow. Introducing these concepts will reduce the thermal conductivity significantly but the carrier mobility will be retained, which is significantly novel and possess new fundamental approach that involves reach chemistry. (Figure 6.1)



The low thermal conductive and high performance thermoelectric materials and devices discovered under this project can be used in waste heat recovery in automobiles, space missions, thermal, chemical, steel, nuclear power plants and oil refiners; also coupled with new renewable technologies such as *solar-thermoelectrics* and heat recovery in *Li-batteries*. Further, thermoelectric energy conversion does not involve any moving parts and any toxic/ hazardous gas emission, thereby proposed project on intrinsically low thermal conductive metal chalcogenides for thermoelectric energy conversion is nearly maintenance free and environmental friendly renewable energy conversion avenue, which have high significance and novelty.

Figure 6.1 : Designing solids (Metal Chalcogenides) by tailoring intrinsic parameters such as chemical bonding, lone pair, and lattice anharmonicity to achieve high thermoelectric performance.

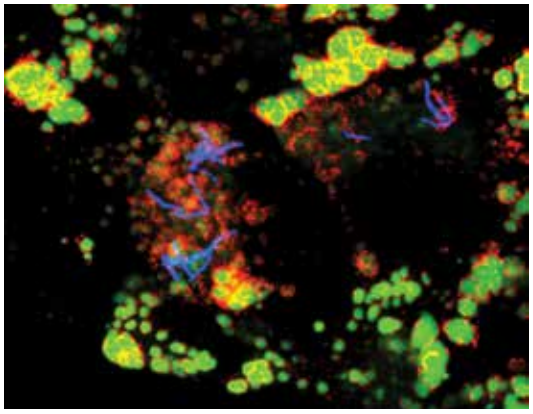
(B) Lipid Droplet associated proteins- functions beyond lipid metabolism in Mycobacterium tuberculosis infected macrophages

Lipids play critical roles as structural and signalling components in biological systems and thus, processes that regulate their trafficking and storage are critical to health and disease. Lipid accumulation in macrophages is associated with pathogenic conditions including atherosclerosis, neurodegeneration, and infections. Tuberculosis exhibits characteristic pathology comprising of caseous granulomas with a higher content of neutral lipids such as triglycerides and cholesterol compared to the healthy lung tissue. The presence of an unusually large number of genes putatively involved in lipid metabolism, and the occurrence of lipid rich granulomas has led to the evolutionary perspective of host-pathogen interaction wherein the development of a lipid rich niche provides nutritional benefit to the pathogen.

Triglyceride accumulation in human macrophages is not essential for mycobacterial survival within these cells, but instead provides the cell with higher capacity to mount an inflammatory response to infection. Current efforts are aimed at understanding mechanisms for this relationship between triglyceride accumulation and the inflammatory response. Critical to this understanding, is the appreciation of how triglycerides are made and stored in the cell.

Being synthesized in the ER membrane, and packaged into lipid droplets, triglycerides are protected depots of excess fatty acids. Lipid droplet membrane, chiefly composed of phospholipids and proteins, regulates how the lipid is trafficked and stored within the cell. In an attempt to understand how these lipid droplets respond to infection, the project aims to investigate the protein composition of lipid droplets. Subcellular organelles from macrophages infected with M. tuberculosis were isolated and the protein composition of these droplets were compared to those of cells infected with either heat killed bacteria or uninfected cells. Using tandem mass tagging of peptides from these proteomes, one can quantitatively compare abundance of proteins across these conditions. The goal of our lab is to

now understand how these changes at the lipid droplet surface can regulate the inflammatory response to infection. The challenge in taking this work forward is that these proteins are not uniquely present at the lipid droplet surface and therefore classical genetic approaches may not allow one to address these questions.



A thorough understanding of how proteins localize to the lipid droplet and how this is regulated during infection are key to answering these questions. In addition, how are functions of these proteins altered if they localize to the lipid droplet? Does this localization have the capacity to alter the immune response to infection? The project aims to strengthen our understanding of dynamic cellular processes that are regulated at the lipid droplet surface. By understanding how the active manipulation of lipid droplets regulates the inflammatory response to infection, this work aims to understand the molecular pathways that may be relevant to the incident pathology during active TB disease.

Figure 6.2: Lipid droplets (green) are not simply a store house of excess fatty acids but also regulate several cellular functions via proteins that localize to the lipid droplet (red). M. tuberculosis (blue) actively manipulates the proteome of lipid droplets.

7 SUPPORT FOR SCIENCE & TECHNOLOGY EVENTS

"Support for Science & Technology Events (SSTE)" provides financial assistance to two major components namely, International Travel Scheme (ITS) and Seminar Symposia (SS), for the events pertaining to science and technological development in the country, or abroad, organized by academic institutes/ national research & development labs or other professional bodies.

7.1 ASSISTANCE TO PROFESSIONAL BODIES & SEMINARS/SYMPOSIA

The financial year (2019-20), **1543** seminar / symposia applications received towards partial support from all the States / UTs across the country in various fields of Science and Technology, out of which **533** applications were financially supported. In addition, partial financial support was extended to twentynine (29) applictions are received under Professional Bodies / Institutes / Societies for publication of Journals, out of which 22 applications were sanctioned for partial financial support (Table 7.1). 533 applications in different subjects/discipline were recommended for support (Figure 7.1).

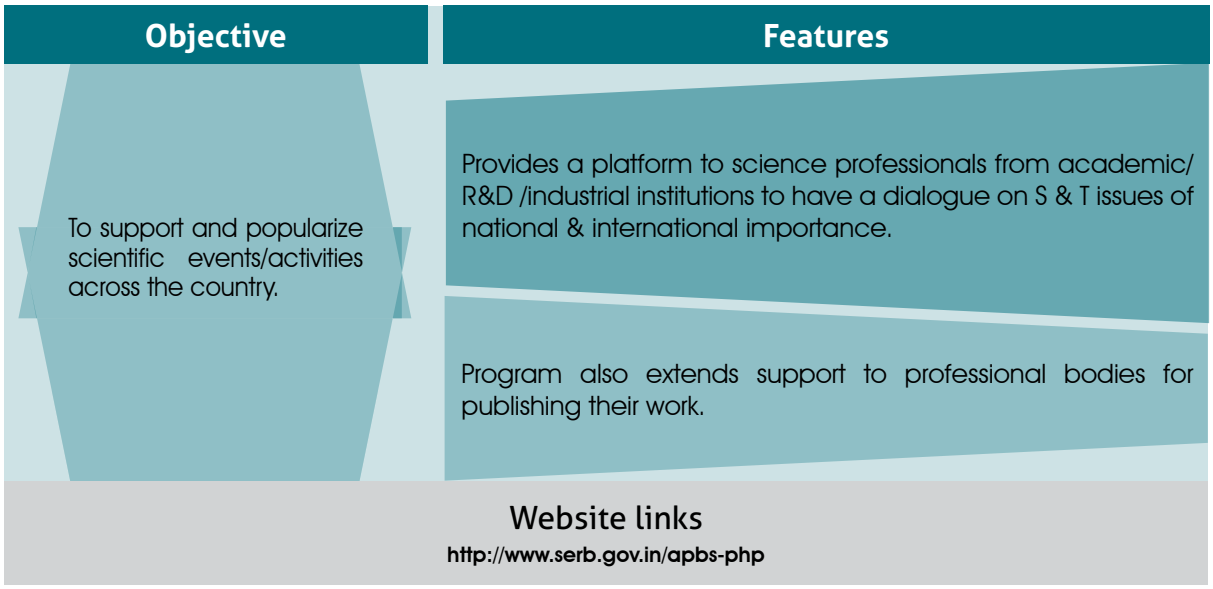


Table 7.1: Information in the form of following table for the year 2019-20

S. No.	Items	Seminar / Symposia	Professional Bodies
	Application Received	1543	29
	Application Sanctioned	533	22

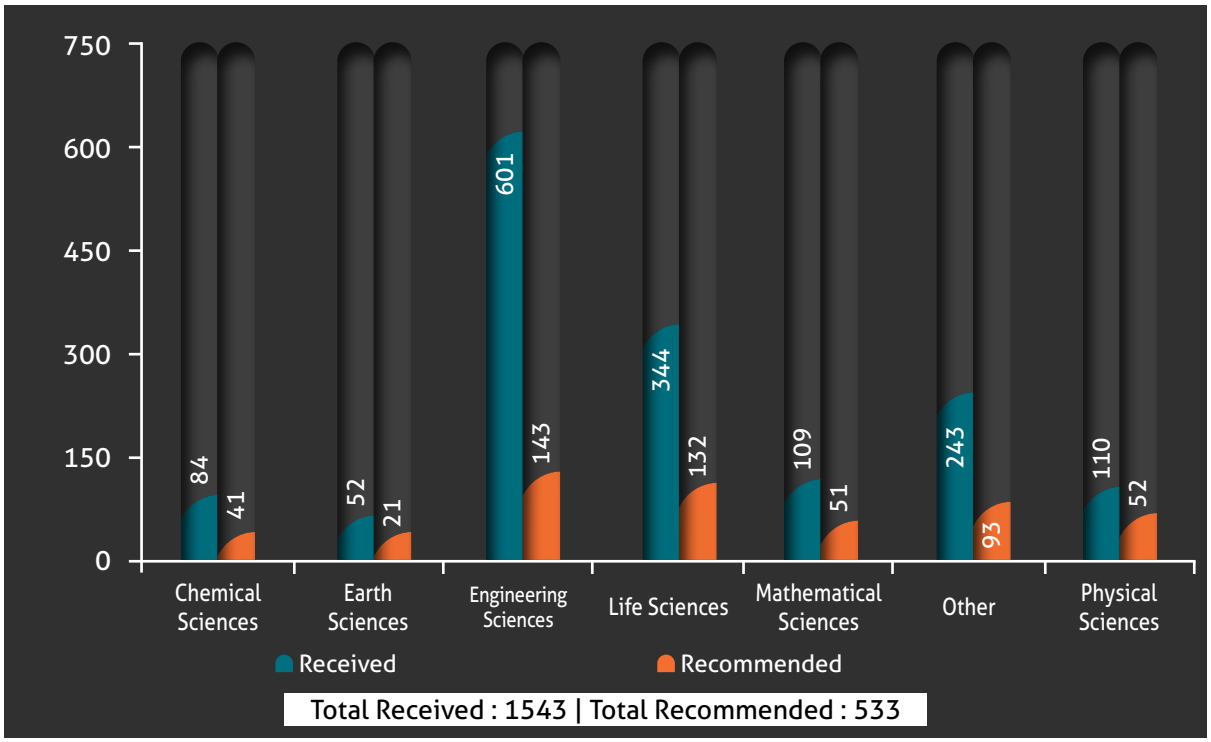


Figure 7.1 : Applications received under each discipline and their details

7.2 INTERNATIONAL TRAVEL SUPPORT (ITS) SCHEME

Objective	Features
Provides an opportunity to emerging and eminent scientist to present the original research findings in the international scientific events held abroad.	The scheme also provides support to young researchers (less than 35yrs) for attending workshop, short term training programmes and schools organized by various international agencies. For eminent scientist (greater than 35 yrs.) the scheme also provides support to chair the session or to deliver keynote address in international scientific event held abroad.

Website links

www.serbonline.in//www.serb.gov.in

During the financial year (2019-20), 6035 Conference/Workshop (ITS Scheme) applications were received towards partial support from all the States/UTs across the country in various fields of STEM (Science, Technology, Engineering and Mathematics) (Table 8.2).

Table 7.2 : Recommended number of applications during year 2019-20

S.No.	Items	Conference/Workshop
1.	Application Received	6035
2.	Application Recommended	1711

Out of 6035 participants where 1254 Young Scientists & 457 Senior Scientists were recommended for support to present their scientific and technical findings on the international platform.

Table 7.3 : Participants supported to attend conferences held at different countries and few of them are listed below:

S.No.	Countries	No of participants visited during 2019-20
1.	USA	530
2.	United kingdom	89
3.	France	93
4.	Spain	89
5.	Singapore	59
6.	Japan	68
7.	Canada	64
8.	Australia	62
9.	China	51

Important events supported

The few important events supported under the Scheme are: American Society for Microbiology, SPIE International Symposium, Gordon Research Conferences& Seminar, 2019 MRS Spring Meeting & Exhibit , 9th International Congress on Industrial and Applied Mathematics - ICIAM, European Materials Research Society, Asia Oceania Geosciences Society, GOLDSCHMIDT 2019 (10), 64th Annual Conference on Magnetism and Magnetic Materials, 46th International Conference on Metallurgical Coatings and Thin Films, IEEE Nanotechnology Materials and Devices Conference.

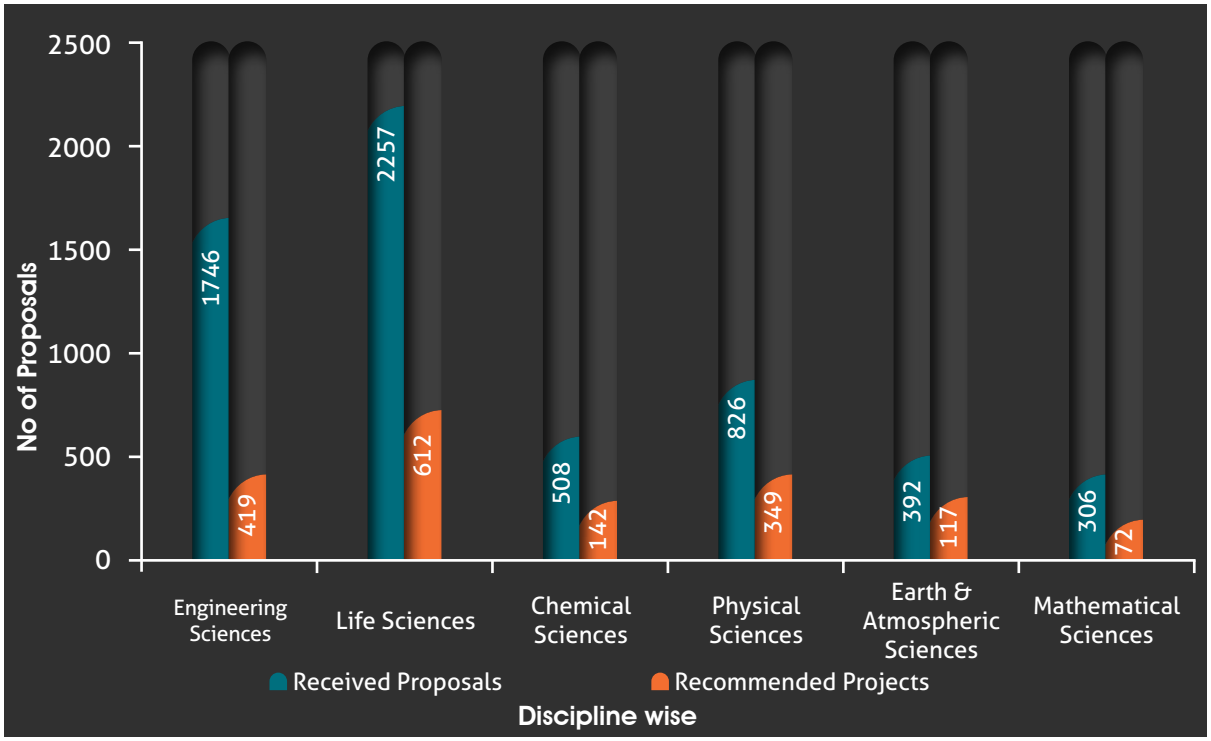


Figure 7.2 : Applications received under each discipline and their details

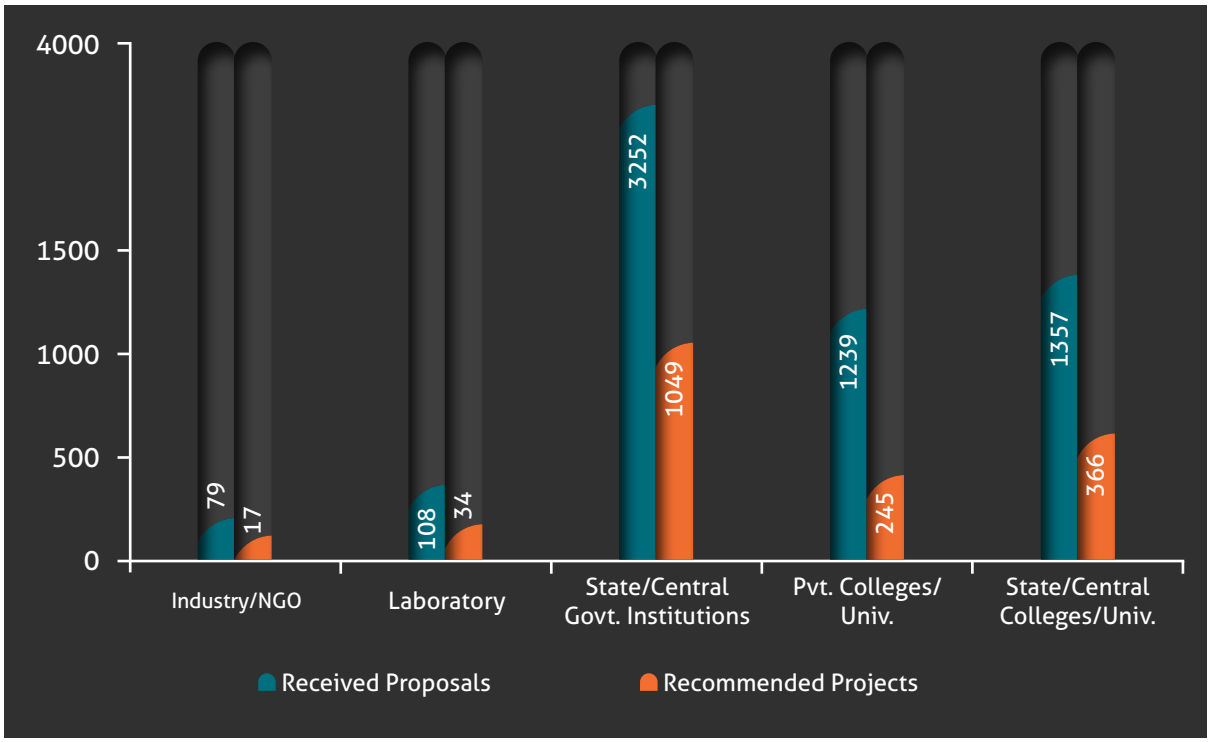


Figure 7.3 : Institute-wise Summary of Received & Recommended Applications (2019-20)

8 PATENTS AND PUBLICATIONS AND OTHER OUTREACH PROGRAMMES

The patents and publications outcome from some of the funded projects during the year is given in this chapter.

8.1 PATENTS FILED/GRANTED

Number of Patents filed in 2019-2020	
Country	**Number of Patents filed**
India	106
USA	01
Canada	01
Total	**108**

8.2 PUBLICATIONS

Scheme	SCI	Non-SCI	Total
CRG	2523	345	2868
ECRA	727	184	911
EMEQ	398	303	701
MATRICS	120	03	123
N-PDF	581	126	707
TARE	19	10	29
JC-BOSE/RAMANUJAN	1488	0	1488

8.3 HUMAN RESOURCES DEVELOPMENT

Manpower sanctioned under different schemes/programs during the year 2019-20

Scheme	JRF/SRF	Staff other than JRF/SRF	Total
CRG	525	137	662
ECRA	207	94	301
EMEQ	126	15	141
IMPRINIT	32	57	92

8.4 TRAINING/SCHOOLS CONDUCTED DURING THE YEAR 2019-20

S. No.	Title	Place of Training/Schools	No. of Participants
1	Plasma Processing of Materials	Indian Institute of Technology, Bombay. Maharashtra	40
2	Role of Symmetries in nuclear physics	Amity University Noida, UP	25
3	Theoretical High Energy Physics	Tezpur University, Tezpur, Assam	40
4	Photonics Phenomena, Materials and Devices	Anna University, Chennai, Tamilnadu	40
5	Main School on "Theoretical High Energy Physics"	Shri Guru Tegh Bahadur Khalsa College, New Delhi	40
6	Nonlinear Dynamics	Indian Institute of Technology, Patna, Bihar	40
7	Advanced Functional Materials at Nano and Atomic Scale	Indian Institute of Technology, Goa	40

8.5 SCIENTIFIC SUPPORT IN EVALUATING MHRD SCHEMES

8.5.1 Third Party Evaluation of MHRD-FAST Scheme

MHRD has an ongoing scheme called Research and Training in Frontier Areas of Science and Technology (FAST) under which 36 Centres of Excellence (CoE) were established for advanced training and Research in identified frontier areas. MHRD requested SERB to carry out the Third Party Evaluation Scheme of MHRD. This was an ambit requirement as per Department of Expenditure for continuation or otherwise of the FAST Scheme beyond March 2020. SERB accepted the request and an Expert Committee was constituted by SERB to carry out the Third-Party Evaluation. The Committee meeting was held on 14th and 15th November 2019 at Delhi in which the Coordinators of the CoEs presented the progress. The Committee evaluated the performance of each CoE and also the scheme as a whole. The Third-Party Evaluation Report was submitted to MHRD.

8.5.2 Third Party Evaluation of MHRD NITT-SIIHEI Scheme

In 2013, MHRD initiated a scheme titled "National Initiative for Technology Transfer (NITT)" with an outlay of Rs. 1000 cr. Under this scheme, two Research Parks at IIT Bombay and IIT Kharagpur were approved at a total cost of Rs. 100 cr each. In 2017, the scheme was revamped as "Startup India Initiative in Higher Educational Institutions (SIIHEI)" and establishment of five new Research Parks, one each at IIT Delhi, IIT Kanpur, IIT Guwahati, IIT Hyderabad and IISc Bangalore at a cost of Rs. 75 cr each over a period of three years. MHRD requested SERB to carry out the Third Party Evaluation of NITT-Startup India Initiative for Higher Educational Institutions (SIIHEI) Scheme of MHRD. This extant requirement of Department of Expenditure instructs continuation of all schemes beyond 14th Finance Commission which comes to an end by March 31, 2020. SERB constituted an Expert Committee for the Third-Party Evaluation and the meeting was held on 21st November 2019 at Delhi. Faculty In-charge of the seven Research Parks presented the progress and the Committee conducted a site visit of IIT Delhi Research Park to appraise the progress.

9 ADMINISTRATION

The administration of any organization plays a vital role in meeting its objectives. All efforts are made to ensure that SERB gets the institutionalized environment for producing results and targets. SERB provides motivation to the work force and makes them conceive their goals.

9.1 ADMINISTRATION AND RECRUITMENT

Prof. Sandeep Verma, IIT Kanpur joined SERB as Secretary (SERB) on deputation basis on 08.04.2019 for tenure of 3 years.

Necessary action for filling up of three posts of Scientist-G and one post of Scientist-C was initiated in June, 2019 by giving a brief advertisement in the Employment news and leading National dailies. Three candidates were selected for the posts of Scientist 'G' and one for the post of Scientist 'C'. Out of these, two candidates selected for the post of Scientist 'G' and one candidate selected for the post of Scientist 'C' have already joined the posts. As such out of 20 scientific sanctioned posts, 19 posts are already filled up and filling up of one post of Scientist 'G' is in progress.

9.2 IMPLEMENTATION OF OFFICIAL LANGUAGE

The SERB, since its inception has been implementing the guidelines issued by the Department of Official Language, Ministry of Home Affairs. Hindi Fortnight was celebrated in SERB from September 02 to 17, 2019. Various activities were organized for the staff/officers, both Hindi and Non-Hindi speaking to promote the official language. At the closure of the Hindi Fortnight, Secretary, SERB, rewarded the winners with cash prizes, certificates and books in Hindi to motivate all the officers/staff of SERB to adopt Hindi.

Further, three Hindi workshops to enhance the working knowledge of the officers/staff, for the maximum use of Hindi language in official work were conducted on 20.06.2019, 13.09.2019 and 27.12.2019.

Quarterly meetings of Official Language Implementation Committee were held regularly to review the progress of the use of Hindi language in SERB and the quarterly reports were sent to Department of Science and Technology (DST) as per schedule. Also, Inspection by DST was conducted on 16.01.2020 to review the progressive use of Hindi language and follow up of instructions issued by the Department of Official Language.

9.3 RIGHT TO INFORMATION ACT, 2005 (RTI)

Fifty Four (54) RTI applications were received during the Financial Year 2019-20. Out of these eighteen (18) were received as transfer from DST and one (1) application was transferred to Ministry of Health and Family Welfare. Appropriate information was provided to the applicants, seeking information under RTI Act, 2005. Eight (08) appeals were also received during the year and disposed-off by the appellate authority. A total fee of Rs.510/- (Rupees five hundred ten only) was received by SERB for providing information under RTI Act, 2005, during the period.

9.4 VIGILANCE AWARENESS

The Vigilance Awareness Week was observed by SERB during the period from 28th October to 2nd November, 2019 with the theme "Integrity- A way of life". All Officers/Staff of SERB assembled in the Conference Room on 29th October, 2019 to take the integrity pledge, to abide by the principles of honesty and integrity to fight against corruption.

9.5 INTERNAL COMPLAINTS COMMITTEE (ICC) -WOMEN

Internal Complaints Committee – Women of SERB has been functioning since 2017. As per the provisions contained in the Act 2013, the Committee meets regularly and discussion on relevant issues are held. Constitution of the committee, guidelines and the related information are available in the website of SERB.

9.6 AUDITED ANNUAL STATEMENT OF ACCOUNTS

As per the provisions laid down in Section 13 of the Science & Engineering Research Board (SERB) Act, 2008, the Annual Accounts of the Board are required to be prepared in the prescribed formats 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 2019-20 have been prepared and audited by a team of Auditors from C&AG. The duly audited Financial Statements and Annual Accounts for the Financial Year 2019-20 form a part of this Annual Report.

ANNUAL STATEMENT OF AUDITED ACCOUNTS FOR THE YEAR 2019-20

Amount in Rs.

Balance Sheet as at 31.03.2020

	Schedule	Current Year	Previous Year
CORPUS / CAPITAL FUND AND LIABILITIES			
Corpus / Capital Fund	Schedule 1	2,007,213,799.90	885,542,810.65
Reserves and Surplus	Schedule 2	-	-
Earmarked / Endowment Funds	Schedule 3A, 3B, 3C, 3D & 3E	171,014,301.00	56,065,019.50
Secured Loans and Borrowings	Schedule 4	-	-
Unsecurred Loans and Borrowings	Schedule 5	-	-
Deferred Credit Liabilites	Schedule 6	-	-
Current Liabilites and Provisions	Schedule 7	150,899,872.00	46,776,077.00
Total		2,329,127,972.90	988,383,907.15
ASSETS			
Fixed Assets (Net)	Schedule 8	76,726,842.00	59,771,314.00
Investments-From Earmarked / Endowment Funds	Schedule 9	-	-
Investments-Others	Schedule 10	-	-
Current Assets, Loans, Advances etc.	Schedule 11	2,252,401,130.90	928,612,593.15
Miscellaneous Expenditure (to the extent not written off or adjusted)			
Total		2,329,127,972.90	988,383,907.15
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

For Science and Engineering Research Board

Sandeep Verma
Secretary
SERB

Director-Finance
SERB

Date : October 13, 2020
Place : New Delhi

As per our report of even date
For and on behalf of
M/s Gaur & Associates
Chartered Accountants
Firm's Reg. No. :005354C

R K Gaur
Partner
Mem. No. :072146

Amount in Rs.

Income & Expenditure Account for the Year Ended on 31.03.2020

	Schedule	Current Year	Previous Year
Income			
Income from Sales / Services	Schedule 12	-	-
Grants / Subsidies *	Schedule 13	9,538,383,417.00	9,964,627,195.00
Fees / Subscriptions	Schedule 14	-	-
Income from Investments	Schedule 15	-	-
Income from Royalty, Publication etc	Schedule 16	-	-
Interest Earned	Scheduel 17	15,627,219.25	89,110,506.99
Other Income	Schedule 18	10,356,447.00	14,573,229.00
Increased/(Decrease) in stock of Finished Goods and Works-in-Progress	Schedule 19	-	-
Total (A)		**9,564,367,083.25**	**10,068,310,930.99**
Expenditure			
Establishment Expenses	Schedule 20	98,091,424.00	89,261,897.10
Other Administrative Expenses	Schedule 21	106,939,722.68	105,944,889.25
Expenditure on Grant, Subsidies etc	Schedule 22	8,356,664,114.46	9,768,461,481.57
Interest	Schedule 23	-	-
Depreciation (Net Total at the Year end)	Schedule 8	10,356,053.00	14,545,362.00
Total (B)		**8,572,051,314.14**	**9,978,213,629.92**
Excess of Income over Expenditure (A-B) (Before PPI & PPE)		**992,315,769.11**	90,097,301.07
Excess of Expenditure over Income (A-B) (Before PPI & PPE)		-	-
Prior Period Income	Schedule 24	257,845,083.82	188,423,801.02
Prior period Expendlture	Schedule 25	1,228,020.68	702,177.90
Excess of Income over Expenditure (A-B) (After PPI & PPE)		**1,248,932,832.25**	277,818,924.19
Excess of Expenditure over Income (A-B) (After PPI & PPE)		-	-
Transfer to Special Reserve (Specity each)		-	-
Transfer to / from General Reserve		-	-
Balance Being Surplus (Deficit) carried to Corpus/Capital Fund		**1,248,932,832.25**	**277,818,924.19**
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

* CY- This amount reflect total grant received by SERB of Rs. 9,56,57,00,000/- less Fixed Assets purchased of Rs. 2,73,16,583/- (transferred to Corpus Fixed Assets Sch. 1)

* PY- This amount reflect total grant received by SERB of Rs. 10,00,00,00,000/- less Fixed Assets purchased of Rs. 3,53,72,805/- (transferred to Corpus Fixed Assets Sch. 1)

For Science and Engineering Research Board

Sandeep Verma
Secretary
SERB

Director-Finance
SERB

Date : October 13, 2020
Place : New Delhi

As per our report of even date
For and on behalf of
M/s Gaur & Associates
Chartered Accountants
Firm's Reg. No. :005354C

R K Gaur
Partner
Mem. No. :072146

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

Schedule 1 - Corpus / Capital Fund

Particulars	Current Year	Previous Year
Corpus Balance at the beginning of the year	825,771,496.65	547,947,449.46
Add: Sale/Exchange of Fixed Assets (Laptop & Printer)	5,002.00	5,123.00
Less: Interest earned during FY 2017-18 & FY 2018-19 transferred to GOI, Consolidated Fund	(144,222,373.00)	-
Add/(Deduct) : Balance of net income/(Expenditure) transferred from the Income & Expenditure Account	1,248,932,832.25	277,818,924.19
Corpus Balance at the end of the year (A)	**1,930,486,957.90**	**825,771,496.65**
Corpus (Fixed Assets) Balance at the beginning of the year	59,771,314.00	38,948,994.00
Add: Contributions towards Corpus/Capital Fund (Fixed Assets)		
FY 2018-19	-	35,372,805.00
FY 2019-20	27,316,583.00	-
Sale/Exchange of Fixed Assets (Laptop & Printer)	(5,002.00)	(5,123.00)
Deferred Revenue Grant for FY 2018-19	-	(14,545,362.00)
Deferred Revenue Grant for FY 2019-20*	(10,356,053.00)	-
Corpus (Fixed Assets) Balance at the end of the year (B)	**76,726,842.00**	**59,771,314.00**
Total of Corpus & Corpus (Fixed Assets) (A) + (B)	**2,007,213,799.90**	**885,542,810.65**
Refer Point No. 12 In Schedule 26 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		**-**		**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

Schedule 3A - Earmarked/Endowment Funds MFPI

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**32,577,350.00**	**36,902,017.00**
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	698,812.00	76,605.00
Interest on MFPI Refund	212,291.00	7,267.00
Refund from previous year Grant FY 2012-13 (Ann. 1 & 1A)		934,442.00
Refund from previous year Grant FY 2013-14 (Ann. 2 & 2A)	7,200.00	-
Refund from previous year Grant FY 2014-15 (Ann. 3 & 3A)	43.00	956,553.00
Refund from previous year Grant FY 2015-16 (Ann. 4 & 4A)	694,559.00	-
Refund from previous year Grant FY 2016-17 (Ann. 5 & 5A)	913,925.00	76,204.00
Refund from previous year Grant FY 2017-18 (Ann. 6 & 6A)	305,640.00	84,864.00
Refund from previous year Grant FY 2018-19 (Ann. 7 & 7A)	257,623.00	-
Total (a+b)	**35,667,443.00**	**39,037,952.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (MFPI- Capital) (Ann. 8 & 8A)	77,349.00	113,356.00
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (MFPI- General) (Ann. 9 & 9A)	501,147.00	6,347,246.00
Total c)	**578,496.00**	**6,460,602.00**
d) Less: Amount given back to Ministry of Food Processing	**20,000,000.00**	**-**
Net Balance as at the year end (a+b-c-d)	**15,088,947.00**	**32,577,350.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

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

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**16,046,676.00**	**118,434,940.00**
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	485,275.00	1,268,257.00
S & T ST-Interest from SERB on Saving Balance	4,067.00	-
S & T SC- Refund from previous year Grant FY 2013-14 (Ann. 10 & 10A)	932,581.00	1,195,360.00
S & T SC- Refund from previous year Grant FY 2014-15 (Ann. 11 & 11A)	-	6,872.00
S & T SC- Refund from previous year Grant FY 2015-16 (Ann. 12 & 12A)	113,852.00	
S & T SC- Refund from previous year Grant FY 2016-17 (Ann. 13 & 13A)	56,412.00	102,679.00
S & T SC- Refund from previous year Grant FY 2018-19 (Ann. 14 & 14A)	359,909.00	
S & T - Interest on Refund -SC	133,870.00	144.00
S & T - Interest on Refund -ST	-	-
Total (a+b)	**18,132,642.00**	**121,008,252.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (S & T- Schedule Castes - Capital) (Ann. 15 & 15A)	-	22,333,945.00
Grant-in-aid (S & T- Schedule Tribe - Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (S & T- Schedule Castes - General) (Ann. 16 & 16A)	-	74,385,631.00
Grant-in-aid (S & T- Schedule Tribe - General) (Ann. 17 & 17A)	-	8,242,000.00
Total c)	**-**	**104,961,576.00**
Net Balance as at the year end (a+b-c)	**18,132,642.00**	**16,046,676.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

Schedule 3C - Earmarked/Endowment Funds ICPS

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**-**	**-**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid- ICPS	1,227,000,000.00	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (ICPS: 349902010049636)	10,409,284.00	-
Total (a+b)	**1,237,409,284.00**	**-**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (ICPS- Capital) (Ann. 18 & 18A)	327,000,000.00	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure- Bank Charges	-	-
Grant-in-aid (ICPS- General) (Ann. 19 & 19A)	900,000,000.00	-
Total c)	**1,227,000,000.00**	**-**
Net Balance as at the year end (a+b-c)	**10,409,284.00**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

Schedule 3D - Earmarked/Endowment Funds DOT

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**7,440,993.50**	**14,912,289.00**
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	401,115.00	-
Total (a+b)	**7,842,108.50**	**14,912,289.00**
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. 20 & 20A)	146,244.50	4,884,411.00
DOT- Meeting Expenses - FY 2018-19 (Ann. 21 & 21A)	-	198,304.00
DOT- Meeting Expenses Reimbursement_FY 2014-15 to FY 2017-18*	-	2,388,580.50
Total c)	**146,244.50**	**7,471,295.50**
Net Balance as at the year end (a+b-c)	**7,695,864.00**	**7,440,993.50**

*** Note: Refer Schedule 24 Prior Period Income**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

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

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**-**	**-**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (IMPRINT-II)	272,000,000.00	310,000,000.00
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (IMPRINT-II: 349902010049001)	2,315,077.00	-
Interest on IMPRINT-II Refund	24,997.00	-
Total (a+b)	**274,340,074.00**	**310,000,000.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (IMPRINT-II- Capital) (Ann. 22 & 22A)	87,362,736.00	172,651,054.00
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	32,916.00
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (IMPRINT-II- General) (Ann. 23 & 23A)	67,289,774.00	137,316,030.00
Total c)	**154,652,510.00**	**310,000,000.00**
Net Balance as at the year end (a+b-c)	**119,687,564.00**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

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	**-**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
A) Current Liabilities				
1. Acceptances		-		-
2. Sundry Creditors				
a) For Goods		-		-
b) Others:				
Moets Catering Service, Delhi	-		11,275.00	
Shree Bhagatrams, New Delhi	6,510.00		-	
Uneecode Inc., Delhi (RSM Enterprises, New Delhi)	14,150.00		35,394.00	
Suresh Malik & Co. (VPCA and Associates)	966,420.00		791,760.00	
National Mission on Bamboo Application	1,080,145.00		1,080,145.00	
FDS Management Services Private Limited	4,127.00		306,774.00	
Mansarover Industrial Corporation, New Delhi	2,350.00		2,350.00	
Sonu Printing Press Pvt. Ltd.	-		27,052.00	
Suncity Projects Private Limited, New Delhi	85,120.00		126,394.00	
Balmer Lawrie & Co. Ltd., New Delhi	1,477,844.00		199,833.00	
Dinesh Singh Tomer, New Delhi	1,242.00		-	
Darsheel Enterprises, New Delhi	8,700.00		-	
Shalu Tour And Travels, New Delhi	184,091.00		117,431.00	
R S Travels Solution Private Limited	145,033.00		105,279.00	
Sonpal	11,970.00		16,815.00	
Sr. Post Master Sarojini Nagar, H.P.O.	1,493.00		4,826.00	
Deldsl-Digital NTC	74,100.00		74,100.00	
Digital NTC-New Delhi	29,770.00		29,640.00	
Airtel	33,942.00		33,941.00	
K B Enterprises, New Delhi	22,128.00		-	
MV Infotech India, New Delhi	29,972.00		-	
Nandini Flower Decoration, New Delhi	5,000.00		-	
Uneecops Technologies Limited, New Delhi	25,189.00		-	
Adeptech Solutions Private Limited, New Delhi	2,835.00		-	
NSDL E Governanace Infrastructure Limited	743.00		830.00	
Net Creative Mind Solutions Private Limited	53,100.00	4,265,974.00	49,622.00	3,013,461.00
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	9,419.00		13,453.00	
TDS - Section 194J	-		1,200.00	
TDS - Section 192	800,561.00		676,119.00	
GST -TDS	181,082.00	991,062.00	143,363.00	834,135.00
Total (1)		**5,257,036.00**		**3,847,596.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
6. Other Current Liabilities				
Expenses Payable				
Salary Payable	6,651,516.00		5,886,354.00	
Wages Payable	7,500.00		7,500.00	
EPF Payable Employee Contribution	163,800.00		158,400.00	
EPF Payable Employer Contribution	182,428.00		176,420.00	
NPS Contribution Payable	590,496.00		485,304.00	
Audit Fee Payable	654,500.00		529,500.00	
Telephone Expenses Payable (Reimbursement)	78,471.00		7,074.00	
Children Education Allowance Payable (Reimbursement)	324,000.00		297,000.00	
Medical Expenses Payable (Reimbursement)	3,131.00		72,850.00	
Newspaper Expenses Payable (Reimbursement)	41,700.00			
Travelling Expenses Payable (Domestic)	16,224.00		47,241.00	
Accomodation Expenses Payable	-		5,807.00	
Honorarium Expenses Payable (Non-Official)	-	8,713,766.00	36,000.00	7,709,450.00
Deductions Payable				
Secretary Deduction Payable (IIT Kanpur)	78,036.00		-	
Secretary Leave Salary & Pension Contribution Payable	201,987.00		-	
Other Employees Deduction Payable	268,039.00	548,062.00	-	-
Expenses (Current Liabilities Staff)				
Satish Marar	-		6,835.00	
Anima Johri	60,401.00		-	
Dr. G. Harish Kumar	751.00		751.00	
Praveen Kumar S	418.00	61,570.00	418.00	8,004.00
Time barred cheques taken back (FY 2011-12) (Ann. 24 & 24A)		344,235.00		344,235.00
Time barred cheques taken back (FY 2012-13) (Ann. 25 & 25A)		11,933,916.00		11,933,916.00
Time barred cheques taken back (FY 2013-14) (Ann. 26 & 26A)		16,251,065.00		16,251,065.00
Time barred cheques taken back (FY 2014-15) (Ann. 27 & 27A)		222,593.00		222,593.00
MINISTRY OF FOOD PROCESSING (PY's Meeting Refund)		554,552.00		-
GOVERNMENT OF INDIA, CONSOLIDATED FUND		99,559,578.00		-
Total (2)		**138,189,337.00**		**36,469,263.00**
Total (A) =(1) + (2)		**143,446,373.00**		**40,316,859.00**
B. Provision		-		-
1. For Taxation		-		-
2. Gratuity		1,697,320.00		-
3. Superannuation / Pension		-		-
4. Accumulated Leave Encashment		5,756,179.00		6,459,218.00
5. Trade Warranties / Claims		-		-
6. Others		-		-
Total (B)		**7,453,499.00**		**6,459,218.00**
Total (A+B)		**150,899,872.00**		**46,776,077.00**

Amount in Rs.

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2020

SCHEDULE 8-FIXED ASSETS		GROSS BLOCK				DEPRECIATION					NET BLOCK	
(PURCHASED OUT OF GRANT-IN-AID RECEIVED FROM DST) DESCRIPTION	Rate of Depre-ciation	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%	23,297,325.00	45,459.00	-	23,342,784.00	10,647,062.00	1,265,026.00	3,871.00	-	11,915,959.00	**11,426,825.00**	12,650,263.00
3. PLANT & MACHINERY	15%	1,572,908.00	-	-	1,572,908.00	519,715.00	157,979.00	-	-	677,694.00	**895,214.00**	1,053,193.00
4. VEHICLES		-	-	-	-	-	-	-	-	-	-	-
5. FURNITURE & FIXTURES	10%	14,046,559.00	1,113,700.00	-	15,160,259.00	5,026,175.00	902,039.00	129,473.00	-	6,057,687.00	**9,102,572.00**	9,020,384.00
6. OFFICE EQUIPMENT	15%	4,049,010.00	31,611.00	-	4,080,621.00	2,104,544.00	291,669.00	4,742.00	-	2,400,955.00	**1,679,666.00**	1,944,466.00
7. COMPUTER/PERIPERALS												
A) COMPUTER SOFTWARES	40%	58,855,802.00	-	-	58,855,802.00	45,321,956.00	5,413,540.00	-	-	50,735,496.00	**8,120,306.00**	13,533,846.00
B) PERIPHERALS	40%	1,105,226.00	301,609.00	-	1,406,835.00	793,959.00	124,506.00	112,996.00	-	1,031,461.00	**375,374.00**	311,267.00
C) PRINTERS/SCANNERS	40%	3,980,959.00	460,898.00	-	4,441,857.00	2,789,881.00	476,431.00	119,577.00	-	3,385,889.00	**1,055,968.00**	1,191,078.00
D) COMPUTERS	40%	10,400,220.00	671,513.00	130,600.00	10,941,133.00	8,331,703.00	825,564.00	197,074.00	125,598.00	9,228,743.00	**1,712,390.00**	2,068,517.00
8. ELECTRIC INSTALLATIONS	10%	2,355,585.00	68,500.00	-	2,424,085.00	1,068,599.00	128,699.00	39,070.00	-	1,236,368.00	**1,187,717.00**	1,286,986.00
9. LIBRARY BOOKS	40%	79,011.00	39,999.00	-	119,010.00	52,796.00	10,486.00	14,340.00	-	77,622.00	**41,388.00**	26,215.00
10. TUBEWELL & W. SUPPLY		-	-	-	-	-	-	-	-	-	-	-
11. INTANGIBLE ASSETS		-	-	-	-	-	-	-	-	-	-	-
a) SERB Website	25%	449,440.00	-	-	449,440.00	379,449.00	17,498.00	-	-	396,947.00	**52,493.00**	69,991.00
b) Logo	25%	412,000.00	-	-	412,000.00	314,231.00	24,442.00	-	-	338,673.00	**73,327.00**	97,769.00
c) Vajra Website	25%	690,000.00	-	-	690,000.00	301,875.00	97,031.00	-	-	398,906.00	**291,094.00**	388,125.00
TOTAL OF CURRENT YEAR (A)		**121,294,045.00**	**2,733,289.00**	**130,600.00**	**123,896,734.00**	**77,651,945.00**	**9,734,910.00**	**621,143.00**	**125,598.00**	**87,882,400.00**	**36,014,334.00**	**43,642,100.00**
PREVIOUS YEAR		**102,191,654.00**	**19,243,591.00**	**141,200.00**	**121,294,045.00**	**63,242,660.00**	**8,675,736.00**	**5,869,626.00**	**136,077.00**	**77,651,945.00**	**43,642,100.00**	**38,948,994.00**
B. CAPITAL WORK IN PROGRESS		16,129,214.00	24,583,294.00	-	40,712,508.00	-	-	-	-	-	**40,712,508.00**	16,129,214.00
TOTAL (A+B)		**137,423,259.00**	**27,316,583.00**	**130,600.00**	**164,609,242.00**	**77,651,945.00**	**9,734,910.00**	**621,143.00**	**125,598.00**	**87,882,400.00**	**76,726,842.00**	**59,771,314.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

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 31.03.2020

Schedule 11 - Current Assets, Loans, Advances Etc

Particulars	Current Year		Previous Year	
A) Current Assets				
1.Inventories :				
a) Stores and Spares (Stationery Stock)		933,172.00		641,261.00
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		9,918.00		20,000.00
Imprest Cash		10,000.00		-
4. Bank Balances :				
a) With Scheduled Banks :				
On Current Accounts	-		-	
On Deposit Accounts	-		-	
On Savings Accounts - SERB (Union Bank of India)	1,714,167,284.90		626,742,669.47	
SERB EPFO Account (UBI)	531.00		112.00	
SERB RTI Account (UBI)	685.00		294.68	
IMPRINT-II Account (UBI)	118,511,462.00	1,832,679,962.90	-	626,743,076.15
b) With non-Scheduled Banks :				
On Current Accounts	-		-	
On Deposite Accounts	-		-	
On Savings Accounts	-	-	-	-
5. Post Office - Savings Accounts		-		-
Total (A)		**1,833,633,052.90**		**627,404,337.15**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2020

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	233,798.00		234,121.00	
Video Conferencing License	827,516.00		827,567.00	
Vajra Website-Updation Expenses	119,934.00		120,263.00	
Membership Fee - India International Centre, New Delhi	73,160.00		61,360.00	
AMC Biometric Attendance System	-		5,708.00	
Lifesize Device Software Subscription-ICON 400	165,402.00		-	
Cyberoam Firewall - Licence Fee	36,108.00	1,455,918.00	15,296.00	1,264,315.00
c) Security Deposit				
Deldsl-Digital NTC (Security Deposit)	20,000.00		20,000.00	
Digital NTC (Security Deposit)	10,000.00	30,000.00	10,000.00	30,000.00
d) Others-				
Centre for Development of Advanced Computing, Noida	-		7,485,920.00	
Lemon Tree Premier, Delhi Airport, New Delhi	-		200,000.00	
Red fox Hotel Aerocity, New Delhi	17,500.00		17,500.00	
Dr. Praveen Kumar S	-		118,376.00	
Bureau of Outreach & Communication, New Delhi (DAVP)	1,000,000.00		-	
Deepak Krishna	5,000.00		-	
Dr. Rajwant	60,554.00		-	
Mrs. Madhu Wadhawan Sinha	-		34,500.00	
AISTDF Expenditure by SERB	-		11,999.00	
Ministry of Human Resource Development	513,668.00		-	
Department of Science & Technology (IMPRINT-II Expenditure by SERB)	386,810,870.00		275,723,693.00	
MFPI Expenditure by SERB	-	388,407,592.00	205,244.00	283,797,232.00
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	17,314,179.00		16,116,709.00	
ICPS (UBI)	10,409,284.00		-	
IMPRINT-II (UBI)	1,151,105.00	28,874,568.00	-	16,116,709.00
4. Claim Receivable		-		-
Total = (B)		**418,768,078.00**		**301,208,256.00**
Total (A) + (B)		**2,252,401,130.90**		**928,612,593.15**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

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	**-**	**-**

Scheudel 13 - Grants / Subsidies

Particulars	Current Year		Previous Year	
1. From Central Government				
a) Grant in Aid (General)	6,687,200,000.00		7,471,500,000.00	
Transferred to Corpus/Fixed Assets (Schedule 1)	(27,316,583.00)	6,659,883,417.00	(35,372,805.00)	7,436,127,195.00
b) Grant in Aid (Capital)		2,100,000,000.00		1,860,000,000.00
c) Grant in Aid (Scheduled Castes - General)		308,500,000.00		308,500,000.00
d) Grant in Aid (Scheduled Castes - Capital)		220,000,000.00		220,000,000.00
e) Grant in Aid (Scheduled Tribe - General)		130,000,000.00		65,000,000.00
f) Grant in Aid (Scheduled Tribe - Capital)		70,000,000.00		35,000,000.00
g) Grant in Aid (Salaries)		50,000,000.00		40,000,000.00
2. State Government(s)		-		-
3. Government Agencies		-		-
4. Institutions Organisations		-		-
5. International Organisations		-		-
6. Other		-		-
Total		**9,538,383,417.00**		**9,964,627,195.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

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	698,812.00	76,605.00	-	-
Interest on S & T SC Balance in Saving Account	485,275.00	1,268,257.00	-	-
Interest on S & T ST Balance in Saving Account	4,067.00	-	-	-
Interest on DOT Balance in Saving Account	401,115.00	-		
Total	1,589,269.00	1,344,862.00	-	-
Transferred to Earmarked/Endowment Funds	1,589,269.00	1,344,862.00		

Schedule 16 - Income from Royalty, Publication Etc.

Particulars	Current Year	Previous Year
1) Income from Royalty	-	-
2) Income from Publications	-	-
3) Other	-	-
Total	-	-

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

Schedule 17 - Interest Earned

Particulars	Current Year		Previous Year	
1. On Term Deposits				
a) With Scheduled Banks	10,250,808.00		22,391,982.00	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	(10,250,808.00)	-	-	22,391,982.00
b)With Non-Scheduled Banks		-		-
c) With Institutions		-		-
d) Others		-		-
2. On Savings Accounts				
a) With Scheduled Banks	89,308,770.00		63,673,845.00	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	(89,308,770.00)	-	-	63,673,845.00
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		15,627,219.25		3,044,679.99
Total		**15,627,219.25**		**89,110,506.99**

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	264.00	27,501.00
2. Export Incentives realized	-	-
3. Fees for Miscellaneous Services	-	-
4. Deferred Revenue Grant (AS-12)	10,356,053.00	14,545,362.00
5. Miscellaneous Income- Other Income RTI Receipts	130.00	366.00
Total	**10,356,447.00**	**14,573,229.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

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	86,768,985.00	81,544,222.00
b) Allowances and Bonus	-	-
c) Contribution to Provident Fund- Employer	2,095,016.00	2,046,953.00
d) Contribution to Other Fund : NPS Employer Contribution	3,944,372.00	2,849,312.00
e) Staff Welfare Expenses	-	-
f) Expenses on Employee's Retirement & Terminal Benefits		
Leave Encashment Provision	-	590,263.00
Gratuity Expense	1,697,320.00	-
Secretary Leave Salary Contribution	291,225.00	-
Secretary Pension Contribution	501,013.00	-
g) Others		
Telephone Expenses Reimbursement	256,566.00	201,808.00
School Fee Reimbursement	324,000.00	297,000.00
Newspaper Reimbursement	92,201.00	61,833.00
Medical Reimbursement	460,849.00	656,042.10
Leave Encashment	105,300.00	108,086.00
Leave Travel Concession	1,554,577.00	906,378.00
Total	**98,091,424.00**	**89,261,897.10**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

Schedule 21 - Other Administrative Expenses

Particulars	Current Year	Previous Year
a) Bank Charges	92,608.68	112,628.75
b) Car Hire Charges	4,833,863.00	4,281,267.00
c) Professional Fees	2,725,823.00	2,004,993.00
d) Electricity Charges	1,895,347.00	1,932,916.00
e) Membership fee : India International Centre, New Delhi	61,360.00	61,360.00
f) Meeting Expenses	8,197,536.00	5,139,575.00
g) Honorarium Expenses (Non- Official)	2,542,040.00	2,413,000.00
h) Hospitality Expenses	1,576,095.00	1,813,293.00
i) Printing & Stationery	4,489,156.00	6,701,805.00
j) Rent- Building	53,499,192.00	52,864,738.00
k) Advertisement/Publication	2,741,021.00	2,227,793.00
l) Water Charges	-	5,992.00
m) Conveyance Expenses	10,244.00	3,484.00
n) Housekeeping/Security Expenses	3,562,592.00	3,408,393.00
o) International Conference	762,138.00	764,387.00
p) Repair & Maintenance	873,359.00	1,330,349.00
q) Travelling Expenses (Domestic)	8,443,966.00	9,326,681.00
r) Travelling Expenses (International)	1,507,973.00	2,130,781.00
s) Audit Fee	449,500.00	449,500.00
t) Accommodation Expenses (Domestic)	919,509.00	128,307.50
u) Accommodation Expenses (International)	511,680.00	439,713.00
v) Computer Hardware & Software	1,344,588.00	1,355,831.00
w) Internet Charges	1,327,701.00	1,330,838.00
x) Newspaper & Periodicals	18,428.00	15,813.00
y) Postage Expenses	47,329.00	113,405.00
z) Telephone Expenses	368,160.00	297,360.00
aa) Festival Expenses	226,412.00	206,500.00
ab) NSDL E Governance Charges	3,272.00	3,490.00
ac) Training Exenses	5,000.00	30,680.00
ad) Conference Expenses	50,534.00	-
ae) AMC	1,721,111.00	2,006,209.00
af) Digitisation Cost	897,786.00	2,262,434.00
ag) Miscellaneous Expenses	1,234,399.00	781,373.00
Total	**106,939,722.68**	**105,944,889.25**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

Schedule 22 - Expenditure on Grants, Subsidies Etc

Particulars	Current Year	Previous Year
Grants given to Institutions/Organisations		
a) Grants in Aid (Capital Assets) (Ann. 28 & 28A)	2,114,226,265.00	2,124,898,354.00
b) Grant in Aid (General) (Ann. 29 & 29A)	5,567,817,241.46	6,957,763,305.57
c) Grant in Aid (Scheduled Castes - Capital) (Ann. 30 & 30A)	150,057,474.00	227,935,104.00
d) Grant in Aid (Scheduled Castes - General) (Ann. 31 & 31A)	345,496,505.00	360,300,422.00
e) Grant in Aid (Scheduled Tribe - Capital) (Ann. 32 & 32A)	77,700,185.00	34,435,000.00
f) Grant in Aid (Scheduled Tribe - General) (Ann. 33 & 33A)	101,366,444.00	63,129,296.00
Total	**8,356,664,114.46**	**9,768,461,481.57**

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	**-**	**-**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

Schedule 24 - Prior Period Income

Particulars	Current Year	Previous Year
A) Refund received against previous year grants		
a) Refund from Projects (Capital) FY 2011-12 (Ann. 34 & 34A)	136,923.00	8,275.00
b) Refund from Projects (General) FY 2011-12 (Ann. 35 & 35A)	343,817.00	240,146.00
c) Refund from Projects (Capital) FY 2012-13 (Ann. 36 & 36A)	785,337.00	2,709,784.63
d) Refund from Projects (General) FY 2012-13 (Ann. 37 & 37A)	294,831.00	2,053,795.00
e) Refund from Projects (Capital) FY 2013-14 (Ann. 38 & 38A)	2,278,137.03	4,151,966.00
f) Refund from Projects (General) FY 2013-14 (Ann. 39 & 39A)	1,360,308.79	2,485,572.66
g) Refund from Projects (SC-Capital) FY 2013-14 (Ann. 40 & 40A)	788.00	939,309.00
h) Refund from Projects (SC-General) FY 2013-14 (Ann. 41 & 41A)	-	226,601.00
i) Refund from Projects (ST-Capital) FY 2013-14 (Ann. 42 & 42A)	21.00	343,873.00
j) Refund from Projects (Capital) FY 2014-15 (Ann. 43 & 43A)	4,751,389.15	9,382,534.71
k) Refund from Projects (General) FY 2014-15 (Ann. 44 & 44A)	3,357,169.90	6,700,754.90
l) Refund from Projects (SC-Capital) FY 2014-15 (Ann. 45 & 45A)	728,197.00	8,453.24
m) Refund from Projects (ST-Capital) FY 2014-15 (Ann. 46 & 46A)	9,288.00	603,713.00
n) Refund from Projects (ST-General) FY 2014-15 (Ann. 47 & 47A)	81,507.00	5,175.00
o) Refund from Projects (Capital) FY 2015-16 (Ann. 48 & 48A)	24,417,743.73	8,734,377.66
p) Refund from Projects (General) FY 2015-16 (Ann. 49 & 49A)	10,151,098.32	8,043,296.64
q) Refund from Projects (SC-Capital) FY 2015-16 (Ann. 50 & 50A)	142,370.00	693,218.00
r) Refund from Projects (SC-General) FY 2015-16 (Ann. 51 & 51A)	1,415,045.00	2,024,960.30
s) Refund from Projects (ST-General) FY 2015-16 (Ann. 52 & 52A)	-	500,406.00
t) Refund from Projects (Capital) FY 2016-17 (Ann. 53 & 53A)	24,963,266.50	17,186,753.44
u) Refund from Projects (General) FY 2016-17 (Ann. 54 & 54A)	15,093,917.25	34,696,267.10
v) Refund from Projects (SC-Capital) FY 2016-17 (Ann. 55 & 55A)	2,400,382.00	175,596.00
w) Refund from Projects (SC-General) FY 2016-17 (Ann. 56 & 56A)	7,115.00	441,606.00
x) Refund from Projects (ST-Capital) FY 2016-17 (Ann. 57 & 57A)	830,982.00	160,000.00
y) Refund from Projects (ST-General) FY 2016-17 (Ann. 58 & 58A)	-	277,817.00
z) Refund from Projects (Capital) FY 2017-18 (Ann. 59 & 59A)	13,801,860.05	9,826,318.60
aa) Refund from Projects (General) FY 2017-18 (Ann. 60 & 60A)	34,305,010.77	68,713,812.22
ab) Refund from Projects (SC-Capital) FY 2017-18 (Ann. 61 & 61A)	841,546.00	211,786.00
ac) Refund from Projects (SC-General) FY 2017-18 (Ann. 62 & 62A)	2,330,590.88	3,676,326.42
ad) Refund from Projects (ST-General) FY 2017-18 (Ann. 63 & 63A)	201,359.00	275,377.00
ae) Refund from Projects (Capital) FY 2018-19 (Ann. 64 & 64A)	7,291,077.00	-
af) Refund from Projects (General) FY 2018-19 (Ann. 65 & 65A)	103,618,895.45	-
ag) Refund from Projects (SC-General) FY 2018-19 (Ann. 66 & 66A)	1,613,376.00	-
ah) Refund from Projects (ST-General) FY 2018-19 (Ann. 67 & 67A)	267,684.00	-
ai) Refund from Projects SERC (Ann. 68 & 68A)	-	20,468.00
aj) Refund from Projects PY (Ann. 69 & 69A)	24,051.00	516,881.00
B) Refund from DOT against previous year grants		
a) Grant-in-Aid (General) FY 2014-15 (Ann. 70 & 70A)	-	2,103,154.50
c) Grant-in-Aid (General) FY 2015-16 (Ann. 71 & 71A)	-	103,413.50
e) Grant-in-Aid (General) FY 2016-17 (Ann. 72 & 72A)	-	31,936.00
f) Grant-in-Aid (General) FY 2017-18 (Ann. 73 & 73A)	-	150,076.50
Total A) + B)	**257,845,083.82**	**188,423,801.02**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2020

Schedule 25 - Prior Period Expenditure

Particulars	Current Year	Previous Year
a) Professional Fees	3,331.00	3,323.00
b) Audit Fee (CAG Auditors)	-	231,025.00
c) International Conference	151,598.00	-
d) Travelling Expenses (Domestic)	14,643.00	22,741.00
e) Conference Expenses	-	22,713.00
f) Grant-in-Aid (Capital)	-	90.00
g) Newspaper Reimbursement	37,881.00	15,598.00
h) Medical Expenses Reimbursement	138,965.00	58,399.90
i) Telephone Expenses Reimbursement	49,504.00	16,830.00
j) School Fee Reimbursement	27,000.00	290,850.00
k) Salary Arrear (Regular Employees)	-	(45,440.00)
l) Salary Arrear (Contract Employees)	25,790.00	-
m) AMC Computers & Printers	29,972.00	29,972.00
n) AMC Photocopier	4,735.00	4,033.00
o) AMC SERB Website	-	50,478.00
p) AMC Video Conferencing System	-	1,565.00
q) Newspaper & Periodicals	1,538.00	-
r) Bank Charges	(245.32)	-
s) Digitisation Cost	1,156,306.00	-
t) EPF Employer Contribution	523.00	-
u) Honorarium Expenses (Non-Official)	4,000.00	-
v) Leave Encashment	(417,520.00)	-
Total	**1,228,020.68**	**702,177.90**

Amount in Rs.

Receipts & Payments for the Year Ended 31.03.2020

	Receipts	Current Year	Previous Year		Payments	Current Year	Previous Year
1	**Opening Balances**			1	**Expenses**		
a)	Cash in hand	20,000.00	20,000.00	a)	**Establishment** Expenses (corresponding to Schedule 20)	95,390,238.00	89,266,991.00
b)	Bank balances			b)	**Administrative** Expenses (corresponding to Schedule 21)	106,998,608.36	107,147,263.25
	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	626,742,669.47	738,773,151.78	a)	Grants in Aid (Capital Assets)	2,114,226,265.00	2,124,898,444.00
	: SERB RTI	294.68	176.68	b)	Grant in Aid (General)	5,567,817,241.46	6,957,763,305.57
	: SERB EPFO	112.00	9.00	c)	Grant in Aid (Scheduled Castes - Capital)	150,057,474.00	227,935,104.00
2	**Grants Received**			d)	Grant in Aid (Scheduled Castes - General)	345,496,505.00	360,300,422.00
a)	From Government of India			e)	Grant in Aid (Scheduled Tribe - Capital)	77,700,185.00	34,435,000.00
	Grant in Aid (General)	6,687,200,000.00	7,471,500,000.00	f)	Grant in Aid (Scheduled Tribe - General)	101,366,444.00	63,129,296.00
	Grant in Aid (Capital)	2,100,000,000.00	1,860,000,000.00	3	**Investments & Deposits made**		
	Grant in Aid (Scheduled Castes - General)	308,500,000.00	308,500,000.00	a)	Out of Earmarked/Endowment Funds	-	-
	Grant in Aid (Scheduled Castes - Capital)	220,000,000.00	220,000,000.00	b)	Out of Own Funds (Investments-Others)	-	-
	Grant in Aid (Scheduled Tribe - General)	130,000,000.00	65,000,000.00	4	**Expenditure on Fixed Assets & Capital Work-in**		
	Grant in Aid (Scheduled Tribe - Capital)	70,000,000.00	35,000,000.00	a)	Purchase of Fixed Assets	2,733,289.00	27,387,950.00
	Grant in Aid (Salaries)	50,000,000.00	40,000,000.00	b)	Expenditure on Capital Work-in Progress	17,097,374.00	-
b)	From State Government	-	-	5	**Refund of surplus money/loans**		
c)	From Other Sources (details)	-	-	a)	To the Government of India	-	-
3	**Income on Investments from**			b)	To the State Government	-	-
a)	Earmarked/Endowment Funds	-	-	c)	To other providers of Funds	-	-
b)	Own Funds	-	-	6	**Finance Charges (Interest)**	-	-
4	**Interest Received**			7	**Other Payments (Specify)**		
a)	On Bank Deposits	99,951,377.00	84,319,068.00	a)	MFPI Earmarked Payment	578,496.00	6,460,602.00
b)	Loans Advances	-	-	b)	Refund to Ministry of Food Processing	20,000,000.00	-
c)	Interest on Refund	15,627,219.25	3,044,679.99	c)	S & T Earmarked Payment	-	105,231,534.00
5	**Other Income**	130.00	366.00	d)	ICPS Earmarked Payment	1,227,000,000.00	-
6	**Amount Borrowed**	-	-	e)	IMPRINT-II Earmarked Payment	154,652,510.00	310,000,000.00
7	**Any Other Receipts**			f)	MFPI Expenditure by SERB	-	450,000.00
a)	Refunds Received Against Previous Year Grant (SERB)	257,845,083.82	186,035,220.52	g)	DOT Earmarked Payment	146,244.50	5,082,715.00
b)	MFPI Earmarked Receipt	2,391,281.00	2,059,330.00	h)	IMPRINT-II Expenditure by SERB	111,087,177.00	275,723,693.00
c)	S & T Earmarked Receipt	1,596,624.00	1,575,013.00	i)	AISTDF Expenditure by SERB	-	11,999.00
d)	ICPS Earmarked Receipt	1,227,000,000.00	-	j)	Bureau of Outreach & Communication, New Delhi	1,000,000.00	-
e)	IMPRINT-2 Earmarked Receipt	273,188,969.00	310,000,000.00	k)	Mrs. Madhu Wadhawan Sinha	-	34,500.00
f)	Receipt against MFPI Expenditure by SERB	759,796.00	4,007,152.00	l)	Praveen Kumar S	-	118,376.00
g)	Dr. P Sanjeeva Rao	-	9,524.00	m)	Centre for Development of Advanced Computing, Noida	-	7,485,920.00
h)	Received from AISTDF	11,999.00	-	n)	Government of India, Consolidated Fund	144,222,373.00	-
i)	Dr. Doyil T Vengayil	2,633.00	-	o)	Lemon Tree Premier- Delhi Airport, New Delhi	-	200,000.00
j)	Dr. Pravakar Mohanty	2,633.00	-	p)	Red Fox Hotel Aerocity, New Delhi	-	17,500.00
				q)	Deepak Krishna	5,000.00	-
				r)	Dr. Rajwant	60,554.00	
				s)	MHRD Expenditure by SERB	504,962.00	
				8	**Closing Balances**		
				a)	Cash in hand	19,918.00	20,000.00
				b)	Bank balances		
					i) In Current Accounts	-	-
					ii) In Deposit Accounts	-	-
					iii) Savings Accounts : SERB UBI	1,714,167,284.90	626,742,669.47
					: IMPRINT-II UBI	118,511,462.00	-
					: SERB RTI	685.00	294.68
					: SERB EPFO	531.00	112.00
	Total	12,070,840,821.22	11,329,843,690.97		Total	12,070,840,821.22	11,329,843,690.97

For Science and Engineering Research Board

Sandeep Verma

Secretary
SERB

Wadhawan

Director-Finance
SERB

Date : October 13, 2020
Place : New Delhi

As per our report of even date
For and on behalf of
M/s Gaur & Associates
Chartered Accountants
Firm's Reg. No. :005354C

R K Gaur
Partner
Mem. No. :072146

SCHEDULE FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31.03.2020

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. 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

Besides the grants-in-aid received from Central Government, SERB also generates income from: -

a. Interest on Short term FDs on the Grant-in Aid
b. Interest on the Saving A/c Balance; and
c. Interest on Refunds

Insofar as 7a. & 7b. are concerned the interest earned is being deposited since 2017-18 in Government of India account (Consolidated Fund of India) as directed by the administrative Ministry i.e. Department of Science and Technology under intimation to the Board. However, income generated and depicted in 7c. above is being used for meeting the expenses as per provisions in para 10(2) of the SERB Act, 2008.

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".

10. Unspent balances of Grants received from DST:

The unspent balances of Grants received from DST are not to be refunded to DST as grants released by the Government are credited to Science and Engineering Research Board in terms of Section 10(1) of SERB Act, 2008.

11. Time barred cheques

All cheques issued by SERB during the FY 2019-20 have been encashed within its validity period of 3 months from the date of the issue of Cheque except 3 cheques issued to M/s Balmer Lawrie & Co. Ltd., New Delhi amounting to Rs. 14,77,844/-, which has been reversed on 31.03.2020.

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. 1,03,56,053/- 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.

For Science and Engineering Research Board

Sandeep Verma

Secretary
SERB

Director-Finance
SERB

Date : October 13, 2020
Place : New Delhi

As per our report of even date
For and on behalf of
M/s Gaur & Associates
Chartered Accountants
Firm's Reg. No. :005354C

R K Gaur
Partner
Mem. No. :072146

SCHEDULE FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31.03.2020

SHCEDULE- 27 CONTINGENT LIABILITIES AND NOTES TO ACCOUNTS

1. CONTINGENT LIABILITIES

1.1 Claims against the Entity not acknowledge 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 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
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 in Current FY 2019-20

Total Income of Current FY 2019-20 is Rs. 956,43,67,083.25 whereas Total Expenditure of Current FY is Rs. 857,20,51,314.14

In Income & Expenditure A/c excess of Income over Expenditure shows a difference of Rs. 99,23,15,769.11 as Gross Profit.

SERB is having Net Profit of Rs. 124,89,32,832.25 in FY 2019-20 after considering Prior Period Income of Rs. 25,78,45,083.82 and Prior Period Expenditure of Rs. 12,28,020.68

6. TAXATION

SERB has got exemption u/s 10(46) of the Income Tax Act, 1961 for 5 financial years from FY 2013-14 to FY 2017-18 vide gazette notification no. 24/2017/F.No.196/15/2013-ITA-I published on 31st March, 2017.

Since our original application for exemption u/s 10(46) was from inception of SERB, the matter has been taken up again with CBDT to grant us exemption for FY 2011-12 and FY 2012-13 also.

Further we have applied for exemption u/s 10(46) of the Income Tax Act, 1961 to CBDT and Income Tax Department for FY 2018-19 and onwards.

In such a situation we have shown Contingent Liability 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.

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	Rs. 7,62,138/-	Rs. 7,64,387/-
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.10,76,30,893/-	Rs. 9,80,67,135/
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. 3,24,500/-	Rs. 3,24,500/-
- Taxation matters	.....	.....
- For management services	.....	.....
- For certificate	.....	.....
- Others	.....	.....

8. Previous Year figures have been regrouped /recast wherever found necessary.
9. Schedules 1 to 27 are annexed to and form an integral part of the Balance Sheet as at 31.03.2020 and the Income and Expenditure Account for the year ended on that date.

For Science and Engineering Research Board

Sandeep Verma
Secretary
SERB

Director-Finance
SERB

Date : October 13, 2020
Place : New Delhi

As per our report of even date
For and on behalf of
M/s Gaur & Associates
Chartered Accountants
Firm's Reg. No. :005354C

R K Gaur
Partner
Mem. No. :072146

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

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E-mail: info@serbonline.in Website : www.serb.gov.in