

# **Annual Report 2020-21**

**Indo-French Centre for the  
Promotion of Advanced Research**

**Centre Franco-Indien pour la  
Promotion de la Recherche Avancée**





# Annual Report

## 2020-21

Indo-French Centre for the Promotion  
of Advanced Research  
(IFCPAR)

Centre Franco-Indien pour la Promotion  
de la Recherche Avancée  
(CEFIPRA)



## *From the Director*



With a great sense of accomplishment, I present this Annual Report to all our patrons and stakeholders for the year 2020-21. It was yet another remarkable year during which Indo-French S&T cooperation further strengthened through CEFIPRA's scientific programmes and activities.

During the year, various new projects emanated from advanced knowledge frontiers of science & technology, were supported. The anticipated outcomes of these projects will generate not only high quality scientific output but also provide distinct leads for real life demonstration and deployment. The ongoing and completed projects resulted into 191 peer reviewed publications in high ranked peer-reviewed international journals.

Various outreach events viz. 31<sup>st</sup> STIP Lecture on “Art of Science in the Brave New World” by Former Secretary DST, Prof. Ashutosh Sharma and “The Role of CEFIPRA: shaping Indo-French ST&I Collaboration” were organized. A highly impactful seminar on “Quantum simulation of molecular energy transport” was also supported to further the interaction between Indian and French scientists. The focus remained in developing new nucleating groups in these domains. People to people contacts were facilitated by mobility support of over sixty scientists and students.

CEFIPRA also organized “Debriefing Session” for the Raman-Charpak Fellows of batch 2018 with various experts and representatives of funding agencies. During the COVID 19 Pandemic, the Centre facilitated all the necessary support to these fellows along with other project personnel involved in CEFIPRA projects.

It is gratifying to note that through the above activities, we have successfully accomplished our mandated charter in being able to seed and spawn a large number of sustainable interactions and establish long term relationships, highlighted in the following pages.

Using our glorious past as a launch pad, we are prepared to embark upon the next leg of our journey with excitement and belief that our best is yet to come. I look forward to the continued support and guidance of all our stakeholders in our journey into the future.

A handwritten signature in black ink, appearing to read "Nitin Seth".

**Prof. Nitin Seth**  
Director, CEFIPRA





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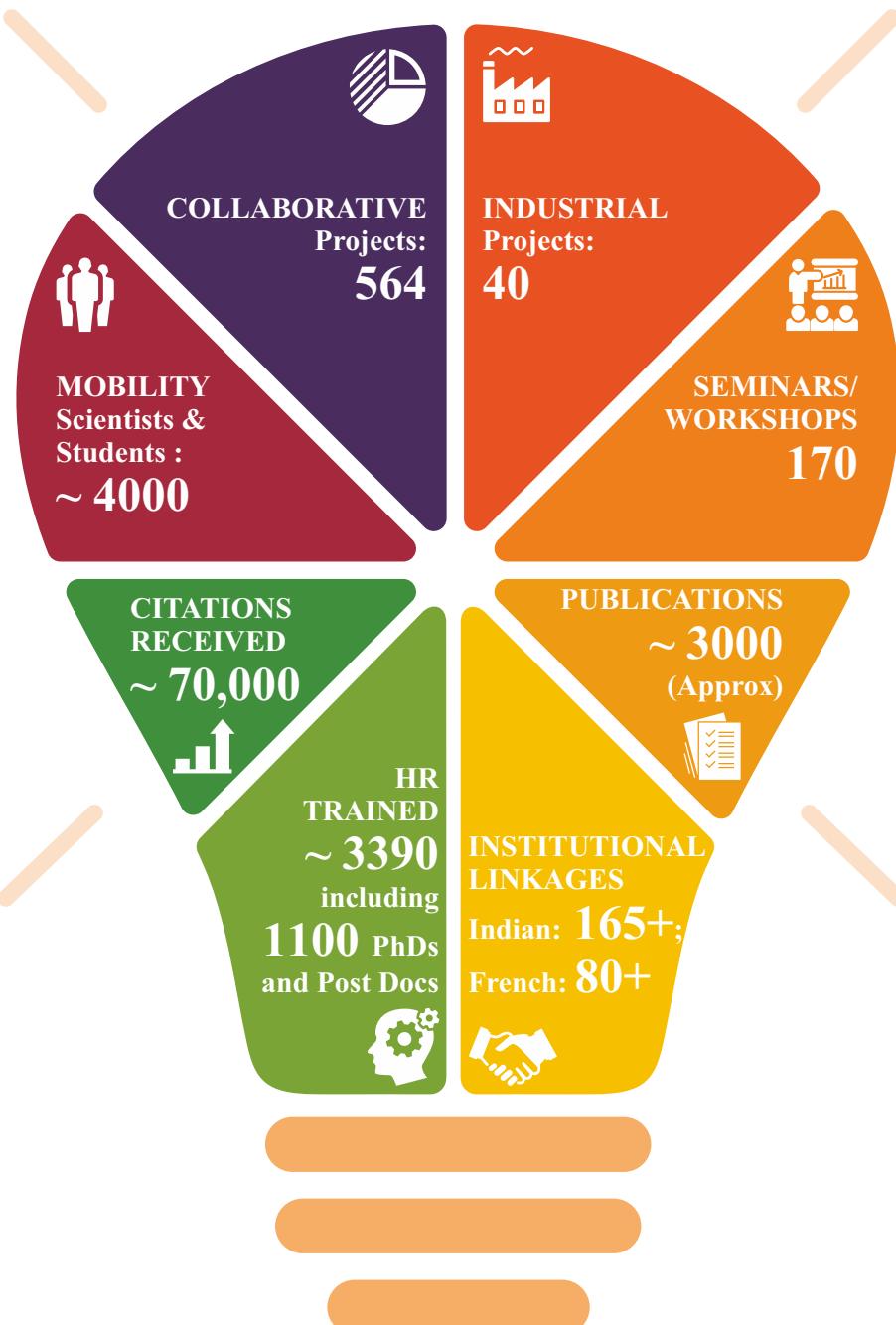
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## I. Overview & Activities of the Centre

## A seamless journey over three decades - At a Glance



### The year under review....

During the year 2020-21, two Calls for Proposals were initiated by CEFIPRA - General Call in July, in response to which the Centre received 78 project proposals; and the thematic call of January 2021, which yielded 19 innovative project proposals.

The 65<sup>th</sup> meeting of the Scientific Council (SC) was held on 27 May, 2020 through a virtual platform. After initial screening at CEFIPRA, the SC considered 37 proposals, 23 from thematic areas [AI & Big Data (9), Science for Sustainability (3), Quantum Materials (5), Addressing Biological Questions Using or Developing Mathematical, Computational or Physical Approaches (6)], 14 from general areas [Computational Science (1), Life and Health Sciences (1), Pure and Applied Physics (1), Pure and Applied Chemistry(2), Earth and Planetary Sciences (2), Materials Science (6) and Environmental Science (1)] and recommended 10 innovative projects.

The 36<sup>th</sup> Industrial Research Committee (IRC) meeting was held on 29 May, 2020 through videoconferencing. Three projects in the areas of Ophthalmology, Nutrition and Affordable healthcare were recommended for funding.

Three seminar proposals were also recommended in the areas of water, Biophysics and Process Chemistry & Technology. Further, areas such as Natural products and cosmetics, Nano toxicology and Smart and digital manufacturing were recommended and would be given preference for next two years for initiating calls for seminars/workshops/training schools etc. A webinar on “Galactic and Extra Galactic Universe in the era of new generation Radio (SKA and pathfinders) and IR/Optical (MSE) facilities” was organized from 22 to 26 March, 2021 through virtual platform. 116 participants from India and France attended this seminar.

The Centre continues to offer a platform to facilitate “Targeted Programmes” of the National funding agencies to bring together and support collaborative scientific research in the focused areas of mutual interest. These include DST-Inria-CNRS and DST-CNRS Programmes under which 11 projects are on-going. Till, 2021, 28 projects supported (11 ongoing + 17 completed). The meeting of the Expert Committee for evaluation of proposals was held virtually on 21 January 2021, along with progress review of completed & ongoing projects. The 8th Call for Proposals was launched in August, 2021 in the areas of Artificial Intelligence, Cybersecurity and Signal Processing with the deadline of 7 October, 2021.

During the COVID 19 pandemic, CEFIPRA facilitated the early return of 16 Indian and 2 French Raman Charpak Fellows 2019 to their respective home countries through Vande Bharat Mission launched by MEA, GoI. Debriefing Session for the Raman-Charpak Fellows of 2018 organized on 2 July, 2020 via videoconferencing. Members of the Expert Committee (4), RC Fellows 2019 (12) and representatives of the funding agency (2) along with CEFIPRA officials participated in the session.

The 5<sup>th</sup> Standard Expert Panel (SEP) meeting of CEFIPRA was organized on 17 June, 2020 through video conferencing. 20 Principal Investigators (PIs) (14 Indian and 6 French) participated from CSRP & IARDP. The agenda of the meeting was to mentor and monitor the PIs on the IP related issues and encourage them to file more patents, if any patentable outcome is available under their research project.

Due to the pandemic, the Call for Women Post-Doctoral Fellowship Programme (WISPROG) was not launched as scheduled in January 2022 for providing women scientists' international collaborative research opportunities, thereby furthering their research capacity & global perspective and forging long-term relationships with scientists, technologists and engineers between France/India.

CEFIPRA organized virtual interactions with scientists, researchers and students from various research institutions of India and France through webinars- “Opportunities for Indo-French S&T partnerships” on 17 & 18 March 2021. Around 170 participants from both the countries attended this online event.

The Centre organized 27<sup>th</sup> and 31<sup>st</sup> STIP lecture on "Space Technology & Applications for Development" delivered by Dr. P. G. Diwakar, Distinguished Scientist, ISRO on 10 Jan, 2020 at IHC, New Delhi and The Art of Science in the Brave New World”, on 17 December, 2020 by Prof. Ashutosh Sharma, Secretary, DST respectively.

## OVERVIEW & ACTIVITIES OF THE CENTRE



The meeting of the Review Committee for evaluation of progress of ongoing and completed projects under DST-Inria-CNRS Targeted Programme along with projects of DST-CNRS Targeted Programme was held on 21 January, 2021. The meeting was attended by six area experts and representative of DST along with CEFIPRA officials. A total of 12 Indian PIs gave presentations on progress of their ongoing and completed projects.



The 13<sup>th</sup> meeting of the Finance Sub-Committee was held at CEFIPRA, New Delhi on 25 Feb., 2021 to discuss the matters related to Action taken of the 12<sup>th</sup> FSC, Grant-in-Aid of the Centre and other finance and administration related matters. The Committee was chaired by Shri Vishvajit Sahay, Joint Secretary and Financial Adviser, DST. Members present were the representatives from DST, French Embassy, Director CEFIPRA with other staff members.

# Debriefing session for Raman-charpak Fellows Batch 2018

The Debriefing Session for the Raman-Charpak Fellows of batch 2018 was virtually organized on 2 July, 2020. Various experts, representatives of funding agencies, 12 Raman-Charpak fellows along with CEFIPRA officials attended this session. It was mentioned that during this COVID-19 Pandemic, CEFIPRA was in regular contact with 16 Indian students and 2 French Students who were working in France and India respectively.

The Experts congratulated Department of Science and Technology (DST), French Embassy & CEFIPRA for putting up this programme for young minds of two countries & for its success in strengthening Indo-French Collaborations. They also highlighted that excellent quality of applications received every year and how significant efforts were put in by the Expert Committee for selecting the best applicants.



## 5<sup>th</sup> Meeting of the Standard Expert Panel (SEP)

17 June, 2020 via videoconferencing



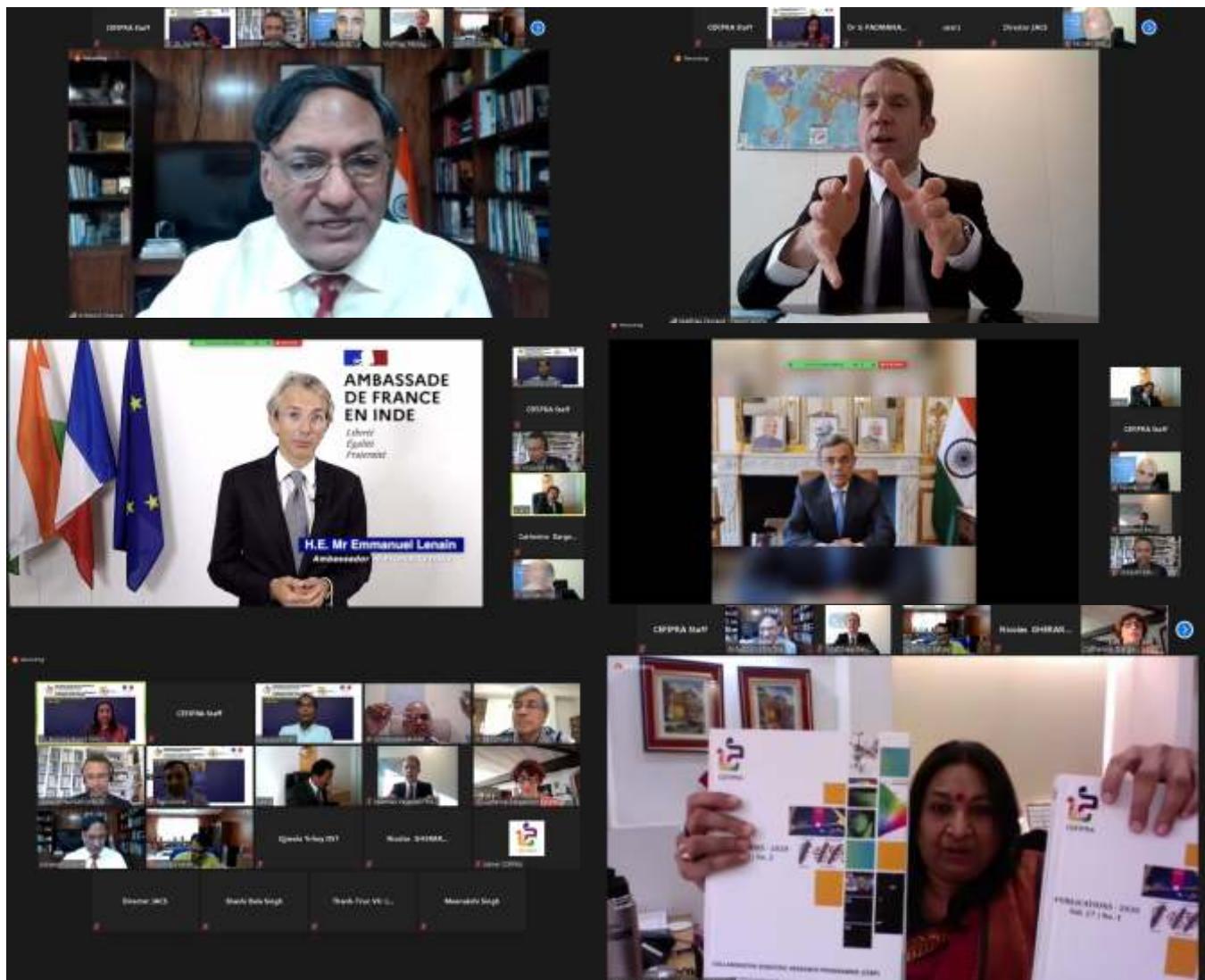




## 2. Governance & Guidance

# 34<sup>th</sup> Governing Body Virtual Meeting

13 April, 2021



CEFIPRA held its 34<sup>th</sup> Governing Body (GB) virtually on 13 April, 2021. The meeting was Co-Chaired by Prof. Ashutosh Sharma, Secretary, Department of Science & Technology (DST), Govt. of India & Mr. Matthieu Peyraud, Director for Culture, Education, Research and Network Coordination, Ministry of Europe and Foreign Affairs, Govt. of France.

Ambassador of India in France, H.E. Mr. Jawed Ashraf and Ambassador of France in India, H.E. Mr. Emmanuel Lenain also addressed the GB meeting virtually. Mr Ashraf urged that there was a need to encourage the expanding network of collaboration with industries in both countries. Also, there was a need to promote greater collaboration and engagement at the level of young scientists and scholars which can benefit the research and collaboration output under the broader strategic partnership between India and France. Some of the areas CEFIPRA could consider for collaboration with France may include supercomputing, artificial intelligence, health sciences, biotechnology, public health, Climate Change, waste management, cleaning up of water bodies to name a few. Blue economy and Deep ocean mission were emerging as a very important area in our strategic partnership, especially in the Indo-Pacific region, he added. He also suggested that the participation of industry networks from both in India and France into CEFIPRA's programmes should be encouraged. He concluded by citing that India- France strategic partnership was one of the most comprehensive, broad based partnerships that India has with any country.

Indian GB members expressed that CEFIPRA was a shining success not only in bilateral cooperation between India & France but was considered as the best model for bilateral cooperation for others to emulate. He added that CEFIPRA had been performing successfully and had set very high standards of performance. Indian GB members expressed his concerns about the limited support for mobility of students and faculty pursuing Indo-French collaborations. He also suggested that appropriate measures should be taken to address the asymmetry of exchanges between Indian and French researchers.

France GB members, representing Ministry of Higher Education, Research and Innovation (MESRI), mentioned that adopting Research and Innovation collaborations with India was a very high priority for his Ministry. He also shared that the French scientific communities, at the grassroot levels, research-oriented universities and international research bodies were strongly motivated to work with India & CEFIPRA could play a central role in the development of these collaborations.

Indian & French GB members, representatives from DST, Indian Embassy in France and French Embassy in India also participated in this meeting. Director, CEFIPRA presented the activities of the CEFIPRA. Prof. Santanu Bhattacharya/ Dr. Catherine Dargemont, Members of the Scientific Council (SC), made a joint presentation on the activities undertaken during the 65<sup>th</sup> (virtual) meeting of SC held on 27 May, 2020. Dr. G. Padmanabham, a Member of the Industrial Research Committee (IRC) presented the activities of the IRC. GB also released the following documents of during the meeting:

- a) Annual Report FY 2019-20.
- b) Compilation of Publications-2020 (Vol 27 Nos 1 & 2) resulted from the Collaborative Scientific Research Programme (CSRP).
- c) Bibliometric Analysis - Report of papers emanated from projects supported under CSRP during 2019.



### **CEFIPRA welcomes the new French Co-Chair**

### **MR. MATTHIEU PEYRAUD**

We are delighted to welcome Mr. Matthieu Peyraud as Co-Chair of CEFIPRA from France. Currently, Mr. Peyraud is the Director for Culture, Education, Research and Network Coordination at the French Ministry for Europe and Foreign Affairs. He has taken over from Ms. Laurence Auer.

He was awarded with Knight of the French National Order of Merit in 2020 and French National Defence Medal in 1999. He is conversant in English, Spanish and German.

CEFIPRA is confident to further enhance its contribution towards Indo-French S&T collaboration under his able guidance.

# 65<sup>th</sup> Scientific Council Meeting

27 May, 2020 via videoconferencing

The 65<sup>th</sup> meeting of the Scientific Council (SC) was held on 27 May, 2020 through videoconferencing. After initial screening at CEFIPRA, the SC considered 37 proposals, 23 from thematic areas [AI & Big Data (9), Science for Sustainability (3), Quantum Materials (5), Addressing Biological Questions Using or Developing Mathematical, Computational or Physical Approaches (6)], 14 from general areas [Computational Science(1), Life and Health Sciences (1), Pure and Applied Physics (1), Pure and Applied Chemistry(2), Earth and Planetary Sciences (2), Materials Science (6) and Environmental Science (1)]. However, The scheduled SC meeting in November, 2020 could not be held due to the Pandemic.



The scientific activities of CEFIPRA under collaborative scientific research programme (CSRP) are guided by Scientific Council (SC), Governing Body of CEFIPRA appreciated the activities of Scientific Council and the performance of academia-academia collaborations under Collaborative Scientific Research Programme. GB in its 34 meeting approved Standard Operating Procedures (SoP) for Scientific Council (SC)/& Industrial Research Committee (IRC) of CEFIPRA.

The SoPs are aimed to establish guidelines for the main components of the evaluation procedure for projects submitted to a programme as a part of the Call for Proposals under CSRP and IARDP, and in arriving at quick recommendations which reflect convergence of decisions taken collectively, healthy discussions and reducing miscommunications amongst members before and during the meetings.

Scientific Council evaluates proposals for joint research, training and any other scientific activity as may be desired by the Governing Body. SC also closely monitors and assesses the progress of collaborative research projects and other programmes of the CEFIPRA. Industrial Research Council evaluates proposals received by CEFIPRA under the Industry Academia R&D programme. IRC also review the progress of the activities of projects approved under Industrial research Programme and also give direction for mid-term corrections for the successful implementation of this programme. SC and IRC shall meet at least once in a year, alternatively in France and in India.

1. Scientific Council (SC) and Industrial Research Committee (IRC) expert members. The expert members of SC & IRC are internationally recognised scientists of high calibre and standing from both the countries, nominated by the respective Governments.
  - a. They are nominated for a term of two years. An expert member would be eligible for nomination for a maximum of two consecutive terms. An expert member who already did two consecutive terms can't be eligible for a new term before four years have passed since the end of his last term. In order to have continuity, to the extent possible, it shall be ensured that not more than half of the expert members of the councils retire at any point of time.
  - b. The term of an expert member shall commence from the date of the first meeting of the SC or IRC after his/her nomination.
  - c. Any change in the nomination of expert member(s) of the SC or the IRC effected either of the two Governments shall be communicated to the Co-Chairman of the Governing Body from the other Government and to the Director of the CEFIPRA immediately after any such change is effected.
2. At least one representative each from DST, Govt. of India and French Embassy in India as Observers.

Both SC and IRC programs consist of joint committee. The number of expert members (same for each country) is defined by the Governing Body. The choice of members of the committees is made such as:

- (i) to cover the major thematic areas
- (ii) possibly with a representativeness of the most important stakeholders of cooperation (organizations, institutions, universities)
- (iii) Gender Parity

As desired by the Expert Members, CEFIPRA will co-opt members for review of proposals if proposals are out of expertise of expert members or if the amount of projects to be evaluated by some experts is too large. These co-opt members are proposed by the respective Governments.



# 36<sup>th</sup> Industrial Research Committee Meeting

*29 May, 2020 via videoconferencing*

The 36<sup>th</sup> meeting of the Industrial Research Committee (IRC) was held on 29 May, 2020 through videoconferencing. A total of five proposals from various thematic areas [Machine Learning (1), Oenology (1), Nutrition (1), Ophthalmology (1) and Affordable healthcare (1)] were evaluated by the expert panel members, out of which three innovative projects were considered for support. The Committee also discussed on improvement of visibility of CEFIPRA's Industry-Academia Programme with Industrial clusters in India and France.

Members of the Industrial Research Committee (IRC) suggested that there was a need to define the starting and ending (TRL) points in each of the projects submitted under IARDP. He emphasised on outreach activities for better visibility of programmes with the stakeholders.



## **Revamping of Industry-Academia Research and Development Programme (IARDP) and suggestion for a new model to support Translational/Applied Research**

The Governing Body of CEFIPRA opined that it was necessary to enhance the activities of Industry-academia collaboration, and emphasized to bring more industries on board in order to supplement the core funding of CEFIPRA for supporting industry relevant research. Additional Secretary & Financial Adviser (AS & FA) proposed that at least 30% of the industry's contribution should be in cash.

A new model to support Translational/Applied Research being carried out under IARDP. Moreover, It was suggested that CEFIPRA should explore the possibility of engaging with Indian and French other agencies with CEFIPRA to make Industry-academia programme more attractive.





### 3. Seminars / Webinars

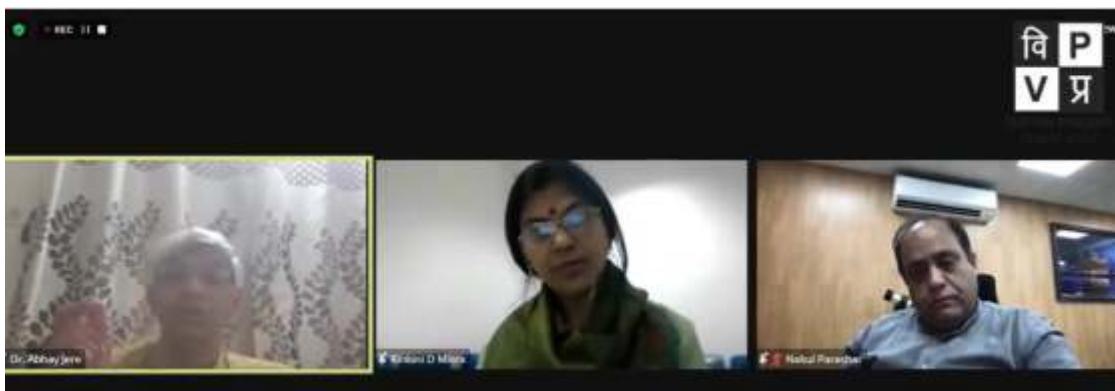
# International Conference on Entrepreneurship, Innovation and Leadership (ICEIL'2020)



Dr. Purnima Rupal, Director, CEFIPRA participated as a Panelist in the technical session entitled “Biotechnology Frontiers: Research and Funding Opportunities – The Way Ahead” on the theme “Harnessing Innovation, Technology, Entrepreneurship and Sustainability” during the 3rd International Conference on Entrepreneurship, Innovation and Leadership (ICEIL'2020) organised by Amity Institute of Biotechnology, Amity University, Noida, U.P. on 18 December, 2020. The Session was Chaired by Dr. Shirshendu Mukherjee, Mission Director, Biotechnology Industry Research Assistance Council (BIRAC). The other Panelists were Dr. Purnima Sharma, Managing Director, Biotech Consortium India Ltd. (BCIL), Deptt. of Biotechnology (DBT), Mr. Narayanan Suresh, Chief Operating Officer, Association of Biotech Ltd. Enterprises (ABLE).

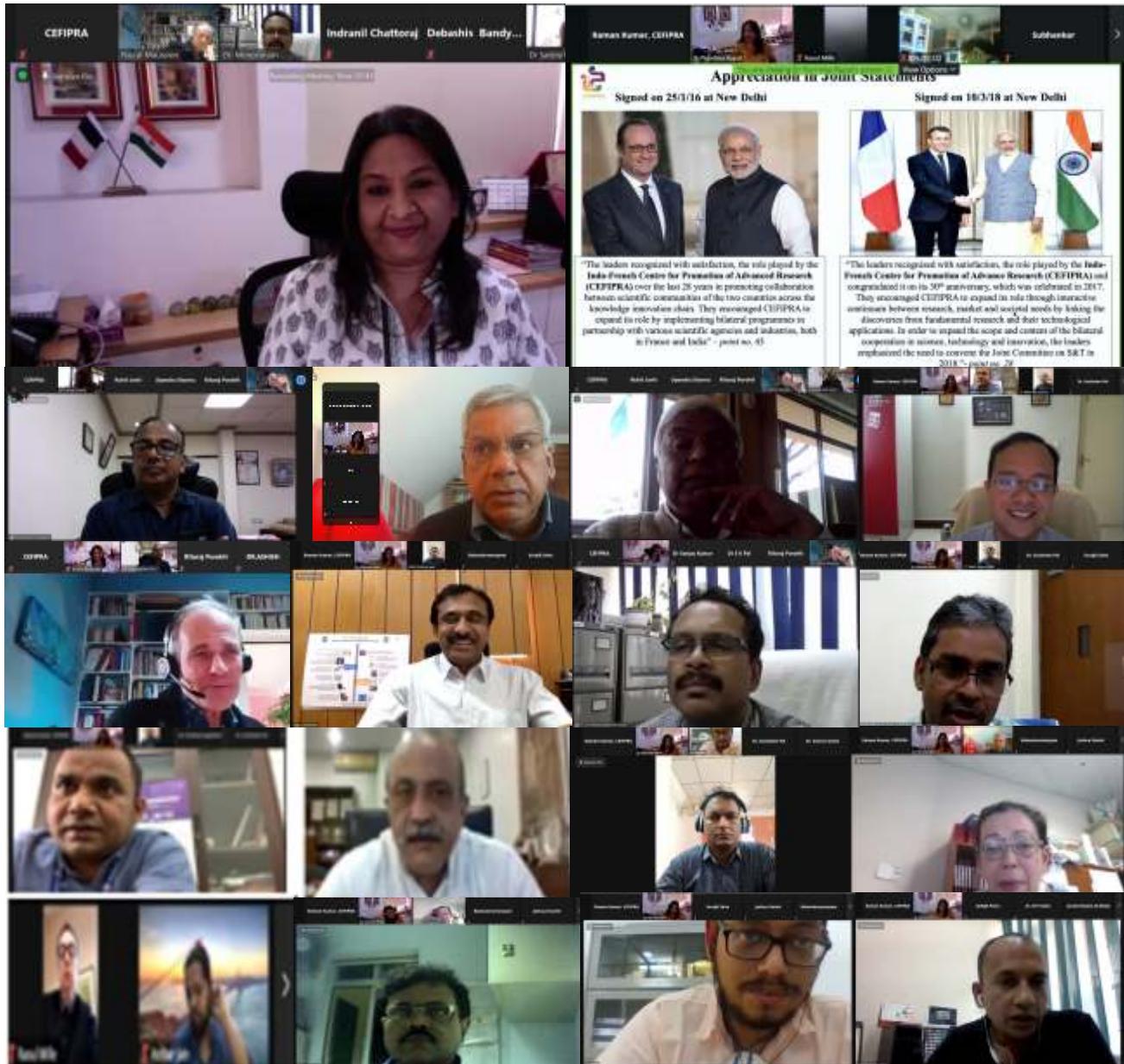
## 34<sup>th</sup> STIP Forum Lecture

*held virtually and organized by Vigyan Prasar on : 24 March, 2021*



Dr. Abhay Jere, Chief Innovation Officer, Ministry of Education, Government of India was invited as speaker and Dr. Nakul Parashar, Director, Vigyan Prasar as convener. Dr. Jere is committed to popularizing the need for innovation and entrepreneurship amongst Indians spoke on “Building Innovation Ecosystem in Educational Institutions”. CEFIPRA has been a partner in Science, Technology and Innovation Policy (STIP) forum lectures, along with other scientific institutions housed in the India Habitat Centre, Lodhi Road, New Delhi. He spoke extensively on the mind set up which needs to be changed starting from the root level. He also highlighted the issue related to parameters used to measure the innovation in educational institutes, research institutes and industries.

# CEFIPRA Webinar on Opportunities for Indo-French S&T Partnerships



CEFIPRA organized virtual interactions for scientists, researchers and students from various research institutions of India and France through webinars- “Opportunities for Indo-French S&T partnerships” on 17 & 18 March, 2021. Around 170 participants from both the countries attended this online event. CEFIPRA presented the overview of various activities & programmes of the Centre. Among the participants, Dr. Indranil Chattoraj, Director, CSIR-National Metallurgical Laboratory, Dr. Ayyappanpillai Ajayagosh, Director, CSIR NIIST - Official, Dr. Sanjay Kumar, Director, CSIR-Institute of Himalayan Bioresource Technology, Prof. Pascal Maussion, Toulouse INP, Dr. Edmond Rock, Research Director, INRAE and other attendees from Indian Institute of Science Education and Research - Mohali, ICAR-Indian Institute of Soil Science, Bhopal, CSIR-Central Glass & Ceramic Research Institute, CSIR-National Environmental Engineering Research Institute, Nagpur, IIT Bhilai, IISER Bhopal, CSIR-IMMT, CSIR-NISTADS and IIT Jammu proposed the preferred areas for Indo-French S&T collaboration. Director, CEFIPRA highlighted that the Indo-French Year of the Environment over the period 2021-2022 would be based on five main themes: environmental protection, climate change, biodiversity conservation, sustainable urban development, and the development of renewable energies and energy efficiency.

## SEMINARS / WEBINARS

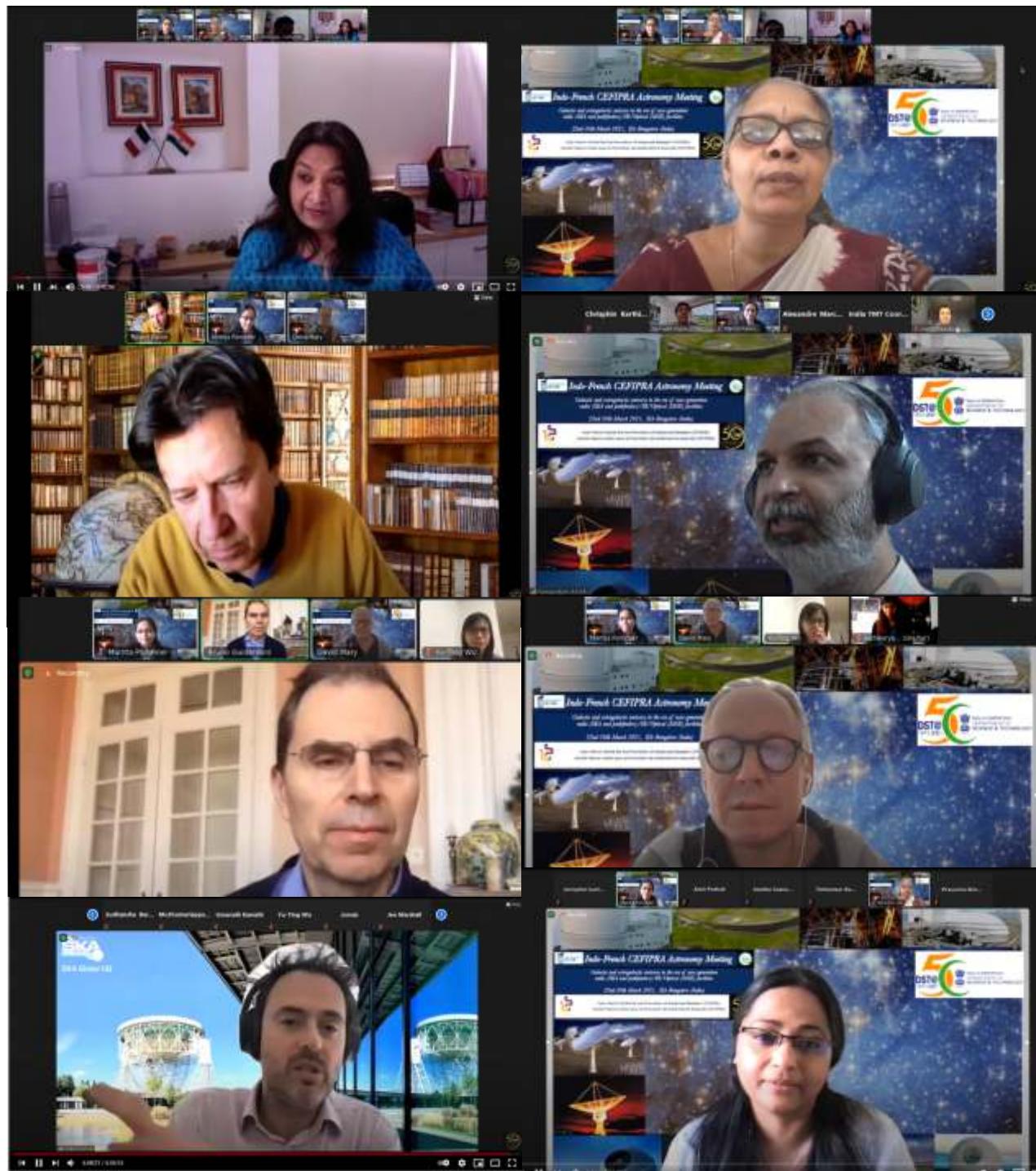
During the discussion, the participants interacted and shared keen interest for collaborative research on following areas:

- Agriculture, (Soil Health and its assessment, Agronomy)
- Climate and atmospheric change
- Remote Sensing/analytics
- Sustainable Technologies
- Biotechnology in natural products
- Health (Cancer Research)
- Artificial Intelligence and Machine Learning



Dr. Purnima Rupal, Director, CEFIPRA was invited to deliver a talk on “Developing research partnerships with French research and academic institutes” by Director, Institute of Science, BHU on 1 March, 2021. This lecture was attended by students, researchers and faculty members interested in research collaboration with France in the areas of *Artificial Intelligence, Quantum Computing and Complex Systems, Clean and Green Energy, Environmental Hydrology, Remote Sensing and GIS, Nanotechnology, Structural Biology, Synthetic Biology, Natural Resources from Plants, Agronomy and Food Process, Marine Sciences etc.*

# Indo-French CEFIPRA Astronomy Meeting



During 22-26 March, 2021 at IIA Bangalore

More than 34 speakers from India and France institutes/organizations deliberated on various aspects of the Galactic and extragalactic universe in the era of new-generation radio (SKA and pathfinders)/IR Optical (MSE) facilities. This virtual seminar was a part of the celebration of the Golden Jubilee (50 years) Commemoration Year of the DST and the Indian Institute of Astrophysics (IIA) and attended by more than 80 participants from France and India. Director CEFIPRA also attended this virtual seminar and presented the talk on “The Role of CEFIPRA: Shaping Indo-French S&TI collaboration” during the inaugural session on 22 March, 2021.

The virtual seminar meeting objective was to deliberate on the new-generation radio/IR/optical facilities. These facilities are expected to advance scientific communities understanding of a wide variety of objects from galactic compact stars up to the most distant galaxies, exo-solar planets, galactic chemical evolution, large scale structures in the extragalactic sky, and the origin and evolution of primordial galaxies and the magnetic fields in the Universe. The upcoming 3D and multi-object spectroscopy, photometry, and imaging using radio/IR/optical telescopes (for e.g. BLUE-MUSE, LSST, TMT, Euclid, 4MOST, WEAVE, SKA) with their large field of view, high sensitivity, and large spatial and spectral resolution would be provided complementary multi-wavelength data and maximize the scientific output. CEFIPRA supported this virtual seminar addressing the forefront scientific goals and discussion on the synergies between various upcoming and new-generation facilities by bringing the Indian and France scientific community related to this area together and build-up collaboration. Existing low-frequency SKA pathfinders (LOFAR, ASKAP, u-GMRT) and IR/optical facilities (MUSE, HST, ALMA, IRAM) are already providing a large survey data with spectral, morphological, and redshifts catalogs, that could be used to investigate the above-mentioned science goals and effectively help the users community for the future generation facilities like the MSE, BLUE-MUSE, TMT, and SKA.

The conference was also aimed to highlight the support activities being carried out by the National Astronomical societies and CEFIPRA to support women in STEM careers viz. Ph.D., postdocs, and early career researchers.

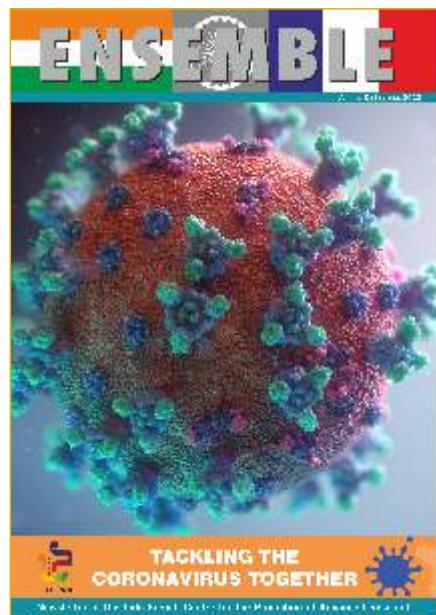
Following topics were deliberated during week long seminar:

- Cosmo-chemistry by chemical tagging of stars and the study of abundances in stars and the associated nucleosynthesis
- Galactic (stars, young stellar objects, and ISM
- Nearby galaxies
- HI studies of galaxies
- Clusters of galaxies
- AGNs
- Primordial galaxies and cosmology
- Primordial magnetic fields
- Discussions on synergies with current and future facilities
- Large scale survey.

# Ensemble: The Newsletter of CEFIPRA

CEFIPRA publishes a periodic newsletter called Ensemble. This is one of the important tools to communicate and highlight the research and developmental activities funded by the Centre, and disseminate the information among the research communities and other officials of India and France. In view of the commitments of Indo-French scientific communities and their concern for the environment, CEFIPRA had taken out only e-version of the Ensemble during the year 2020-21.

These editions highlighted Indo-French collaborative projects aimed Tackling the corona-virus together; Forging new bridges; Ensuring Gender parity in Indo-French collaboration and sustainable science solutions. These newsletters also showcase research achievements of CEFIPRA supporting projects in area of Astronomy and Climate system and sharing a few testimonials of women scientists, women researchers engaged in CEFIPRA supported projects as PI, Co-PI, students which might give them visibility.







## 4. Dedicated Mobility Support Programmes

# Raman-Charpak Fellowship

The Raman-Charpak Fellowship programme was launched in honour of two Nobel Laureates in Physics, Prof C.V. Raman, Indian Nobel Laureate (1930) and Prof. Georges Charpak, French Nobel Laureate (1992) during the State visit of the President of France to India during February, 2013.

The aim is to facilitate the exchange of doctoral students between the two countries, in order to broaden the scope and depth of future engagements in Science, Technology and Innovation.

The Raman-Charpak Fellowship is the only Indo-French bilateral Fellowship programme jointly funded by the Department of Science and Technology (DST), Government of India and the French Institute in India (IFI), French Embassy in India, Ministry for Europe and Foreign Affairs, Government of France.

This programme implemented by CEFIPRA aims at improving the doctoral skills of Indian and French students by providing them an opportunity to carry out part of their research work in a University / Research & Development Institute based in France or India respectively.

The programme was initially approved for 3 years from year 2013-2015. Based on the success of the programme, the Governing Body (GB) of CEFIPRA in its 29<sup>th</sup> meeting held on 4 March, 2016 renewed the Programme for another 3 years (2016-2018) with enhanced slots. Since year 2013 to 2019, 173 Raman-Charpak Fellows have been supported/awarded under this programme including the French Masters' students (4), for whom the call was launched first time in year 2016. The students selected for the year 2019 are undertaking their visits.

Further, the Governing Body of CEFIPRA in its 32<sup>nd</sup> meeting held on 8 March, 2019 have renewed the Programme for 3 more years (2019 to 2021) and have also suggested to analyse the Programme based on the publications emanated from the students. Accordingly, CEFIPRA contacted fellows of batch 2013-2016 and requested the desired information on which this report is prepared for the funding agencies. The Summary and Publication Analysis for RCF is given as follows:

## Summary and Publication Analysis for RCF

	Batch 2013	Batch 2014	Batch 2015	Batch 2016
No. of Students	15 Indian 5 French	17 Indian 4 French	5 Indian 5 French	25 Indian 5 French
No. of Male and Female students	11 Males & 4 Females	16 Males & 5 Females	12 Males & 8 Females	19 Males & 11 Females
No. of Publications	16	29	12	27
Thrust area of Maximum Publication	Life and Health Sciences (7)	Physical Sciences (8)	Materials Science (5)	Life and Health Sciences (7)
Average Impact Factor	2.82	2.40	1.95	3.004
% of students made self contacts with Host supervisor	69%	50%	64%	44%
Did Post- Doc in France after completing RCF	3	7	2	6
Rating of RCF	Excellent (85%) & Very Good (15 %)	Excellent (81%), Very Good (13%) & Good (6%)	Excellent (100%)	Excellent (88%) & Very Good (8 %)





## 5. Brief Reports of Research Projects

### A. Collaborative Scientific Research Programme

# Wavelet graphs for gravitational wave searches

## Background

The Theory of General Relativity predicts the existence of gravitational waves (GW). The direct search for astrophysical GW made notable progress with the advent of dedicated instruments. One of the prominent astrophysical sources are coalescences of compact binaries of neutron stars and/or black holes (CBC). With the installation of a world-wide network of new generation instruments (which includes both French and Indian participations), the first discovery of GW is expected within the decade. It is proposed to collaborate on the development of new methods to analyse the data from this global multi-detector network and investigate, implement and test alternative coherent multi-detector searches for GW chirp signals from CBC.

Pure & Applied Physics

Project No. 5504-1

Apr. 2016 to Apr. 2020

## Objectives

- To improve the analysis of second-generation data and ensure its readiness for the upcoming first Gravitational Wave (GW) detection

## Knowledge Generated/Products Developed

- Identification the algorithm that provides the best approximation of the signals that are most with a reasonable computational cost
- Detection statistics and noise rejection
- The analysis algorithm has been implemented and integrated to the source code of Coherent WaveBurst. It is freely available online
- The tools developed have been integrated into the LIGO/Virgo collaboration and can therefore be used in production

## Principal Collaborators



**Archana Arun Pai**  
IIT - Bombay  
Mumbai



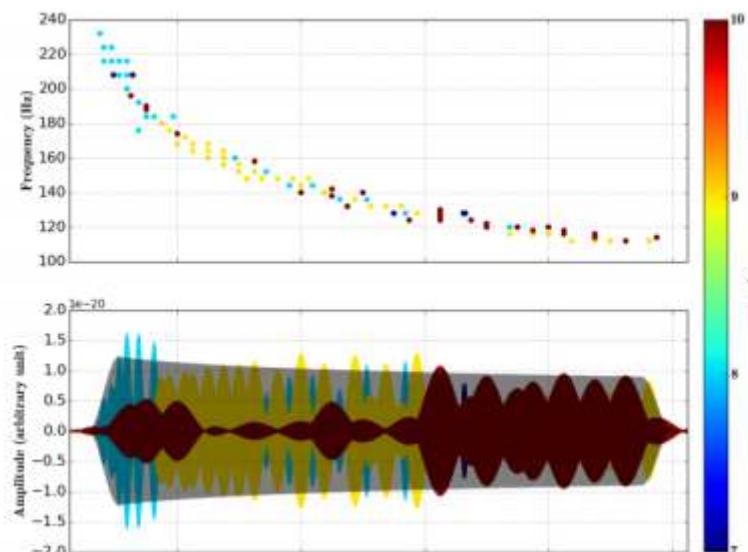
**Eric Chassande-Mottin**  
Laboratoire, Astroparticule et  
Cosmologie laboratory (APC)  
University Paris Diderot  
Paris

## Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 10

## Mobility Support

- India to France: 3
- France to India: 1



Time-frequency cluster obtained with the updating matching pursuit algorithm applied to the GW waveform model associated to an accretion disk instability which develops in a newly formed  $10M_\odot$  black hole with spin  $a = 0.95$  surrounded by a  $1.5M_\odot$  accretion disk. The bottom plot shows the extracted wavelets (time domain) by WG and how they describe the signal (light black). The approximation error of the UMP is fixed to 10% and the decomposition results in 89 time-frequency pixels

# Modeling Soft Glassy Flow from Micro to Macro Scale

Pure & Applied Physics

Project No. 5604-1

Dec. 2016 to May 2020

### Objectives

- To develop appropriate coarse-grained description of the response of an amorphous solid to external stress. PIs want to understand the transient response of the system, in the vicinity of the yielding threshold, depending upon the initial state of the material. This is of utmost importance in many practical applications, where stress is a control parameter
- Studying the origin of residual stress in soft glasses. Understanding how stresses get locked in, once the external straining is stopped, is important for using these materials. PIs will study how coarse-grained models can correctly reproduce the spatio-temporal distribution of local stresses, once the deformation has been stopped, validating against particle simulation results
- Probing response to oscillatory shear. By using our multi-scale analysis, PIs aim to understand the origin of the predicted non-equilibrium transition in such a shear protocol

### Knowledge Generated/Products Developed

- For the study of creep response using particle based simulations, PIs have developed a novel simulation protocol that is based on a feedback mechanism. PIs could thereby perform the first simulational study of the bulk response of an amorphous solid to an externally imposed stress, using periodic boundary conditions. This is a setup that is very common for a fixed driving rate but that was lacking for the study of the creep response to an imposed external stress
- PIs evidenced and characterised precursor dynamics prior to yielding that can be detected in the variance of shear-rate fluctuations prior to catastrophic failure. This type of signal could be helpful in preventing failure by removing the causing stresses in time (example: closing a bridge before catastrophic collapse)
- To study the mechanical response of athermal amorphous solids PIs developed a novel framework via a coupling of mesoscale and microscopic models. Using measurements of coarse grained quantities from simulations of dense disordered particulate systems, PIs present a coherent elasto-plastic model approach for deformation and flow of yield stress materials. For a given set of parameters, this model allows to match consistently the transient and steady state features of driven disordered systems, under both applied shear-rate and creep protocols
- PIs developed a particle based protocol to study the rheology of active systems that account for an internal activity of the constitutive particles in the form of breathing. It is possible to fluidise the system upon a critical breathing amplitude. PIs characterise in detail this transition that we think to be of importance for example in the dynamics of biological tissues
- To understand better the underlying physics of the fluidisation process of active materials, PIs derived a mesoscopic description based on the knowledge obtained from the particle based simulations. PIs successfully reproduce the fluidisation transition within this approach and can relate it to the statistical properties of the mechanical noise that is created by the active particles and the induced plasticity in the surroundings

### Background

The focus of this project lies on the physics of amorphous materials, which are ubiquitous in industrial applications, nature and even in biological matter. PIs derive a multi-scale approach for the mechanical response of such systems, paving the path to new material design strategies via microscopic tuning leading to tailored responses, in terms of yielding or failure. Thus, the project's scope is interdisciplinary, bridging physics, material science and engineering. The applications lie in the realm of soft materials (foams, gels, emulsions, colloids) constituting a variety of industrial products. Further, based on ideas of universality and scale invariance close to the dynamical phase transition (onset of flow), PIs expect these approaches, primarily built for soft matter, to be relevant on a much wider range. Thus, even understanding geophysical phenomena (like avalanches, landslides etc.) can also build on this kind of multiscale studies, with the aim of building strategies for risk management.

### Principal Collaborators



**Pinaki Chaudhuri**  
*The Institute of Mathematical Sciences  
Chennai*



**Kirsten Martens**  
*Laboratoire Interdisciplinaire  
de Physique UMR5588  
Grenoble*

### Publications

- No. of publications in SCI journals: 5
- No. of papers presented in conferences: 3

### Mobility Support

- India to France: 2
- France to India: 1

# Studies on the topological insulator behaviour in heavy metal based ternary chalcogenides

## Background

Topological insulators (TI) are fascinating quantum materials which are characterized by an insulating bulk and a conducting surface. The topological surface state is protected by time reversal symmetry and it is robust against scattering from non-magnetic scattering. They are expected to be useful for various applications including high frequency electronics, transparent electrodes, spintronics, and quantum computations. The main objective of this proposal is to synthesis of novel and theoretically proposed TI materials. The investigator propose the probability of new compounds and discover them using different synthesis strategies. After understanding the probable TI behaviour in these ternary compounds by theoretical calculations, it will be experimentally realized by temperature and pressure dependent XRD, Raman and Hall measurements on the polycrystalline samples. Investigators also try to grow the single crystals of the promising compounds by Bridgeman or vapour transport or even flux methods for the Angle resolved photoemission spectroscopy (ARPES) measurements. The project will be extended to further level with the possibility of doping heavy metals to tune the TI behavior.

## Materials Science

Project No 5608-2

Jan. 2017 to Jul. 2020

## Objectives

- Synthesis and crystal growth of known and novel heavy metal based chalcogenide having zero/narrow band gap at the Fermi level
- Experimental realizations of the topological insulator behavior using high pressure XRD, RAMAN, resistivity and Hall measurements
- Direct observation of the surface states by Raman and Angle resolved Photo Electron Spectroscopy (ARPES) Techniques
- Electronic structure calculations will be performed to understand the band inversion and comparison between the experimental data
- Examination for isostructural Electronic Topological Transition under high pressure by Raman scattering and Hall effect under pressure

## Knowledge Generated/Products Developed

- Successfully prepared Sb doped Bi<sub>2</sub>Te<sub>2</sub>Se single crystals were prepared using direct reaction technique
- Magneto-transport studies were done on these single crystals
- Magneto-transport and Hall measurements were carried out on Bi<sub>2</sub>Te<sub>2</sub>Se, Sb<sub>2</sub>Te<sub>2</sub>Se and Bi<sub>2</sub>Te<sub>2</sub>S
- Apart from these compounds, PIs tried to probe the topological surface states in half-Heusler ScPdBi single crystals
- PIs have successfully synthesized the ScPdBi single crystals and studied electrical transport properties under extreme conditions

## Principal Collaborators



**Sebastian Chirambatte Peter**  
Jawaharlal Nehru Centre  
For Advanced Scientific Research  
Bangalore



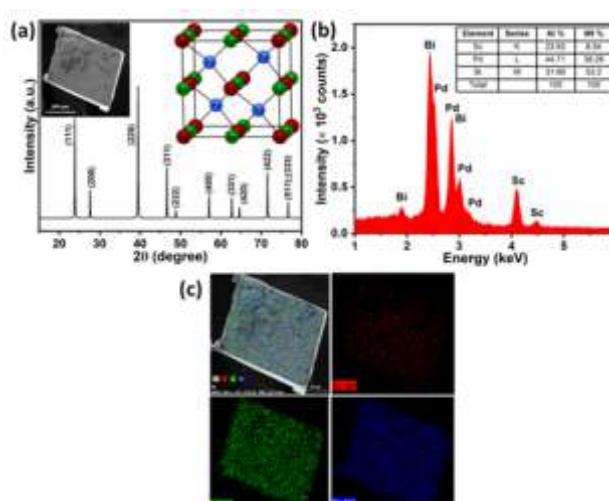
**Marie-Aude Measson**  
NEEL Institute  
Grenoble

## Publications

- No. of publications in SCI journals: 6
- No. of papers presented in conferences: 1

## Mobility Support

- India to France: 1
- France to India: 1



(a) Powder X-ray diffraction pattern of ScPdBi, insets show the crystal structure and scanning electron microscopic image of ScPdBi single crystal  
(b) Compositional analysis on ScPdBi single crystals (c) Elemental colour mapping on ScPdBi single crystal, showing uniform distribution of Sc, Pd and Bi elements (J. Alloys Compd.848, 156632 (2020))

# The Economics of Networks and Queues

Computational Science

Project No. 5702-1

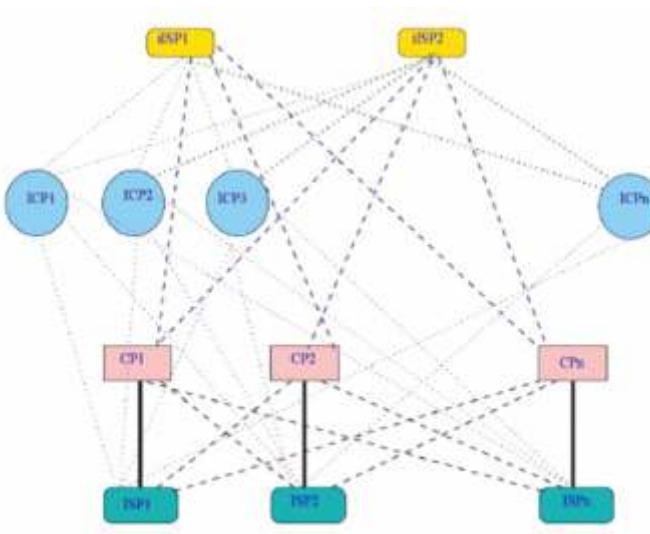
May 2017 to Oct. 2020

### Objectives

- Differential Pricing in the Internet Ecosystem: To understand the impact of such schemes on society, new models will be developed and studied effect of zero-rating schemes; Analyse the effect of new schemes on the pricing strategies of the content providers and quality of service experienced by the end users in the zero-rated platforms
- Neutrality of Scheduling Schemes: This work will a) evaluate the performance of new type of schedulers that are non-dominant service disciplines. b) develop methods to determine automatically, only by observing partial information about the queue like the arrival rate and departure rate of packets, which type of scheduler or service discipline is currently used in the queue. Then, a non-neutral behavior from the queuing manager could be identified and denounced

### Knowledge Generated/Products Developed

- Six journals and 10 conference papers
- One patent filed
- Workshop Organized
- An Android app developed for net neutrality detection



### Background

The project aims to study various issues in the telecommunication networks that have been recently considered by the telecom authorities in several countries for regulation. Specifically, it will be focussed on the differential pricing in the Internet and the Spectrum sharing between the telecom operators, and study the impact of the current rulings on the interests of the various players. Several of current rulings are based on public consultations and are subjected to revision in the near future. The goal is to systematically validate the claims of the various stakeholders and develop policy guidelines that lead to efficient utilization of network resources, and can be adapted as amendments to the current rulings. In this project, scheduling schemes that improve quality of service for all types of packets when the traffic consists of multiple class of packets will be studied. In the process, it is aimed to develop techniques that the regulators can use to identify type of scheduling schemes employed by the service providers.

### Principal Collaborators



**Manjesh Kumar Hanawal**  
Indian Institute of Technology,  
Bombay,  
Mumbai



**Yezekael Hayel**  
Université d'Avignon,  
Avignon

### Publications

- No. of publications in SCI journals: 4
- No. of papers presented in conferences: 5

### Mobility Support

- India to France: 6
- France to India: 3
- Patent : 1

# Yielding in glasses and colloidal systems under cyclic deformation

## Background

The study of the non-linear response of glassy systems to periodic perturbations is proposed in the project. Disordered and glassy systems under the effect of an external constant driving often present a discontinuous response that goes, according to the context, under the names of crackling noise, stick-slip motion, earthquakes or avalanches and is characterized by power-law scaling and critical behavior. A lot of these systems show a yielding behavior; since they start to present plastic rearrangements that will ultimately make them flow.

In recent times, a new phenomenon has been uncovered for glassy systems undergoing cyclic deformations, namely a transition from a localized phase where particles go back to their positions after a cycle to a diffusive one as a function of the amplitude of the deformation. The nature of plastic rearrangements in the localized phase, and the manner in which they change as the amplitude of strain increases hold a key to understanding the nature of the yielding behaviour of amorphous solids.

In this project, it is planned to perform extensive computer simulations to explore the role of cyclic deformation on glasses.

Pure & Applied Physics

Project No. 5704-1

Jun. 2017 to Mar. 2021

## Objectives

- To understand the physical mechanisms that underlaying plastic rearrangements during cyclic deformation on amorphous materials and to link them to the nature of yielding behaviour
- To investigate the mechanical response and the memory effects in colloidal glasses under cyclic mechanical deformations

## Knowledge Generated/Products Developed

- Investigation of the existence hyperuniform states in cyclically deformed glass former
- Observation of loss of hyperuniformity upon yielding
- Investigation of the yielding transition in amorphous silica, a network forming glass
- Characterisation of plastic deformation events using a new method
- Plasticity and yielding of 2D systems under cyclical deformation

## Principal Collaborators



**Srikanth Sastry**  
Jawaharlal Nehru Centre for  
Advanced Scientific Research  
Bangalore



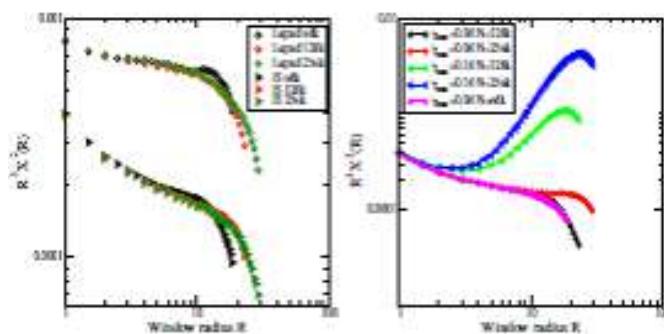
**Giuseppe Foffi**  
Université Paris sud - Paris XI  
Orsay

## Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 1
- France to India: 2



The weighted volume fraction variance  $X(R)$  times  $R^3$  is plotted for different system size

## Bifunctional catalysts for cooperative C-H bond cleavage via intramolecular deprotonation toward direct functionalizations of alkanes

Pure & Applied Chemistry

Project No. 5705-1

May 2017 to Apr. 2020

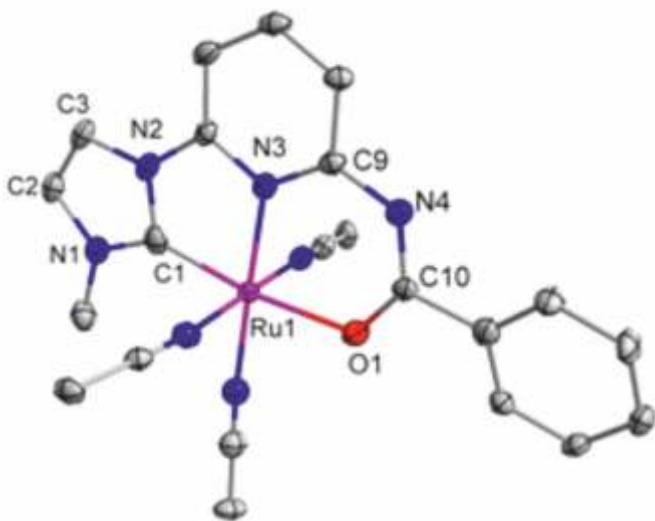
### Objectives

The central aim of this project is to examine Intramolecular Pendent-Base Assisted Concerted Metalation Deprotonation (IPB-CMD) protocol for direct C-H functionalization. Towards this goal, the present project will seek to achieve the following objectives:

- Design and synthesis of ligand (scaffold = bipyridine, phosphine and NHC) with pendent Brønsted bases, e.g., -OH, -CO<sub>2</sub>-, -NTf, -NTs, -SO<sub>3</sub>-, -PO<sub>3</sub>-, etc.
- Catalytic evaluation of newly synthesized metal-complexes bearing these ligands for direct arylation and alkylation of (hetero)arenes
- Application and screening of a wide range of catalysts with different ligand systems- obtained by varying pKa of the base unit, length and identity of the linker group, the metal ion and the ancillary ligands around the metal

### Knowledge Generated/Products Developed

- Synthesis of ligand and Pd and Ni complexes with pendent Brønsted bases
- Discovery of chemoselective C(sp<sup>2</sup>)-H bond sulfonylation



X-ray structure of 2 with selective atoms labelled. Displacement ellipsoids are set at 30% probability and hydrogen atoms omitted for clarity. Selected bond distances (Å) and angles (°): Ru1-C1 1.973(3), Ru1-N3 2.029(3), Ru1-O1 2.092(2), C1-Ru1-N3 79.82(11), N3-Ir1-C11 93.64(8), C5-N3-C9 118.8(3)

### Background

This project seeks to examine inner sphere C-H activation by Brønsted base covalently attached to ligand framework. Milsteins bifunctional Ir-PNP system exploits aromatization/dearomatization motif to activate C-H bond of benzene. The C-H bond activation mechanism in this project is based on deprotonation/protonation principle. At the beginning, ligand scaffolds (bipyridine, NHC, phosphine) with pendent Brønsted bases, e.g., -OH, -CO<sub>2</sub>-, -NTf, -NTs, -SO<sub>3</sub>-, -PO<sub>3</sub>-, etc, will be synthesized in Kanpur. The catalytic utility for metal-complexes bearing these ligands for direct arylation of (hetero)arenes will be evaluated in Rennes. The design scheme allows easy variations in the ligand system, 1. pKa of the base unit, 2. length and identity of the linker group, 3. the metal ion, 4. the ligand scaffold, that would permit the screening a wide range of catalyst systems. Applications of these catalysts for direct functionalization of inert and non-acidic C(sp<sup>3</sup>)-H bond (alkanes) will constitute a major part of this work. Substrates without directing group will be employed. Kinetic experiments, isolation and characterization of intermediates, deuterated studies and DFT calculations will be undertaken to gain insight on the mechanism.

### Principal Collaborators



**Jitendra Kumar Bera**  
Department of Chemistry, IIT Kanpur,  
Kanpur



**Henri Doucet**  
Université de Rennes 1  
Rennes

### Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: 2

### Mobility Support

- India to France: 2
- France to India: 1

# Durable fuel cells based on Polymer coated Nanocarbon Composites (DUPONT)

## Background

Fuel cells are alternatives to internal combustion engines in automobile applications due to their higher efficiency and zero CO<sub>2</sub> emission. PEMFCs currently use Pt as the catalyst both at the cathode and at the anode due to its high stability under the operating conditions of the cell, but reduce the economic viability of these devices. PIs propose to disperse Pt alloy nanoparticles (NPs) on highly active and stable heteroatoms incorporated ionomer coated polymer wrapped CNT/graphene based catalyst support. This will lead to a higher electrochemical surface area of the catalyst and enhance the ionic conductivity. The mechanism of degradation at different temperatures will be studied using state of the art characterization techniques. The catalyst performance will be evaluated by the Indian partner in single PEM fuel cells with a cell performances of a maximum power density of 500 mW/cm<sup>2</sup>. The French partner will play an active role applying characterization techniques.

## Principal Collaborators



**Sundara Ramaprabhu**  
Indian Institute of Technology Madras,  
Chennai



**Wolfgang S Bacsa**  
Centre d'élaboration de matériaux  
et d'études structurales (CEMES)  
UPR8011, Toulouse

## Publications

- No. of publications in SCI journals: 4
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 4
- France to India: 1

## Materials Science

Project No. 5708-1

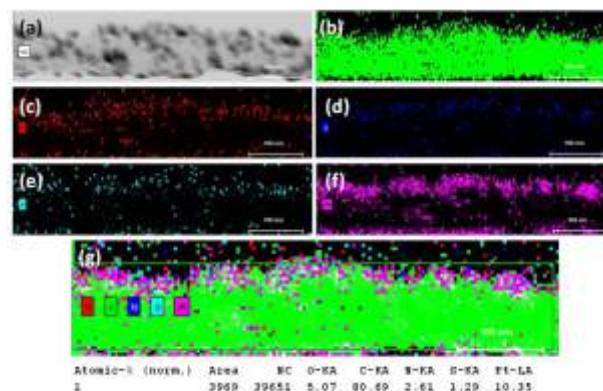
May 2017 to May 2020

## Objectives

The objective of the project addresses two key challenges by reducing the use of Pt and at the same time improving the activity and durability of the catalyst. PIs propose to disperse Pt alloy nanoparticles (NPs) on highly active and stable heteroatoms incorporated ionomer coated polymer wrapped CNT/graphene based catalyst support. The presence of the heteroatom (N or S) on CNTs or graphene improves the substrate-catalyst interaction and achieves a higher electrochemical surface area of the catalyst. In addition, the ionic conductivity of the electrode is improved by the ionomer coating on the catalyst support. A second objective of the project is to study the durability of our catalyst by an in-depth study of the mechanism of degradation of the electro-catalyst using a combination of state of the art characterization techniques including HRTEM, EELS, WAXS and RAMAN

## Knowledge Generated/Products Developed

- Visit of Professor Ramaprabhu in Toulouse (2018, 2019) and Professor Bacsa (2017, 2019) in Madras
- Visit Toulouse: Meenakshi Seshadri (2018), Rashmi Chandrabhan Shende (2018)
- Postdoc in Toulouse 2017-2019, Divya Nechiyil
- 1 publication: D. Nechiyil, M. S. Garapati, R. Ch. Shende, S. Joulié, D. Neumeyer, R. Bacsa, P. Puech, S. Ramaprabhu and W. Bacsa, Journal of Colloid and Interface Science 561 (2020) 493
- 1 manuscript under review: "Proton Conducting Polymer wrapped Cathode Catalyst for Enhancing Triple-Phase Boundaries in Proton Exchange Membrane Fuel Cells" M S Garapati, Divya N, Sébastien Joulié, Revathi Bacsa, S Ramaprabhu, and Wolfgang Bacsa



STEM-EDX analysis of Pt/PVPA6 NSPNT (a) STEM image, the spatial distribution of (b) carbon, (c) oxygen, (d) nitrogen, (e) sulfur and (f) platinum, and (g) quantification of elements over a selected region

# Interactions between dynamical systems, geometry and number theory

Pure & Applied Mathematics

Project No. 5801-1

Jan. 2018 to Jan. 2021

### Objectives

- The objective of the project is to investigate interactions between dynamical systems on homogeneous spaces, the geometry of discrete groups and number theory, especially Diophantine analysis and to develop new techniques to address outstanding problems in these subjects and g-position of carbonyl compounds

### Knowledge Generated/Products Developed

- Progress was made on the main objectives. On the ergodic front, several results were obtained by Nogueira, Laurent, Maucourant and Ghosh
- On the number theoretic front, by Nogueira, Bugeaud and Ghosh; and on the geometric front, by Mj, Dahmani and Maucourant
- Several papers have been written by the PI's and co-PI's and submitted to top journals and made available on the arxiv
- Talks have been given in national and international conferences on the advances made
- A postdoctoral scholar has been appointed on the Indian side and is making good progress

### Background

The project will study central problems in the ergodic theory and geometry of group actions and related number theory. Recent years have seen dramatic advances in the ergodic theory of group actions and Diophantine analysis. The focus of the team will be the study of group actions on homogeneous spaces and applications, using a variety of tools from ergodic theory and geometry. Let  $G$  be a Lie group and  $\Gamma$  a discrete subgroup of  $G$ . On the geometric side, PIs are interested in the dynamics of discrete group actions on homogeneous varieties of  $G$ , and dually, the action of subgroups  $H$  of  $G$  on  $G/\Gamma$ . In the case that  $\Gamma$  is a lattice subgroup, namely when  $G/\Gamma$  carries a finite  $G$ -invariant measure, this is a well studied topic and includes the famous theorems of M. Ratner. However, the case when  $\Gamma$  is not a lattice but a 'thin' group is a rapidly emerging subject which is witnessing intense development right now. This work is likely to have many applications in number theory and geometry.

### Principal Collaborators



**Anish Ghosh**  
*Tata Institute of Fundamental Research  
Mumbai*



**Arnaldo Nogueira**  
*Aix Marseille University  
Marseille*

### Publications

- No. of publications in SCI journals: 1
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: 2
- France to India: 3

# Micro-SQUID magnetometry of nano-scale magnetic structures

## Background

The collaborators propose a  $\mu$ -SQUID magnetometry setup using non-hysteretic  $\mu$ -SQUIDs, to investigate the magnetism in nanoparticles. The set up with 1.3K base temperature will be developed in IIT Kanpur and it will use the non-hysteretic  $\mu$ -SQUIDs fabricated in Institut Néel in Grenoble. The previous results of our collaboration in getting hysteresis-free -  $\mu$ -SQUIDs will be essential here.

After testing the setup using sub  $\mu$ -m size permalloy thin film structures, the PIs purposed to measure the switching field distribution and magnetization relaxation times in single domain ferromagnetic and hybrid nano-particles. It is proposed to investigate the coupled dynamics of nanoparticle magnetization and the SQUID's phase to observe the predicted Shapiro steps and magnetization reversal. This could also provide further insights into the magnetization dynamics. After achieving spin sensitivity below  $100\mu\text{B}/\sqrt{\text{Hz}}$  in our setup with further optimization of electronics and SQUID design. Investigate the antiferromagnetic and spin-frustrated nanoparticles. To understand the physics of different magnetic phases and associated dynamics in different magnetic nanoparticles.

## Principal Collaborators



**Anjan Kumar Gupta**  
Indian Institute Of Technology  
Kanpur



**Hervé Courtois**  
CNRS et Université Grenoble Alpes  
Grenoble

## Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 2
- France to India: 2

## Pure & Applied Physics

Project No. 5804-2

Jan. 2018 to Dec. 2020

## Objectives

- Development of a micro-SQUID magnetometry setup with temperatures down to 1.3 K and vector magnetic fields up to 1 T using non-hysteretic micro-SQUIDs
- Investigating the switching fields and magnetization dynamics in individual magnetic nano-structures, for instance some of the correlated oxide nano-structures with ferromagnetic ordering and hybrid nanoparticles with core-shell structure
- Further optimizing the setup to obtain magnetic moment sensitivity better than  $100\mu\text{B}/\sqrt{\text{Hz}}$  so as to investigate the nano-structures with non-ferromagnetic orderingI

## Knowledge Generated/Products Developed

- A setup for magnetometry with up to 1 T field and 1.3 K cryostat base temperature has been successfully made in IITK (India)
- Some earlier fabricated micro-SQUIDs were tested for the anticipated phase dynamic regime and results published in Phys. Rev. B. A novel technique for eliminating hysteresis by using an inductive shunt was also found and published in Phys. Rev. B. This is partially towards the objective-3 of the proposal. Another manuscript that was recently submitted is on the stochastic resonance in superconducting weak links. This helps us in understanding the micro-SQUIDs noise better for improving the performance
- The magnetometry setup has been successfully made and tested by making anisotropy studies on permalloy nano-structures using both hysteretic and non-hysteretic SQUIDs. This was published in JMMM. Thus Objective-1 of the project has been successfully achieved
- Some detailed studies on switching statistics in Magnetite nano-particles have also been done using this setup. PIs see unusually narrow switching field and time histograms that PIs understand from presence of serial barriers in the path of a vortex. A manuscript for this work is in preparation



# Nuclear structure at the extreme of isospin and spin

Pure & Applied Physics

Project No. 5604-4

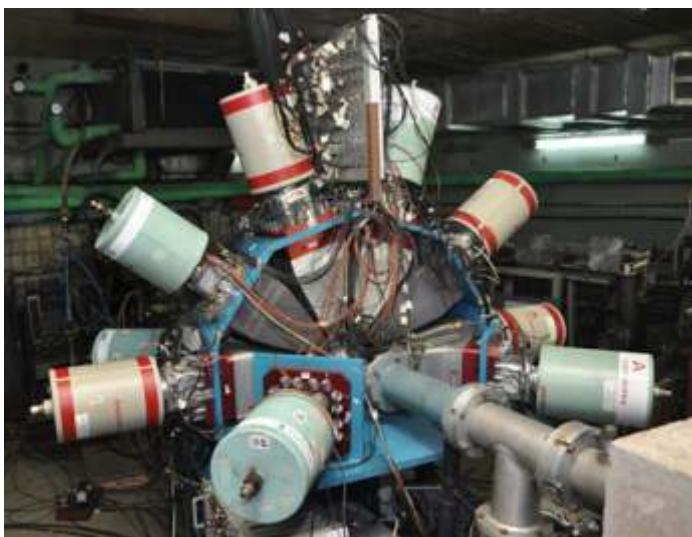
May 2017 to Apr. 2022

### Objectives

- The evolution of nuclear structure of most neutron rich nuclei produced in fission for various elements ranging from Sr to Pm. In particular, the odd-Z isotopes around Sn will be investigated and presence of isomers will be looked for from prompt-delayed spectroscopy

### Knowledge Generated/Products Developed

- Identification of isotopes (A,Z) has been done from data of experiment with VAMOS++ coupled to AGATA at GANIL
- Analysis on spectroscopy of Sb and In isotopes from AGATA data has been completed. Manuscript is under preparation
- Analysis of Pm isotopes from VAMOS++ coupled to EXOGAM
- One experiment at VECC has been performed to study the single particle and collective structures of  $^{131}\text{Xe}$ , using Indian National Gamma Array (INGA) setup and alpha beam from K-130 cyclotron at VECC, Kolkata



The setup of Indian National Gamma Array (INGA) at the K-130 cyclotron at VECC, Kolkata. Figure shows the setup of 8 Compton suppressed Clover HPGe detectors and 2 LEPS (Low Energy Photon Spectrometer) of Indian National Gamma Array (INGA) at the K-130 cyclotron at VECC, Kolkata

### Background

The project addresses an open question, viz., how do the internal properties of the complex many-body quantum system, the nucleus, evolve when there is an imbalance of neutron to protons (compared stable nuclei) AND simultaneously undergoing fast rotation. Studies have shown the presence of new phenomena like new shapes, change of shell structure etc. occur in exotic short lived nuclei. The present project will explore the presence of new phenomena as a function of isospin (neutron-proton asymmetry, N/Z) AND spin in particular around doubly magic  $^{132}\text{Sn}$ . A part of the work will use the VAMOS++ magnetic spectrometer and the Advance Gamma Tracking Array (AGATA) to study the prompt gamma rays emitted from the isotopically identified fission fragments produced in inverse kinematic reactions at energies around the Coulomb barrier (in France) increasing the selectivity and sensitivity by at least an order of magnitude over other methods.

### Principal Collaborators



**Sarmishtha Bhattacharyya**  
Variable Energy Cyclotron Center,  
Kolkata



**Navin Alahari**  
Grand Accélérateur National d'Ions Lourds  
Caen

### Publications

- No. of publications in SCI journals: 1
- No. of papers presented in conferences: 4

### Mobility Support

- India to France: 3
- France to India: 3

# Control of microtubule dynamic instability by the tubulin code

## Background

Microtubules (MTs) are key elements of the cytoskeleton, and as such involved in virtually every function of the cell. MTs are assembled from highly conserved alpha/beta-tubulin heterodimer, which are expressed from multiple tubulin genes across metazoans. While the core structural elements of tubulin, which are directly involved in the MT assembly, are highly conserved across eukaryotes, the unstructured carboxy-terminal tails (CTTs) are divergent between different tubulin gene products. Additionally, the CTTs are also hotspot for unique posttranslational modifications (PTMs) such as detyrosination, polyglutamylation and polyglycylation. The high degree of variability in the CTTs led to the project of a tubulin code that modulates interactions between MTs and their multiple associated proteins, thus controlling key cellular functions. This is strongly supported by recent studies showing that kinesin and dynein motors show motility preferences towards particular tubulin code elements, in particular to PTMs. However it is still not clear whether the tubulin variations control MT dynamic instability, a key MT property. In this project this question is addressed by engineering tubulin isotypes and PTMs into fission yeast, and characterizing MT dynamics *in vivo*.

## Principal Collaborators



**Minhaj Sirajuddin**  
Institute for Stem Cell Biology and Regenerative Medicine  
Bangalore



**Carsten Janke**  
Institut Curie  
Orsay

## Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 2
- France to India: 2

## Life and Health Sciences

Project No. 5703-1

May 2017 to Apr. 2022

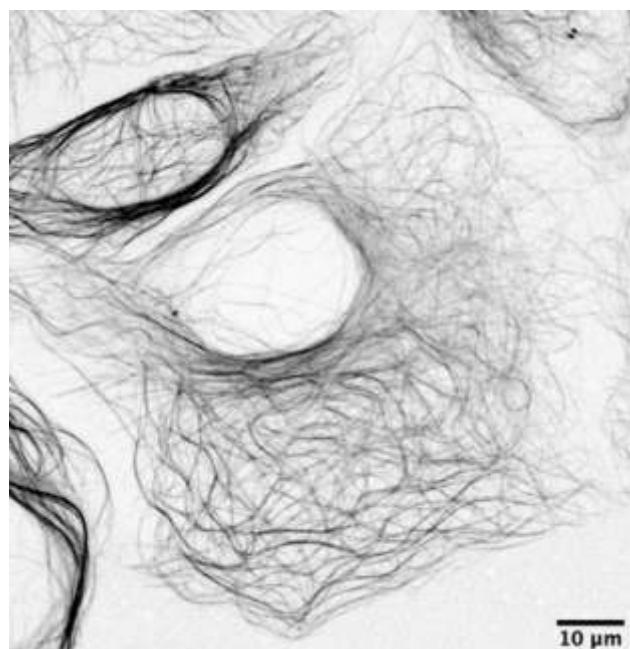
## Objectives

To understand the contribution of tubulin diversity in microtubule growth and dynamics, the objectives are as follows:

- Comparative analysis of tubulin variations in microtubule growth and dynamics
- Engineering fission yeast to measure the impact of the tubulin code on microtubule dynamics *in vivo*
- Developing sensors to detect microtubule modifications in live cells

## Knowledge Generated/Products Developed

- Recombinant tubulin purification and *in vitro* microtubule polymerization assay
- Screening binders and identifying the sequence of binder proteins
- Determining biochemical properties of binders against tubulin PTMs
- Validating the binders as live cell sensors of tubulin PTMs
- Commercialization of tyrosination sensor



Microtubules of human cells in grey scale imaged using Tyrosination sensor developed during the duration of CEFIPRA funded study.

# A genome-wide study to identify novel regulators of chromosome stability using a human pathogenic yeast *Candida albicans* as the model system

Life and Health Sciences

Project No. 5703-2

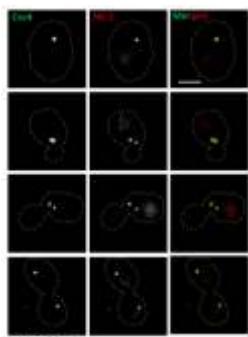
May 2017 to Apr. 2021

## Objectives

- Construction of a strain collection for the identification of genes whose over-expression alters chromosome stability and ploidy
- Identification of *C. albicans* genes whose over-expression triggers gross ploidy changes or chromosome loss: the impact of a gene's over-expression on ploidy variation will be determined after staining the transformants obtained in objective 1 with propidium iodide followed by flow cytometry
- Functional characterization of *C. albicans* genes whose over-expression affects chromosome stability and ploidy
- Molecular and biochemical characterization of selected genes

## Knowledge Generated/Products Developed

- The LOH reporter strain for screening the genes of genome stability in *C. albicans* has been constructed and validated using several assays that promote chromosome loss
- DNA preparation for ~2,522 over-expressing plasmids has been carried out by the Indian and French partners in a 96 well plate format (in the French lab). These plasmids are currently being transformed in the above mentioned LOH reporter strain in the French lab. Using the well-established *C. albicans* 96-well plate transformation protocol from the French lab, the Indian lab has successfully generated ~1200 *C. albicans* over-expression strains
- The flow cytometry analyses of ~1000 over-expression strains has been carried out to determine the effect of over-expression on LOH frequency in *C. albicans*. Our primary and secondary screens have identified six genes which upon over-expression showed an increased rate of LOH in *C. albicans*
- Out of the six genes identified, overexpression of three genes increased LOH frequency in *C. albicans* through non-chromosome loss events. The remaining three genes shifted the ploidy of *C. albicans* towards 4N
- Among the six genes identified, there is one novel gene (Csa6) that was previously unknown to have a role in genome maintenance. Functional characterization of Csa6 showed it is essential for proper cell cycle progression in *C. albicans*



Sub-cellular localization of one of the identified regulators of genome stability in *C. albicans*: Hit 2 is a novel regulator of genome stability that we identified from our over-expression screen. Cse4 is a known kinetochore protein. Hit 2 localizes close to the kinetochores throughout the cell cycle phases.

## Background

In this project, it is proposed to identify novel regulators and their role in maintaining genome integrity in *C. albicans*. To this aim, first a collection of *C. albicans* over-expression strains will be generated by transforming an existing collection of over-expression plasmids for ~5000 *C. albicans* genes into a *C. albicans* reporter strain that allows monitoring loss-of-heterozygosity (LOH) events at the single cell level thanks to three fluorescent markers (BFP, GFP, mCherry) whose genes have been conveniently positioned on the two arms of the two homologues of *C. albicans* chromosome 4. In a second step, the ~5000 over-expression strains will be individually monitored for the effect of over-expression on gross ploidy change, or whole chromosome loss (WCL). Ploidy changes will be determined by propidium iodide staining and subsequent analysis by flow cytometry. WCL events will be identified by analysing loss of both BFP and mCherry signals (that are genetically unlinked) but maintenance of the GFP signal using high-throughput confocal microscopy.

## Principal Collaborators



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**Christophe d'Enfert**  
Institut Pasteur  
Paris

## Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: 3
- France to India: 2

# Yielding in glasses and colloidal systems under cyclic deformation

## Background

The study of the non-linear response of glassy systems to periodic perturbations is proposed in the project. Disordered and glassy systems under the effect of an external constant driving often present a discontinuous response that goes, according to the context, under the names of crackling noise, stick-slip motion, earthquakes or avalanches and is characterized by power-law scaling and critical behavior. A lot of these systems show a yielding behavior; since they start to present plastic rearrangements that will ultimately make them flow.

In recent times, a new phenomenon has been uncovered for glassy systems undergoing cyclic deformations, namely a transition from a localized phase where particles go back to their positions after a cycle to a diffusive one as a function of the amplitude of the deformation. The nature of plastic rearrangements in the localized phase, and the manner in which they change as the amplitude of strain increases hold a key to understanding the nature of the yielding behaviour of amorphous solids.

In this project, it is planned to perform extensive computer simulations to explore the role of cyclic deformation on glasses.

Pure & Applied Physics

Project No. 5703-2

May 2017 to Apr. 2021

## Objectives

- To understand the physical mechanisms that underlaying plastic rearrangements during cyclic deformation on amorphous materials and to link them to the nature of yielding behaviour
- To investigate the mechanical response and the memory effects in colloidal glasses under cyclic mechanical deformations

## Knowledge Generated/Products Developed

- Investigation of the existence hyperuniform states in cyclically deformed glass former
- Observation of loss of hyperuniformity upon yielding
- Investigation of the yielding transition in amorphous silica, a network forming glass
- Characterisation of plastic deformation events using a new method
- Plasticity and yielding of 2D systems under cyclical deformation

## Principal Collaborators



**Srikanth Sastry**  
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Bangalore



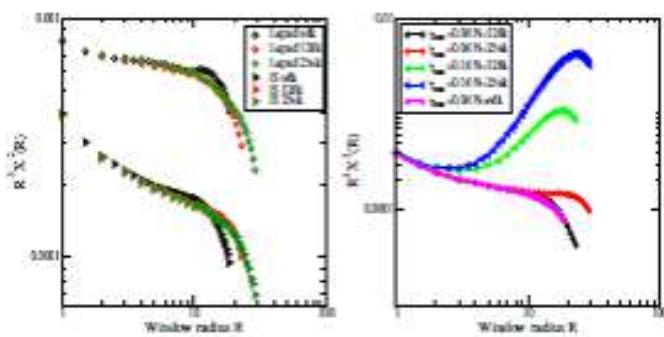
**Giuseppe Foffi**  
Université Paris sud - Paris XI  
Orsay

## Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 3
- France to India: 2



The weighted volume fraction variance  $X(R)$  times  $R^3$   
is plotted for different system size

# Mechanism of polarity reversals in *Myxococcus xanthus*

## Life & Health Sciences

Project No. 5803-1

Jan. 2018 to Sept. 2021

### Objectives

To understand the mechanism of polarity reversals in *Myxococcus xanthus* by studying:

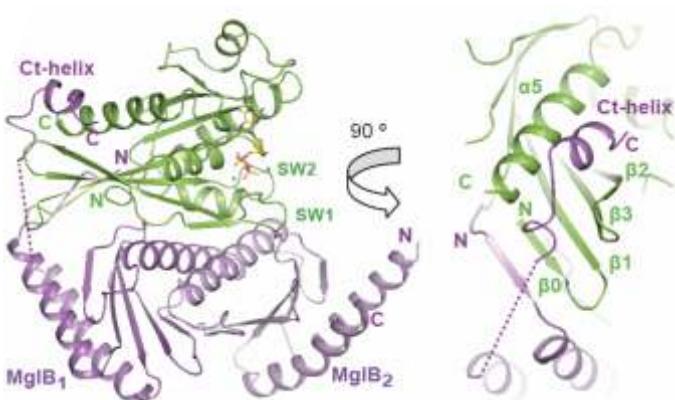
- the role of the GTPase MglA and MglB in driving the oscillations
- the role of the bacterial cytoskeleton MreB in positioning the motility complexes
- how FrzCD senses the signal that modulates the frequency of oscillation

Revised objectives, if any

- Interaction studies of MglA and MglB with RomR and FrzX have been initiated since this was found to be important based on our results from objective 1

### Knowledge Generated/Products Developed

- Structure determination of the different nucleotide-bound states of MglA in complex with MglB, Biochemical studies of MglA and MglB and their mutants, and corroborative *in vivo* experiments, genetic construction of mutants and cell biology measurements have been carried out. Manuscript related to this work is under communication to *PloS Biology*
- Overexpression of *Myxococcus xanthus* MreB in *E. coli* and large scale purification of homogenous protein sample suitable for electron microscopy studies was achieved. Stability assays for purified MreB are in progress. Efforts to improve stability are ongoing
- Overexpression of *Myxococcus xanthus* FrzCD and domain-wise constructs in *E. coli* and large scale purification of homogenous protein sample suitable for structural studies have been achieved. Oligomeric studies are ongoing. Construction of domain deletion mutants for corroborative analysis is ongoing. Super-resolution analyses of DNA receptor-bound complexes has been achieved
- Analysis of MglA and B oscillations in multicellular contexts and their role in the formation of multicellular patterns is ongoing



Crystal structure of MglAB complex highlighting the C-terminal helix of MglB bound to MglA

### Background

Frequent reversals of cell polarity facilitate motility and organization into fruiting bodies in the soil bacterium *Myxococcus xanthus*. Studying the molecular basis of polarity reversals in *M. xanthus* contributes towards understanding fundamental principles in cell motility, polarity determination and spatial localization in biology. Roles of a small Ras-like GTPase MglA and regulatory proteins that act as switch, the bacterial cytoskeleton MreB that forms part of the motility complex, and a novel signal sensing mechanism, involving FrzCD as receptor, that drives oscillations in response to external stimuli, are some of the features that make the spatial oscillatory mechanism in *M. xanthus* very interesting.

The study has implications in understanding spatial positioning in bacteria, regulation of bacterial motility, novel roles of bacterial cytoskeleton, and characterization of a cytoplasmic chemosensory signal sensing mechanism. Detailed characterization of the mechanism will help identifying analogous systems in pathogenic bacteria and eukaryotes by bringing out the conserved features.

### Principal Collaborators



**Gayathri Pananghat**  
Indian Institute Science Education  
and Research  
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**Tam Mignot**  
Laboratoire de chimie bactérienne  
CNRS  
Marseille

### Publications

- No. of publications in SCI journals: 4
- No. of papers presented in conferences: 4

### Mobility Support

- India to France: 2
- France to India: Nil

## Directing the ballet of Meiotic chromosomes: regulation of Separase and control of Monopolar Kinetochore orientation

### Background

Proper distribution of chromosome at mitosis and meiosis is crucial to preserve genome integrity, prevent aneuploidy and carcinogenesis. Control of chromosome segregation during cell division requires precise temporal control of the activity of Separase the protein that cleaves Cohesin, the protein complex that holds sister chromatids together at metaphase. In fungi and animals, Separase activity is controlled by Securin, a direct inhibitor that binds Separase. However, in plants Securin has not been yet identified, leaving regulation of separase elusive in this clade of eukaryotes.

Life & Health Sciences

Project No. 5803-2

Jan. 2018 to Dec. 2021

### Objectives

- Identify and characterize factors that regulate separase activity at meiosis and mitosis in *Arabidopsis*
- Identify and characterize factors that ensure monopolar orientation of kinetochores at meiosis I

### Knowledge Generated/Products Developed

- Screens for the separase interactant achieved
- Identification of the Securin
- Genetic screen for monopolar orientation completed
- Identification of a series of mutants and corresponding genes for monopolar orientation

### Principal Collaborators



**Imran Siddiqi**  
CSIR - Centre For Cellular &  
Molecular Biology  
Hyderabad



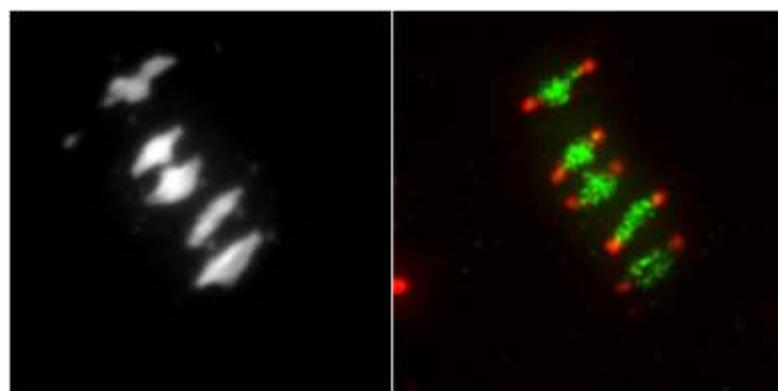
**Raphael Mercier**  
INRA, Plant Biology and Breeding  
Versailles

### Publications

- No. of publications in SCI journals: 1
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: 2
- France to India: 2



The pairs of meiotic chromosomes (bivalents) held together by crossovers are arranged on the metaphase plate (left). The protection of cohesin and monopolar orientation of sister kinetochores at the first meiotic division (Right).

# The assembly history of disk galaxies over the last 8 billion years

Pure & Applied Physics

Project No. 5804-1

Jan. 2018 to Dec. 2021

### Objectives

- To derive star-formation rate, stellar mass using multi-wavelength Spectral Energy Distribution constructed from UVIT/ASTROSAT (FUV, NUV), HST (Optical, IR), and IRAM NOEMA interferometry (Millimetre) for a sample of disk galaxies in the GOODS-South/North field as a function of redshift  $z$ , starting from  $z \sim 1$  to  $z \sim 0$
- Get different structural components using multi-component decomposition techniques and quantify (by analysing imaging data from HST) the strength of non-axisymmetric features in the disk galaxies. Carry out this analysis at the same redshift bins from  $z \sim 1$  to  $z \sim 0$
- Run and analyse zoom-in cosmological simulations of disk galaxies with minor mergers and cold gas accretion. Estimate time scales for the formation and assembly of different structural components

### Knowledge Generated/Products Developed

- PIs have discovered a clumpy galaxy at  $z=1.42$  leaking ionizing radiation caught by the far-UV filter of the UVIT/AstroSat. This galaxy lies in the GOODS-South field and a detailed modeling of the broadband spectral energy distribution has been performed. PIs estimated at least 20% of the ionizing photons are leaking from this galaxy to the intergalactic medium. This might have important consequences on how early galaxies might have formed. This work has been published in Nature Astronomy recently
- Dr. Soumavo Ghosh has analyzed a set of numerical simulations of minor mergers using the GALMER database provided by the French side. In this setup, the energy as well as the morphology of the perturber has been varied. A general result has emerged from this study — namely the bar is weakened at the end, in some cases the bar is completely destroyed. This work has been submitted for publication. In continuation to this effort, PIs are also analysing new suit of simulations to understand the impact of thick disk on galactic bar formation
- Dr. Ghosh has also shown that the commonly observed lopsidedness ( $m=1$  asymmetry) naturally arises during the minor mergers. This work is under review in MNRAS and in arXiv:2105.05270
- Anshuman Borgohain (a PhD student) has worked on an interesting problem of detecting extended-UV (XUV) emission from the outskirts of distant blue compact dwarf (BCD) galaxies. This work primarily uses the deep imaging observation of the GOODS-South field using the far and near-UV filters of the UVIT/AstroSat. In other words, the UV observation of the BCDs come from the AstroSatUv deep field that PIs have created. Finding XUV emission from dwarfs provides a tale-tale signs of the inside-out growth mode of galaxy formation and that in dwarfs is a bit surprising. One draft is fully ready and another with more than 90% complete. PIs plan to release both the draft simultaneously
- With Barbara Mazzilli, PIs observed in UV a series of Double-Peaked spectrum galaxies (DP), a rare event in the sky, corresponding to close mergers. PIs are accumulating multi-wavelength data of these DP in atomic and molecular gas (HI and CO), Halpha/NII velocity field with MANGA, to understand the dynamics of the systems, and their merger stage

### Background

This project aims to uncover the history of disk galaxy assembly over the last 8 billion years (which is more than half the age of the universe) using state-of-the-art observing facilities and numerical simulations. More specifically, the collaborators would like to decode how and when different structural components of a disk galaxy, e.g., bulge, disk, non-axisymmetric structures such as bars, spirals that are abundant in present-day disk galaxies, have assembled as it evolved over time. Both star formation and a number of physical processes such as minor mergers, accretion of cold gas, secular evolution identified as potentially important; contribute to the assembly of disk galaxies. In order to have a better planning, the project is divided into two broad sections - observations, data analysis and numerical simulations.

### Principal Collaborators



**Kanak Saha**

*Inter University Center for Astronomy & Astrophysics (IUCAA)  
Pune*



**Francoise Combes**

*Observatories de Paris  
Paris*

### Publications

- No. of publications in SCI journals: 5
- No. of papers presented in conferences: 1

### Mobility Support

- India to France: 3
- France to India: 1

# Phase transitions in sub-saturation nuclear matter and applications to core-collapse supernova and nuclear experiments

## Background

Nuclear clusters are abundantly formed in heavy ion collisions and believed to compose the dense matter in the universe that characterizes the cores of supernovae and the inner crust of neutron stars. Both aspects are the manifestation of the same physical phenomenon, namely the liquid-gas phase transition of nuclear matter. A realistic description of such clusters interacting inside the medium composed by their continuum states is important for both fields. Specifically, nuclear experiments can provide constraints to the parameters of the theory that cannot be fixed by ab-initio considerations, and in turn these constraints can be translated into confidence levels for astrophysical observables such as, among others, neutron star radii. The effective interaction among nucleons and the in-medium binding energy shift of the clusters due to the nucleons can be both described through Density Functional Theory. A model independent energy functional will be used which only depends on empirical parameters.

## Pure & Applied Physics

Project No. 5804-3

Mar. 2018 to Sept. 2022

## Objectives

- Clarify the confidence interval on empirical equation of state parameters through heavy-ion collision data, and measure its impact on neutron star observables
- Improve the description of nuclear clustering, both for multifragmentation and core collapse evolution, including in the best available models the missing in-medium binding energy shifts
- Analyze the impact of sophisticated ab-initio treatments of hyper-nuclear matter on the possibility of multi-strange cluster production, and on the evaluation of the complete hyper-nuclear matter phase diagram at low density

## Knowledge Generated/Products Developed

- An improved cluster function was implemented in the canonical thermal model and extended calculations were performed to study the N/Z cluster ratio predicted by this improved model in comparison to the prediction of the spinodal instability
- A paper was submitted to Physical Review
- A thermodynamically consistent procedure to treat the continuum states was developed and implemented in the Nuclear Statistical model that PIs have built during the first year of the project
- A paper was submitted to Physical Review
- Extended calculations were performed on central collisions of Ni+Ni systems in collaboration with an experimental team

## Principal Collaborators



**Gargi Chaudhuri**  
Variable Energy Cyclotron Center  
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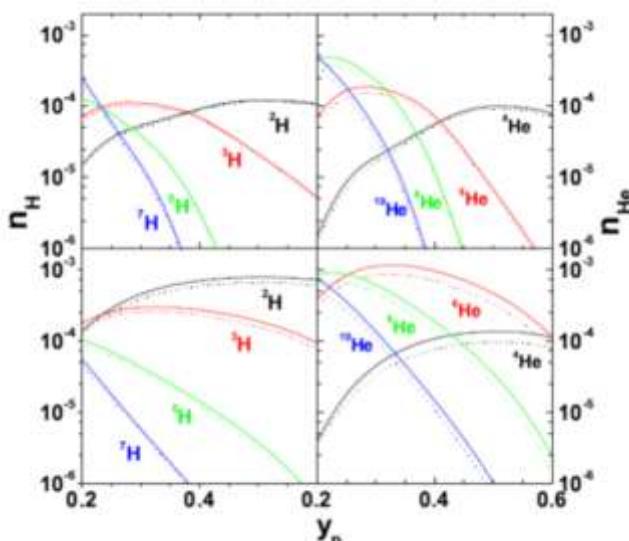
**Francesca Gulminelli**  
LPC / ENSICAEN  
Caen

## Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 2
- France to India: 1



Density of Hydrogen (left panels) and Helium (right panels) isotopes as a function of the global proton fraction, in four different density and temperature conditions explored both in supernova dynamics and in experimental multifragmentation

# Novel Chiral First row Transition Complexes for Asymmetric Catalysis via Activation of inert C-H and C-Heteroatom bonds

Pure & Applied Chemistry

Project No. 5805-1

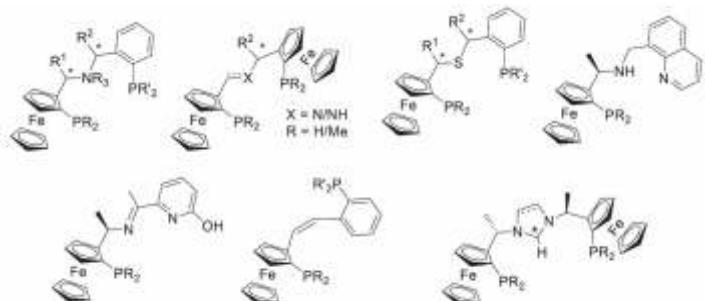
Oct. 2017 to Apr. 2021

## Objectives

- To develop new efficient catalytic systems based on cheap first row late transition metals (cobalt, iron and manganese) for asymmetric transformations of unreactive substrates via activation by dehydrogenation. Chiral complexes of the selected metals with different chiral ferrocene-based ligands will be in particular tested in asymmetric C-N bond formation from unreactive alcohols by dehydrogenation/hydrogenation sequence and in the asymmetric functionalization of alkanes through C-H bond activation (dehydrogenation)/functionalization (hydrosilylation, hydroboration) sequence

## Knowledge Generated/Products Developed

- PIs have successfully prepared ultrathin films as per the sample geometry promised in the proposal
- The sample morphology was checked by atomic force microscopy and the thickness was confirmed by XRR measurements
- By tuning the FM thicknesses near SRT, they have stabilized skyrmions in both Pt/Co and Pt/CoFeB systems
- It is observed that the pinning potential of the prepared samples is significantly less which is very important for practical applications purposes
- PIs have determined the depinning field of Pt/Co40Fe40B20/MgO multilayer which is around 10 mT. The depinning field gives an idea about magnetic disorder that acts on a magnetic domain or a skyrmion
- PIs have quantified iDMI first time in Pt/CoFeB/MgO and Bi2Se3/CoFeB/Ta thin films by BLS, where Bi2Se3 is a topological insulator
- Nanotacks were prepared via EBL to study the skyrmion current induced dynamics and the threshold current density is significantly low ( $0.8 \text{ A/m}^2$ ) than previous reports



Schematic representation of some targeted planar-chiral ligands

## Background

The aim of the project is to develop new efficient catalytic systems based on inexpensive first row transition metals for asymmetric transformations of unreactive substrates via activation by dehydrogenation. For this purpose, various chiral ferrocene-based metal complexes will be used with cobalt, iron and manganese. A large variety of ligands with various coordination pattern and different elements of chirality (planar chirality, central chirality) will be prepared in few steps in diastereoisomeric and enantiomerically pure form. The redox properties of the new complexes will be exploited for unknown or underdeveloped catalytic transformations, in particular for the asymmetric version of dehydrogenation/hydrogenation, C-N bond formation and C-H bond activation/functionalization reactions. The best catalytic systems will be grafted on polymeric or inorganic supports and mechanistically studied.

## Principal Collaborators



**Basker Sundararaju**  
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**Rinaldo Poli**  
Laboratoire de Chimie Coordination (LCC)  
Toulouse

## Publications

- No. of publications in SCI journals: 11
- No. of papers presented in conferences: 1

## Mobility Support

- India to France: 2
- France to India: 2

# Tuning the interfacial Dzyaloshinskii-Moriya interaction in ultrathin magnetic films:toward the stabilization of skyrmions in spintronics devices

## Background

The project aims to develop an experimental project towards fabrication of ultrathin magnetic films and nanostructures where interfacial Dzyaloshinskii-Moriya interaction (iDMI) plays an important role in determining the domain wall chirality and dynamics. iDMI has drawn intense research attention over the last decade because of their potential in applications as well as in fundamental research. One of the most fascinating issue of iDMI is the stabilization of skyrmions (a novel chiral texture characterized by a topology different from the ferromagnetic uniform state), which drives an intense worldwide research. Using combined magneto-optical Kerr effect (MOKE) based microscopy and magnetic force microscopy (MFM) it is planned to investigate the current driven motion of skyrmions in ultrathin films with structural absence of inversion symmetry. The challenge is to tailor the chirality and energy of the domain walls in such a way that the skyrmions remain stable at room temperature, in a structure where they can be efficiently driven via spin transport torque, in particular induced by the spin Hall effect (SHE). Controlling the skyrmion size by tuning the DMI strength and magnetic anisotropy by varying the deposition conditions is a first challenge in view to produce ultrasmall skyrmions for spintronics application. Another important aspect is to produce films with low damping and pinning, in order to enable efficient nucleation and motion in devices.

## Principal Collaborators



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**Stanislas Rohart**  
Universités Paris-Sud  
Paris

## Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 4
- France to India: 3

## Materials Science

Project No. 5808-1

Jan. 2018 to Dec. 2021

## Objectives

- Preparation of ultrathin ferromagnetic film with perpendicular magnetic anisotropy with the structure of heavy metal (HM)/ ferromagnet (FM)/ oxide (O)
- Micro/nanofabrication on the as prepared thin films with iDMI using photolithography and electron beam lithography to connect the ferromagnetic nanostructures for transport measurements
- Structural characterization of the films will be performed using atomic force microscope (AFM), small angle x-ray reflectivity (XRR) and scanning electron microscopy (SEM)
- Determination of iDMI of the films and its variation as a function of the deposition parameters
- Characterization of domain wall pinning under the pulsed magnetic field and/or current
- Investigation of skyrmions (size) using magneto optic Kerr effect (MOKE) based microscope and magnetic force microscope (MFM) depending on the size of the skyrmions
- Study of skyrmion nucleation and motion using current pulse et optimization of the spin Hall effect torque

## Knowledge Generated/Products Developed

- PIs have successfully fabricated Si/SiO<sub>2</sub>(native)/Ta (5 nm)/Pt (6 nm)/Co (t<sub>Co</sub>)/Ta (5 nm) and Si/SiO<sub>2</sub>(100 nm)/Ta (5 nm)/Pt (6 nm)/Co<sub>40</sub>Fe<sub>40</sub>B<sub>20m</sub> (t<sub>CFB</sub>)/MgO (2 nm)/Ta (2 nm) series of samples in order to achieve perpendicular anisotropy (PMA). The PMA plays a crucial role to host a skyrmion in a thin film. The competition between PMA, exchange energy, DMI energy and Zeeman energy has stabilized skyrmions in thin films. Here, the skyrmion size is found to be in the range of 100-300 nm. PIs have also stabilized skyrmions at zero field in Pt/CoFeB/MgO thin film which is very useful for practical application purpose
- PIs have determined the depinning field of Pt/Co<sub>40</sub>Fe<sub>40</sub>B<sub>20</sub>/MgO multilayer which is around 10 mT. The depinning field gives an idea about magnetic disorder that acts on a magnetic domain or a skyrmion
- PIs have prepared nanotacks with different width for transport measurements of skyrmions using EBL. The widths of track are 1 mm and 3 mm. Dynamics (nucleation, propagation) studies are beginning
- iDMI constant has been quantified for the Pt/CoFeB/MgO using BLS. Also, PIs have investigated the dependency of iDMI on FM thickness. The linear dependency of iDMI with  $1/t_{CFB}$ ,  $t_{CFB}$  = thickness of CoFeB, confirms its interfacial nature. The observed iDMI value varied in between 0.44-0.56 mJ/m<sup>2</sup> for Pt/CoFeB/MgO
- PIs have quantified iDMI first time in Bi<sub>2</sub>Se<sub>3</sub>/CoFeB/Ta thin films by BLS, where Bi<sub>2</sub>Se<sub>3</sub> is a topological insulator. This opens some perspectives of new materials for skyrmions, with an expected increased sensitivity to current induced dynamics

# NOVIS60: Non-contact vital sign estimation with 60 GHz radar technology

## Computational Sciences

Project No. 5902-1

Jul. 2018 to Jul. 2022

### Objectives

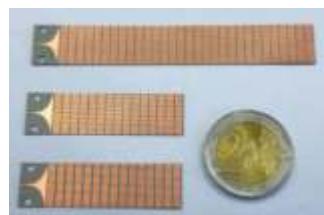
- To design the 60 GHz antenna system that will be able to scan in 2-dimension the room to be monitored
- To design the radar transmitter and receiver with frequency scanning capabilities in 65nm UMC Technology
- To operate the radar in order to estimate its accuracy and its robustness

#### Revised objectives, if any

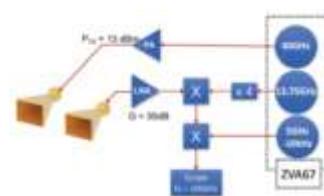
- To design the radar transmitter and receiver with frequency scanning capabilities in 40 nm TSMC Technology (As validated model are not available in 65 nm UMC for 60 GHz design, especially for inductor)

### Knowledge Generated/Products Developed

- Design of oscillator is done for 60 GHz and achieved approx. 3 GHz bandwidth
- Frequency of oscillators is 57.06 GHz to 59.9 is achieved
- Design of an enhanced beam-scanning antenna using metasurface
- A specification of the transceiver has been finalized with the help of literature survey and experiment done at Sorbonne University, France
- Preliminary design of a metamaterial-based switch to switch the signal input of the antenna in order to switch beams in one dimension



Three prototypes of enhanced leaky wave antennas based on metasurfaces



Block Diagram for the measurement of the Radar implemented prototype



Laboratory setup for the measurement of the Radar

### Background

NOVIS60 aims to develop an innovative electronic system capable of detecting people's vital signs (namely, respiration and heartbeat rate) in a remote and contactless way.

NOVIS60's solution will be based on a Doppler radar operating in the license-free 60 GHz band. A radio-frequency wave will selectively illuminate a person, whose vital signatures will be responsible for micro-movements of the body. These movements will affect in turn the reflected wave, which will be received and processed by the system in order to extract vital signs information. Due to the directive illumination of the system, it will be possible to monitor several people simultaneously, and to recognize possible situations of stress/danger. A first proof of concept has been obtained within the consortium and NOVIS60 aims to develop a demonstrator to assess such radar in real situations. This demonstrator will include a novel beam-scanning antenna and its dedicated 60 GHz transceiver and will enable drawing the fundamental limitations of this approach while better highlighting its potential.

### Principal Collaborators



**Jayanta Mukherjee**  
Department of Electrical Engineering  
IIT Bombay  
Mumbai



**Julien Sarrazin**  
L2E  
Sorbonne Université  
UPMC – University Pierre and Marie Curie  
Paris

### Publications

- No. of publications in SCI journals: 15
- No. of papers presented in conferences: 11

### Mobility Support

- India to France: 2
- France to India: 1

# Hematopoiesis and metabolism

## Background

This research proposal aims to conduct a cohesive understanding of hematopoiesis with specific emphasis on their origin and associated functions allied to metabolic homeostasis in animal physiology. Being a question of broader relevance, but given the nature of complexity it may not be easily addressed in a vertebrate system. The PIs plan to utilize the *Drosophila* hematopoietic model to establish a genetically tractable platform to explore this in detail.

A conclusive understanding of hematopoiesis and metabolic homeostasis in animal physiology will be obtained by employing metabolic approaches along side developing genetic tools to precisely modulate embryonic and definitive hematopoietic cells. Finally, it is proposed to investigate the relevance of myeloid origin in defining susceptibility to dietary and metabolic stresses. The overarching goal of this effort is to decipher conserved molecular mechanisms underlying myeloid development and homeostasis in global metabolic physiology and to truly understand the cross talk between immune cells and the organism.

## Principal Collaborators



**Tina Mukherjee**  
Institute for Stem Cell Biology and Regenerative Medicine  
Bengaluru



**Angela Giangrande**  
Institut de Génétique et de Biologie Moléculaire et Cellulaire  
Strasbourg

## Publications

- No. of publications in SCI journals: 6
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 1
- France to India: 2

## Life And Health Sciences

Project No. 5903-1

Aug. 2018 to Jan. 2022

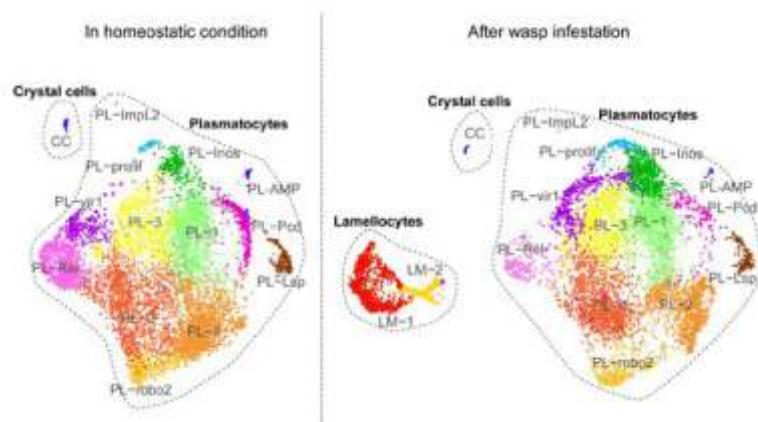
## Objectives

- Energy distribution of *Drosophila* myeloid cells across developmental scales
- Investigate effects of altering myeloid cells on systemic metabolism

## Knowledge Generated/Products Developed

- Non-autonomous control of animal growth and metabolism by blood cells in *Drosophila*
- Generation of blood specific driver lines and established mass-spectrometric analysis of *Drosophila* larval blood cells, both circulating and from the lymph gland
- Differential gene expression profile of blood cells from *Drosophila* embryo and larvae
- Identification of thirteen hemocyte populations in the *Drosophila* immune system
- Hemocytes undergo a transcriptional and metabolic switch during development

Single cell RNA seq of hemocytes from *Drosophila* larvae



# Modelling and observing pulsars: from high energy to radio emission

Pure & Applied Physics

Project No. 5904-1

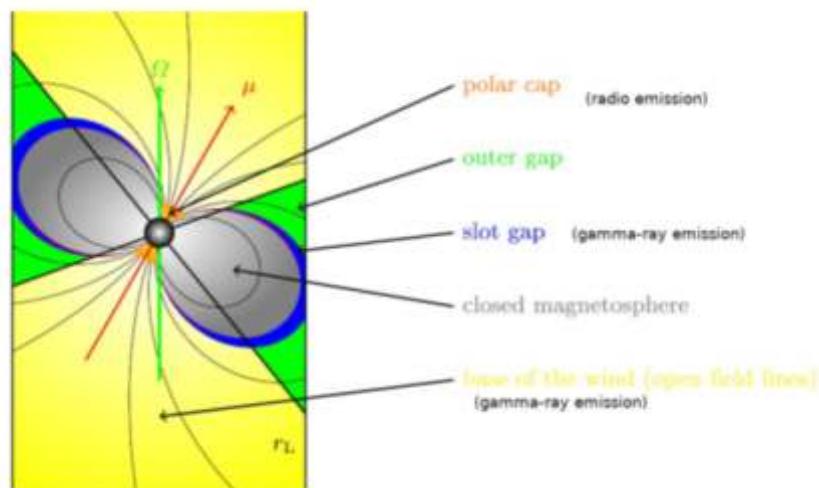
Jun. 2018 to Jun. 2023

### Objectives

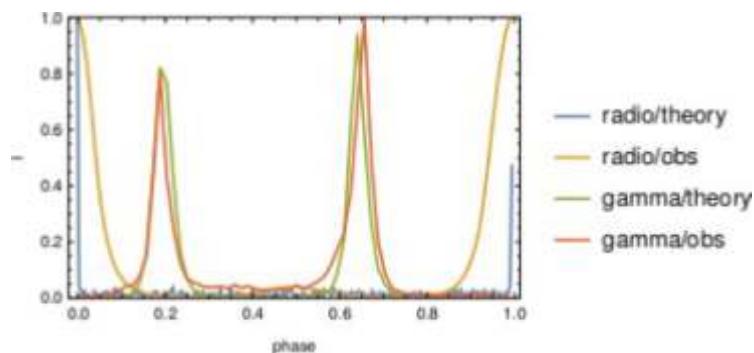
- Analysing existing radio and X-ray data
- Computing equilibrium configurations of the pulsar magnetosphere
- Interpreting results in the light of multipolar fields within the magnetosphere

### Knowledge Generated/Products Developed

- Simultaneous radio and non thermal X-ray emission from off-centred dipole (Petri & Mitra, 2020)
- Simultaneous radio and gamma-ray light curves fitting for millisecond pulsars (Postdoc et al, in preparation)
- Simultaneous radio and gamma-ray light curves fitting for young pulsars (Petri & Mitra, in preparation)



Sites of radio and gamma-ray emission in a pulsar magnetosphere



Radio and gamma-ray light-curve best fit for PSR J1028-5819

### Background

Studying radio pulse profiles and polarization helps to get unprecedented insight into the emission physics of pulsar and constraints on the magnetic topology. Only recently, theoreticians went beyond the dipole paradigm, trying to constrain multipolar components from joint radio and X-ray observations. The goal is to determine the role of multipoles on pulsar emission physics. Observationally the existence of such fields is still being probed and future space and ground based telescopes are being designed to assert the magnetic topology. Probing multipolar fields requires observing neutron stars close to their surface. There are primarily two ways of probing the region below 10% of the light cylinder, namely the coherent radio emission and the emission of thermal X-rays from hot polar caps.

The radio pulse shape, its polarization and spectral properties suggest that pulsar emission arises from regions of open dipolar field lines. Pulsar radio emission is highly linearly polarized and in several pulsars the linear polarization position angle exhibits a S-shaped traverse.

### Principal Collaborators



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Observatoire astronomique de Strasbourg,  
CNRS  
Strasbourg*

### Publications

- No. of publications in SCI journals: 28
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: 1
- France to India: 1

# Composite Models at the Interface of Theory and Phenomenology

## Background

The major physics goal of high-energy physics is to understand the structure of matter in terms of its most elementary constituents. One possible approach to knowing what lies beyond the present theoretical paradigm of high-energy physics, known as the Standard Model, is to ask whether the particles of the Standard Model are composite. Experiments tell us that some of the particles are elementary, to a large extent at least, but for others PIs do not have the comfort of this knowledge. These particles could well be composite objects arising from an underlying more-fundamental theory. The questions sought here to address in this proposal are then:

- i) What theoretical models of compositeness can be written down in a mathematically consistent way?
- ii) Do these models stand the test of current experiments?
- iii) What new predictions do composite models have that can be searched for in experiments?

## Principal Collaborators



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## Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 4

## Mobility Support

- India to France: 1
- France to India: 1

## Pure & Applied Physics

Project No. 5904-2

Jun. 2018 to May 2022

## Objectives

- Investigation of specific models of compositeness and their viability from a theoretical point of view
- Issues of UV-completion and the inputs to model-building from perspectives of duality
- Using existing collider information and precision electroweak measurements to constrain the parameter space of the models
- Examine the role of flavour physics and cosmology in understanding such scenarios
- Predicting new effects from the models and suggesting suitable search strategies at present and future experiments for these effects

## Knowledge Generated/Products Developed

- The study of vector-like quarks at present and future collider experiments as a search for compositeness
- Probes of novel interactions resulting from models of compositeness as a way of zeroing on to smoking-gun signals of composite models
- Studying collider signatures in models of strong dynamics which are related by duality to higher-dimensional theories
- Studying possible signatures of strong dynamics in Higgs precision studies
- Completing an up-to-date review of the subject of Compositeness

# Pre-evolutionary processes in autocatalytic RNA networks

Multi Disci (Physics, Chemistry, Biology)

Project No. 5904-3

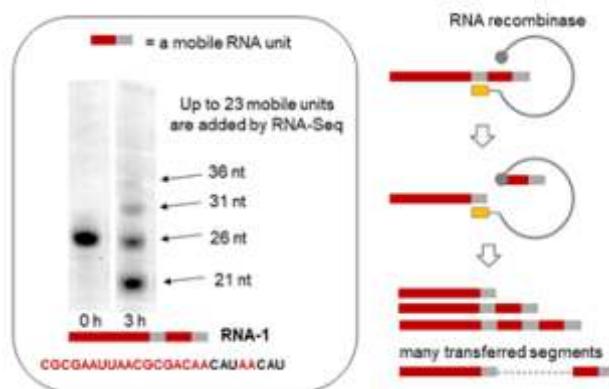
May 2018 to Apr. 2021

## Objectives

- Objective 1 has been partially fulfilled, as PIs have discovered that certain topology has more compositional memory than others. But we have also discovered a limitation of the system: in the RNA system originally used, heredity is limited by self-assembled catalysts. Thus, a novel objective has emerged
- Objective 1 bis: optimize RNA sequences so that self-assembled molecules have negligible catalytic activity compared to covalent catalysts
- Objective 2 has been fulfilled. However, PIs have found a novel dynamics of variation, which could allow open-ended evolution, using recombination. Thus Objective 2 is now extended to
- Objective 2 bis: Study RNA sequence variation in the presence of a recombinase ribozyme
- Objectives 3, 4 and 5: On-going work extending over the second period; these objectives have not been modified in their overall scope, and integrate the findings of the first period

## Knowledge Generated/Products Developed

- A technology to screen RNA network compositions at a very high-throughput
- Perturbation laws in autocatalytic RNA networks
- Network determinants of heredity
- Mechanisms of RNA shuffling using a recombinase
- Conditions for evolution of autocatalytic networks



Recombinase-mediated transfer of mobile units. Left box: representative PAGE after the diversification of sequences.

## Background

Building artificial systems able to evolve by natural selection would allow to better understand the origins of life and conceive novel strategies to screen for chemical reactions. Here, it is proposed to explore how ensembles of RNA molecules that replicate collectively - or CAS for Collectively Autocatalytic Sets - could have started to evolve according to the laws of natural selection when compartmentalized in protocells. This requires to implement several pre-evolutionary properties in autocatalytic systems: heredity, variation and selection. The Indian partners have pioneered the study of CAS evolution, recently showing reaction structures for robust reproduction and memory effect. The French partners have pioneered the droplet microfluidics technology for biochemical applications, and have recently coupled it with molecular barcoding and Next Generation Sequencing to study catalytic RNA networks. It is proposed to use RNA system, derived from a ribozyme from the *Azoarcus* bacterium, which allows to design and build a huge diversity of CAS connectivities. It is proposed to implement pre-evolutionary properties in this system in a stepwise manner.

## Principal Collaborators



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TIFR  
Mumbai



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Chimie Industrielle (ESPCI)

## Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: 7

## Mobility Support

- India to France: 4
- France to India: 3

# Boron-controlled CO<sub>2</sub> reduction

## Background

Due to the increasing level of CO<sub>2</sub> in the atmosphere, its use as a carbon source has attracted considerable interest in recent years. Borane compounds have played a key role thanks to a dual character of Lewis acidity and of hydride donor ability. On one hand, hydroborane, with a catalyst, and hydroborate, without, are able to reduce CO<sub>2</sub> by transferring hydride(s) to the electrophilic central carbon atom of CO<sub>2</sub>. On another hand, the Lewis acidity of the borane moiety has been used in ambiphilic compounds to activate CO<sub>2</sub>. In this proposal, it is proposed to combine both properties and propose to design and synthesize hydroborane/borate compounds featuring pendant Lewis bases, in a FLP-inspired strategy. The compounds will then be coordinated to prepare the corresponding metal complexes containing M-H, B-H and/or M-H-B moieties. The ability of these compounds and of the complexes to activate/reduce CO<sub>2</sub> will be investigated in detail.



Sundargopal Ghosh's group with Sylviane Sabo-Etienne after her lecture at IIT Madras

## Principal Collaborators



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Chennai



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Chargé de Recherche  
Laboratoire de chimie de coordination du CNRS  
Narbonne

## Publications

- No. of publications in SCI journals: 7
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: 1
- France to India: 2

## Pure & Applied Chemistry

Project No. 5905-1

May 2018 to Apr. 2022

## Objectives

- To get benefited from both the Lewis acid and the hydride donor ability of boron-based reagent to activate and transform CO<sub>2</sub>
- Designing and synthesizing boron-based compounds with a pendant Lewis base moiety
- To study the reactivity of these compounds and of the related complexes toward CO<sub>2</sub> and to get deeper insights about mechanistic pathways and to disclose new transformations

## Knowledge Generated/Products Developed

- Synthesis of diborane(5) stabilized in the classical form in the coordination sphere of bimetallic tantalum complex,  $[(Cp^*Ta)(\mu,\eta^2:\eta^2-B_2H_5)(\mu-H)(\kappa^2,\mu-S_2CH_2)_2]$ , from the reaction of [Cp<sup>\*</sup>TaCl<sub>4</sub>] with LiBH<sub>4</sub>·THF followed by addition of S<sub>2</sub>CPPh<sub>3</sub> has been demonstrated
- Synthesis of B-H activated ruthenium complexes and ruthenium silyl complexes from borane and hydrosilane activation by  $\kappa^2-N,S$ -chelated ruthenium borate species, respectively. These compounds have been completely characterized by multinuclear NMR spectroscopy and single crystal X-Ray diffraction analysis. The reactivity of these synthesized borate and silyl complexes with CO<sub>2</sub> under different reaction conditions will be explored
- Synthesis and structural characterization of various novel rhodium – diborane(6) species,  $[(\{OC\}_4Re)\{Re(CO)\}_2(\mu_3-\eta^2:\eta^2-B_2H_6)(\mu-H)]$ ,  $[\{(\{OC\}_4Re)\}_2\{Re(CO)\}_3(\mu_3-\eta^2:\eta^2:\eta^1-B_2H_6)(\mu-H)]$  and  $[\{(\{OC\}_4Re)\}_2(\mu-\eta^2:\eta^2-B_2H_6)]$  with diverse coordination modes of the [B<sub>2</sub>H<sub>6</sub>]<sup>2-</sup> ligand was carried out
- Synthesis of a series of 4 mono-phosphine borate compounds featuring various borate moieties with a phenyl or naphtyl linker. These species are original species since only one type of mono Lewis base-borate compound was reported before with an amine borate compound.
- PIs were able to characterize P-B coupling by thorough NMR investigations. Several evidences point toward an unprecedented through space P-B coupling
- Reactivities of these phosphine borate compounds toward metal precursors and CO<sub>2</sub> were probed showing their propensity to release the hydride moiety. PIs exploited this feature to get a new synthetic pathway to phosphine borane compounds which are important species as catalysts or ligands. PIs used this strategy to get access to a new phosphine borane compound featuring a chiral boryl moiety. The latter compound traps CO<sub>2</sub> reversibly
- New (PBP)borate pincer type ligands Li[R<sub>2</sub>B(C<sub>6</sub>H<sub>4</sub>-P'Pr<sub>2</sub>)<sub>2</sub>] (R<sub>2</sub>= (Ph)<sub>2</sub>, BBN) were synthesized and their coordination chemistry will be studied
- Hydride transfer property of our new phosphine borate allowed PIs to isolate and crystallographically characterize a lithium Ru complex featuring 5 hydride ligands and stabilized by two tricyclopentylphosphines. The corresponding potassium salt was briefly mentioned in the literature but not isolated nor characterized
- Preliminary tests of coordination of ligands provided by the Indian side were conducted in the French side. The covid situation precluded us to continue on this study

# Nutrient transfers through groundwater in India (NUNDERGROUND)

Earth & Planetary Sciences

Project No. 5907-1

Aug. 2018 to Jul. 2022

## Objectives

NUNDERGROUND, Nutrients transfer through groundwater in India, will focus on C, N, Si cycles in groundwater along the Indian land-to-ocean continuum with the following objectives:

- Identify the external SOURCES of macronutrients in Indian groundwater
- Characterize groundwater PROCESSES that contribute to and modify their macronutrient contents
- Identifying the fate of GW macronutrients – and when possible estimate the fluxes, of nutrients to the estuaries and/or coastal ocean and to the atmosphere in the form of Greenhouse Gases (CHG)
- understand the seasonal and regional variability of these transfers along land use, lithology and climatic gradients

## Knowledge Generated/Products Developed

- Field trip during wet season (August) to sample GW and surface water when available at the three locations studied Mule Hole (forest), Berambadi (agriculture), Godavari estuary
- Measurements of most core biogeochemical parameters of the wet season samples (nutrients, cations and anions)
- First series of measurements of silicon isotopes and completion of water isotopes of the wet + dry season samples (Si isotopes analyses need to be validated / duplicated)
- Measurements of  $\text{NH}_4^+$ ,  $\text{NO}_2^-$ ,  $\text{NO}_3^-$  concentrations and of  $\delta^{15}\text{N}$  &  $\delta^{18}\text{O}$  of  $\text{NO}_2^-$  and  $\text{NO}_3^-$ ,  $\delta^{15}\text{N}$  of  $\text{NH}_4^+$



Preparing the water sampling device to collect groundwater from a well in a village next to Godavari estuary (Andhra Pradesh, August 2019)

## Background

There are a limited number of studies of GW biogeochemical processes and contribution to chemical budgets of Indian Ocean. NUNDERGROUND proposes to gather ongoing complementary surveys from different labs in France and India adding advanced isotopic tools and expertise on C, N, Si, Ca, Sr,  $\text{H}_2\text{O}$  to help identifying the external sources (natural and anthropogenic) of macronutrients and carbon in Indian ground will take advantage from on-going efforts by Indo-French teams to combine expertise on GW processes from continental hydrogeologists and geochemists (IISc, GET, IEES) with biogeochemical expertise on estuaries (NIO and LOCEAN). To achieve this, it is proposed to apply an advanced isotopic toolbox common to the studied systems that should provide the added value needed to unlock gaps in our current understanding on nutrient sources and processes in GW as well as their potential contribution to estuaries and coast.

## Principal Collaborators



**V.V.S.S. Sarma**  
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**Damien Cardinal**  
LOCEAN  
Laboratoire d'Océanographie et du Climat -  
Expérimentations et Approches Numériques  
Sorbonne Université, Paris

## Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: 1

## Mobility Support

- India to France: Nil
- France to India: 1

## A novel high temperature selective coating on superalloy substrates stable up to 600 deg. C in air for solar thermal electricity receivers: Studies on improved efficiency and accelerated aging tests

### Background

The proposal addresses the challenges in developing new optically efficient solar selective coatings which are stable in air for temperatures greater than 580 deg. C. For this purpose, thermally stable nitrides, carbides, oxynitrides and oxides of W, Si and Ti will be synthesized by sputtering processes. Their composition and thicknesses will be tailored to develop a novel spectrally selective coating on superalloy substrates with a gradient of refractive indices, leading to very high spectral selectivity (absorptance above 94%, emittance below 15%), and high temperature stability in air (up to 600 deg. C). The coating design will be optimized using optical simulation tools and fine tuning of process parameters, and its thermo-optical performance will be experimentally validated using a large number of characterization techniques available with the collaborators, including UV-VIS-NIR and IR spectrophotometry. In addition, solar absorptance will be measured under natural solar irradiation (DISCO) and thermal emittance will be evaluated at high temperature up to 500 deg. C, to assess the solar-to-electric efficiency of the coating system. Accelerated aging tests with various atmospheres and thermal cycling, in electrical (ALTHAIA) and solar (SAAF) furnaces, will be applied to evaluate the coatings service life for high temperature CSP applications.

### Principal Collaborators



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**Audrey Soum-Glaude**  
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Font Romeu Odeillo

### Publications

- No. of publications in SCI journals: 4
- No. of papers presented in conferences: 1

### Mobility Support

- India to France: Nil
- France to India: 1

Material Sciences

Project No. 5908-1

Sept. 2018 to Sept. 2021

### Objectives

- Develop a novel metal carbide, oxide, oxynitride and oxide based spectrally selective high temperature solar absorber coating
- Achieve coating high selectivity (absorptance above 94%, emittance below 15% at 82 deg. C) and thermal stability (600 deg. C in air under cyclic conditions) on superalloy substrates
- Optimize the coating structure by optical simulation and experimental validation of optical properties, substrate pre-treatment and fine tuning of process parameters
- Accurately evaluate the coating thermo-optical properties, including with unique solar facilities and equipment, and estimate the solar-to-heat efficiency of thus coated solar receiver
- Qualify the coating thermal stability, investigate its aging behavior and predict its service life in solar thermal applications

### Knowledge Generated/Products Developed

- Development of a novel high temperature stable tandem absorber of WAIN/WaSiN/SiON/SiO<sub>2</sub> on various substrates with very high absorptance and low thermal emittance
- Complete characterization of the developed coating using FESEM, AFM, SAD, HRTEM, XPS, FTIR, UV-Vis-NIR, scratch tester, etc. To understand the microstructure and optical properties
- Thermal stability studies carried out till 700°C in air and vacuum. Coating stable up to 700°C in vacuum for longer durations
- Solar accelerated cyclic thermal ageing tests of the developed materials in a solar furnace with concentrated solar irradiance typical of aimed CSP applications (SAAF). Coating stable in such conditions up to 450°C
- High temperature measurements of optical properties, up to 500°C, for better representativity of performance assessment



Solar Accelerated Aging Facility (SAAF) at the focus of 1.5 kW solar furnace in PROMES-CNRS Odeillo/France (left) and its sample holder mounted with CSIR-NAL Bangalore sample (right)

## 2D Materials for novel nano electronic device applications

### Material Sciences

Project No. 5908-2

Aug. 2018 to Jul 2022

#### Objectives

- Identification of materials for specific hybrid device
- Characterization of hybrid layers and heterostructures for optoelectronics applications
- Development of instrumentation as well as micromanipulator following characterization

#### Knowledge Generated/Products Developed

- Fabrication of chalcogenide few layers on different substrates and precursors and their characterization
- Establishments of standard operating process for heterostructure fabrication of TMDC materials
- Inhouse instrumental development for deterministic transfer
- Successful fabrication of heterostructures of InSe and GaSe and study of their interlayer interaction using standard characterization techniques
- Development of laboratory prototypes for photoelectrochemical activity

#### Knowledge process/product developed, if any

Indian student appointed as Post Doc have acquired know-how on 2D materials and specific techniques developed in IMPMC in France for these materials. He is being trained in clean room techniques and device fabrication. The Indian SPPU group has a strong background in testing of solar cells. Indian group also has good hands and expertise on control synthesis of various 2D chalcogenide materials using different Physical and chemical methods. Once the initial phase of the project is over French students will visit India to be avail training in their area of expertise



RF Sputtering system utilized for thin film deposition

#### Background

In this project PIs are interested in light-matter interaction in 2D materials and their heterostructures for the applications of optoelectronic devices.

During this year, in SPPU, atomically thin, few-layer indium selenide ( $\text{In}_2\text{Se}_3$ ) have been synthesized by RF sputtering and their photoelectrochemical properties investigated, namely the electron transfer kinetics and electric double-layer capacitance, supported by an extensive physical and chemical characterization. Thin films of vacuum-processed few layer  $\text{In}^2\text{Se}^3$  display n-type photocurrent densities of  $0.15 \text{ mA cm}^{-2}$  simulated solar irradiation. PIs have also synthesized lead free inorganic  $\text{K}_3\text{Bi}_2\text{I}_9$  perovskite thin films by facile one-step spin coating method and investigated its structural, optical and morphological properties. The fabricated films showed strong absorption in UV and visible region of solar spectrum and possess optical band gap  $\sim 2 \text{ eV}$ .

At Sorbonne PIs have advanced with the objectives of the project which includes synthesis, fabrication and characterization of materials and devices. In materials we have chosen the mono to few layer  $\text{MoS}_2$  for electrostatic doping and likewise, for bipolar devices PIs have chosen the few layer InSe. While working on these approaches, we have also modified & developed the new protocols & instruments which can be generalized for other optoelectronic experimentation.

#### Principal Collaborators



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**Abhay Shukla**  
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Matiériaux et de Cosmochimie (IMPMC)  
UPMC Sorbonne Université  
Paris

#### Publications

- No. of publications in SCI journals: 5
- No. of papers presented in conferences: 1

#### Mobility Support

- India to France: Nil
- France to India: Nil

# High performance formation control in the presence of uncertainties and communication constraints

## Background

Cooperative control has application in many areas of mechanical/aerospace engineering, electrical engineering, computer science and social networks/infectious disease networks. Our focus is on primarily on aero-mechanical systems cooperating over networks. Network interaction bring about several issues, one of them is related to inaccurate relative information collection. This effects the performance of the cooperating systems adversely and hence these errors in information need to be accurately estimated. Another set of concerns arise from network connections that are state and time varying, analysis of systems evolving over such networks brings about its own challenges and standard results in literature do not apply. Another impactful area is that of sparse control of large cooperating networks under constraints. Typical social marketing schemes require sparse schemes which impact very few nodes in the network directly, but the user expect the opinion to propagate uniformly over the network. It is therefore critical to devise such sparse control strategies for networks.

## Principal Collaborators



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Vandoeuvre-Lès-Nancy

## Publications

- No. of publications in SCI journals: 9
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: 1
- France to India: 1

## Pure & Applied Mathematics

Project No. 6001-1

Feb. 2019 to Aug. 2023

## Objectives

Cooperative control of mechanical systems and in particular formation control has recently seen a proliferation of research and applications, primarily due to low cost, robustness and specific application requirements. The target of the current proposal is to establish formation control while minimizing communication and control effort under a variety of uncertainties due to modelling and measurement errors . The specific application domain for the current proposal will be mechanical systems interacting through a variety of communication channels (optical, wireless, ultrasound etc.) with the objective being that individual agents achieve and maintain a relative pose (position and orientation) with respect to its neighbours. The current proposal extends recent research activity of the proposers in three fundamental directions namely, a) formation under sensor bias and graph uncertainties, b) formation under time-varying and state-dependent interconnections, and c) optimal control for formation under constraints

## Knowledge Generated/Products Developed

- H. Oza, R.N. Banavar, S. Sukumar, I.-C. Morarescu - *Formation Control Using Optimal Time Multiplexing*. 59<sup>th</sup> Conference on Decision and Control (CDC 2020), 2020, South Korea
- V. Varma, B. Adhikari, I.C. Morarescu, E. Panteley – *Optimal campaign strategy for social media marketing with a contrarian population*, International Conference on NETwork Games, Control and Optimisation (Netcoop), 2020, France
- V. S Varma, S. Sukumar, I.C. Morarescu, *Finite time bias removal in multi-agent non-linear systems*, European Nonlinear Dynamics Conferences, 2020



# Computing on Encrypted Data: New Paradigms in Functional Encryption

## Computational Sciences

Project No. 6002-1

Feb. 2019 to Jan. 2022

### Objectives

- Supporting the Turing machine and RAM models of computation and overcome the limitations of the circuit model of computation, which are two-fold: (I) It prevents dynamic data length as the input length must be a priori bounded; (ii) It incurs running in worst-case time on every input
- Improving hardness assumptions underlying constructions of functional encryption so as to rely on better understood ones
- Obtaining efficient constructions for specific functionalities of practical relevance
- Investigate the space between standard lattice assumptions and existing ill-understood assumptions by introducing principled new assumptions which may lead to new cryptographic constructions

### Knowledge Generated/Products Developed

- Realization under a well-accepted LWE assumption of a multi-client functional encryption scheme allowing to evaluate linear functions over inputs coming from distinct parties
- Evidence that functional encryption schemes for linear functions can satisfy a strong definition of simulation-based security for adaptive adversaries
- Construction of attribute-based encryption for (deterministic and non-deterministic) finite-automata from standard assumptions 4. Optimal efficiency tradeoffs for public-key broadcast encryption using bilinear maps and the Learning-With-Errors assumption
- Attacks and fixes against obfuscation candidates and recently proposed assumptions used in the designed of FE schemes
- Optimal efficiency tradeoffs for public-key broadcast encryption using bilinear maps and the Learning-With-Errors assumption

### Background

This proposal addresses one of the fundamental and most powerful tools in the setting of computing on encrypted data: functional encryption (FE). This primitive allows utmost control of the data being disclosed to the users of the system. In functional encryption, each user can be provided with a key that corresponds to a circuit  $C$ , which we denote by  $\text{SK}(C)$ . The user can apply this key to any ciphertext  $\text{CT}(X)$ , to obtain  $C(x)$  and nothing else. The flexibility and fine-grained access control afforded by Functional Encryption makes it a very attractive tool for modern day encryption needs. As an example, consider the case of a mail gateway which must route incoming emails according to the characteristics of each email. If email is encrypted, then the gateway cannot perform spam filtering directly, while giving the gateway access to the user's secret key might be dangerous. However, if the email is encrypted using a functional encryption scheme, then the gateway can be given a key that lets it check whether the email is spam, but nothing more. The study of functional encryption is a new and exciting field, which has displayed tremendous progress in a short time, and shows even more potential for the future.

### Principal Collaborators



**Shweta Agrawal**  
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Indian Institute of Technology-Madras  
Chennai*



**Benoit Libert**  
*Ecole Normale Supérieure de Lyon  
Lyon*

### Publications

- No. of publications in SCI journals: 8
- No. of papers presented in conferences: 13

### Mobility Support

- India to France: Nil
- France to India: Nil

# Membrane Biogenesis in Apicomplexa parasites: Trafficking and recycling lipid sources for membrane remodelling as drug targets against malaria and toxoplasmosis

## Background

Apicomplexa is a phylum of obligate intracellular parasites, including major pathogenic parasites such as *Plasmodium spp.* and *Toxoplasma gondii*, causative agent of malaria and toxoplasmosis, respectively. There is no vaccine against these diseases and appearances of multi-drug resistant strains, especially for malaria, both argue for the urgent development of new drugs. This project aims to understand the lipid-processing pathway involved in the transfer of fatty acids from the host and within the parasite and their recycling into lipids. It will focus on a group of non-characterized proteins, putatively important for parasite membrane biogenesis: (lyso) phospholipases. Molecular tools such as knockout, knockdown strains and tagged protein expression strains will be generated in both *P. falciparum* and *T. gondii*. Second, using those modified strains, protein localization and their phenotypes will be assessed. Third, the protein function in the parasite lipid metabolism will be determined by lipidomic analysis on mutant parasite lines. Final goal of this project is to understand the complex parasite mechanisms of lipid trafficking and biogenesis and identify novel drug targets by initiating in vitro drug screening.

Life and Health Sciences

Project No. 6003-1

Apr. 2019 to Mar. 2023

## Objectives

- PIs originally did not include acyl-CoA synthetases in the initial project, but PIs uncovered that these enzymes play an essential role in activating the fatty acid putatively generated from lysophospholipases. Molecular and functional characterization of these enzymes are now fully part of our project
- On the organisation/logistic levels, PIs initially planned several meetings, conferences as well as the mobility of the French PhD student (Ms Serena Shunmugam), which all had to be reprogrammed or postponed due to the global Covid-19-related sanitary situation. Instead, PIs have organized regular virtual meetings and attend international workshops and conferences, such as the prestigious Annual XXXth and XXIst Molecular Parasitology Meeting (2019 and 2020, respectively), where both Indian (Pradeep Sheokand) and French PhD students (Serena Shunmugam) were selected to give oral presentations about the project (CEFIPRA acknowledged), in 2019 and 2020, respectively. PIs have now reprogrammed the project of the French PhD student to be mostly conducted in France, accordingly to the sanitary situation

## Knowledge Generated/Products Developed

- Specific LPLs are identified as drug targets. PIs have established robust LPL in vitro activity assay which will be used to screen chemolibraries to identify specific inhibitors of selected LPLs

## Principal Collaborators



**Asif Mohmmmed**  
International Centre for Genetic Engineering and Biotechnology  
New Delhi



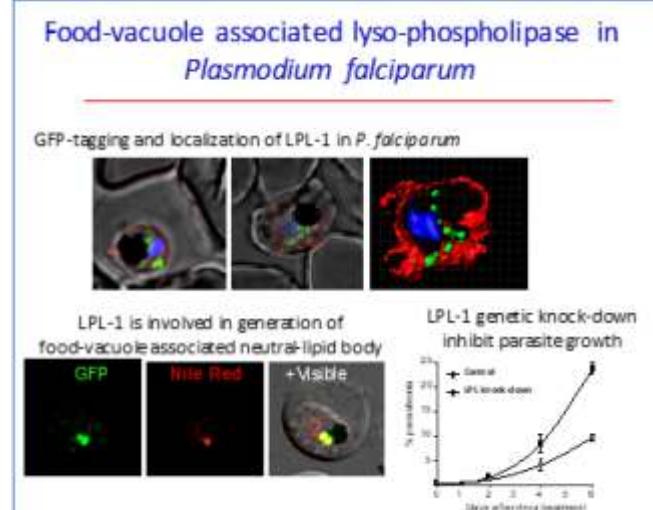
**Cyrille Yan Botté**  
Institut Albert Bonniot (IAB)  
Grenoble

## Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: 4

## Mobility Support

- India to France: Nil
- France to India: Nil



# Mechanism of miRNA-dependent and independent targeting of mRNAs to P-bodies

Life &amp; Health Science

Project No. 6003-2

Nov. 2019 to Nov. 2022

## Objectives

Role of organelles like mitochondria, endosomes and endoplasmic reticulum dynamics for miRNA and mRNA trafficking to P-bodies

## Knowledge Generated/Products Developed

- Aim A has been achieved and a paper describing the high-throughput smFISH method is in revision at Nature Commun (preprint available at <https://doi.org/10.1101/2020.09.04.28203>)
- An *in vitro* assay system with ghost cells has been under way and initial results suggests success of the protocol to monitor protein and mRNA targeting to P-bodies
- For Aim B, we performed an smFISH screen with ~150 RNAs in HeLa cells and found a handful that are highly enriched in P-bodies, with a large cell-to-cell variability suggesting regulated transport
- For Aim B, an smFISH screen with 500 mRNA coding synaptic protein has been done, and will be repeated with a PB marker
- For Aim C and D we are expressing the tagged RNA binding proteins in differentiated PC12 cells in order to purify the P-bodies for subsequent detection of associated mRNAs
- With this additional objectives in place, we have identified role of mitochondria associated mTORC1 complex in miRNA trafficking and export of miRNA in mammalian cells (Chatterjee et al. J Cell Sci. 2020)

## Background

The present proposal aims at deciphering the mechanistic details of how the targeting of mRNAs to P-bodies is achieved, in a context relevant for the physiology of neuronal cells. Indeed, differentiation and death of neuronal cells has been previously shown to be P-body dependent. Using state-of-the-art imaging and biochemical techniques, PIs will first perform screens to identify mRNAs that localize to P-bodies in a regulated manner during neuronal differentiation. Using few model mRNAs, PIs will then determine the RNA targeting element and interacting protein factors, thereby identifying the decisive factors/steps in P-body compartmentalization of mRNAs. Finally, PIs will perform experiments to demonstrate the functional significance of this transport. Overall, the proposed work will provide mechanistic insights into how mRNAs are transported to P-bodies, and will reveal how P-bodies contribute to the physiology of neuronal cells.

## Principal Collaborators



**Suvendra Nath Bhattacharyya**  
Indian Institute of Chemical Biology  
Kolkata



**Edouard Bertrand**  
Institute of Molecular Genetics of Montpellier  
Montpellier

## Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: 3

## Mobility Support

- India to France: Nil
- France to India: Nil

# Design and Control of many-body states in hybrid quantum systems

## Background

Nonequilibrium conditions are emerging as a new way of controlling quantum matter. The most spectacular applications are expected in systems of strongly-interacting particles, and studying their nonequilibrium dynamics has become a pressing theoretical challenge. This proposal consists of concrete routes to realize interesting nonequilibrium many-body states in strongly-coupled light-matter systems. A nonequilibrium scheme is proposed to generate the long-sought long-lived multipartite quantum entanglement, by bringing ideas from driven-dissipative systems and from solid-state physics to design the interactions between distant qubits and their direct nonequilibrium photonic environment. The concrete scheme will be geared towards the rapidly maturing cavity quantum electrodynamics architectures in both 1D and 2D.

This objective relies on the parallel development of theoretical and numerical tools much needed to advance the understanding of nonequilibrium states of open quantum interacting systems. We propose to mostly focus on advancing steady-state methods which can bypass the compute-intensive transient dynamics.

## Principal Collaborators



**Manas Shreekanth Kulkarni**  
International Centre for Theoretical Sciences  
(TIFR)  
Bengaluru



**Camille Aron**  
Ecole Normale Supérieure  
(CNRS)  
Paris

## Publications

- No. of publications in SCI journals: 13
- No. of papers presented in conferences: 5

## Mobility Support

- India to France: 2
- France to India: 1

## Pure & Applied Physics

Project No. 6004-1

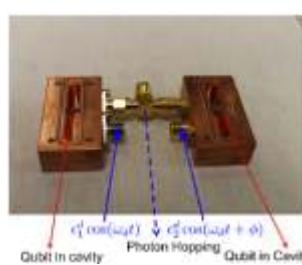
Feb. 2019 to Jan. 2024

## Objectives

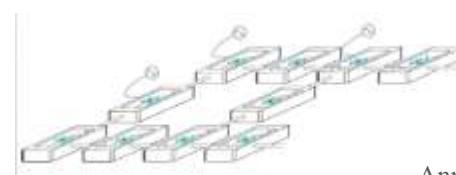
- This objective relies on the parallel development of theoretical and numerical tools much needed to advance the understanding of nonequilibrium states of open quantum interacting systems. PIs propose to mostly focus on advancing steady-state methods which can bypass the compute-intensive transient dynamics

## Knowledge Generated/Products Developed

- Submitted joint paper to Phys. Rev. Res.: Camille Aron and Manas Kulkarni, “NonAnalytic Non-Equilibrium Field Theory: Stochastic Reheating of the Ising Model”, arXiv: 2007.00666 (2020)
- Published/submitted papers in high impact journals directly related to the CEFIPRA project objectives:
  - A. Dey, M. Kulkarni, Phys. Rev. Res. 2, 042004, Rapid Communications (2020), “Emergence of chaos and controlled photon transfer in a cavity-QED network”
  - A. Purkayastha, M. Kulkarni, Y. N. Joglekar, Phys. Rev. Res. 2, 043075 (2020), “Emergent PT symmetry in a double-quantum-dot circuit QED set-up”
  - A. Dey, M. Kulkarni, Phys. Rev. A 101, 043801 (2020), “Engineering indefinitely long-lived localization in cavity-QED arrays”
  - B. K. Agarwalla, M. Kulkarni, D. Segal, Phys. Rev. B 100, 035412 (2019), “Photon statistics of a double quantum dot micromaser: Quantum treatment”
  - J. Lebreuilly, C. Aron, C. Mora, Phys. Rev. Lett. 122, 120402 (2019), “Stabilizing Arrays of Photonic Cat States via Spontaneous Symmetry Breaking”
- In the process of developing close collaboration with theoretical and experimental groups (both in France and India). Some such new collaborations as a result of CEFIPRA visits have already yielded publications in high impact journals
- In the process of successfully developing and adapting theoretical and computational tools as planned to tackle non-equilibrium problems in light-matter systems (Keldysh formalism, Nonequilibrium Dynamical Mean Field Theory solvers, Quantum Master Equation techniques)



3D microwave cavity implementation of the entanglement driven-dissipative scheme that the PIs proposed and realized in the Quantum Nanoelectronics Laboratory at UC Berkeley



Proposed scheme on a Lieb lattice. The qubits are represented by the blue boxes and three external wave drives have been represented

# Enhanced CO<sub>2</sub> adsorption and its photo-electrochemical conversion using semiconductor-metal complex hybrids

Pure & Applied Chemistry

Project No. 6005-1

Apr. 2019 to Mar. 2023

### Objectives

The prime objective of the research proposal is to develop semiconductor-metal complex hybrids particularly, using polyoxometalates (POM), silicon nanowires (SiNW), SiNW/TiO<sub>2</sub>, MoS<sub>2</sub> or SiNW/TiO<sub>2</sub>/MoS<sub>2</sub> composites for enhanced CO<sub>2</sub> adsorption and its simultaneous conversion to high value chemicals such as formic acid, formates, methanol via photochemical or photo-electrochemical conversion route using visible light. CO<sub>2</sub> adsorption is of highest concern during the CO<sub>2</sub> reduction process because CO<sub>2</sub> reduction kinetics is highly correlated to the CO<sub>2</sub> concentration. Thus, it is targeted to design an adsorptive interface by combining inorganic-organic hybrid consisting of mono- or multi-nuclear transition metal complexes/ metallic clusters which can bind CO<sub>2</sub> through CO<sub>2</sub>-M bond and thus enhance the adsorption of CO<sub>2</sub> on its surface.

### Knowledge Generated/Products Developed

- Synthesis of Ni/NiO grafted Co(II) complex at CSIR-IIP
- Synthesis of silicon nanowires SiNW) and MoS<sub>2</sub> supported SiNW at IEMN, France
- Modification of SiNW and MoS<sub>2</sub>/SiNW and PEC evaluation at CSIR-IIP
- Characterization of the materials (CSIR-IIP and IEMN, France)
- Joint publications



CSIR-IIP staff/ students with Prof. Rabah

### Background

The prime objective of the research proposal is to develop semiconductor-metal complex hybrids particularly, using polyoxometalates (POM), silicon nanowires (SiNW), SiNW/TiO<sub>2</sub>, MoS<sub>2</sub> or SiNW/TiO<sub>2</sub>/MoS<sub>2</sub> composites as semiconductors support for grafting of metal complexes for enhanced CO<sub>2</sub> adsorption and its simultaneous conversion to high value chemicals such as formic acid, formates, methanol via photo-electrochemical conversion route using visible light. CO<sub>2</sub> adsorption is of highest concern during the CO<sub>2</sub> reduction process because CO<sub>2</sub> reduction kinetics is highly correlated to the CO<sub>2</sub> concentration. Thus it is targeted to design an adsorptive photo-electrochemical interface by combining inorganic-organic hybrid consisting of mono- or multi-nuclear transition metal complexes/ metallic clusters which can bind CO<sub>2</sub> through CO<sub>2</sub>-M bond and thus can enhance the adsorption of CO<sub>2</sub> on its surface. In this concept, visible light will be harvested by semiconductor and an enzyme mimicking molecular complex mainly of ruthenium as well as low cost metals such as Co, Cu will be immobilized to POM to accelerate and regulate the electron transfer for CO<sub>2</sub> reduction.

### Principal Collaborators



**Suman Lata Jain**  
CSIR-Indian Institute of Petroleum  
Dehradun



**Rabah Boukherroub**  
Institute for Electronics Microelectronics  
and Nanotechnology  
Villeneuve d'Ascq

### Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 1

### Mobility Support

- India to France: Nil
- France to India: Nil

# From molecules to aerosols and dust particles: applications to the physics and chemistry of planetary atmospheres and the interstellar medium

Pure & Applied Chemistry

Project No. 6005-2

Mar. 2019 to Mar. 2023

## Background

The project aims to uncover the detailed nucleation mechanisms and the associated rates through the exploration of elementary reaction steps. The investigation will be carried out with the help of supersonic flow reactors associated with mass and optical spectrometers and with free jets combined to a FTWM spectrometer. The focus will be put on the nucleation enhancement of prototype molecules (e.g. H<sub>2</sub>O) by polar species which play the role of rainmakers. It is proposed to explore the hypothetic link between hydrogenated amorphous carbons and polycyclic aromatic hydrocarbons, the role of olivine grains as catalyst for the generation of singular forms of carbons, and the decomposition products of silicate grains in an effort to identify additional tracers of shock regions. Dust analogs processing will be studied using shock tubes and a variety of ex-situ analytical methods. In a second phase, in-situ real-time optical and mass-spectrometry techniques will be implemented. Complementary, the formation of carbon particles in hypersonic flow from the pyrolysis of light hydrocarbons will be explored in an effort to identify key molecular intermediates.

## Principal Collaborators



**E. Arunan**  
Department of Inorganic and Physical Chemistry  
Indian Institute of Science  
Bengaluru



**Ludovic Biennier**  
Institut de Physique de Rennes (UMR U1-CNRS 6251)  
Université de Rennes 1  
Rennes

## Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 5

## Mobility Support

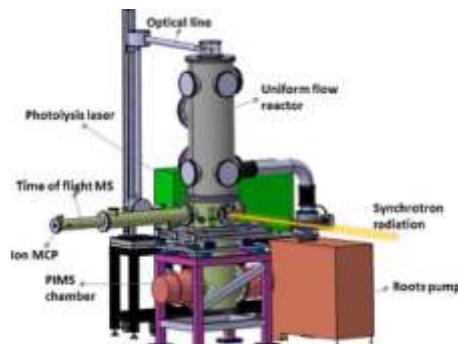
- India to France: 3
- France to India: 3

## Objectives

The main goal of PIs fundamental research proposal is to investigate the first steps of grain/aerosol formation and its evolution through a collaborative effort across the fields of laboratory astrophysics, physical chemistry and molecular physics

## Knowledge Generated/Products Developed

- First absorption NIR spectral signature of solid C60
- Measurement of integrated emission spectrum of shock-induced C60 and SiC
- Measurement of time-resolved emission of shock induced dust analogues
- Microwave observation of propargyl alcoholwater and CH3CN-CO2 complexes
- Computational work on formation pathways for CH3SCH3. Will it be observed in interstellar space?



Outside view of the CRESUSOL instrument installed on the DESIRS beamline of the SOLEIL synchrotron facility

### Petrologic, Os isotopic and platinum-group element (PGE) geochemical studies of the Archean komatiites from the Singhbhum craton (eastern India): implications for chemical differentiation of the Earth and prospects for Ni-Cu-(PGE) sulfide mineralization

Earth & Planetary Sciences

Project No. 6007-1

Feb. 2019 to Jan. 2023

#### Objectives

This project has the broad goal of better understanding the chemical differentiation of the early Earth, and the more specific goal of searching for Ni-Cu-(PGE) sulfide deposits. The objectives are based on the collaborative study of Archean komatiites from the Singhbhum craton, India. The project seeks to determine (1) PGE and Os isotopic characteristics of these rocks and their mantle sources, and the processes creating these characteristics, including the timing of these processes; (2) the implications of the observed PGE and Os isotope signatures for the evolution of the Earth's mantle; and (3) whether these komatiites contain any Ni-Cu-(PGE) sulfide mineralization, and if so, the nature and origin of this mineralization. The collaboration will promote exchange of research scholars and postdoctoral fellows. Prof Sisir Mondal will organize workshops during visits of Dr Laurie Reisberg. This brings together two of the most active research teams on this subject from France and India.

#### Knowledge Generated/Products Developed

- With the research scholar under the CEFIPRA project PIs have completed collecting samples in two field seasons from the entire Gorumahisani belt
- Representative samples were petrologically characterized and in-situ major and trace element data were procured from chromite and Ni-Cu-sulfide minerals. One manuscript has been prepared and another one will be prepared based on these data
- A hitherto unknown section of a Komatiitic suite of rocks has been discovered in the westernmost part of the belt (known as the Chuka Pahar section) and extensively sampled for analytical work under this project
- A postdoc (Xiaoyu Zhou) has joined the CNRS-CRPG team to work on the CEFIPRA project. Originally planned for June 2020, her arrival was postponed until mid-September due to the Covid crisis. She will conduct PGE and Re-Os and Pt-Os isotopic studies of the CEFIPRA samples, and she is currently engaged in implementing an improved PGE analytical protocol based on techniques she developed during her thesis
- Dr Reisberg (France) has already visited Prof Mondal's laboratory and presented 2 talks in the oneday workshop under the CEFIPRA at the Dept. of Geological Sciences (JU), and presented a seminar at Presidency University, Kolkata



Ratul Banerjee (middle), CEFIPRA Research Scholar with Chirasree Bhattacharjee (DST-INSPIRE Research Scholar) and Aranab Dey (UGC-Research Scholar) conducting fieldwork and collecting metavolcanic samples from Tiring area in the last winter under the CEFIPRA 6007-1 project

#### Background

Komatiites are >2.5 billion-year-old high-Mg lavas attributed to plumes from the lower mantle that inform about our planet's earliest history and the chemistry of the deep Earth. Platinum-group elements (PGE) show extreme preference for liquid metal relative to silicate melt (experimental D values >105) and thus should have strongly partitioned into the metallic core, leaving the mantle almost devoid of these elements. However, PGE contents of planetary mantles are much higher than predicted from these partition coefficients. PIs will assess the processes proposed to explain this discrepancy using PGE abundances and Re-Pt-Os isotope systematics of Singhbhum komatiites. Ni-Cu-(PGE) sulfide deposits are rare and economically valuable. Preliminary exploratory work and geology similar to that hosting Ni-Cu-(PGE) sulfide mineralization elsewhere suggest that such deposits, though not yet found, may exist in India. Field geology, petrology, geochemistry, PGE-abundances and Os isotopes will be used to characterize komatiitic rocks from the Archean Gorumahisani-Badampahar greenstone belts of Orissa and Jharkhand and to understand the nature and origin of their mantle source. PIs will also find and study areas with visible Ni-Cu-(PGE) sulfide mineralization, using geochemical data to identify sulfide saturation of the magma.

#### Principal Collaborators



**Sisir Kanti Mondal**  
Department of Geological Studies  
Jadavpur University  
Kolkata



**Laurie Reisberg**  
Centre de Recherches  
Pétrographiques et Géochimiques (CRPG)  
Vandoeuvre-Lès-Nancy

#### Publications

- No. of publications in SCI journals: 3
- No. of papers presented in conferences: 2

#### Mobility Support

- India to France: 1
- France to India: 1

# Nanowire white LEDs based on innovative nano-phosphors

## Background

Flexible light emitting diodes (LEDs) are today a topic of intense research, motivated by their easy integration on a soft surface. The ambition of this project is to demonstrate a high-efficiency and high purity white light flexible LEDs based on the combination of nitride NWs and nanophosphors. To reach this goal, it is proposed to focus on the optimization of flexible NW blue LEDs and on the synthesis of novel nanosized phosphors producing not only yellow but also the red spectral component. C2N-CNRS will develop organized InGaN/GaN NW arrays with high quantum efficiency (QE) in the blue spectral range. Hence, large area (several cm<sup>2</sup>) fully flexible blue LEDs will be optimized. CSIR-NIIST will work on the synthesis of nanophosphors with high QE. Especially, a novel concept for nanophosphor synthesis to achieve high quantum yield, small size (to be integrated in a flexible NW LED) and an appropriate shape producing low light scattering will be developed. These novel nanophosphors will solve the color purity and the efficiency issues faced by standard WLEDs. Based on a scalable technology of nanophosphors/ flexible blue-LEDs integration, the WLED devices will be optimized to deliver a novel and improved WLED for a variety of lighting applications requiring mechanical flexibility.

## Principal Collaborators



**Subrata Das**  
CSIR-NIIST -  
National Institute for Interdisciplinary  
Science and Technology  
Thiruvananthapuram



**Maria Tchernycheva**  
Center for Nanosciences and  
Nanotechnologies  
Orsay

## Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 2

## Mobility Support

- India to France: Nil
- France to India: Nil

## Material Sciences

Project No. 6008-1

Apr. 2019 to Mar. 2023

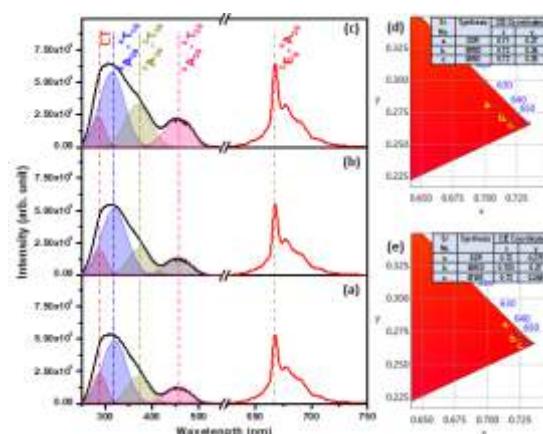
## Objectives

To demonstrate a high-efficiency flexible WLEDs based on nitride NWs and nanophosphors producing a high purity white light. The point-by-point objectives of the project are:

- Synthesis of novel nanophosphors with high quantum efficiency using a new fast elaboration approach
- Demonstration of a flexible NW LEDs using organized NW arrays with a wire diameter below 100 nm to achieve a homogeneous light generation with high quantum efficacy
- Integration of the nanophosphors into a NW LED to demonstrate a flexible white light source with an EQE above 40% and high color purity

## Knowledge Generated/Products Developed

- Color optimization of phosphor-converted flexible nanowire white light-emitting-diodes
- Heat dissipation in flexible nitride nanowire light-emitting diodes
- Synthesis of organized nitride nanowire arrays by Molecular Beam Epitaxy
- Elevated colour rendering of white light emitting diode by microwave synthesized red-emitting Li<sub>3</sub>RbGe<sub>8</sub>O<sub>18</sub>:Mn<sup>4+</sup>, Mg<sup>2+</sup> nanophosphors
- Synthesis of YAG: Ce<sup>3+</sup> nanoparticles with enhanced red color component
- Optimized synthesis process for synthesizing nanosized germanite phosphors



Comparative plots for the deconvoluted PLE and PL spectra for the sample prepared through (a) SSR, (b) MWD and (c) MWS under the UV excitation of 300 nm. The CIE color diagram and the corresponding coordinates of the sample prepared via three different methods recorded under the excitation wavelengths at (d) 300 nm and (e) 455 nm

# Maximal abelian subalgebras in operator algebras

Pure & Applied Mathematics

Project No. 6101-1

Jun 2019 to May 2023

## Objectives

- Global and generic properties of MASAs in von Neumann algebras
- Analysis of MASAs in quantum group von Neumann algebras

## Knowledge Generated/Products Developed

- The French team developed new genericity methods to study actions of groups. This is a first towards the study of MASAs in crossed products von Neumann
- The French and Indian teams are making progress on the notion of mildly mixing MASAs related to crossed products
- The Indian team establishes that a generator subalgebra in a q-Araki-Woods factor is quasi-split, hence not a MASA
- The French team obtained new results on the Gromov boundary of free quantum groups. PIs are currently working on applications to MASAs
- The French team obtained new inequalities for free random variables based on an algebraic approach

## Background

The project aims to make a systematic study of maximal abelian subalgebras (MASAs) of operator algebras, from both local and global perspectives.

The proposal can be broken up into three interconnected modules. They are 1- Properties of MASAs in specific von-Neumann algebras, 2- A study of MASAs from a global perspective and 3- A systematic study of singular MASAs in von-Neumann algebras.

A study of MASAs in von-Neumann algebras from a global perspective will be carried out, which will involve study of subspaces of MASAs in spaces of von-Neumann algebras given specific topologies like Effros-Marechal topology and Christensen topology. The aim here is in particular to show that singular MASAs are in fact the generic MASAs and hence, are the natural object of study. This study will be carried out first individually, and will leverage a preliminary investigation carried out on this topic. Finally, this will lead to a comprehensive study of singular MASAs in von-Neumann algebras, where the collaborators aim to obtain a satisfactory structure theory of the same. Since this is envisioned to be the hardest part of the program, this will involve close collaboration of all participants, and will be the most intense part of the program. This study will lead to unprecedented insights not just into MASAs in von-Neumann algebras, but into the theory of von-Neumann algebras as a whole.

## Principal Collaborators



**Kunal Krishna Mukherjee**  
Indian Institute of Technology- Madras  
Chennai



**Eric Ricard**  
Université de Caen Normandie  
Basse-Normandie  
Caen

## Publications

- No. of publications in SCI journals: 5
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: Nil
- France to India: Nil

# Integrating machine learning with feature selection to build interpretable models for precision oncology

## Background

There is a growing realisation that single-gene markers are generally too simple to be able to predict tumour response for most drugs. This has opened the door to the use of machine learning algorithms to build models combining instead multiple gene alterations. The project is timely owing to the recent availability of more suitable training data in terms of size and relevance to patients.

Two challenges posed by this emerging approach will be addressed in this project. First, tumours are characterised by high-dimensional multi-omics data sets. Optimal combinations of machine learning and feature selection techniques to reduce overfitting in modelling these data sets will be investigated. Second, these models will identify concise lists of genes predictive of tumour response to the treatment. Using these gene lists and associated multi-omics data sets, it is proposed leverage of current knowledge of cancer pathways to help understanding the molecular basis of tumour sensitivity or resistance to the treatment.

The codes of the developed methods will be made freely available too in order to facilitate their use by the relevant communities as well as reproducibility.

## Computational Sciences

Project No. 6102-1

Aug. 2019 to Mar. 2023

## Objectives

The primary objective of the project is to predict drug response for a particular cancer type, when data is scarce. This could be achieved by developing a machine learning (ML) model using data from all the other cancer types. Such pan-cancer models have been shown to be very predictive when trained with *in vitro* pharmacogenomics data. Utilizing advanced preclinical data: *in vivo* mouse models known as Patient-Derived Xenografts (PDX), PIs hypothesize that ML models can also learn and predict the drug response across pancancer PDXs. In particular, this study will:

- Discover the subset of gene alterations that results in the best ML predictor for each drug
- Compare the performance of the most predictive gene alterations between the cancer-specific and pancancer setting for each drug
- Investigate the predictive accuracy of pancancer ML models where there is not sufficient PDXs to train cancerspecific models

## Knowledge Generated/Products Developed

- PIs have identified an optimal combination of random forest model with hierarchical clustering as feature selection algorithm
- This algorithm with performance comparable to the recent study (1) is now being expanded to pan-cancer analysis
- The feature selection resulted in reduced set of gene modifications, that can further be analysed to deduce a gene lists to gain a multi-omics understanding of tumour sensitivity and resistance to these treatments

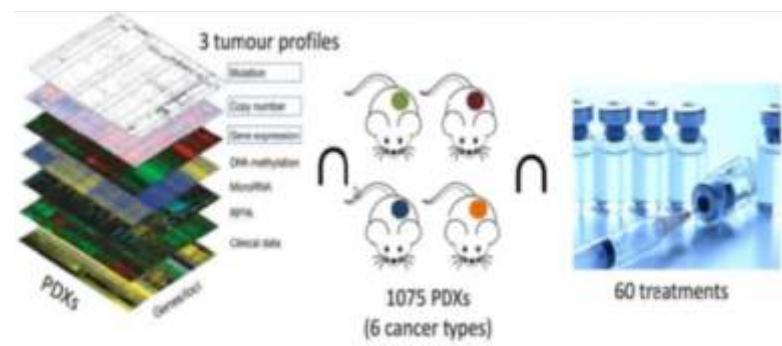
## Principal Collaborators



**Shandar Ahmad**  
Jawaharlal Nehru University  
New Delhi



**Pedro Ballester**  
Cancer Research Centre of Marseille,  
INSERM U1068  
Marseille



## Publications

- No. of publications in SCI journals: 1
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: Nil
- France to India: Nil

# How mechanical conflicts contribute to organ shape reproducibility in plants

Life &amp; Health Science

Project No. 6103-1

May 2019 to Apr. 2023

## Objectives

PIs address a key question in developmental biology: how do organisms reach final size and shape, in the face of stochastic variation at the cellular level? PIs propose that cell-cell communication mechanisms coordinate cell stochastic variability so as to yield consistent organs. Since growth remains locally heterogeneous, these mechanisms may, counter-intuitively, maintain or even enhance local heterogeneity. PIs will test this hypothesis in *Arabidopsis thaliana*, as it produces numerous, almost identical floral organs and early leaves with stereotyped shape and size. PIs choose to work on sepals, cotyledons and first leaf, since they are of varied ontogenetic origin and are easily accessible for live imaging and mechanical measurements. PIs will use genetic manipulations to generate mosaic tissues with heterogeneous mechanical properties and investigate how adjacent cells behave. PIs will investigate whether organs use growth heterogeneity to sense their global shape and/or whether organs filter growth heterogeneity to generate reproducible organ shapes.

## Knowledge Generated/Products Developed

- Cre-Lox plants expressing wall modifiers have been generated
- Patterns of growth and mechanical properties have been quantified in the *vip3* mutant, which exhibits increased transcriptional noise
- A pPDF1::mTCP4:GR;jaw-D transgenic line has been generated wherein a dominant and chemically inducible form TCP4 protein is expressed only in the epidermis in the CIN-TCP loss-of-function backgrounds
- A pPDF1::TCP4:VP16 transgenic line has also been generated wherein a hyperactivated form of TCP4 protein is expressed only in the epidermis
- Initial phenotypic characterization of these transgenic lines has been carried out. Preliminary results indicate that activation of TCP4 triggers cell expansion and the expression of cell wall-modifying genes
- Sets of transcriptomes have just been generated that respond to various durations of TCP3/4 activation. This data has been shared between the two labs and being analysed for the cell wall-specific genes downstream to TCP proteins

## Background

How does an organism reach its final size and shape, in the face of stochastic variation at the cellular level? In this project, it is proposed that cell-cell communication mechanisms coordinate cell stochastic variability so as to yield consistent organs. Since growth remains locally heterogeneous, these mechanisms may, counter-intuitively, maintain or even enhance local heterogeneity. It is proposed to test this hypothesis in *Arabidopsis thaliana*, as it produces a large number of almost identical floral organs and early leaves with stereotyped shape and size. The PIs will choose to work on sepals, cotyledons and first leaf pair, since they are of varied ontogenetic origin and are easily accessible for live imaging and mechanical measurements. It is proposed to use genetic manipulations to generate mosaic tissues with heterogeneous mechanical properties and investigate how adjacent cells behave. In other words, it is proposed to investigate whether organs use growth heterogeneity to sense their global shape and/or whether organs filter growth heterogeneity to generate reproducible organ shapes.

## Principal Collaborators



**Utpal Nath**  
Indian Institute of Science  
Bangalore



**Olivier Hamant**  
INRA Plant Biology and Breeding  
Lyon

## Publications

- No. of publications in SCI journals: 1
- No. of papers presented in conferences: 5

## Mobility Support

- India to France: Nil
- France to India: Nil

# The genomic and evolutionary landscape of azole resistance in budding yeast

## Background

It is proposed in the project proposal to test species-wide variation in azole drug resistance and pathogenic related traits in a large cohort of 1011 clinical, domesticated and wild sequenced *S.cerevisiae* strains. Genome-wide association studies on these traits will identify drug resistance natural genetic variants. By generating recombinant combinations from specific founders, genetic networks regulating drug-resistance and the impact of rare variants will be identified. To study the mechanisms of acquired drug resistance in clinical environments, experimental evolution of isogenic lines from multiple backgrounds will be performed to identify pre-existing and de-novo mutations. Finally, genetic analysis of evolved strains will identify how genetic networks vary in response to the drug, giving a comprehensive framework for drug resistance.

## Principal Collaborators



**Himanshu Sinha**  
Indian Institute of Technology-Madras  
Chennai



**Gianni Liti**  
Institute for Research on Cancer and Ageing of Nice  
(IRCAN), Nice

## Publications

- No. of publications in SCI journals: 1
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: Nil
- France to India: Nil

## Life and Health Sciences

Project No. 6103-2

Dec. 2019 to Nov. 2022

## Objectives

- Species-wide variation in azole drug resistance and pathogenic related traits
  - a) High-resolution phenotypic screening of sequenced collection that include large cohorts of clinical, domesticated & wild *S.cerevisiae*, and *S.paradoxus* strains
  - b) Genome-wide association study for azole resistance and pathogenic related traits
- Generation of recombinant populations from selected founders
  - a) Multiple linkage analysis approaches
- Experimental evolution of drug resistance and combined stresses
  - a) Evolution of isogenic lines from multiple genetic backgrounds
  - b) Evolution of heterogeneous populations to identify pre-existing and de novo mutations
- 4. An integrated view of drug resistance by experimental validation and multi-omics approach
  - a) A deep catalogue of pathogenic variants
  - b) The phenotypic landscape of pathogenic variants

## Knowledge Generated/Products Developed

- Defined a set of antifungal drugs and respective concentrations
- PIs started the phenotypic screening of the 1011 sequenced isolates
- Optimised the GWAS pipeline
- PIs discovered that natural variation in YRR1 confer resistance to the antifungal drug cycloheximide
- PIs are exploring the application of the pangenome graph for providing fatty acids for energy purposes during extracellular life stages of Toxoplasma under low host nutritional environment. TgACS3 allows the generation of activated fatty acids for phospholipid synthesis and thus membrane biogenesis during intracellular development. (French side). PIs are now having the Indian side generating the recombinant proteins for activity assays and drug development. (French side)

# Turbulent flows in equilibrium

## Pure & Applied Physics

Project No. 6104-1

Jun. 2019 to Dec. 2023

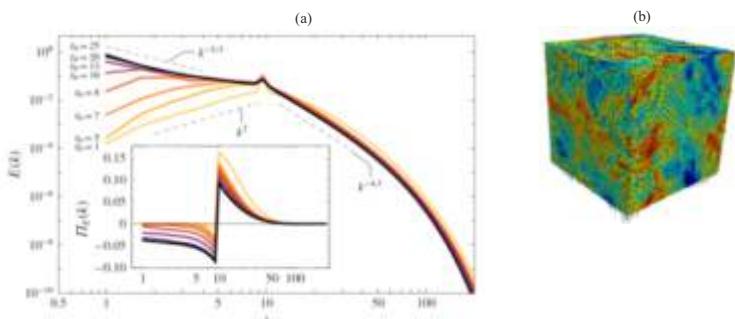
### Objectives

Experimental, numerical, and analytical studies of helical turbulent flows with forcing at small scales both in hydrodynamics and in magneto-hydrodynamics

- Analyse the kinetic energy spectrum and flux of such flows.
- Analyse scale-by-scale energy transfers at large scales of the flow
- Test whether the modes in above flow are in equilibrium, for example, do they satisfy principle of detailed balance?
- Compare the experimental, numerical, and analytical results
- From the above results deduce the conditions for efficient dynamos generated by turbulent flows

### Knowledge Generated/Products Developed

- PIs observed an inverse cascade of kinetic energy (towards the large scales) in numerical simulations of helical turbulence with multiscaling forcing
- PIs derived a four-mode model for the Kolmogorov flow using Galerkin truncation and Craya-Herring basis. This model captures the essential features of bifurcation including the critical Reynolds number
- PIs employed random initial condition as in white noise in Euler and Burgers turbulence, and observed equilibrium-like behaviour (on-going work)
- PIs measured the temperature fluctuations that result from viscous dissipation in turbulent flows and characterized their statistical properties
- PIs studied the coherence of velocity fluctuations in turbulent flows and show that it decays exponentially both versus the distance between the two measurement points and versus the frequency



(a) Kinetic energy spectra and fluxes (inset). The energy injection is applied at wavenumber  $k=10$ . The helicity injection is applied at all wave numbers. The level of helicity injection is given by the parameter  $e_h$ . An inverse cascade of energy is obtained provided the level of helicity injection is sufficiently high. (b) Snapshot of the velocity field on the three faces of the cubic resolution domain for  $e_h=25$ , showing that the turbulent flow is three-dimensional

### Background

In this project it is proposed to investigate latter kinds of flows using experimental, numerical, and analytical tools.

The first objective of the project is to understand the dynamical and statistical properties of turbulent flows at scales larger than that of forcing, which are beyond the range of the Kolmogorov cascade. The fundamental questions in this field are as follows: What is the energy spectrum? Is there an equipartition of energy among large-scale modes as is typically assumed? What is the nature of nonlinear energy transfers? For example, does the mean energy flux at the scales larger than the forcing scale vanish? Do fluctuation-dissipation theorem or detailed balance apply to such systems? How to quantify the fluctuations in the energy flux and the velocity correlations? How do we model the large scales flow patterns in such flows?

The second objective of the project is to study similar mechanism in dynamo (magnetic field generation). The magnetic field growth rate is enhanced when the flow is mirror-asymmetric, and when it is forced at scales smaller than the system size. It is proposed to study the dynamo mechanism for such turbulent flows; the insights gained will be useful for designing efficient dynamo experiments.

### Principal Collaborators



**Mahendra Kumar Verma**  
Indian Institute of Technology-Kanpur  
Kanpur



**Stéphan Fauve**  
Ecole Normale Supérieure  
LPS  
Paris

### Publications

- No. of publications in SCI journals: 10
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: Nil
- France to India: Nil

# Optoelectronics in van der Waals heterostructures: from fundamentals to quantum device engineering

Pure &amp; Applied Physics

Project No. 6104-2

Apr. 2019 to Oct. 2023

## Background

The project aims at demonstrating novel optoelectronic phenomena, including in the single photon regime by profiting from the aforementioned assets of 2DM. Meeting these technologically relevant challenges requires addressing the following fundamental questions:

Q1 Are conventional descriptions of interlayer charge and energy transfer (IET, ICT) between 2DM still valid in the case of sub-nanometer thick van der Waals gaps between interacting 2DM? How to tailor the dissociation of tightly bound excitons at a 2D heterointerface? Can one selectively probe and engineer the efficiencies of ICT and IET in charge tunable vdWH?

Q2 How does substrate-induced doping, scattering and screening affect the electronic transport and optical properties of 2DM? How to engineer the substrate to tune the (opto-) electronic properties of 2DM? Can PIs detect strain and doping-induced phase transitions electronically?

Q3 Single photon emitters embedded in 2DM can be formed by strain engineering. How can PIs harness this unique possibility to demonstrate quantum optoelectronic systems and devices?

## Principal Collaborators



**Atikur Rahman**  
Indian Institute Science Education and Research  
Pune



**Stephane Berciaud**  
Université de Strasbourg  
Strasbourg

## Publications

- No. of publications in SCI journals: 1
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: Nil
- France to India: Nil

## Objectives

There are at present no significant deviations from the original objectives. PIs have however, refined some original objectives and we also plan to exploit the mechanical degrees of freedom of 2D materials in order to control optoelectronic phenomena within “atomicallythin opto-electro-mechanical systems (ATOEMS)” made from suspended 2D materials. Another emerging topic concerns “twistronics”, that is the exploitation of the rotational degree of freedom in van der Waals heterostructures for novel electronic and optoelectronic functionalities. PIs have identified several cases where fine tuning the rotational mismatch would be highly beneficial for the tasks listed in the project and would allow to bring some expected outcomes to a higher level

## Knowledge Generated/Products Developed

- Growth and comprehensive characterization of large area, high quality TMD monolayers using chemical vapour deposition
- Nanotexturing various types (including flexible) of substrates and Growth of various kinds of TMD monolayers on textured substrates
- Fabrication of high quality, charge tunable van der Waals heterostructures
- Evidence for a novel filtering effect of graphene coupled to TMD monolayers
- Demonstration of electromechanical resonators based on 2D materials and evidence for dynamically enhanced strain



Photoluminescence image of monolayer Ws<sub>2</sub>

# ROYCE (diVeRsity Oriented sYnthesis of Complex hEterocycles)

Pure & Applied Chemistry

Project No. 6105-1

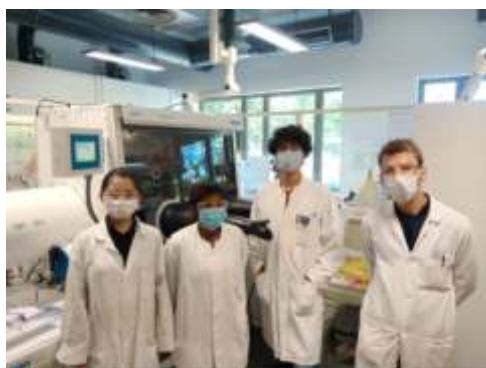
Aug. 2019 to Jul. 2024

## Objectives

ROYCE is a research project in synthetic chemistry. It aims at preparing complex heterocycles by a combination of pericyclic reactions and metallo-catalyzed transformations, starting from commodity chemicals such as N-heterocycles. The originality of this joint investigation is to find simple and efficient triggers to activate intrinsically unreactive chemicals. The final products of these transformative sequences are heterocycles relevant for pharmaceutical and/or agrochemical industries which are always looking for new scaffolds that populate uncharted regions of the chemical space.

## Knowledge Generated/Products Developed

- Investigation of the scope and limitations of the intramolecular ied-DA between 1,2-diazines and alkynes for the synthesis of indazoles. Starting point of an extended collaboration between Mumbai and the University of Giessen in Germany
- Investigation of the scope and limitations of the intramolecular ied-DA between pyridines and alkynes for the synthesis of indazoles. Starting point of an extended collaboration between Mumbai, the University of California in Los Angeles (UCLA, USA) and the pharmaceutical company Novartis in Switzerland.
- Initial investigation of copper catalyzed domino C-N bond coupling reaction, especially with aliphatic amine as one of the components has been successfully done in Mumbai, India
- In the lockdown period, literature collection pertaining to this project is being done and bibliographical work for 2 book chapters due in 2021 was performed (radical chemistry of ynamides; oxetanes and oxetenes for the “Comprehensive Heterocyclic Chemistry 4th Edition” encyclopedia (Ed. Elsevier)
- Many attempts have been made to carry out this domino reaction with meta-amino substituted pyridines but without



Ms. Diksha Singh in the French Laboratory with her labmates.  
Pictures taken on September 8<sup>th</sup>, 2020

## Background

The ROYCE project aims at capitalizing on the complementary expertise developed by the French and the Indian PIs to expand significantly the Chemical Space of pyridines and benzimidazoquinazolinones by preparing the promising class of N-pyridinyl benzimidazoquinazolinones. A general synthetic strategy that relies on two key steps: a pericyclic cascade (Objective 1) followed by a copper-catalyzed cascade amination (Objective 2) are proposed in this project. It is proposed to investigate reaction mechanisms at the DFT level (Objective 3) to shed light on the intimate details of the transformation, with the goal to improve the synthetic sequence.

## Principal Collaborators



**Krishna Pillai Kaliappan**  
*Indian Institute of Technology-Bombay  
Mumbai*



**Nicolas Yves Blanchard**  
*CNRS/UHA/UNISTRA, Laboratoire  
Moléculaire Applications (Lima)  
Mulhouse*

## Publications

- No. of publications in SCI journals: 4
- No. of papers presented in conferences: 15

## Mobility Support

- India to France: Nil
- France to India: Nil

# Plasmonic hot electron pockets as exciton luminescence promoters and regioselective chemical triggers

## Background

This collaboration aims at exploiting the spatial and spectral addressability of SP modes borne by ultrathin 2D metallic crystals to locally trigger (1) nonlinear luminescence of excitons in monolayer transition metal dichalcogenides (TMD) and (2) chemical reactions by thermal activation or hot electron transfer. Beyond the fundamental understanding of light matter interactions in these hybrid plasmonic structures, the proposed work will contribute to engineering advances in sensing and optoelectronic nanodevices and on-surface catalytic chemistry.

## Material Sciences

Project No. 6108-1

Apr. 2019 to Apr. 2022

## Objectives

- To design more efficient excitonplasmon coupled systems that influences the nanooptical response from 2D-TMD plasmonic hybrids
- To investigate chemical anisotropy mediated by hot spots enabling design of chemical or biomedical sensors with better selectivity. Revised objectives, if any None. However, progress of the project has been affected due to the Covid19 pandemic. In view of this, PIs may have to shorten the project by omitting fabrication of chemical or biomedical sensors

## Knowledge Generated/Products Developed

- Successfully developed synthesis protocol for 2D structures like Au nanoplates and MoS<sub>2</sub>
- Fabricated MoS<sub>2</sub>@Au hybrid nanostructures
- Non-linear optical studies (nonlinear luminescence and life-time measurement on hot electron generation) have been successfully carried out on Au nanoplates
- Completion of preliminary optical studies (photoluminescence and Raman) on hybrid nanostructures

## Principal Collaborators



**Jadab Sharma**  
Panjab University  
Chandigarh



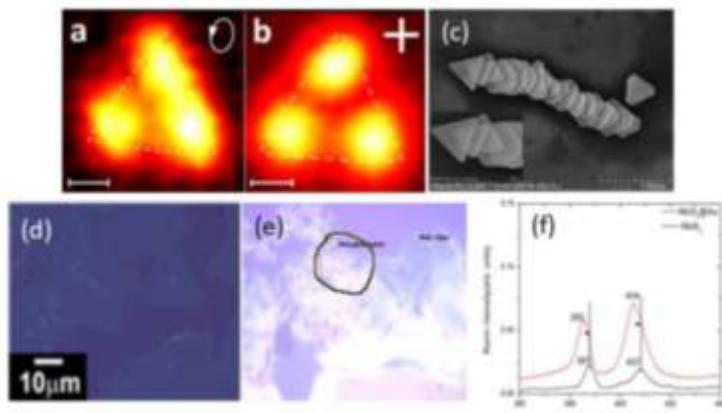
**Erik Dujardin**  
Centre D'Élaboration de Matériaux et  
D'Études Structurales  
(CEMES), UPR8011  
Toulouse

## Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: Nil
- France to India: Nil



Two photon luminescence (TPL) signals and plasmonic density of states. (a) Experimental map of an Au nanoprism excited with quasi-circularly polarized light. (b) Symmetrical TPL map of another nanoprism obtained by summing the images obtained for two orthogonal linearly polarized excitations. (c) SEM images of Au nanoprisms. (d) Optical image of MoS<sub>2</sub> grown on SiO<sub>2</sub>/Si substrate. (e) Optical image of Hybrid nanostructures: MoS<sub>2</sub>@Au on SiO<sub>2</sub>/Si substrate. (f) Raman spectra of MoS<sub>2</sub>@Au hybrid nanostructures

# Chromium isotopes as tracers of environmental contamination and remediation

Environmental Sciences

Project No. 6109-1

May 2019 to Apr. 2022

## Objectives

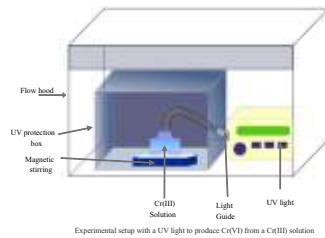
PIs have decided to modify one of the objectives of this project in light of the results we obtained during the first part of this project. Initially PIs had planned to work on Cr isotope as an environmental tracer using both mass dependent fractionation (MDF) and mass independent fractionation (MIF). The first tracer is classic and rather widely used, while the second one is entirely novel. There was a potential high risk/high gain in the project if the MIF tracer did not work at all. However, our experimental work has demonstrated that the MIF signal exists and since this is new and exciting, PIs decided to focus on this rather than investing time in developing a different analytical technique that exists elsewhere for the measurements of MDF signatures. The discovery that mass independent fractionation of chromium can take place with UV light was not really predictable, which explains why we had taken the precaution of having a fall-back plan.

## Knowledge Generated/Products Developed

A new method for sample preparation, chemical separation and mass spectrometry analysis of Cr mass independent fractionation has been developed

- Samples were collected from the leather factories that use Cr additives (various samples from the industrial chain) Thereafter, a large number of soil and water samples were collected from known polluted areas (Figure 1) as well as from wells, near the towns of Rania and Akbarpur, located in the south of Kanpur
- The samples were analysed in our laboratory for major elements, cations, anions, and TOC, and common contaminants such as Cr, As, and Pb by ICPMS. Also, samples were analyzed for Cr(VI) and Cr(III) concentrations using an IC-ICPMS. Additionally, the weathered COPR and soils collected from waste sites were characterized for solid phase TOC and X-ray diffraction analyses. This represents an important sample collection that will be used for the rest of the project. A large part of these samples, after preliminary analysis in India, were brought back to France for isotope analysis. The Cr isotope analyses of these samples is underway and the results are still being collected
- PIs have managed to set up a new experimental device (Figure 4) where a high power UV light could produce carcinogenic Cr(VI) from a Cr(III) solution. The experiments produced measurable Cr(VI)

A new chemical procedure was set up to separate Cr(VI) from the remaining Cr(III). The next step was to analyse some of the separated Cr(III) and Cr(VI) solutions for their isotopic signatures. The first set of results indicate that there is indeed mass independent Cr isotope fractionation, which is being observed for the first time for a photochemical process. This new type of isotope signature could therefore be a unique signature of photo-oxidation in natural systems



## Background

This project will focus on the application of Cr isotopes to understand and control the fate of chromium in the environment (soils, waters, aquifers) with a combination of laboratory experiments and a field study located near Kanpur, Uttar Pradesh, where numerous tanneries have released Cr in the environment as chromite ore processing residues that are dumped illegally. Cr-rich waters are also released from effluent treatment plants. First, the collaborators may characterize the isotope signature of chromium released from Cr rich solid wastes sampled in the field. This will enable us to identify the main sources and processes that release Cr (VI) to the environment. The ores, Cr-rich wastes, and soils will also be characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy and electron microscopy to understand the parameters controlling its Cr release. Second, through lab experiments, it is proposed to determine the variations in Cr isotope compositions, the rates of oxidation of Cr and with MnO<sub>2</sub> or during photooxidation and Cr (VI) remediation with chemically or electrochemically dosed ferrous iron. An important novelty is that both mass dependent and mass independent Cr isotope fractionation will be investigated. Third, it is proposed to sample waters from local wells, and determine their Cr concentrations and speciation, and analyze them for Cr isotopes, as well as trace and major elements.

## Principal Collaborators



**Abhas Singh**  
Indian Institute of Technology- Kanpur  
Kanpur



**Bernard Bourdon**  
ENS de Lyon  
Lyon

## Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: 1

## Mobility Support

- India to France: Nil
- France to India: Nil

## Macrophage lipid mobilization in tuberculosis infection

### Background

Tuberculosis is characterized by the presence of lipid rich foamy macrophages where the causative pathogen, *Mycobacterium tuberculosis*, finds a safe haven despite an active host immune response. This proposal aims to understand how manipulation of host lipid droplets by live *M. tuberculosis* regulates lipid trafficking to the bacilli. Stemming from our lipid droplet proteomics studies from Mtb infected macrophages, it is proposed to hypothesize that vesicular trafficking proteins may be key to lipid trafficking to intracellular bacilli. How do these proteins alter lipid homeostasis in the infected cell, and what would be the consequence of inhibiting these processes for lipid transfer to the bacilli?

Answers to these questions require the amalgamation of experimental approaches of biophysics, cell biology, and mycobacterial infection biology, with expertise in lipid droplet biology. The team comprising of mycobacteriologist and biophysicist has a common interest of understanding lipid droplet homeostasis in health and disease. The Indian investigators lab will lead experiments on genetic manipulation of macrophages and bacilli, performing experiments to understand changes in lipid droplet abundance, localization, and lipid transfer to bacilli. The French investigators lab will lead experiments on evaluating lipid droplet-protein interaction and structural alterations to lipid droplets upon binding of the candidate protein.

### Principal Collaborators



**Sheetal Gandotra**  
Institute of Genomics and Integrative Biology  
New Delhi



**Abdou Rachid Thiam**  
Ecole Normale Supérieure  
Paris

### Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: Nil
- France to India: Nil

### Host-Microbe-Interactions in Health & Agriculture

Project No. 62T4-1

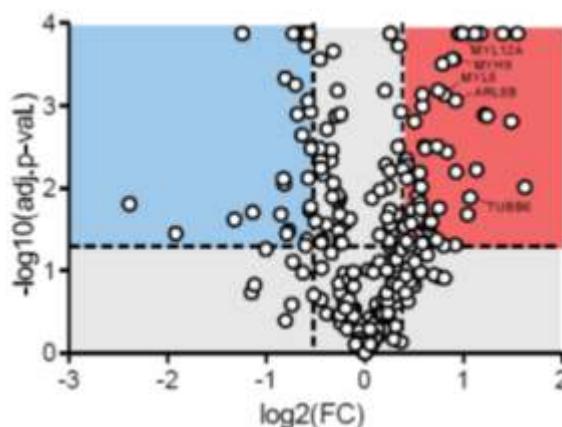
Feb. 2020 to Jan. 2023

### Objectives

While the project's main goal was to understand the role of ARL8B in infection, PIs studies demonstrated a key role of ARL8B in not only infection but also basal homeostasis of triglyceride/LD turnover in human macrophages. A deeper understanding of the latter has emerged as a necessary first step in completing the objectives of the project and therefore efforts are focussed currently on defining the role of ARL8B in macrophage lipid mobilization and this knowledge will be extended to the in vitro infection model

### Knowledge Generated/Products Developed

- Established role of ARL8B in bacterial control
- Established mechanism of ARL8B recruitment to LDs via its N-terminal amphipathic helix and GDP-binding
- Established a role for ARL8B in lysosomal lipase
- mediated turnover of lipid droplets
- Established that the GDP-locked mutant of ARL8B offers a dominant negative phenotype for LD turnover
- Established new collaborations via the primary collaboration in Paris



Volcano plot representing significantly differentially abundant (FDR adjusted p-value<0.05) proteins, pink region reflects proteins increased by a ratio of >1.3 while blue region reflects protein decreased by a ratio<0.7 in the LD proteome of macrophages infected with live Mtb to that of heat killed Mtb

# Understanding mechanobiological basis of the evolutionary diversity in spindles dynamics of nematodes

Biological Questions Using or Developing Mathematical, Computational or Physical Approaches

Project No. 62T5-1

Feb. 2020 to Jan. 2023

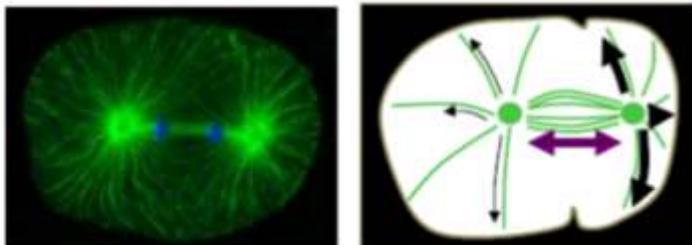
## Objectives

To understand to what extent biophysical parameters of the cell evolve during asymmetric embryonic cell division in diverse nematode species by

- Estimating the variability in forces acting on the spindle in 10 selected species;
  - i) Exploring evolutionary changes in spindle dynamics using in silico simulations
  - ii) Experimentally perturbing the mechano-chemical components of the spindle/model testing

## Knowledge Generated/Products Developed

- Establishing a microscopy (France) and image-analysis (India) pipeline to study the dynamics of nematode cytoplasm
- Open source programme in MATLAB for intracellular viscosity measurement from DIC images (India)
- Experimental dynamics of spindles on laser ablation from 6 species (France)
- Combining the viscosity and elasticity measurements to develop a model of the mechanobiology governing spindle dynamics in 1-celled embryos of related nematodes
- PIs have developed a software and deposited in the OpenSource community for single-particle tracking and analysis of viscosity from differential interference contrast (DIC) microscopy (India). This will allow us to non-invasively study the intracellular fluid mechanical properties of other cells. <https://github.com/CyCelsLab/DICOT>
- The experimental team has developed protocols for spindle cutting and microscopy from nematode strains that had not been examined before (France). 3. The experimental team has overcome an important technical obstacle by improving a protocol to generate CRISPR-Cas9 based transgenics in nonmodel species (manuscript in preparation). We are now in a situation to generate transgenic lines in several species in order to follow cytoskeleton dynamics with GFP reporters



One-cell embryo of *C.elegans* (Mts in green and Dna in blue). Below schematic representation of the spindle (green) and the asymmetric pulling forces (black). Posterior side of the cell is to the right

## Background

Evolutionary theory and practice has for long remained distinct from cell biology. The remarkable conservation in basic cell functions across organisms however raises a vital question: to what extent do cellular mechanisms evolve without disrupting the basic function that they sustain?

French PIs team pioneered the study of the first asymmetric embryonic cell division of nematodes as a model to address this longstanding problem. In parallel, the lab of Indian PIs has been simulating the transport and positioning of microtubule (MT) asters during spindle assembly by molecular motors. By reconciling computer simulations to experiments, they have identified some principles of aster positioning based on motor-MT mechanics.

The project will focus on i) measure key biophysical parameters in 10 species displaying the most divergent phenotypes when compared to *C. elegans*, ii) extend pre-existing mechanical models of the spindles and phenocopy the different species by changing parameters and iii) test the model by experimentally perturbing the cytoskeleton and its associated proteins in embryos. The results are expected to reveal novel cross-disciplinary insights in the study of asymmetric cell division and the evolution of cellular systems.

## Principal Collaborators



**Chaitanya Anil Athale**  
Indian Institute Science Education and Research  
Pune



**Marie Delattre**  
Laboratoire de Biologie et Modélisation de La Cellule (LBMC)  
Lyon

## Publications

- No. of publications in SCI journals: 2
- No. of papers presented in conferences: 1

## Mobility Support

- India to France: Nil
- France to India: Nil

## New electron sources based on nonmetallic nanoneedles for ultrafast electron bunches

### Background

Project aims to develop new ultrafast electron sources due to One-dimensional (1D) heterostructures illuminated by femtosecond (fs) laser pulses. The field electronemitters (cold cathodes) owing to their unique features such as monoenergetic, low power consumption, high brightness, miniature size, etc., are superior to the thermionic emitters and thus, being used in electron microscopes, X-ray sources, and Electric Propulsion Thrusters for space applications. In addition, thermal-field and photo enhanced field emitters have been developed to relax the stringent operating conditions imposed by pure field emitters. In the context of photo-field emitters, various semiconducting nanostructures (CdS, TiO<sub>2</sub>, SnS<sub>2</sub>, Bi<sub>2</sub>Se<sub>3</sub>, etc.), along with CVD diamond been investigated subjected to light illumination using lamps (polychromatic and noncoherent sources). Project proposes to develop new ultrafast electron sources due to novel 1D heterostructure emitters illuminated by femtosecond laser pulses, which has been unexplored at international level. Proposed hetero structure emitters be comprised of rare earth hexaborides (LaB<sub>6</sub> and GdB<sub>6</sub>), wide band gap semiconductor (HfO<sub>2</sub>) coated Si nano needles, and CVD diamond mico-nanocrystalline (un-doped and N-doped) thin films grown on Si substrates. Furthermore, attempts will be made to reveal the underlying physics and understand the mechanisms of electron emission from these hetero structure emitters under ultra-short laser (fs) illumination.

### Principal Collaborators



**MA More**  
Savitribai Phule Pune University  
Pune



**Angela Vella**  
Groupe de Physique des Matériaux – CNRS  
UMR6634, University of Rouen  
Rouvray

### Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: Nil
- France to India: Nil

### Multifunctional Materials and The Underlying Science

Project No. 62T8-1

Feb. 2020 to Sept. 2023

### Objectives

- To develop and optimize novel field emitters due to Si nano needles coated with ultra-thin layer of rare earth hexaborides (LaB<sub>6</sub> and GdB<sub>6</sub>), and wide band gap semiconductor (HfO<sub>2</sub>). Optimization of process variables followed by physico-chemical characterization
- To characterize these new electron sources by the combination of various techniques including high resolution TEM, Atom probe tomography and ultraviolet Photoelectrons spectroscopy (UPS)
- To characterize the field emission properties of these new electron sources with and without femtosecond laser illumination. Optimization of the illumination conditions to enhance the specific features of these sources such as the electron energy dispersion and the current density
- To reveal the underlying physics and provide better understanding of the laser-matter interaction under high electric field, at the origin of the laser assisted field emission process

### Knowledge Generated/Products Developed

- Synthesis of Si nanowires on silicon substrate HFCVD and nano-lithography
- Coating of LaB<sub>6</sub> and GdB<sub>6</sub> thin films on Si nanowires
- Physico-chemical characterization of assynthesized samples using XRD, Raman, SEM, TEM, and XPS. 4. Field emission studies of pristine and coated samples
- Field emission study of single Si nanowire. 6. Field emission study of single crystal LaB<sub>6</sub> nanotips with and without laser illumination

# Q-Walker: programmable quantum dynamics simulator

## Exotic States of Materials and Quantum Criticality

Project No. 62T9-1

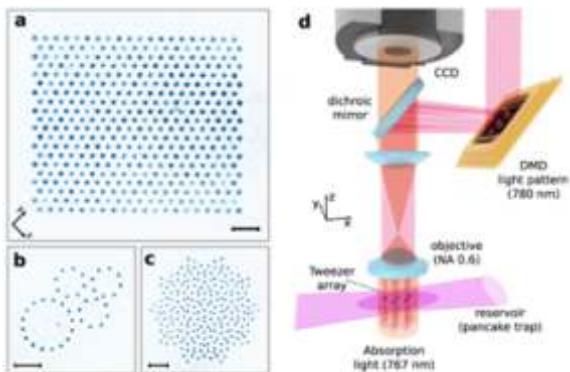
Mar. 2020 to Aug. 2022

### Objectives

- Realisation of the Q-Walker programmable quantum dynamics simulator
- Quantum transport enabled network tomography

### Knowledge Generated/Products Developed

- Realization of a novel approach to preparing large arrays of atomic ensembles in programmable spatial geometries using a digital micromirror device
- Fast control of the excitation lasers to prepare small numbers of Rydberg excitations each atomic ensemble and to observe their subsequent dynamics
- Implementing field-ionization detection to allow for single atom sensitive detection of Rydberg excitations
- Demonstrated how measurement induced decoherence can lead to binding and trapping



Quantum simulations of 2D spectroscopy (a) Two-dimensional spectrum of Rydberg dimer, (b) comparison between simulation and analytical calculation. (c) The 2D spectrum is obtained by interrogating Rydberg dimers in an ultra cold gas through microwave pulses

### Background

The transport of energy, charge and information is of fundamental importance in nature and technology as it plays key roles in diverse settings ranging from chemical reactions to the operation of nano-electronic devices and future quantum information networks. Q-Walker: the programmable quantum dynamics simulator will leverage strong and long range dipolar state-changing interactions between Rydberg dressed ultracold atoms to improve understanding of quantum transport, but under very controllable conditions concerning the spatial and temporal scales and coherence properties. By preparing the atoms in programmable arrays of optical micro-traps, it is proposed to study how a quantum of excitation migrates through non-trivial networks with different system-bath interactions and find general laws linking key transport quantities with the underlying network topologies. This can ultimately lead to novel exotic light harvesting materials, exploiting room temperature quantum coherence. A crucial ingredient of this project is the intensive interaction between theory and experiment, which will be needed to bring Rydberg-atom quantum simulation to full maturity where it can compete with and exceed state-of-the-art classical quantum dynamics simulations.

### Principal Collaborators



**Sebastian Wüster**  
IISER Bhopal  
Bhopal



**Shannon Whitlock**  
Université de Strasbourg  
Strasbourg

### Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: Nil
- France to India: Nil

# Fluorescent-amyloid-beta peptides to study interaction with copper, aggregation and reactive oxygen species

## Background

There is a large body of evidence that a dyshomeostasis of Abeta, Zn and Cu ions occurs in Alzheimers disease (AD). Approaches to restore the homeostasis of Abeta and metal ions have shown a limited success so far. The current compounds used to intervene in metal homeostasis with a therapeutic aim were rather unspecific metal ion binders. Targeting specifically Cu instead of Zn seems to be of interest as Cu, but not Zn, is able to catalyze the production of reactive oxygen species and hence to induce oxidative stress, a key feature commonly observed in AD.

The project aims at developing luminescence tools to monitor several critical events linked to the etiology of AD at physiologically relevant concentrations in the test tubes and in cell cultures. The targeted events are: i) the binding of Cu ions to Abeta and their release, ii) the production of reactive oxygen species by the Cu-Abeta complex. These new tools will then be combined with established and commercial available tools to study the oligomerization of the Abeta peptide. Then, these tools will be used to follow Cu events, iii) at physiological relevant concentrations (nM to low  $\mu$ M) in the test tube and in more biological relevant environment like cell medium or cell culture.

## Principal Collaborators



**Govindaraju Thimmaiah**  
Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR)  
Bangalore



**Peter Faller**  
Université de Strasbourg  
Strasbourg

## Publications

- No. of publications in SCI journals: Nil
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: Nil
- France to India: Nil

## Biological Chemistry

Project No. 62T10-3

Mar. 2020 to Feb. 2023

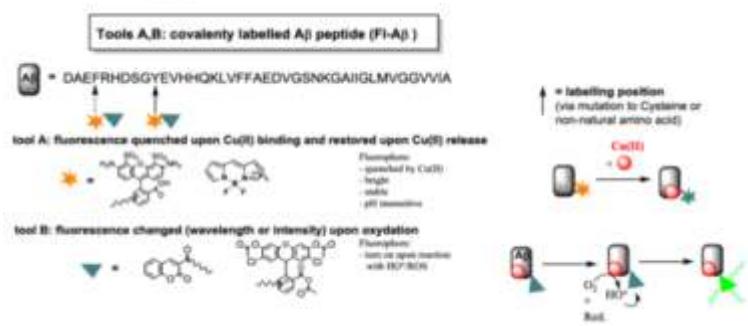
## Objectives

Synthesis and validation of different fluorescence labelled amyloid-beta peptides (Abeta) enabling to:

- measure Cu(II)-binding and release of Abeta
- monitor aggregation of Abeta - measure reactive oxygen species production by Cu-Abeta all at low concentration and in a biological relevant medium

## Knowledge Generated/Products Developed

- Synthesis and production of 6 fluorescent tagged peptides, two for therapeutic approach in Alzheimer's, two as tools
- evaluation of their Cu-binding properties
- evaluation of their redox activity
- evaluation for the therapeutic peptides for their ability to abstract Cu from amyloid-beta
- three out of four therapeutic peptides show positive results



# Development and Biophysical Investigations of Small Antimicrobial Peptide Mimetics

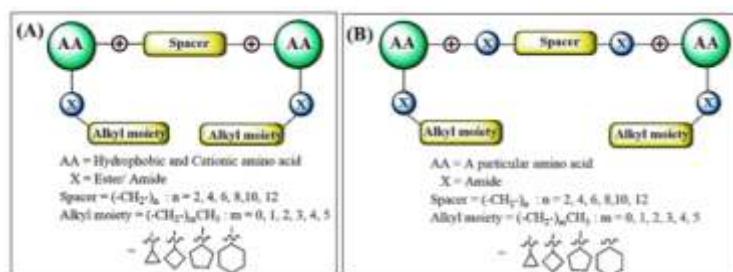
## Biological Chemistry

Project No. 62T10-1

Nov. 2020 to Oct. 2023

### Background

Based on preliminary data it is proposed to overcome the limitations of natural antimicrobial peptides (AMPs) by incorporating subtle but necessary structural parameters in small molecules. Utilizing natural amino acids and lipophilic moieties, it is proposed to design small molecular AMP mimics that will maintain the advantages of AMP, i.e. broad-spectrum activity and evasion of bacterial resistance, and at the same time act against biofilm related infections. The project aims to create a library of compounds and through structure activity studies to obtain lead compounds which will have the clinical potential. In contrast to the peptide templates these compounds should not easily be degraded by proteases, can be administered orally, act at lower doses and are easier and more economical to prepare in large amounts. The understanding of the membrane active mechanism of action as well as interactions with biofilm related bio macromolecules, will benefit to optimize the design of the lead compounds. Antibacterial and anti-biofilm assays will be complemented by a wide variety of biophysical techniques. By incorporating isotope labeled amino acid ( $^{2\text{H}}$ ,  $^{13\text{C}}$  and/or  $^{15\text{N}}$ ) in the design, will investigate the structure, topology and lipid interactions through state-of-the art solidstate NMR spectroscopy at high-resolution and this understanding will then feedback to develop potent antibacterial and anti-biofilm agents driven by rational design.



Schematic of proposed molecular design

### Principal Collaborators



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Bangalore*



**Burkhard Bechinger**  
*UMR CNRS 7177  
Institut de Chimie de Strasbourg  
Strasbourg*

### Objectives

The goal of this study is to fine-tune the structural properties of small compounds that mimic the physio-chemical and thus biological properties of antimicrobial and anti-biofilm peptides by rational design, thereby creating a library of superior antibacterial agents with clinical potential. This will be achieved by four specific aims: 1. To develop amino acid based cationic small molecular AMP mimetics and test their in-vitro antibacterial activity and toxicity 2. To study the anti-biofilm activity of the optimized compound and to evaluate the ability of this class of molecules to tackle bacterial resistance propensity 3. To synthesize isotope labeled lead compounds and study their detailed membrane active and anti-biofilm mechanism of action through solid-state NMR 4. To study the detailed membrane active and antibiofilm mechanism of action through spectroscopic, light scattering and microscopic techniques

# In cellulo and in vivo imaging of gut and tumour-associated receptor guanylyl cyclase C: chemically synthesized novel fluorescent peptides as tools

## Principal Collaborators



**Sandhya S Visweswariah**  
Indian Institute of Science  
Bangalore



**Laurence A Mulard**  
Institut Pasteur  
Paris

## Objectives

- Establish procedures to synthesize ST, guanylin and uroguanylin peptides and test their efficacy in receptor binding analysis and cellular assays
- Optimize procedures and synthesize uroguanylin, guanylin and ST peptides equipped with the best fluorescent/spacer combination. Assess probe potency by testing their affinity to GC-C in biochemical assays
- Localize GC-C in colon cancer cell lines by using these peptides and monitoring fluorescence by confocal and super resolutions microscopy
- Utilize fluorescently labelled peptides for in vivo monitoring of GC-C in murine models. Orally gavaged peptides will provide information on intestinal localization and distribution of GC-C along the gut.
- Generate organoids from the gut and utilize fluorescently labelled peptides to localize GC-C expression in different cell types.
- Administer fluorescently labelled peptides to novel transgenic mice to identify GC-C expression levels in mice harbouring disease-associated mutations in GC-C

## Biological Chemistry

Project No. 62T10-2

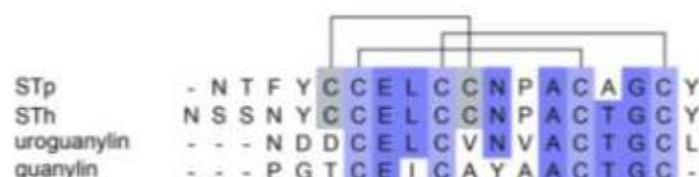
Jul. 2020 to Jun. 2023

## Background

The intestine is the primary site of nutrient and water absorption and plays host to a variety of microorganisms which make up the gut flora. The numbers of both commensal and pathogenic microorganisms are kept in check by the guts immune system, and the high turnover of the epithelial cell lining of the intestine is carefully regulated. In this proposal, it is proposed to synthesis peptides (ST analogs or analogs of the endogenous ligands of GC-C, namely guanylin and uroguanylin), fluorescently labelled, to detect expression of GC-C in cellulo and in vivo. These peptides will be used to localize sites of GC-C expression in different cell types and importantly to image GC-C in live animals by in vivo imaging approaches. PIs will also monitor GC-C expression in murine colonic tumours in vivo and intestinal organoid cultures prepared from transgenic mice harbouring mutations analogous to those seen in patients. Administration of these peptides intravenously would allow them to localize to extra intestinal tissues, such as the brain. The Indo-French team hopes that the use of these novel detection tools will provide greater insight into the complexities of GC-C signaling. Importantly, findings using these peptides could result in therapeutic approaches for the treatment of ST-mediated diarrhoea and congenital secretory diarrhoea.

	Guanylin									
Rat/Mouse	P	N	T	C	E	I	C	A	Y	A
Human	P	G	T	C	E	I	C	A	Y	A
Uroguanylin										G
Rat/Mouse	T	D	E	C	E	L	C	I	N	V
Human	N	D	D	C	E	L	C	I	N	V
STh										G
Linaclotide	N	S	S	N	Y	C	C	E	L	C
Plecanatide										Y

A



B

Cited peptides: (A) sequences and conserved residues among families (blue & yellow) and (B) disulfide bridges.

# Exploring the role of DNase1L3 in obesity-associated metaflammation and type 2 diabetes

Life and Health Sciences

Project No. 6203-1

Mar. 2021 to Feb. 2024

## Background

Obesity and associated type 2 diabetes are major global health problems. The present project aims to bring together the complementary expertise of Indian and French Labs to explore role of DNase1L3 in regulating extracellular abundance of interferogenic self-DNA in VAT, and whether any role in VAT inflammation deregulation of DNase1L3 play in obesity. Indian lab, with expertise in human immunology, will collect VAT from obese individuals undergoing bariatric surgery and perform gene expression and functional studies on VATresident macrophages to explore role of DNase1L3. DNase1L3 function in the regulation of extracellular abundance of the TLR9 ligands (self-DNA), activation of human pDCs and induction of type I IFNs in VAT will also be addressed. Mechanistic and phenomenological association of DNase1L3 function with the clinical outcomes will also be investigated. French experts on in vivo immunology of the DNase1L3-deficient mice will evaluate impact of DNase1L3 deficiency in a preclinical model of diet-induced obesity and metabolic syndrome. Role of macrophage-intrinsic and pDC-intrinsic DNase1L3 will be analyzed using the same preclinical model. Identification of deregulation of this enzyme in obesity associated metaflammation and associated metabolic disorders will establish DNase1L3 as a novel therapeutic target in this clinical context.

## Principal Collaborators



**Dipyaman Ganguly**  
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Kolkata*



**Patrick Olivier Blanco**  
*Bordeaux University  
CNRS UMR 5164  
Bordeaux*

## Objectives

- Study DNase1L3 function in visceral adipose tissue inflammation and metabolic disorders in obese individuals
- Study the impact of DNase1L3 genetic deficiency in a preclinical murine model of obesity-associated metabolic syndrome

# On the cohomology and deformations of leavitt path algebras and applications

## Principal Collaborators



**Anita Naolekar**  
*Indian Statistical Institute  
 Bangalore*



**Abdenacer Makhlof**  
*Université de Haute-Alsace  
 Mulhouse*

## Objectives

- Study the structure and the variety of Leavitt path algebras, and Compute derivations
- State a specific cohomology theory and provide properties of the complexes
- State a Deformation theory and cohomological characterizations
- Applications and Computations
- Twisted and Dual Leavitt path algebras

## Pure and Applied Mathematics

Project No. 6301-1

Nov. 2020 to Nov. 2022

## Background

During the last decade, the algebraic structures known as Leavitt path algebras have attracted significant interest and attention, because of their importance role in ring theory and Number theory, but also for new applications in  $C^*$ -algebras, group theory, and symbolic dynamics. The ultimate goal of the project is to develop a cohomology theory for Leavitt path algebras, and explore whether the cohomology has an underlying G-algebra structure. It is proposed to define the cohomology theory in a way so that it turns out to be the deformation cohomology for such kind of algebras. Moreover, it is planned to study dual version of Leavitt path algebras and to use the skills of the project's members in homological algebra and Deformation theory to create a network dealing with these topics in the case of Leavitt path algebras.

# All-optical probing of caveolae-mediated local membrane tension regulation in 2D and 3D-like microenvironment

Life and Health Sciences

Project No. 6303-1

Aug. 2021 to Jul. 2023

## Background

The aim of this proposal is to dissect the role of caveolae in sculpting the spatial profile of membrane tension in cells stably inhabiting different mechanical microenvironments. Caveolae are relatively stable invaginations that have been shown to flatten upon mechanical stress (stretching or swelling) and participate to membrane tension homeostasis. In parallel, new features of membrane tensions involving static tension distribution and slow flow have been recently proposed to be relevant in living cells, which opens up new fundamental questions in the field. Caveola integrity is cholesterol dependent, and remarkably, recent studies show that cholesterol displays two kinds of lateral mobility in the plasma membrane, while Project Investigators show that cholesterol depletion enhances intracellular heterogeneity in mechanical membrane tension rendering cells prone to rupture. Interestingly, while erythrocytes (lacking caveolae) become very prone to rupturing on cholesterol depletion, cholesterol compromised nucleated cells (having caveolae) have a much higher tolerance. These observations and other (like non-uniform intracellular caveolae distribution in motile cells) lead us to hypothesize that caveolae might safeguard cells against large intracellular local tension variations through structural changes.

## Principal Collaborators



**Bidisha Sinha**  
*Indian Institute of Science Education and Research Kolkata*



**Christophe J Lamaze**  
*Institut Curie Paris*

## Objectives

- To decipher how caveolae may set the local as well as the global cell membrane tension in cells
- To design non-uniform mechanical environments as well as highly confined environments to understand how the presence of caveolae affects local/spatial regulation

## Understanding the mechanism of crack-entry adapted root nodule symbiosis

### Principal Collaborators



**Maitrayee Dasgupta**  
Calcutta University  
Kolkata



**Fabienne Cartieaux**  
Institut de Recherche  
Pour le Développement  
Montpellier

### Objectives

- To understand the significance of high expression of genes encoding subtilase during intercellular invasion through cracks
- 2. To investigate the role of Asp proteases expressed during crack-entry symbiosis in *Arachis hypogaea* and *Aeschynomene evenia*

### Life and Health Sciences

Project No. 6303-2

Oct. 2020 to Sep. 2023

### Background

Biological nitrogen fixation performed by Legumes in symbiosis with rhizobia is crucial to maximize food production while minimizing negative effects on the environment. During Root Nodule Symbiosis (RNS), rhizobial invasion and nodule organogenesis are host controlled processes where, in most legumes, rhizobia enter through infection threads and the nodule primordium is induced in root cortex from a distance. The main molecular actors that control intracellular symbiotic infection are well described today (Oldroyd, 2013). But in Dalbergieae like *Arachis hypogaea* and *Aeschynomene evenia*, rhizobia directly invade cortical cells through epidermal cracks to generate the nodule primordia. Much less information is available for this so-called intercellular pathway characterized by the absence of infection threads inception (Ibáñez et al., 2017). In earlier project of CEFIPRA (CEFIPRA 5103-4), Project Investigators (PIs) developed the transcriptome during the progress of symbiosis in both *Arachis hypogaea* and *Aeschynomene evenia*, and compared it with the symbiotic transcriptome of infection thread (IT) legumes. Several Dalbergieae specific signatures (e.g. delay in PUB1 and NIN induction, absence of RPG) were highlighted in this effort justifying the contrasting invasion and developmental processes in these legumes (Gully et al., 2018; Karmakar et al., 2019). Interestingly, transcriptome analysis indicated protease genes belonging to subtilase and aspartic proteases to be overexpressed during symbiosis in *Arachis hypogaea* and *Aeschynomene evenia*. Proteases belonging to these two families are involved in plant developmental processes and also in beneficial and pathogenic plant-microbe interactions (Gao et al., 2017; Taylor and Qiu, 2017; Xia et al., 2004), but there is no information of their role regarding the infection mode. In this project it is intend to investigate the signature involving protease functions and protease-regulated signaling processes. PIs primary target would be subtilases, the serine proteases of the subtilisin family and the secondary target would be Asp proteases. The objective of the present project is to understand the role of these proteases in the symbiotic interaction of *Arachis* and *Aeschynomene* with rhizobia.

# Profiling of gut microbiota and its metabolites during endocrine-disrupting chemical induced-glucose dyshomeostasis: Implications on host glucose metabolism

Life and Health Sciences

Project No. 6303-3

Sep. 2020 to Aug. 2023

## Background

Diabetes, a disorder characterized by chronic hyperglycemia has emerged as a global epidemic disease. The Indo-French study from rural India revealed the association of organophosphate (OP) insecticides with diabetes prevalence mediated by gut microbial metabolism of the endocrine-disrupting chemicals (EDCs). Recent studies explored the indispensable role of gut microbiota on host glucose metabolism via gut-brain axis signalling. But the changes in gut microbiota and its impact on host metabolism during EDC-induced diabetes is largely unexplored. In this study, two different diabetes mice models will be established by treatment with high-fat diet or chlorpyrifos (an OP as a prototype for EDC). Development of diabetes will be confirmed by periodical monitoring of fasting blood glucose, oral glucose tolerance test and other assays. Variation in gut microbial diversity and its metabolites will be explored by metagenomics and mass spectrometry studies respectively. Subsequently, the changes in the host glucose metabolic pathways including gluconeogenesis in liver, intestine and kidney will be studied using gene knock-out mice models. The key bacterial species or metabolites identified as the differential factor between the two models will be validated in human diabetes subjects. In overall, this study will provide a new understanding on pathophysiology of EDC induced glucose dysregulation, which will have profound implications on diagnosis, control and therapy of diabetes.

## Principal Collaborators



**Velmurugan Ganesan**  
KMCH Research Foundation  
Kovai Medical Center & Hospital  
Coimbatore



**Gilles Mithieux**  
University Claude Bernard Lyon1  
Lyon

## Objectives

- Profiling of gut microbial diversity and its metabolites during endocrine-disrupting chemical (EDC) - induced diabetes
- Understanding of the changes in the microbiota-derived gut-brain signalling on host glucose metabolism during EDC induced diabetes.
- Validation of outcomes from animal experiments in human diabetes samples and establishment of biomarkers for diagnosis and targets for treatment

## Human Guided Impedance Control of Cobotic Arm

### Principal Collaborators



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Research Institute  
Durgapur



**Ganesh Gowrishankar**  
Laboratoire d'Informatique,  
de Robotique et de Microélectronique  
de Montpellier (LIRMM)  
Montpellier

### Objectives

To develop a novel controller to enable impedance regulation by collaborative robots (cobots), in order for them to be used in tasks requiring physical interaction with the environment (for example: industrial tooling, that will be demonstrated in the project) and humans. The detailed set of objectives required for achieving this goal are explained in the main proposal

### Computer Science

Project No. 6304-1

Mar. 2021 to Mar. 2024

### Background

Present day robots still suffers from inadequacies in their perceptive and cognitive abilities. This project proposes to develop a human guided impedance controller for cobots. The project will (1) estimate the impedance changes in a human cobot operator by utilizing electromyography (EMG), along with hand force and accelerometers, (2) develop a relevant impedance controller for a cobotic (a) active controlled manipulator, and (b) a manipulator driven by variable impedance actuators, and (3) develop the test bed and experimentally evaluate our controller on an industrial jig saw cutting and hammering task. The new controller will greatly expand the applications for cobots, enabling them work in tasks requiring physical interaction, such as contact tooling, and physical assistance of humans.

# Beyond Standard Model Physics with Neutrino and Dark Matter at Energy, Intensity and Cosmic Frontiers

Pure and Applied Physics

Project No. 6304-2

Dec. 2020 to Nov. 2023

## Background

The project aims to address two fundamental questions in nature - the origin of the neutrino masses and the nature of dark matter. This research proposal proposes to set up a bridge between these two apparently different sectors, by focusing on those models that provide answers and a fundamental understanding to both the questions. The prime objective is to analyse the discovery prospects of viable extensions of the SM that describe neutrino mass generation as well as dark matter at energy, intensity and cosmic frontiers. In particular, it is proposed to focus on seesaw models, radiative models of neutrino mass generation, as well as supersymmetric models. Additionally, it is proposed to aim new theoretical frameworks, including Effective Field Theory, that address both the questions and that have yet to be explored. It is proposed to analyse the detection prospects of these extensions of the SM at high-energy colliders, low energy and precision experiments, fixed-target experiments, and dark matter direct and indirect detection experiments. In order to achieve this goal, , it is proposed to develop and improve the numerical tools and techniques that facilitate the interpretation of collider results as well as provide reliable predictions of dark matter observables.

## Principal Collaborators



**Manimala Mitra**  
Institute of Physics  
Bhubaneswar



**Genevieve Belanger**  
CNRS -Lapth  
Grenoble

## Objectives

- To analyse the testability of well-motivated Beyond Standard Model Theories of neutrino mass and dark matter at energy, intensity and cosmic frontiers
- To propose new theoretical frameworks including effective field theory based frameworks that can explain Standard Model neutrino masses and mixings as well as dark matter, and analyse their testability at different experiments
- To develop and improve numerical tools and techniques for collider and dark matter simulation

# Novel Non-Perturbative Approaches to Strongly Coupled QCD Matter

## Principal Collaborators



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Chennai



**Giuseppe Policastro**  
Laboratoire de Physique  
Theorique de l'Ecole Normale Supérieure  
Paris

## Objectives

- Study of the QCD phase diagram combining non-perturbative approach and comparing with lattice
- Study of the collective flow of the Quark-Gluon-Plasma and effects of fluctuations of initial conditions via non perturbative approach and relate to phenomenological observables
- Study of the physics of jets in Quark-Gluon Plasma and understanding of what can infer about the degrees of freedom of the system using non-perturbative approach

## Pure and Applied Physics

Project No. 6304-3

Oct. 2020 to Sept. 2023

## Background

The project proposes to bring together different approaches - perturbative QCD, Holographic duality and Monte-Carlo simulations that have so far remained largely separated, to the study of strongly interacting phases of QCD matter. The main motivation comes from trying to understand the complex dynamics of the quark-gluon plasma (QGP), a state of matter that exists at very high temperature (3 trillion Kelvin); it should have been a component of the early universe microseconds after the Big Bang and has been recreated in heavy ion collision experiments at RHIC (Brookhaven) and LHC (CERN). Future experiments planned eg. FAIR (Darmstadt), NICA (Dubna) and EIC (Brookhaven) will further explore extreme QCD matter in different temperature-density regimes. Despite large amount of theoretical work, with many partial successes in the last years, the real-time dynamics of the QGP is still far from being understood. The proposal takes the challenge of combining diverse approaches consistently in order to form a comprehensive nonperturbative formalism that is able to describe the physics at the different scales involved, continuing along the lines already taken by the PIs and other participants in the project for the construction of semiholographic models. Focus will be laid on phenomenology of collective flow and jets in the QGP.

# Pairing in neutron-star matter with renormalization-group based low-momentum interactions

Pure and Applied Physics

Project No. 6304-4

Oct. 2020 to Mar. 2025

## Background

Neutron stars provide a unique laboratory with an interplay of a wide range of phenomena. In this proposal, Project Investigators (PIs) focus on neutron matter and in particular its superfluid properties, which are crucial for the understanding of astrophysical observables such as pulsar glitches or neutron-star cooling. The aim of the proposal is to study superfluid neutron matter with these new techniques. As a preliminary step, it is proposed to first consider a toy model that describes the physics of ultracold atomic Fermi gases. So far, the power of the RG approach has practically not been exploited in the theoretical description of these systems, which are experimentally very well studied. This preliminary study will allow to quantitatively benchmarking the method, before it is applied to neutron matter. It is proposed to study singlet pairing in dilute neutron matter, which is from a theoretical perspective quite similar to the ultracold atoms case, and finally address pairing in the triplet channel which becomes dominant at densities corresponding to the neutron-star core.

## Principal Collaborators



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Chennai*



**Michael Urban**

*Institut de Physique Nucléaire (IPN)  
Orsay*

## Objectives

- Reliable prediction of pairing gap and superfluid critical temperature in neutron matter and neutron-rich nuclear matter at densities relevant for the neutron-star inner crust and outer core
- Set up in-medium renormalization group (IMSRG) method for uniform matter
- Application of the IMSRG method to ultracold atomic Fermi gases

## Discovery and understanding of new glycosylation methods

### Principal Collaborators



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*Indian Institute of Science Education and Research Pune  
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**Florian Jaroschik**  
*Institut Charles Gerhardt Montpellier  
Ecole Nationale Supérieure de  
Chimie de Montpellier  
Montpellier*

### Objectives

- Understanding the reaction mechanism of glycosylation with alkynyl carbonate glycosyl donors via an in-depths mechanistic study using a combined experimental and theoretical approach involving organometallic chemistry, FTICR mass spectrometry and DFT calculations
- Based on mechanistic study find more efficient reaction conditions, such as the use of non-toxic, cheap and abundant metals, lower catalyst loading, higher regio and Stereo selectivity, to make this procedure even further attractive for future applications in oligo or polysaccharide synthesis with medicinal purposes.
- The exploration of conceptually new glycosyl donors, such as the synthesis of glycosyls with appendages containing CF<sub>3</sub> or =CF<sub>2</sub> groups and their use via C-F activation processes to provide new entries for selective and efficient glycosylation reactions

### Pure and Applied Chemistry

Project No. 6305-1

Aug. 2020 to Aug. 2023

### Background

Glycosylation, the enzymatic transfer of a carbohydrate moiety onto another organic (macro) molecule, plays a pivotal role in biological processes. Chemical glycosylation is still a challenging task even though Emil Fischer synthesized the very first glycoside some 120 years ago. The main aims of this project are (i) An in-depth study of the mechanism of alkynyl carbonate glycosyl donors, developed in the Indian group over the last five years. This should provide insights for the development of new chemistry for activation of appendages at the anomeric position so that they can become more potent glycosyl donors. (ii) The discovery of novel leaving groups that will be much more facile for glycosylation of all sugars, with a special focus on carbon-fluorine bond activation, a field currently developed by the French group. (iii) The evaluation of the various glycosylation methodologies of this project in continuous flow processes towards increasing efficiency and scale-up. Overall, the proposed research will deepen the understanding of chemical glycosylation and open up new synthetic pathways towards complex polysaccharides via more efficient, selective and sustainable reaction processes.

# DINDE - Dinitrogen Fixation in the Indian Ocean: an interbasin and seasonal comparison

Earth and Planetary Sciences

Project No. 6307-1

Nov. 2020 to Oct. 2023

## Background

The goal of DINDE (Dinitrogen Fixation in the Indian Ocean: an inter basin and seasonal comparison) is to decipher the role of N<sub>2</sub> fixation in the two sub-basins of the Indian Ocean, focusing on the two most unknown seasons: winter monsoon and inter monsoon. DINDE will examine the magnitude of N2 fixation rates according to environmental variability, untangling the diversity of local diazotroph assemblages and their metabolic controls. Moreover, DINDE will isolate strains with the aim of discovering diazotroph species unique to the Indian Ocean. DINDE will integrate the second International Indian Ocean Expedition (IIOE-2), a novel international effort to study the oceanography of the Indian Ocean. The in situ work will be performed during four oceanographic cruises (two per basin in each target season, two in German vessels and two in Indian vessels). As the Indian Ocean is warming faster than any other basin in the world's oceans, quantifying its N2 fixation capacity and understanding its biogeochemical dynamics emerges as a priority in current oceanographic research. DINDE lays the ground for a new collaboration between India and France, opening new research avenues in the most unknown oceanic basic.

## Principal Collaborators



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**Mar Benavides**

*French National Research Institute for  
Sustainable Development (IRD)  
Mediterranean Institute of  
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Marseille*

## Objectives

- Inter-seasonal and inter-basin comparison
  - a) Environmental settings and core parameters
  - b) Cyanobacterial vs. non-cyanobacterial N2 fixation rates
  - d) Diazotroph quantification
- Metabolic controls
  - a) Inorganic nutrient limitation
  - b) Potential for mixotrophy in cyanobacterial diazotrophs
  - c) Identification of non-cyanobacterial organic matter users
- Strain isolation

# Effect of dislocation-interface interactions on deformation behaviour: coupling discrete dislocation dynamics with Fast Fourier Transform based elasticity module and the validation of the coupled mode

## Principal Collaborators



**Prita Pant**  
Indian Institute of Technology Bombay  
Mumbai



**Prof. Marc C Fivel**  
SIMaP-GPM2/Univ. of Grenoble Alpes  
Grenoble

## Objectives

Goal of the proposal is to study the effect of dislocation interface interactions on deformation behaviour using optimized discrete dislocation dynamics simulations. The proposal is divided into the following objectives:

- Coupling the French Discrete Dislocation Dynamics (DDD) code NUMODIS with Fast Fourier Transform (FFT) method for elasticity calculation
- Validation of the DDD-FFT combined model using experimental results and MD simulations
- Using this coupled model to study the effect of specific interfaces by considering the density of dislocations near the interfaces

Material Sciences

Project No. 6308-1

Oct. 2020 to Sep. 2023

## Background

The interaction of dislocations with boundaries plays a vital role in the deformation behaviour of any crystalline material. In this project, it is proposed to develop an Fast Fourier Transforms (FFT) based elasticity module in the French discrete dislocation dynamics (DDD) code NUMODIS to compute the elastic interaction of dislocations. Project Investigators (PIs) believe that this module will considerably speed up the stress calculations as compared to the box method used currently in NUMODIS. Moreover, using this method, the stress state at the interfaces can be accurately captured. It is also possible to efficiently parallelise the FFT module with relatively few efforts using the Graphics Processing Units (GPUs). By this approach, PIs are interested in making contact with experiments as well as atomistic simulations. The Indian side has been working on Cu-rich Cu-Al alloys using deformation experiments and atomistic simulations. Expertise in these areas will help us benchmark our Fast Fourier Transforms (FFT) module. PIs also want to study the spreading of the dislocation densities in vicinity of specific boundaries (annealed twin boundary and high angle grain boundary) during deformation and also compare the FFT based DDD simulations with atomistic simulations performed at IITB.

# Correlated Quantum Materials: exploring spin transport properties in non-stoichiometric Iridium oxide thin films and single crystals

Material Sciences

Project No. 6308-2

Oct. 2020 to Sep. 2023

## Background

Recently spin-Hall Magnetoresistance (SMR) technique has been proved as a tool to probe the interfacial magnetic ground state in Metal/Magnetic Insulator (MI) heterostructures. The proposal propose a systematic study to probe correlation of oxygen non-stoichiometry and strain effects in Pyrochlore iridate single crystals and thin films to construct a detailed magnetic phase diagram. Project Investigators (PIs) propose a detailed study on spin ordering in single crystals by tuning the oxygen stoichiometry which in turn can tune the Irvalence state that can significantly influence the Ir-O-Ir bond angle bringing about variations in the whole structural and electronic band structure which in turn affects the spin Hall conductivity. Recent studies have revealed that the oxygen doping level can drive the system to novel ground states as  $\text{Ir}^{5+}$  has an intrinsic magnetic order. Spin transport measurements will be carried out to probe the magnetic phases as a function of oxygen content in  $\text{PIO}$  and  $\text{SIO}$  thin films which will be further elucidated through synchrotron like XMCD and XMLD. A comprehensive understanding of these oxide systems in terms of spin conversion efficiency and its complete phase diagram while varying the oxygen content will be achieved through this project. The project aims to explore spin transport properties in epitaxial thin films (PLD@IITM) and single crystals (TSFZ@UM), which will further get characterized in a multi-technique approach, essentially using Large Scale Facilities (X-ray synchrotron and neutron scattering techniques @ ESRF). Both PIs are heavily involved in the Erasmus Mundus Master's program, MaMaSELF, Master in Materials Science Exploring Large Scale Facilities (<http://mamaself.eu>), thus naturally allowing direct cooperate with different beam line scientists from different facilities.

## Principal Collaborators



**M S Ramachandra Rao**  
*Indian Institute of Technology Madras  
Chennai*



**Werner Paulus**  
*University of Montpellier  
Montpellier*

## Objectives

- Exploring spin transport properties on iridium based oxides
- Exploring the influence of oxygen non-stoichiometry for the transport properties
- Comparison of the spin transport properties on epitaxial thin films and single crystals
- Multi technical characterization approach using Xray (synchrotron & lab. equipment) and neutron scattering techniques (single crystal diffraction and reflectivity, magnetism, lattice dynamics, X-ray absorption and emission spectroscopy, Raman, high resolution TEM)
- Understanding of the quantum correlation effects from above mentioned studies in hitherto unexplored iridates





## 5. Brief Reports of Research Projects

### B. Industry Academia Research & Development Programme

# Development of loop heat pipe for avionics and terrestrial applications

## Background

Passive thermal management of aero-space vehicles, Loop Heat Pipe (LHP), Phase-change thermo-physics, Mechanical engineering, fundamentals of evaporation in porous media (LHP wick structures), flow condensation, wick development via powder metallurgy, thermal/configuration design, testing, characterization, manufacturing of thermo-mechanical demonstrator prototype

Loop heat pipes (LHPs) are advanced passive thermal management systems that can ensure highly efficient transport of heat from source (for example an electronic platform for avionics or a concentrated solar collector, in terrestrial application). The heart of successful LHP operation is a specialized wick structure, wherein efficient evaporation of working fluid is achieved which transports heat in the form of latent heat to a condenser.

## Indian Partners



**Sameer Khandekhar**  
Dept. of Mechanical Engineering  
IIT, Kanpur



**Siddharth Y. Paralikar**  
Chief Executive Officer (CEO)  
Golden Star Technical Services Pvt. Ltd.  
Pune

## French Partners



**Jocelyn Bonjour**  
CETHIL, INSA Lyon,  
Villeurbanne

**Claude Sarno**  
Thermal Systems Packaging  
Thales Avionics (THALES)  
Valence

Domain: Avionics

Apr. 2017 to Mar. 2020

## Objectives

- Industrial capability build-up for manufacturing specialized LHP wicks, as per design guidelines and specifications of avionics industry
- Characterization of the developed wick structures, in terms of relevant porous media and thermal-hydraulic properties
- Development of a high performance thermo-mechanical LHP demonstrator with specified wick structure (Typically Cu/Ni/Ceramic) to handle up to 100 W thermal power at all orientations
- Research output on convective condensation, local evaporator dry-out and system level thermal-hydraulics via the development of a transparent LHP system

## Knowledge Generated/Products Developed

- Copper and Nickel wicks have been developed
- Optimization of Nickle wicks is in progress
- Loop heat pipe with Copper wicks has been performance tested. Some design issues due to higher heat leak from the evaporator to the compensating chamber have been identified and are being addressed. This will enhance the performance even further
- LHP at INSA Lyon has been made operational and an adsorber based anti-freezing system (patented by INSA) has been tested by the post doc scholar. This is importance from avionics application point of view



# Piezoelectric actuator systems for automotive translation systems (PASATS)

Domain: Automotive

Feb. 2017 to Sep. 2020

## Objectives

Demonstration of automatic slider actuation system for automatic seating using piezoelectric actuators

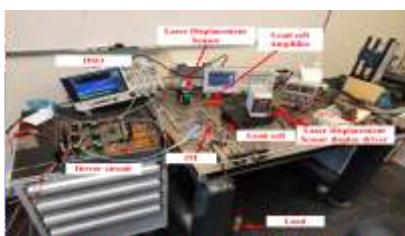
## Knowledge Generated/Products Developed

Main achievements (French Side)

- Proposition of two motor designs based on piezoelectric actuators
- Geometrical modelling of the necessary mechanical system design for automotive applications
- Prototype development of the actuation system for two different configurations
- Experimental analysis of the mechanical actuation system
- Collaboration between the French and Indian sides in order to test the actuation system under different frequency

Main achievements (Indian Side)

- Mathematical modelling and simulation of the piezoelectric actuators and inchworm motor
- Design of three adaptive, non-linear control algorithms for piezoelectric actuators with performance evaluation
- Prototype development of high frequency amplifier driver circuit to actuate the inchworm motor under different control pulse test cases
- Experimental analysis of the power electronics based electrical actuation system with car battery
- Interfacing of Inchworm Motor in real time controller environment along with forward and reverse direction control



Experimental test bench to measure speed of the Inchworm motor at high frequency in loaded and unloaded condition (In French Laboratory)



At GeePs laboratory, Paris, in Jan 2020

Sandip Jana – JRF, Indian Side, CSIR CMERI, Saikat Kr Shome – PI, Indian Academia, CSIR CMERI, Laurent Daniel – PI, French Academia, GeePs/CentraleSupelec, Yves Bernard – Co – PI, French Academia, GeePs/University of Paris- Sud, Sofiane Ghenna – Post Doc for the project, French Side

## Background

Piezoelectric actuation is a promising candidate for this actuation system but some challenges remains to be unlocked. A main challenge is to design a piezo actuating device able to provide the required power to lift up a standard tailboard. This has to be done with the minimum amount of motion transformation from the motor to the tailboard, and keeping the cutting edge advantages of piezoelectric actuation devices. However, several non linearities tend to hinder the precision positioning applications of piezo actuators viz hysteresis, creep, vibration, etc. Besides, several errors related to parameter uncertainties and external disturbances need to be compensated by proper robust control system design. Another main feature of such a device, for safety purpose, is to remain locked if the electrical power is cut off. The operation of the system under dysfunctional conditions has also to be included in the project so as to ensure a fault tolerant behaviour and control. This has significant implications in the chosen design. The present proposal aims at including all these constraints to design a full tailboard actuation system based on the latest development of piezoelectric system design.

## Indian Partners

**Saikat Kumar Shome**  
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West Bengal*

## French Partners

**Laurent Daniel**  
*Faurecia / CentraleSupelec / Esigelec  
GeePs, Gif-sur-Yvette*

**Yves Bernard**  
*Ignacio Alvarez  
Brières-les-Scellés*

# Reactive programming and compilation for the redefine manycore

## Background

This project addresses certain important, pertinent and topical challenges in the realization of a FADEC, consolidating computationally intensive control and health monitoring components on a single hardware platform. Synchronous reactive programming of sequential, periodically scheduled real-time control systems is routinely used in avionics. But moving to parallel architectures is a huge challenge, both scientifically (in terms of efficiency, accountability, isolation, timing analysis) and in terms of industrial practice and certification according to safety standards.

Domain: Comp. Sc.

Feb. 2018 to Jan. 2021

## Objectives

The objective of the project is to realize a FADEC on REDEFINE, a massively parallel, reconfigurable manycore system for safety criticality. To provide the expected levels of safety, by design, the project will rely on synchronous reactive programming, and extend it to enable automatic parallelization and mapping of the FADEC to the REDEFINE architecture. The certification of the code generator and parallelization tools is out of the scope of such a research project; but we will validate the safety requirements from a realistic FADEC model on the model and generated code using formal methods and extensive tests. PIs will also demonstrate performance levels of automatically generated code on par with manually written, low-level REDEFINE programming

## Knowledge Generated/Products Developed

Following are the list of tools developed in the project:

- Heptagon language extension and OpenCL backend
- Functional simulator of REDEFINE with system level modeling
- REDEFINE ISA simulator for measurement-based System level WCET estimates
- Micro-Architectural support for High-Availability in REDEFINE NoC

## Indian Partners



**S. K. Nandy**  
IISc  
Bangalore



**Ranjani Narayan**  
Morphing Machines  
Bangalore

## French Partners



**Dumitru Potop-Butucaru**  
Inria  
Paris

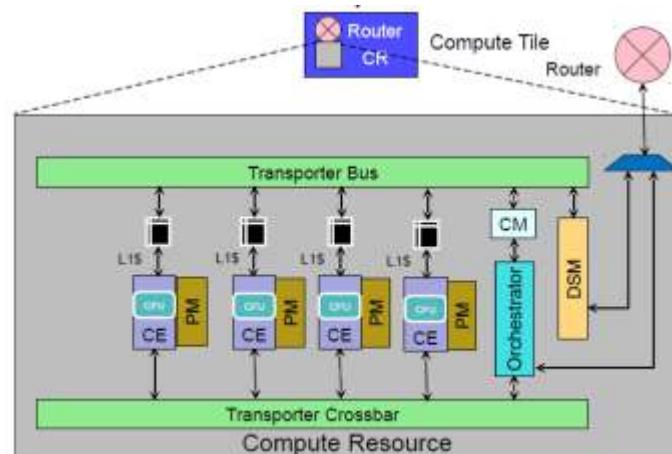


**François Neumann**  
Safran Electronics and Defense  
Massy Cedex



**Marc Pouzet**  
École Normale Supérieure,  
Département d'Informatique  
Paris

## REDEFINE COMPUTE RESOURCE



CE : Compute Element; CFI: Custom Function Unit; DSM: Distributed Memory;  
PM: Private Memory; CM: Context Memory

# Packmark-development of new anti counterfeit printing techniques for medicine packaging

Domain: Printing

Aug. 2017 to Jun. 2021

## Objectives

- To develop a generic watermark method for printed aluminium foils
  - Enhance the printed surface coverage of watermarks
  - To develop an adaptive watermark method taking into account the spatial information to be printed
  - Study the temporal stability of watermarks against light exposition, humidity rate
  - To develop a solution to protect packaging against expiry date changes.
- Objectives were revised to add a third security level to the barcode:
- Level 1: Classical barcode. It will enable customers to have access to additional info about the pharmaceutical product using their smartphone
- Level 2: Low security mark. It will enable customers to check using their smartphone if the pharmaceutical product was produced or not by the right pharmaceutical company. PIs will use for that a solution similar to this solution:  
[https://github.com/jeromeetienne/AR.js/  
blob/master/README.md](https://github.com/jeromeetienne/AR.js/blob/master/README.md)
- This new security level will be implemented and tested during Task 3c
- Level 3: High security mark. It will enable authorized people to authenticate the product and to check if the pharmaceutical packaging has been counterfeit (i.e. the security pattern has been scan and printed in an illegal way)

## Knowledge Generated/Products Developed

- Developed variable watermark to protect specific time dependent information of the pharmaceutical product
- Color characterization for printing authentication
- Accomplished study for the effect of temporal stability of the printed watermark against light exposition, humidity rate, etc
- Established light fastness properties of prints on blister foils by spectral reflectance
- Developed artificial neural network approach to predict the light fastness of gravure prints on the plastic film
- Predicted the water fastness Rate of Foil Print applying above approach



Presentation of Scholar in JU on December 2019

## Background

In today's world counterfeiting and piracy are increasing hugely. It affects a variety of goods and the worst affected area is pharmaceuticals and healthcare. Counterfeit drugs may include products without active ingredients, with incorrect quantities of active ingredients, wrong ingredients, and incorrect quantities of active ingredients with fake packaging. Counterfeited medicines may lead to death in severe cases such as heart attack, epilepsy etc. Counterfeit pharmaceuticals product is a product that is deliberately and fraudulently mislabeled with respect to identity. Sometimes expire dates are manipulated in order to clear the stock. In counterfeit packaging the batch number are copied from the original batch number. It is very difficult to identify counterfeit products from genuine products. Hence, anti-counterfeiting is needed urgently for the brand protection.

## Indian Partners



**Swati Bandyopadhyay**  
*Jadavpur University  
Kolkata*



**Mr. Ashish Bhattachariya**  
*Sergusa Solutions Pvt. Ltd.  
Mumbai*

## French Partners



**Tremeau Alain Anne**  
*Laboratoire Hubert CURIEN  
(UMR 5516)*

## Publications

- No. of publications in SCI journals: 4
- No. of patents: 1

# Cost-effective strategy for the induction of immune tolerance to the therapeutic factor VIII in hemophilia A

## Background

Development of anti-factor VIII (FVIII) antibodies (FVIII inhibitors) is a major concern during FVIII replacement therapy for patients with hemophilia A. Mucosal administration of recombinant FVIII fragments produced from plants blocks the production of FVIII inhibitors. However, this technology may have limitations in terms of cost and efficiency in preventing or eradicating FVIII inhibitors. This project proposal aims to produce recombinant FVIII fragments in large amounts in a relatively short amount of time using a *Pichia pastoris* expression system. PIs produce and purify recombinant FVIII fragments (Heavy and Light Chain) using proprietary technologies. The safety and capacity of the FVIII fragments to confer oral tolerance to FVIII will be pre-clinically tested in hemophilia A mice. This technology could be industrially integrated to produce recombinant FVIII fragments in large amounts in a cost effective manner and could be made clinically available for hemophilia A patients.

## Indian Partners

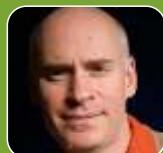


**Krishnan Venkataraman**  
Centre for BioSeparation Technology (CBST),  
Vellore Institute of Technology (VIT)  
Vellore



**Murali Tummuru**  
M/s Virchow Biotech Private Limited,  
Hyderabad

## French Partners



**Sebastien Lacroix-Desmazes**  
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**Daniela Balvay**  
R&D Director, SPAN Diagnostics S.A.R.L.  
Parc Technologique des Rives de l'Oise,  
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Domain: Immunology

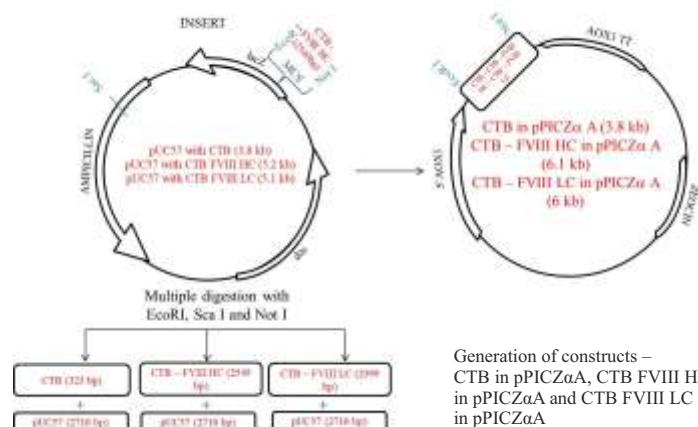
May 2018 to Apr. 2022

## Objectives

- Cloning and optimization of production by *Pichia pastoris* of recombinant FVIII heavy and light chains alone or fused to CTB
- Process optimization for scale up at the 2L fermentor level in a cost effective manner (CBST team and Virchow Biotech team)
- Scale up and the optimization of production of various constructs of FVIII in *Pichia pastoris* expressing FVIIIHC, FVIIILC, CTB-Fused FVIIIHC and CTB-fused FVIIILC in 15L or 30L
- In vivo* animal model studies to validate the efficacy of Factor VIII molecules in the inhibition of antibody development against FVIII

## Knowledge Generated/Products Developed

- Developed recombinant cDNA coding for Cholera Toxin B, Cholera Toxin B-fused Factor VIII Light Chain and Factor VIII Heavy chain in pPICZα vector and corresponding stable *Pichia pastoris* GS115 strain coding for each polypeptide
- Developed recombinant cDNA coding for Cholera Toxin B, Cholera Toxin B-fused Factor VIII Light Chain and Factor VIII Heavy chain in pPIC9K vector with new signal sequence for better expression of corresponding polypeptide
- Optimized expression of Cholera Toxin B, Cholera Toxin-fused Heavy Chain Factor VIII and Cholera Toxin-fused Light Chain Factor VIII in shake flask conditions (50- 100ml).
- Standardized Cholera Toxin B and Cholera Toxin B-fused Light Chain binding to GM1
- Established Hemophilia mice colony for testing the effectiveness of the Cholera Toxin B fused Factor VIII Light Chain and Cholera Toxin Factor VIII Heavy chain in inducing immune-tolerance



## ONGOING PROJECTS

To develop an effective extraction and separation technology to selectively extract rare earth elements – Erbium (Er), Terbium (Tb), Europium (Eu), Praseodymium (Pr), Neodymium (Nd) and Dysprosium (Dy) from WEEE (Waste Electrical and Electronics Equipments)

Domain: E-Waste

May 2018 to Nov 2021

### Objectives

- Development of process parameters for selective leaching of rare earths metals from WEEE (Waste Electrical and Electronic Equipments - NdFeB magnet and fluorescent lamps)
- Design of suitable solvent-extractant combination (e.g. task specific ionic liquids) using molecular modelling techniques
- Synthesis and characterization of recommended solvent-extractant combination or task specific ionic liquids for separating rare earth ions (Nd, Pr, Dy) or (Y, Eu, Tb, Er)
- Optimization of process parameters for the separation of rare earth ions (Nd, Pr, Dy) or (Eu, Tb, Er) by solvent extraction using commercially available extractants
- Conduct large scale trial of the complete process developed for scrap magnets and fluorescent lamps

### Knowledge Generated/Products Developed

- Proof of concept for recovery of rare earths from spent NdFeB magnets using chloridizing roasting and water leaching method has been developed
- High pure mixed rare earth oxides of neodymium, praseodymium and dysprosium were prepared, having applications in pigment industries
- Design and synthesis of lipophilic hydromagnetic and EDTA/DTPA ligands
- Studies and optimization of process parameters for the separation of rare earth ions (Nd, Pr, Dy) by solvent extraction
- Under conditions relevant to the solvent extraction of REEs by acidic ligands, the interface is 'rough' with a variety of complexes formed between the ligands, metal ions and water molecules
- Machine learning models have been developed to predict the lanthanide ligand binding affinities under a variety of conditions
- For the first time ever, a large scale prediction of the binding affinities of all molecules in the PubChem database with all the lanthanide ions has been carried out

### Background

The current project proposal is focused on the development of suitable process scheme for the utilization of waste for the recovery of valuable rare earth metal ions. "Selective Leaching" has been targeted in the current proposal, so that rare earth ions (Nd, Dy, Pr) or (Er, Tb, Eu, Y) present in the magnet or lamps respectively comes in the aqueous solution. For the individual separation of rare earth ions from aqueous solution, suitable solvent extractant combination will be designed with the help of molecular modelling techniques. To compare the performance of developed combination of extractant, separation studies will also be carried out by using commercially available extractants. Therefore, the idea of the proposal is to give complete "Extraction" and "Separation" scheme for the recovery of rare earths from scrap magnets and fluorescent lamps, so that it can be tried on the larger scale.

### Indian Partners



Aarti Kumari &  
S. K. Sahu  
*CSIR-National Metallurgical Laboratory  
Jharkhand*



Beena Rai  
*Tata Research Development and  
Design Centre, TCS  
Pune*

### French Partners



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Christian Louis Thomas  
*Terra Nova Development  
Lille*

### Publications

- No. of publications in SCI journals: 3
- No. of patents: 4

# Design of flexible sweat sensors and stretchable batteries embedded in e-textile to monitor personal health and fitness parameters

## Background

The innovative approach of the microbattery technology relies on the assembling of two stretchable substrates carrying arrays of serpentine micropillar electrodes and being separated by a self-healing polymer electrolyte. The technological approach proposed in this project is new in terms of 1) Achieving the fabrication of a stretchable micropower source fully integrated into the wearable device. 2) Attaining high electrochemical performance and long life due to the use of 3D microstructured electrodes and a good electrode/electrolyte interface that can be restored (polymer with self-healing properties). Compared to results reported in the literature, the design proposed in this work will lead to stretchable batteries showing high energy and power densities as well as long lifetime under multiple engineering strains.

## Indian Partners



**Aloknath De**  
Samsung R&D Institute India  
Bangalore



**Siddhartha Panda**  
Indian Institute of Technology  
Kanpur

## French Partners



**DJENIZIAN Thierry**  
Ecole Nationale Supâ©Rieure  
Des Mines De Saint-Etienne,  
Provence-Alpes-Cote Dazur



**David Noel Christophe**  
@Health, Provence-Alpes-Cote Dazur,  
Aix-En-Provence

## Publications

- No. of publications in SCI journals: 3

Domain: Nano Materials | Aug. 2019 to Jul. 2022

## Objectives

- Flexible biosensor design for sweat analysis
- Fabrication and optimization of a new stretchable microbattery
- E-textile design and integration
- Electronic system design and device prototype

## Knowledge Generated/Products Developed

- Developed sweat sensor design and a corresponding machine learning model to estimate/predict blood sugar levels from sweat biomarkers
- Stretchable micro-battery design and prototype with high areal capacity ( $>> 1 \text{ mAh/cm}^2$ )
- Wearable platform to integrate the sweat sensor, battery with a processing and communication module
- Prototype device with the biosensors and battery integrated into e-textile



Conceptual design of the sensing unit, its construction and integration in a wearable device



# Commercial pigment production by microalgae: towards the development of new biotech process

Domain: Biotechnology | Sep 2020 to Aug 2023

## Objectives

The main aim of the project is to build an innovative biotechnology process allowing carotenoid milking from microalgae

The target carotenoids are astaxanthin and fucoxanthin, two biocompounds with high added value, produced by the green alga *Haematococcus pluvialis* and the diatom *Phaeodactylum tricornutum*. Local strains will be used in the project. Their complete identification will constitute the 1st objective of the project (O1.1 in the Table of objectives) To attain the project target, a strong set of biological and biotechnological data must be generated on

- The regulation of the carotenoid production by microalgae under stress: the optimization of the carotenoid production by the microalgae will be studied using biochemical, transcriptomic and proteomic and stress physiology analyses (O1.2.). Using the data, the regulatory circuits controlling the carotenoid accumulation in the microalgae will be deciphered. These data are crucial to ensure the productivity of carotenoids by the microalgae
- The capacity of PEF to favour the extraction of these carotenoids: Biocompatible extraction of carotenoids is the key to the success of the innovative biotechnology process at the aim of the project (O2.1). The modulation of the PEF parameters will allow reaching biocompatibility that will be verified through the physiological measurements and microscopic observations
- The capacity of the microalgae to survive the PEF treatment and to regenerate the pool of extracted carotenoids: milking microalgae imply that the extracted carotenoids are regenerated after each extraction. The kinetics of the process will be measured using biochemical methods and the eventual modifications in the regulatory circuits of carotenoid production will be established using transcriptomic and proteomic and stress physiology measurements (O2.1.)
- Building a setup combining carotenoid biological production ((photo)bioreactor) and electroextraction: the final aim of the project is to create an innovative biotechnological process for carotenoid milking from microalgae. The data obtained in points 1-3 will be combined to generate this setup. The capacity of the setup will be tested at the lab scale in terms of carotenoid production yield and milking capacity (O3.1.)

## Background

Biotechnological production of carotenoid from microalgae is slowly developing because of (1) lack of data on the regulation of biomolecules production and (2) high costs of production, including the downstream processes. The project aims to reduce these difficulties by providing a strong data set on the regulation of carotenoids production by microalgae i.e. the green alga *Haematococcus pluvialis* producing astaxanthin and the diatom *Phaeodactylum tricornutum* producing fucoxanthin. These two carotenoids have a high added value. The project combines two novelties: (1) metabolically forced microalgae used as microscopic countless pigment factories and (2) an innovative biocompatible electroextraction process allowing carotenoid milking from microalgae

## Indian Partners

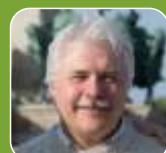


**V. Vinayak**  
Department of Criminology and Forensic Science, Diatom Nanoengineering and metabolism (DNM), School of Applied Science, Dr Hari Singh Gour Central University, Sagar, M.P, India



**Harish**  
Department of Botany, Mohanlal Sukhadia University, Udaipur – 313001 (Rajasthan) India

## French Partners



**B. Schoefs**  
MIMMA, Laboratoire Mer, Molécules, Santé, UFR Sciences et techniques, Le Mans University, Avenue Olivier Messiaen, 72085 Le Mans, France



**S Roux**  
Bioconcept Scientific, 40 rue de la Peanne, 53000 Laval, France

## Publications

- No. of publications in SCI journals: 3

# Green Valorization of sheep wool wastes towards biocomposites and bioactive building materials

## Background

The concept of circular economy or zero agricultural waste is gaining tremendous importance across the world. Conversion of agricultural residues and co-products into value added materials is one of the major issues being addressed to maximize the use of natural resources and minimize environmental pollution due to burning or burying of agricultural wastes. This project is aimed at using wool directly (ie.without keratin extraction) in order to satisfy economic viability. To solve the problem of slow degradation by moth leading to material failure and insect contamination of the housings, several treatments can be performed in which: spraying a Borax solution, adding Titanium nanoparticles, synthetic biocides like permethrin..., but in order to minimize the use of chemicals, to keep an eco-friendly process and match the 'Reach' policy (E.U.), we will investigate the use of 'green' insects-repellents. PI. Reddy, N. (main Indian partner) has developed biobased composites and his team was recently able to construct new composites made of wool and polypropylene fibres in which the main component is wool. The process used was hot compressing which is simple and easily adaptable in large scale.

## Indian Partners



**Narendra Reddy**  
Center For Incubation, Innovation,  
Research And Consultancy(CIIRC),  
Bangalore



**Balaji Sriramulu**  
Agringenium Innovations Private Limited  
Bangalore

## French Partners



**Grohens Yves**  
University of South Brittany, Brittany, Vannes  
**Francois Touchaleaume**  
Umr Iate (Inra, Supagro Montpellier,  
Univ Montpellier, Cirad),  
Languedoc Roussillon, Montpellier



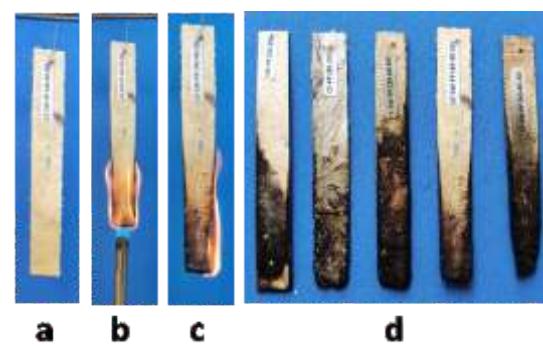
**Gilles Detiege**  
Moulin de Bay  
64660 ASASP  
NFP,Aquitaine,  
Pau

Domain: Circular Economy

Jul 2020 to Jun 2022

## Objectives

- To develop techniques for bioscouring and washing of wool progress: PIs have done studies on various conditions and their effects on wool washing and scouring. The effect of hot water washing and alkali washing have been studied. Further studies are in progress to determine the effect of enzymes and chemicals on wool properties after washing
- To produce biodegradable polyesters and use them as matrix with wool fibers as reinforcement progress: Biodegradable polyesters have been produced and will be shared with the Indian team. The Indian team will develop composites using the biodegradable polyesters and compare them with polypropylene
- To develop composites from waste wool progress: Waste wool has been combined with gypsum and made into composites. The composites developed show similarities to gypsum based false ceiling tiles and could be used for construction applications. Further, sheep wool was combined with poultry feathers in various ratios and composites were developed. A manuscript on sheep wool-poultry feather hybrid composites has been developed and will be submitted for publication
- To impart additional functionalities to the wool fibers: PIs have started work on this objective. Wool fibers are being treated with essential oils to increase their resistance to microorganisms. Various flame retardants are being purchased and incorporated into the wool fibers to improve their flame resistance



Digital images depict the flame resistance and propagation through the wool-feather polypropylene composites. Images a, b and c show the 50/50 wool/feather blend sample before, during and after ignition. Images of the individual and hybrid composites after the ignition test (d) did not show any dripping or extensive flame propagation.





## 5. Brief Reports of Research Projects

### C. Targeted Programmes

## IoT software testing using timed automata

### Background

The main scientific goal of the project is to design rigorous development and testing methods for IoT applications. A peculiar feature of IoT applications is their high degree of parallelism, soft time constraints, and absence of a global clock synchronizing all the components. PIs plan to find variants of networks of timed automata suitable to model IoT systems. The challenge here lies in incorporating the peculiarities of such systems without losing the efficient algorithmic properties of the model. PIs will also propose new verification algorithms and implement it as a part of a verification tool for timed systems. Our starting point will be the existing industrial cooperation with the Indian industry, and the verification tool for timed systems (called T-Checker) developed by the Bordeaux group. Recently, the Verification and Validation (V & V) group at Tata Research Development and Design Centre (TRDDC) in Pune (India) have developed a formalism called Expressive Decision Tables (EDT) that can be used to specify requirements of a system. This formalism has gained wide popularity among system engineers and has an increasing user base, especially in the automotive industry.

### Completed Project

Nov. 2017 to Nov. 2020

### Objectives

The aim of this project is to build on this fruitful collaboration, base our work on the existing accepted EDT formalism, construct verification algorithms, and implement a tool that will be used in testing and verification of IoT systems specified in EDT. More specifically, the objectives are as follows:

- Construct a corpus of representative examples of IoT systems using EDT formalism
- Improve timed automata technology to efficiently handle EDT benchmarks
- Develop automated test generation for EDT using timed automata technology
- Develop a tool-chain for testing IoT applications

### Knowledge Generated/Products Developed

- Partial order reduction for timed automata
- Liveness verification for timed automata: Work on liveness for timed automata commenced during the first year has been accepted for publication in the journal ACM Transactions on Computational Logic (ToCL)
- Timed automata with diagonal constraints
- Open source tool T-Checker released: An open source tool for real-time modelling and verification using timed automata has been released in the last year
- Formal semantics for EDT: A preprint of the formal semantics for Expressive Decision Tables is ready

### Principal Collaborators



**B. Srivathsan**  
Chennai Mathematical Institute  
Chennai



**Igor Walukiewicz**  
LaBRI (Bordeaux)  
UMR CNRS 5800  
Bordeaux

### Publications

- No. of publications in SCI journals : 1
- No. of papers presented in conferences: 2

### Mobility Support

- India to France: 2
- France to India: 2

# Looking beyond backpropagation in deep learning

## Completed Project

Nov. 2017 to Oct. 2020

### Objectives

- Leveraging acceleration techniques for gradient-like methods, such as majorization-minimization approaches or generalized projectors to replace backpropagation so as to improve its convergence speed
- Instead of going for the traditional pre-training and fine-tuning phases of deep learning, resorting to parallel / distributed techniques to optimally solve deep architectures in one go
- Starting from recent works on proximal algorithms for non-convex optimization taking into account non smooth penalization terms in order to improve the performance in terms of learning accuracy while conserving high estimation speed

### Knowledge Generated/Products Developed

- Preconditioning strategies relying on MM formulations
- Subspace strategies (memory gradient / L-BFGS)
- Block alternating MM algorithms
- Parallel / distributed versions + numerical implementation on GPGPUs
- Block alternating proximal algorithms

### Background

Deep Learning has gained immense momentum since its onset about a decade back. However the concepts of deep learning were not new; they were known to the early proponents of neural networks. However it did not become a reality for two reasons:

1. Deeper networks meant more parameters (network weights) to learn; in turn this required more training data. In the early days of neural networks 90s, such humongous amount of data was not available. Big Data was a distant dream.
2. Even if large volumes of data were available for some specific problems, in early days of neural networks, computers were not powerful enough to store and manipulate such volumes.

Currently, there are two major focus in deep learning research: (1) new application areas (speech, vision, NLP etc.), and (2) new hardware architectures tailored for deep learning – in this context Nvidia's GPGPU for deep learning is well known.

### Principal Collaborators



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Indraprastha Institute of  
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**Emilie Chouzenoux**  
LIGM UMR CNRS 8049,  
Université de Paris-Est Marne-la-Vallée  
Marne-la-Vallée

### Publications

- No. of publications in SCI journals : 2
- No. of papers presented in conferences: 1

### Mobility Support

- India to France: 4
- France to India: 2

# Machine learning for network analytics

## Background

In the past couple of decades network science has seen an explosive growth, enough to be identified as a discipline of its own, overlapping with engineering, physics, biology, economics and social sciences (see, e.g., the recent monographs). Much effort has gone into modelling, performance measures, classification of emergent features and phenomena, etc, particularly in natural and social sciences. The algorithmic side, all important to engineers, has been recognised as a thrust area (e.g., two recent Nevanlinna Prize (J. Kleinberg 2006 and D. Spielman 2010) went to prominent researchers in the area of network analytics). Still, in our opinion the area is yet to mature and has a lot of uncharted territory. This is because networks provide a highly varied landscape, each flavour demanding different considerations (e.g., sparse vs dense graphs, Erdos-Renyi vs planted partition graphs, standard graphs vs hypergraphs, etc). Even adopting existing methodologies to these novel situations is often a nontrivial exercise, not to mention many problems that cry out for entirely new algorithmic paradigms. It is in this context that PIs propose this project of developing algorithmic tools, drawing not only upon established as well as novel methodologies in machine learning and big data analytics, but going well beyond, e.g., into statistical physics tools.

Completed Project

Dec. 2017 to Nov. 2020

## Objectives

- **Network inference:** Estimating network characteristics such as diameter, edge conductances, average occurrence of specified motifs, testing hypotheses regarding graph structure, rumor source detection, network tomography, etc., furthering ongoing work in some of these as well as some new directions
- **Network algorithms:** This includes distributed algorithms on networks such as gossip based, distributed learning and optimization, and also algorithms for networks such as ranking, approximate computation of centrality measures, clustering etc.
- **Dynamic and strategic issues:** This will cover graph dynamics, dynamics on the graphs and related optimisation and estimation issues, strategic behaviour on networks, e.g., resource allocation, network based games, belief propagation, etc.

## Knowledge Generated/Products Developed

- Reinforcement learning algorithms for learning threshold policies and Whittle index policies in Markov decision processes
- Opinion shaping on networks
- Analysis of content caching and delivery schemes under various settings
- Dynamic urn models and their algorithmic applications

## Principal Collaborators



**Vivek S. Borkar**  
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## Publications

- No. of publications in SCI journals : 4
- No. of papers presented in conferences: 6

## Mobility Support

- India to France: 1
- France to India: 4

# Modelling of human intention during gait rehabilitation

## Ongoing Project

Nov. 2017 to Apr. 2021

### Objectives

- Human Biomechanics for design of novel robotic aids for rehabilitation using machine learning
- Design, Modeling and virtual prototyping of device for augmenting gait assistance
- Machine learning techniques using hybridized bio-signal and gait sensor data for event and intent identification

### Knowledge Generated/Products Developed

- Modelling, Simulation and Design of experiments for intent-based control of Exoskeleton for Ankle therapy
- Validation of CSIR-CSIO developed Wireless Foot Sensor Module (WFSM) performance w.r.t. high precision digital encoder integrated in NAO bipedal robot during dynamic gait
- Model for estimation of Zero Moment Point (ZMP) for bipedal walking from force as well as joint angle data measured using developed WFSM
- Machine learning methods for evaluation of Spatiotemporal features of Gait Recognition using indigenously developed wireless wearable sensors

### Background

Human Cognitive and functional augmentation was a science fiction in the recent past, these are gaining a foothold in the real world, thanks to the advances in frontiers of science & technology. Exoskeleton is an enabling technology that augment the human body and its capabilities. From a military soldier to a spinal injured patient, are expected to be hugely benefitted from the advent of this technology. Correlating electrical activity in the muscles to motor intentions is essential for developing new generation of prosthetic systems. Despite significant progress, the available techniques cannot yet master the control of prosthetic devices, thus not clinically viable. The big challenge is programming it to be pliable for human anticipation with a more natural, co-operative, adaptive, bi-directional and multi degree of freedom control. This predilection motivated the research community to think in the direction to accommodate sensors for acquiring myoelectric and nerve signals to detect the wearer's intention to move before applying the assistive force.

### Principal Collaborators



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### Publications

- No. of publications in SCI journals : 2
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: 5
- France to India: 7

## Formal verification of autopilot software for UAVS

### Background

- A Deep Neural Network (DNN) based controller for a quadcopter, the neural network controller is expected to mimic the behaviour of a Model Predictive Controller (MPC) for the quadcopter. The MPC has a high computational cost. The replacement of MPC with the DNN controller helps us reduce the online computation cost of the quadcopter and enhance its flight time. Though the DNN controller is computationally more efficient than the traditional controller, it is not clear if it can control the quadcopter in all possible states. A verification of the DNN controller is then becomes essential. However, there are a very few tools that can address the verification problem of a closed loop dynamical system where the controller is of the form of a Neural Network. The available tools have been applied only to low dimensional dynamical systems. The verification of a quadcopter with DNN controller is out of the reach of the currently available tools and techniques.

- PIs have proposed a heuristic-based automated technique that synthesizes feedback controllers guided by STL specifications. Our technique involves rigorous analysis of the traces generated by the closed-loop system, matrix decomposition, and an incremental multi-parameter tuning procedure. In case a controller cannot be found to satisfy all the specifications, PIs propose a technique for modifying the unsatisfiable specifications appropriately. PIs demonstrate our technique on seven controllers used as standard closed-Loop control system benchmarks, including a complex controller having multiple independent or nested control loops. Their experimental results establish that the proposed algorithm can solve complex feedback controller synthesis problems automatically within a few minutes.

Ongoing Project

Nov. 2018 to Oct. 2022

### Objectives

- Create an autopilot that is driven by a controller synthesized in the form of a Deep Neural Network (DNN) and attempt to verify it
- Model this autopilot and the closed loop system in the ROS Gazebo simulator
- Translate the closed loop model manually to a hybrid system with the dynamics of the quadcopter and the DNN controller
- Develop a framework for verifying a closed-loop dynamical system with DNN controller
- Verify the UAV Autopilot with the DNN controller
- Update the DNN controller automatically to satisfy the safety requirements

### Knowledge Generated/Products Developed

- Created an autopilot software that is driven by a controller synthesized in the form of a Deep Neural Network (DNN)
- Modeled this autopilot and the closed-loop system in the ROS Gazebo simulator
- Translated the closed-loop model manually to a hybrid system. The closed-loop model contains the dynamics of the quadcopter and the DNN controller
- Evaluated the currently available tools for verifying closed-loop systems with DNN controllers, for example, Verisig from UPenn and Sherlok from the University of Colorado Boulder
- Developed a controller parameter synthesis technique for complex systems, including UAVs
- Developed a DNN controller generation, verification, and retraining framework for cyber-physical systems

### Principal Collaborators



**Indranil Saha**  
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Kanpur



**Goran Frehse**  
Laboratoire Verimag  
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### Publications

- No. of publications in SCI journals : 2
- No. of papers presented in conferences: 3

### Mobility Support

- India to France: 2
- France to India: 1

# Efficient quantitative verification

## Ongoing Project

Sep. 2018 to Dec. 2022

### Objectives

- Efficient Algorithms for Timed and Concurrent Models
- Efficient Control of Stochastic Systems
- Timed & stochastic games

### Knowledge Generated/Products Developed

- PIs have considered the problem of resilience in timed systems. This models how a timed system may recover from a fault and hence is a desirable property in many situations. A paper based on this work was accepted in FSTTCS'21
- PIs looked at powerful model of timed systems with a pushdown stack and developed efficient practical techniques for verification. Work based on this has resulted in 1 conference publication at CAV'21, the flagship conference on verification and PIs expect at least one journal submission in the coming months
- On linear dynamical systems, PIs studied theoretically hard problems and defined robust variants, which are significant from a practical point of view. This work resulted in a publication at STACS'22

### Background

The project produced new results along three research directions: The first direction was dedicated to timed systems, with an emphasis on efficiency of algorithms for the verification of timed properties of resilience with a control flavor. The second was effective algorithms and tools for verification of timed recursive systems. The third line of research considered control of linear dynamical and stochastic models.

**Resilience in timed systems:** PIs have considered resilience of timed systems, and provided techniques to check whether a system modeled as a timed automaton can recover from a significant delay. This question was first addressed as a universal resilience problem, that consists in deciding whether after an unexpected delay a system always return to a specified behavior. PIs have then considered existential resilience, i.e. whether after an unexpected delay a system can return to a specified behavior. Universal resilience is undecidable in general, but we have identified several decidable subclasses. Existential resilience is decidable, and in PSPACE for most specifications. Our paper on this work was accepted and presented in FSTTCS'21, a top-ranked international conference, held last year in the online mode.

**Effective Reachability in Timed and Recursive systems:** PIs have three new developments on this front.

**Robust variants of the Skolem problem and Opacity in Labeled Markov chains:** With an undergraduate student M. Vahanwala from IIT Bombay, who did an online summer internship with colleagues at Rennes, PIs have tackled some problems on linear dynamical systems and their control, especially taking into account approximate behavior. This has resulted in a paper in STACS'22, a top conference in this area. During the internship of K. Garg in 2020, PIs have considered opacity, i.e. the question of whether one can deduce some confidential information from his observation of a system. This work has considered a quantitative notion of opacity.

### Principal Collaborators



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Mumbai



**Loïc Hélouët**  
SUMO Team, INRIA CRI  
Rennes

### Publications

- No. of publications in SCI journals : 3
- No. of papers presented in conferences: 5

### Mobility Support

- India to France: Nil
- France to India: Nil

# Games and optimization for energy management with stochasticity (GOEMS)

## Background

The main focus of the project is on applied problems where it is necessary to take optimal decisions in the presence of risk and uncertainty together with dependence between the random events, where the source of uncertainty is twofold. One component of uncertainty is exogenous, and results from substantially incomplete knowledge of important dependent problem data, like demand for goods and services, weather conditions, prices for commodities, high impact technical failures and other disruptions occurring with low probability. If only this kind of uncertainty is present, then the adequate methodology for modelling and solution of such decision problems is stochastic programming and game theory. PIs plan to develop a modelling framework which can accommodate single/multi-player non-cooperative decision making and endogenous and exogenous uncertainties together. PIs consider stochastic Nash game problems in various stochastic and distributionally robust optimization setups. In this project, PI will answer two fundamental questions for each stochastic Nash game problem under consideration, i) whether there exists a Nash equilibrium of the game, ii) how to compute Nash equilibrium efficiently. PIs will answer these questions by using the tools from fixed point theory, convex optimization, semi-definite programming and conic optimization. PIs aim to pursue possible applications in energy management.

## Principal Collaborators



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## Publications

- No. of publications in SCI journals : 5
- No. of papers presented in conferences: Nil

## Mobility Support

- India to France: 2
- France to India: 3

Ongoing Project

Sep. 2018 to Dec. 2022

## Objectives

- Existence of Nash equilibrium for chance constrained game problems
- Numerical Techniques to compute the Nash equilibrium.
- Application to energy network design problems
- Existence of Nash equilibrium and possible computational approaches for N-player joint chance constrained Nash game problems under mixture distributions.
- Equivalence between zero-sum distributionally robust chance-constrained games and second order cone programs.
- Leader-follower games under chance constraints
- Application in Electricity Market
- Develop theoretical framework for leader-follower game arising from electricity market.
- Chance-constrained games under dependent chance constraints using Copula
- Uncertain Constraint Markov decision problems using robust optimization, chance-constraint programming, and distributionally robust optimization approaches.
- Applications from electricity markets

## Knowledge Generated/Products Developed

- PIs proposed a primal-dual pair of second order cone programs whose optimal solutions give a saddle point equilibrium of a zero-sum chance constrained game
- PIs showed the existence of Nash equilibrium, based on their results they have submitted a research paper entitled “Games with distributionally robust joint chance constraints”
- Proposed an application of chance-constrained games in financial market. This work is published in “Mathematical Methods of Operations Research”
- Proposed the tractable reformulations for constrained Markov decision processes (CMDPs) under uncertain cost. PIs showed that a CMDP problem is equivalent to a linear programming problem, a second order programming problem and a semi-definite programming problem if the cost vector belong to a polytopic uncertainty set, an ellipsoidal uncertainty set and conic uncertainty set, respectively. Theoretical results are illustrated using a machine replacement problem
- PIs proposed equivalent SOCP approximations of CMDP problem, as an application
- PIs formulated the game as a distributionally robust chance-constrained game and proposed an equivalent mathematical program to compute the Nash equilibria of the game
- Considered a Leader-Follower game with two leaders and one follower under chance constraints and showed that there exists a leader-follower Nash equilibrium. To compute Nash equilibrium, PIs proposed an equivalent mathematical program. Application of this game is considered in electricity market

# FOGCITY: QoS-aware resource management for smart cities

## Ongoing Project

Aug. 2018 to Jul. 2021

### Objectives

- Selection of a Data Center to ensure the QoS of applications in terms of the service latency
- Fine-grained resource fragmentation and selection of the computing node(s) for optimal resource utilization within fog data centers

### Knowledge Generated/Products Developed

- Designed a QoS-aware bargaining scheme, named FogBarg, for resource management in fog networks
- In FogBarg, used an asymmetric-bargaining game-based online scheme to allocate resources dynamically in fog networks
- Implemented the proposed scheme in real-system – Grid5000 – in France
- Simulated the proposed scheme, FogBarg, in a python-based simulation platform, and compared the performance of FogBarg with a scheme named FIXED. In FIXED, the master nodes follow the same affinity for all the incoming applications
- Designed a pricing-based resource management scheme, named FogPrime, for fog networks
- In FogPrime, used dynamic coalition-formation game with transferable utility to allocate resources in intra-cluster of fog networks
- Additionally, used utility game to allocate resources in inter-clusters of fog networks
- Simulated the proposed scheme, FogPrime, in a python-based simulation platform, and compared the performance of FogPrime with the existing schemes

### Background

The proposal considers a smart city scenario comprising of static and mobile. The data from the static sensors are routed to pre-decided data centers and data from the mobile sensors are to be routed to the appropriate data center based on the QoS requirements of the applications. It is to be noted here that the city infrastructure serves a mixture of both latency-sensitive and non-latency-sensitive applications. The focus of the research is to select the suitable node(s) with a data center to eventually optimize the QoS of the applications in terms of the latency.

The primary objectives of the proposal are as follows:

Objective 1: Selection of a data center to ensure the QoS of applications in terms of the service-latency (Duration: 1 to 18 Months)

Objective 2: Fine-grained resource fragmentation and selection of the computing node(s) for optimal resource utilization within fog data centers (Duration: 19 to 36 Months)

### Principal Collaborators



**Sudip Misra**  
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**Christine Morin**  
*Research Director at Inria  
Rennes*

### Publications

- No. of publications in SCI journals : 2
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: 3
- France to India: 2

# Monitoring and modelling of the Mahanadi river basin in preparation of the SWOT

## Background

This project examines the potential of satellite altimetry to measure water levels over Mahanadi river basin, India through the futuristic mission called Surface Water and Ocean Topography (SWOT) proposed to be launched by year 2022. The quality check for SWOT products require an absolute vertical accuracy owing to which an intense calibration/validation works are planned to be conducted right after launch for a 6 week period. There is lack of such cal/val works over south Asian countries like India. Therefore, we select the Mahanadi basin to be the first ca/val site for SWOT in India. Through this project, we aim to understand the water level time series data from existing mission (especially SARAL), to run and set up hydrological models and create rating curves, to conduct field visit in Mahanadi river basin to select an appropriate study site for future projects focussed on SWOT validation over India.

Ongoing Project

Jan. 2020 to Jan. 2023

## Objectives

This project associates the expertise of two teams in the cal/val, the processing and interpretation of satellite data for the spaceborne monitoring of the water cycle. It is also an opportunity for the altimetry mission SWOT to be better validated and consequently better renowned and valued by academics and stake-holders working in the domain of the water cycle in the Indian Subcontinent. During the project, PIs intend to

- Calculate water level time series with all the past and in-flight altimetry missions. In this work, PIs will pay a particular attention to:
  - The measurements of the SARAL mission (2013-2016) since it was (1) the first Indo French altimetry mission and (2) its altimeter AltiKa was the only one operating in the Ka band, as SWOT will
  - The measurements collected today by the SENTINEL-3 missions of the EU COPERNICUS space program since they are planned for two decades at least, hence they will still operate in 2021, at the time of SWOT
- Assess the quality of these series in the basin by comparison with the gauge data and with model outputs. In this work PIs will collaborate with researchers leading the Indo-French satellite mission MEGHA-TROPIC. This mission is dedicated to measure hydrometeors in the Tropical band. Owing to this collaboration, PIs will analyze the ability of different hydrological (rain-discharge) / hydrodynamical models in retrieving more or less accurately the water flows in the basin when different rain field data are used as input
- Gather, inform, train people potentially interested in joining a larger project on this question

## Principal Collaborators



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## Publications

- No. of publications in SCI journals : 5
- No. of papers presented in conferences: 7

## Mobility Support

- India to France: 1
- France to India: Nil

## Knowledge Generated/Products Developed

- Evaluation of data from existing altimetry missions (Jason, SARAL, Sentinel) over Indian water bodies
- Examining temporal sampling intervals of satellite altimetry which impact uncertainty when comparing with in-situ gauge measurements
- Simulation of SWOT Large scale Hydrology simulator to generate proxy SWOT data over Mahanadi river basin
- To assist in generating proxy SWOT data, a new open-source web application was developed for mapping inland water extents using Python and Google earth engine
- Setting up SIC model and MGB models over Mahanadi river basin to create rating curves
- It is also an opportunity for the altimetry mission SWOT to be better validated and consequently better renowned and valued by academics and stake-holders working in the domain of water cycle in India subcontinent

# LOC approaches for Separation and Analysis of Exosome derived biomarker for Cancer Prognostic

## Ongoing Project

Jan. 2020 to Jan. 2023

### Objectives

- LOC based exosome separation: The aim of this task is to develop a microfluidic module enabling the separation of exosomes from the biological sample (blood in our case) and their sorting according to their size. Hydrodynamic and acoustofluidic methods will be investigated
- Detection of exosome derived protein by nanomaterial-based electrochemical system for cancer diagnosis: Electrochemical based biosensors have been shown to be a promising alternative to massand fluorescence-based sensors for the specific detection of exosome or which is the biomarker for liquid biopsy. Exosome or exosome-derived proteins etc. are believed to be important for cancer diagnosis and prognosis serving as reliable molecular biomarkers. In this work, PIs propose an electrochemical sensor for exosome or exosome-derived protein detection based on the different nanomaterials. Specifically, exosome or exosome-derived proteins will be captured by the pre-immobilized probes on the electrode and recognized by electrochemically active redox mediator
- Coupling all the suitable methods to realize an Integrated LOC platform for Exosome derived protein analysis: The objective of this task is to demonstrate LOC compatible exosome separation and electrochemical analysis of exosome derived protein. Lab On Chip platform (i.e., one that involves the fusion of acoustics and microfluidics) which can isolate exosomes directly from biofluids like blood samples. This LOC based, automated point-of-care system allows singlestep, on-chip isolation of exosomes from biological fluids (such as blood, urine, saliva, plasma, and breast milk) or in vitro cell cultures. It also represents a unique integration of exosome isolation Module, exosome lysis module and electrochemical sensing module

### Knowledge Generated/Products Developed

- The LAAS team has made the proof of concept of separation of particles of diameter <700nm in a lab -on-a chip
- The FEMTO-ST team has developed an acousto – fluidic device allowing the control trajectories of particles with a diameter of nanometer
- The IIIST team has developed suitable method for lysing the exosome and releasing the protein
- The IIIST team has developed enzymatic electrochemical sensors for the selective detection of Brest cancer proteins. However, the optimization is still going on in terms of reliability. The team is looking for patient derived blood sample for further optimization. However, due to the pandemic situations for last two years (2020 and 2021), it was very difficult to continue the activity for repeating lab shutdown

### Background

Molecular profiling of liquid biopsies is now emerging as pivotal for cancer biomarker discovery as well as for cancer diagnosis and prognosis. Exosome or exosome-derived proteins etc. are believed to serve as reliable molecular biomarkers. The analysis of exosomes, thanks to the lab on chip (LOC) approach, is receiving an increasing interest but is currently limited to the separation step, the detection of exosomes being operated off-chip by conventional approaches. Even more, to our best knowledge, processing online, on-chip, exosome separation, and molecular profiling of exosomederived biomarkers (DNA, proteins) is well above the state-of-the-art. The fundamental positioning and originality of this project are to tackle online (on-chip) the separation of exosomesflowing in their complex native medium and the extraction/analysis of derived protein. This is an ambitious objective which implies that each step, taken individually, must be highly efficient and compatible with the upstream or downstream one. This project benefiates, however, from encouraging preliminary results obtained by the French and Indian partners.

### Principal Collaborators



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### Publications

- No. of publications in SCI journals : Nil
- No. of papers presented in conferences: Nil

### Mobility Support

- India to France: Nil
- France to India: Nil

# France-India Group for High Technology Equipments at Colliders

## Background

Following the discovery of the Higgs (H) boson in the year 2012 by the ATLAS and CMS collaborations at the Large Hadron Collider (LHC), the experiments are now focusing on the new physics searches opportunities offered by the LHC and the future high luminosity LHC (HL-LHC). The measurements of the H boson properties in all the main production and decays channels has shown that it resemble the boson expected in the Standard Model (SM) with a minimal scalar sector containing one doublet of complex scalar fields. The existence of at least one physical boson was predicted by the Brout-Englert-Higgs mechanism and incorporated in the SM for electroweak Z and W boson vector boson interactions. The scalar sector in the SM is responsible for the existence of massive particles and is at the origin of the distinction between flavour families. The H boson is expected to regularize the SM interactions, especially in vector boson (VV) scattering, and allows to extend the validity of the theory beyond the TeV scales. The parameters of the fundamental scalar potential of the SM will be tested via the search for Higgs boson pair (HH) production and via VV scattering at HL-LHC. The H boson unfortunately introduces a fundamental instability in the theory because its own mass is not protected by any symmetry. This creates a problem in understanding the hierarchy between the scale of electroweak interactions of O (100 GeV) and the scale of a grand unification O(10<sup>16</sup> GeV) or of quantum gravity at the Planck scale O(10<sup>19</sup> GeV). The HL-LHC ultimately allow to better explore the sensitivity to new physics beyond the standard model in connection with possible extension of the scalar sector and the existence of new particles necessary stabilize the scalar sector and solve the hierarchy problem. The HH production and VV scattering measurements at HL-LHC have sensitivity to many new physics models.

Ongoing Project

Sep. 2020 to Aug. 2023

## Objectives

The HH production as well as the VV scattering are rare processes that will greatly profit from the increase of luminosity expected at the LHC and the HL-LHC. The next three years are absolutely crucial to understand the capability of the actual CMS experiment at the LHC and of the upgraded experiment at HL-LHC. The research and developments concerning a new high granularity calorimeter (HGCAL) for electron and photon measurements, energy flow and timing measurements for the forward (large rapidity) regions in CMS are expected to converge within the next three years. Understanding the sensitivity to new physics in HH production and VV scattering in the actual and future CMS experiments is on the critical path for the CMS experiment. With this French-Indian FIGHTEC project, PIs intend to contribute to the performance studies for HGCAL in test beam before the final detector production, contribute to the electron clustering and identification for HGCAL in situ, with machine learning techniques for shower analysis, contribute to the legacy analysis for the search of HH production at LHC, and study the impact of very forward reconstruction of electrons with HGCAL on physics in the scalar sector and for VV scattering n searches for physics beyond the standard model of particle physics

## Knowledge Generated/Products Developed

- Measurement of the noise and pedestal for the silicon based highly granular calorimeter prototype with an ASIC having excellent timing capabilities providing a high precision 5D particle radiation detector with position, energy and timing measurements
- Measurement of the response of positrons in the new silicon based highly granular calorimeter prototype with studies of the longitudinal shower profile of positrons in the detector as a specific contribution
- Electrical Characterisation of the silicon pad sensors for macro-parameter studies in the laboratory using a probe station and a probe card with switching matrix

## Principal Collaborators



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# Deep Summarization Evaluation

## Ongoing Project

Jan. 2020 to Jul. 2023

### Objectives

- To build extractive and abstractive summarization methods
- To evaluate the summarization system PIs will use traditional evaluation metrics
- To build textual entailment/ semantic text similarity approaches based on deep learning methods
- To evaluate the summarization system by our text entailment/semantic text similarity approaches

### Knowledge Generated/Products Developed

- A Deep Neural Network based abstractive summarization method is developed
- A textual similarity based automatic summary evaluation method is developed to assess the quality of the summary text
- Text Summary generation approaches have been designed on various datasets
- Along with the text summary generation, a knowledge graph representation module is added to highlight the key concept of the generated summary
- Highlights the most frequent word to depict the background of the input text
- Participated in Manthan 2021 - organized by the Government of India - under INTL-NLP-11 - Abstraction-based text summarization track - Selected as up to final round for system demonstration in the task of abstractive text summarization, Link: <https://manthan.mic.gov.in/>

### Principal Collaborators



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Marseille

### Publications

- No. of publications in SCI journals : 1
- No. of papers presented in conferences: 4

### Background

Automatic summarization is one of the most difficult tasks in Natural Language Processing as it requires a comprehensive understanding of input documents, identification of relevant content, and generation of a synthetic perspective of the document, often subject to a length constraint. Yet, this task is very important in the context of the deluge of varying quality information our generation has to tackle. Even with recent advances in the field, building reliable automatic summarization systems remains a challenge, due to the variety of ways to express important concepts using language. Building better summarization systems requires progress in summarization evaluation metrics, which are used to assess the quality of the summaries they produce. There are two current trends to summarization evaluation: manual and automatic evaluation. Manual evaluation consists in ranking summaries or parts of summaries according to a set of factors such as faithfulness to the original, linguistic fluency. Automatic evaluation focuses more on comparing the system production to a set of human-authored summaries deemed a gold standard. Manual evaluation is more accurate but much more costly than automatic evaluation, and it is often not actionable in a machine learning environment (systems require rapid and repeated evaluation of their output in order to learn how to summarize). Current methods for automatic evaluation fail because they involve a too candid representation of meaning (through word n-grams for ROUGE, for example), a problem which has been identified as a major hurdle for the advancement of the field. This project proposes to tackle automatic evaluation of summaries by tracking how systems select and present information independent of their meaning representations. In order to do so, PIs plan on leveraging and extending advances in machine reading, representation learning and textual entailment, in the context of summarization.

# Design Automation for Intelligent Vision Hardware in Cyber

## Background

The project is focused on the design and development of artificial intelligence based embedded vision architectures for cyber physical systems (CPS). Embedded vision architectures for cyber physical systems (CPS), sometimes referred to as “Visual IoT”, are challenging to design because of primary constraints of compute resources, energy and power management [2]. Embedded vision nodes in CPS, when designed with the application of Artificial Intelligence principles and algorithms, will turn into intelligent nodes (self-learning devices) capable of performing computation and inference at the node resulting in node-level cognition. This would allow only necessary and relevant post processed data to be sent to a human or a computer-based analyst for further processing and refinement in results. However, design and development of such nodes is non-trivial. Many existing computer vision algorithms, typically ported to embedded platforms, are compute and memory intensive thus limiting the operational time when ported to battery powered devices. In addition, transmission of captured visual data, with minimal processing at the node to extract actionable insights poses increased demands on computational, communication and energy requirements.

Visual saliency i.e. extraction of key features or regions of interest in images or videos captured by an embedded vision node and related post processing for inference using AI techniques is an interesting and challenging research direction. The primary reason being that such an approach is expected to cover a wider range of application specific scenarios than statically determined approaches specific to each scenario involving remote off-loading of compute or scenario specific data on servers.

Apart from a general approach to visual saliency in nodes using AI based methods (machine and deep learning methods), another principal goal of the proposed project is also to examine and propose methods that allow rapid deployment of AI techniques in these nodes. Many AI techniques are data driven and for a node to adapt from one environment or application specific scenario to another, rapid deployment of AI techniques over the air (OTA) would be an interesting and challenging research direction

Ongoing Project

Nov. 2019 to Mar. 2023

## Objectives

- Automated analysis of machine learning (ML) and deep learning (DL) based (i.e. AI based) vision algorithms for their computational complexity from the perspective of hardware implementation
- Design Space Exploration of ML/DL based vision algorithms with respect to energy and power consumption by examining bitwidth optimization and number system selection
- Automated Design Flow: Vision Algorithm to Architecture with focus on hardware assisted acceleration using Field Programmable Gate Array (FPGA) and FPGA-Systems on Chip
- Immediate goal is to release an open source library based on the work done in this project

## Knowledge Generated/Products Developed

- The project team has developed a novel exponent sharing method for representing weights in neural network based ML/DL algorithms using IEEE floating point which results in model compression, thus paving the path for implementation on embedded devices
- The approach used in (1) along with further enhancements has been extended to feature maps in neural network based ML/DL algorithms. The aim is to examine model compression during both training, testing and inference by compression of weights and feature maps. Experimental results for compression during training and testing are promising. This would help in reducing memory requirements for training phase as well
- The project team has incorporated the optimization method in (2) in the tool N2D2 from CEA LETI, France- thus enabling an end to end design flow. It is currently under integration in Tensorflow Lite and PyTorch by the project team

## Principal Collaborators



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Goa



**Olivier Senteys**

INRIA and University Rennes 1  
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Rennes

## Publications

- No. of publications in SCI journals : Nil
- No. of papers presented in conferences: 2

## Mobility Support

- India to France: Nil
- France to India: Nil

# Data Collection for Smart Crop Management

## New Project

Mar. 2021 to Feb. 2024

## Objectives

- Beyond DC4SCM, our goal is to investigate the use of reinforcement learning to make recommendation of practices to farmers

## Knowledge Generated/Products Developed

- The data collection platform is developed for smart crop management i.e. maize in wet season followed by wheat and maize in dry season. The platform captures data on
  - a. Climate information
  - b. Irrigation
  - c. Crop development
  - d. Land information
  - e. Crop health
  - f. Sowing
  - g. Fertilization
  - h. Tillage
  - I. Harvest
  - j. Weeds management
  - k. Weeds observation
  - l. Wildlife presence and absence

## Background

A project on “Data Collection for Smart Crop Management (DC4SCM)” in the category of Artificial Intelligence (Reinforcement Learning, RL) is jointly implemented by Bihar Agricultural University (BAU), Sabour and Institut National de Recherche en Informatique et en Automatique (Inria), France. The BAU received the fund from the Department of Science and Technology (DST), India under the Indo-French Programme in Information and Communication Science & Technology (ICST) Targeted Programme of CEFIPRA. This collaboration is the first one with Inria SequeL, Inria FUN, and BAU Sabour. This joint project is coherent with each individual research direction. Sequential decision-making methods for sustainable development are one of the new research directions of the Inria SequeL team. Inria FUN team is currently working with agricultural sensors for smart data acquisition and transmission with limited network access, in developed country contexts. BAU is working at enhancing smallholder decision-making thanks to Artificial Intelligence and technological opportunities, such as field sensors. Those teams naturally combined their expertise in this project. Reinforcement Learning (RL), a field of Machine Learning, is an ensemble of methods based on the problem of an agent. To date, RL has been poorly applied for crop-management decision-support a new context appeared: increasing computational power, new tools for practitioners and a new data context.

In DC4SCM, RL for crop management is envisioned in a continual learning setting, learning from farmers' own experiences. Such a setup requires real-world data in order to train an RL agent as a proof-of-concept of this approach. Beyond DC4SCM, our goal is to investigate the use of reinforcement learning to make recommendations of practices to farmers. To reach this goal, PIs need relevant data: DC4SCM is precisely about investigating the features that are relevant and may actually be collected in situ: in a nutshell, what is an ideal, yet within reach, dataset for our longer-term goal?. Hence, selection of sensors; calibration and test, setting the network of sensors; investigation of the best multihop routing protocols and set-up of the data server are envisioned and some of the aforesaid contexts are posited. Rest is yet to action due to insufficient funds.

This project is working of two major crops viz. wheat and maize (wet and dry seasons) of Bihar.

## Principal Collaborators



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Bihar Agricultural University,  
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India



**Philippe PREUX**  
Sequel, Inria Lille,  
Université de Lille,  
France

## Publications

- No. of publications in SCI journals : Nil
- No. of papers presented in conferences: 1

## Mobility Support

- India to France: Nil
- France to India: Nil

## Sequential Motor Skills: A Dual System View

### Background

**From IIIT Hyderabad:** PIs made reasonable progress, considering that most of the intervening period from March 2021 till now has been the pandemic period. They had an online meeting between the French and Indian counterparts. The Indian PIs had couple of online meetings to exchange progress and ideas. There are three lines PIs worked on during this period. One is to submit a paper to the Journal of Neurobiology of Learning and Memory, jointly with the French scientists on a dual system model for representation of timing and magnitude information in the Basal Ganglia and related brain areas (details below). Review comments have been addressed and the manuscript has been resubmitted. Secondly, PIs communicated a conference paper to World Congress on Computational Intelligence (WCCI) which proposes a Deep RL based model for a perception task called dot motion task (details below). Combination of RL and drift diffusion model (DDM) was used to model human skill learning data and the results look promising. PIs would be communicating these results to a conference shortly.

**From IIT Madras:** Since the aim of the project is to model sequential motor functions, they have developed a model of basal ganglia capable of modelling sequential tasks. This was done by adding Flip-flop neurons as memory elements to the striatum part of the model. The model was applied to simulate a set of 4 sequential paradigms the data for which was received from a lab in University of California, San Diego. A shorter version of the work was presented at Bernstein Conference on Computational Neuroscience. The work is written up and the manuscript is ready for submission. The developed model is current being applied to other standard sequence processing tasks and working memory tasks used to evaluate basal ganglia function. Another line of work that PIs are pursuing is to modelling sequence processing using networks of neural oscillators. Our first work in this area, which shows how sequential inputs can be stored and retrieved in a network of neural oscillators, was published last year. Another paper that generalizes it to a “deep network” version is being written up.

One of the aims of the project is to combine the oscillatory elements from the second line of work to the basal ganglia model. Such an expanded model of the basal ganglia would be suitable to model timing functions of the basal ganglia. There have been proposals in the past (the striatal beat frequency model of (Buhusi and Meck 2005)) that oscillations in the striatum play a key role in the timing functions of the basal ganglia.

New Project

Mar. 2021 to Mar. 2024

### Objectives

The primary objective is to investigate when and how the brain switches from a flexible action selection system to a more static (habitual) one in the context of sequential tasks like skill learning, etc. Similarly, in the AI/ML domains, it is important to investigate how to combine pure reward-based learning with schemes that learn based on the model of environment and be able to switch between these depending on the learning context. The biological models incorporate the Basal Ganglia (BG), the prefrontal/frontal cortex (PFC/FC) and the Hippocampus (HC) and their interconnections. In the ML models, model-based and model-free reinforcement learning (RL) models would be integrated in a dual system framework

### Knowledge Generated/Products Developed

- Submitted a revised manuscript on the timing and magnitude aspects of RL to the Journal of Neurobiology of Learning and Memory
- Submitted a conference paper to the World Congress on Computational Intelligence (WCCI) on Deep RL model for Dot Motion Task
- Successfully modelled human skill learning data using RLDDM
- Presented a poster at Bernstein Conference: Vignayanandam R. Muddapu, Pragathi P. Balasubramani, Jyoti Mishra, Dhakshin S. Ramanathan & V. Srinivasa Chakravarthy, A Generalized Reinforcement Learning-Based Deep Neural Network Model for Diverse Cognitive Constructs, Bernstein Conference (virtual) 2020.
- Published a journal paper in Frontiers in Computational Neuroscience: Dipayan Biswas, Sooryakiran Pallikkulath, and V. Srinivasa Chakravarthy. "A Complex-valued Oscillatory Neural Network for Storage and Retrieval of Multidimensional Aperiodic Signals." *Frontiers in Computational Neuroscience*, 2021. doi: 10.3389/fncom.2021.551111

### Principal Collaborators



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### Publications

- No. of publications in SCI journals : 1
- No. of papers presented in conferences: 1

### Mobility Support

- India to France: Nil
- France to India: Nil



## 6. Analysis of Scientific Activities

The Indo-French Centre for the Promotion of Advanced Research (IFCPAR) or Centre Franco-Indien Pour la Promotion de la Recherche Avancée (CEFIPRA) is a model for bilateral cooperation in Science and Technology. As a Single window for scientific community from both the countries for application of R& D grants its permits greater visibility easier monitoring and control and avoids multiplicity of bureaucracy. Thus, CEFIPRA has proven to promote/facilitate/accelerate scientific cooperation between two countries by reducing bureaucratic hurdles.

The Centre in its 33 years of existence has supported 564+ projects academia-academia under CSRP and other activities 40+ Industrial projects through various programmes, 170+ Seminars/ Workshops, More than 165+Indian and 80+ French institutions are linked on both sides via joint projects, 3000+ Publications, 3390+ Manpower trained including 1100 PhDs and Post Docs & more than 3650 visits of scientists/ students/ researchers from both sides were organized. There are a large number of institutions/universities having adequate infrastructure facilities, experienced researchers and capabilities which have not participated in CEFIPRA programs which can be either due to lack of awareness/publicising of CEFIPRA or lack of confidence in participation in collaborative programs.

## Core Programmes

The programmes which are funded by the Centre are Core Programme like Collaborative Scientific Research Programme (CSRP), Industry-Academia Research & Development Programme (IARDP) and Seminar etc. whereas for Non-Core Programmes, National Funding agencies for research & development in India and France are coming together.

In search of excellence in Science Technology & Innovation collaboration, CEFIPRA has devised a mechanism of highly competitive project formulation criteria. This institutional mechanism ensures involvement of researchers of both the countries and addresses scientific problems which are of current relevance and importance. The CSRP thematic call in the areas interface of basic sciences with sustainable sciences launched in following areas1.Host-Microbe interactions in Health, Water & Agriculture; 2. Habitability of the Earth & Planets; 3. Marine Biology and Ecology & 4. Chemical & Synthetic Biology with a deadline of 15 January, 2021.

During the reporting year, the final selection/approval of projects is done by the Scientific Council (SC) and the Industrial Research Committee (IRC) of CEFIPRA in a time bound manner in May, 2020 via virtual meeting platform. However, for the November, 2020 cycle the SC and IRC dates were shifted due to pandemic and reviews of new proposals did not happen as scheduled and planned. In addition, the ongoing projects could not be reviewed midway and final review is done for completed projects.

CEFIPRA's Industry-Academia Research & Development Programme (IARDP) for promoting linkages between Industry and Academia from France as well as India by enhancing the competitiveness of the industrial partners. This programme is monitored by the Industrial Research Committee (IRC). However, during the year it was emphasized that the Industry-academia programme of CEFIPRA was unable to commercialize the research output. To address these gaps, it was suggested to renew models of industry-academia programmes. Some of the projects completed under the IARDP have also been successful in terms of novel processes and increase in technology readiness level, along with enhancement of industrial capacity.

## Collaborative Scientific Research Programme

In the year 2020-21, despite disruptions due to pandemic the 65<sup>th</sup> meeting of the Scientific Council (SC) was held on 27 May, 2020 through virtual platform wherein, a total of 37 proposals were considered for evaluation (23 from thematic areas and 14 from general areas). The Scientific Council recommended 10 proposals (9 from call under various thematic and general areas and one deferred from 64th SC meeting) for support.

To encourage advanced research in interdisciplinary areas SC recommends 6 -new projects (1 each in area of AI & Big Data, Science for Sustainability) 2 each in area of Quantum Materials& Addressing Biological Questions Using or Developing Mathematical, Computational or Physical Approaches.) and 4 From General Areas, one project each in area of Life and Health Science, Materials Science, Environmental Science and Earth & Planetary domains under the Collaborative Scientific Research Programme (CSRP) of CEFIPRA. Whereas, fifty nine projects were ongoing from the previous years, out of which were completed during the period.

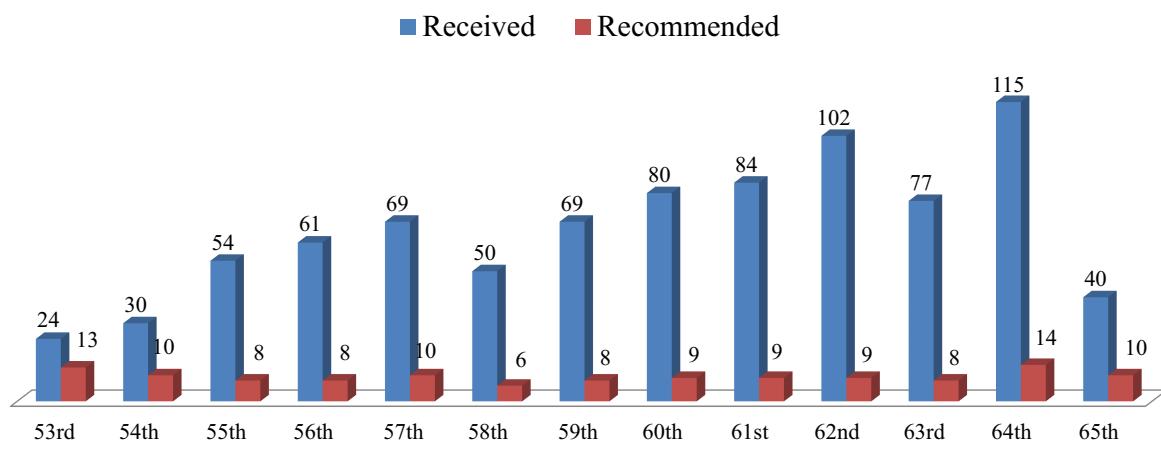
As an outcome, the completed and ongoing projects during the period has connected more than ~200 industries & institutions through 44 project consortiums comprising research institutions, academia & industries in 15 + thematic areas. CEFIPRA has also supported -- workshops which have resulted in networking close to 4000+ scientists, industry personnel and early career researchers.

It was observed that over the past few years various programmes/fellowships/workshops which were launched/conducted by CEFIPRA have witnessed a dominant presence of limited institutions/universities of India. There are a large number of institutions/universities having adequate infrastructure facilities, experienced researchers and capabilities which have not participated in CEFIPRA programs which can be either due to lack of awareness/publicising of CEFIPRA or lack of confidence in participation in collaborative programs. CEFIPRA was directed to enhance its visibility.

During the year 2020-21, two Calls for Proposals were initiated by CEFIPRA - General Call in July, in response to which the Centre received 78 project proposals; and the thematic call of January 2021, which yielded 19 innovative project proposals.

The 65<sup>th</sup> meeting of the Scientific Council (SC) was held on 27 May, 2020 through a virtual platform. After initial screening at CEFIPRA, the SC considered 37 proposals, 23 from thematic areas [AI & Big Data (9), Science for Sustainability (3), Quantum Materials (5), Addressing Biological Questions Using or Developing Mathematical, Computational or Physical Approaches (6)], 14 from general areas [Computational Science (1), Life and Health Sciences (1), Pure and Applied Physics (1), Pure and Applied Chemistry(2), Earth and Planetary Sciences (2), Materials Science (6) and Environmental Science (1)]. The discipline wise distribution of the proposals.

## Proposals received and recommended during last 7 years by Scientific Council



For the 15<sup>th</sup> July, 2020 Deadline; 78 proposals received in General Areas

Figure 1: Proposals received and recommended during last 7 years by SC

## Area-wise Distribution of Proposals Considered by 65<sup>th</sup> SC (37)

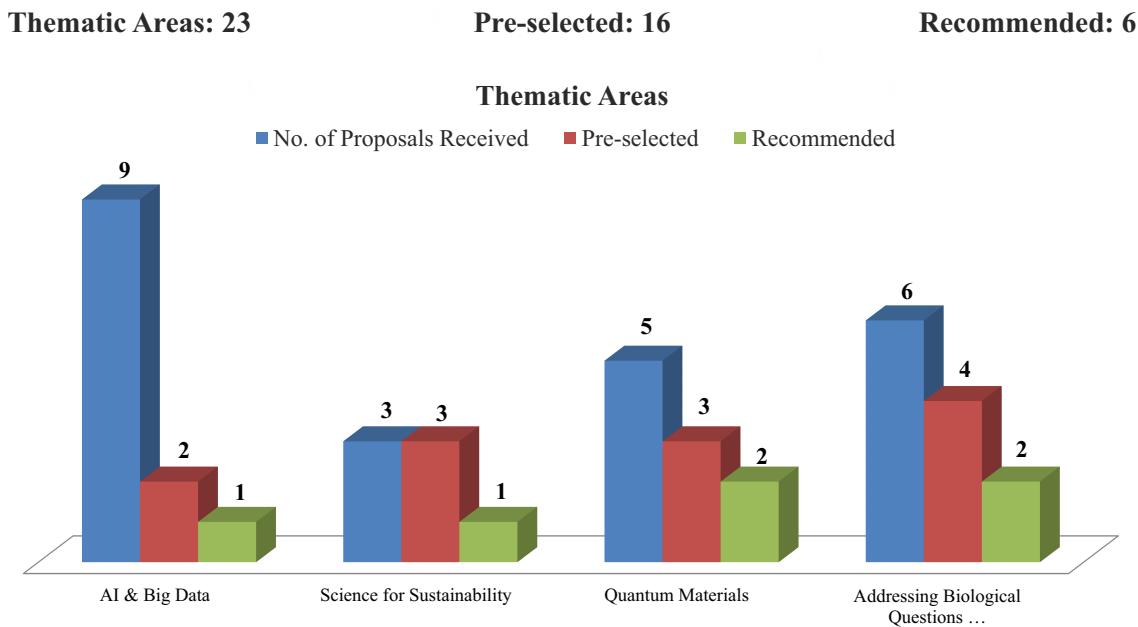
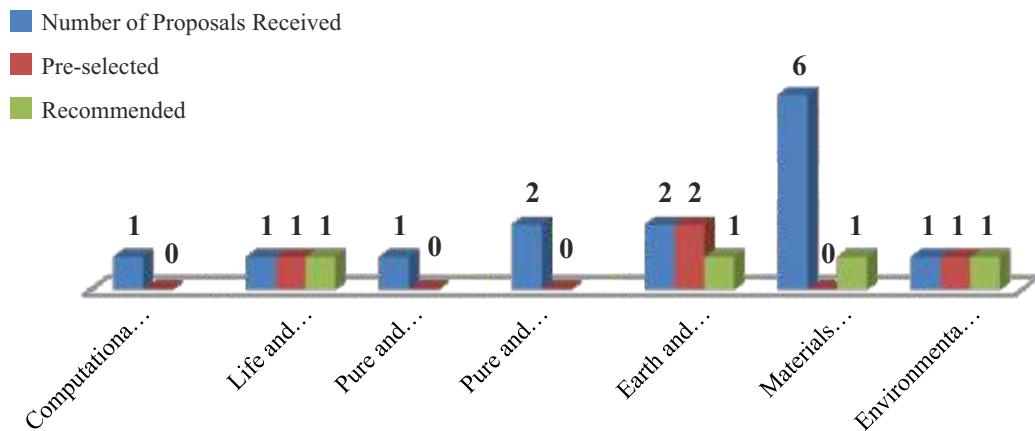
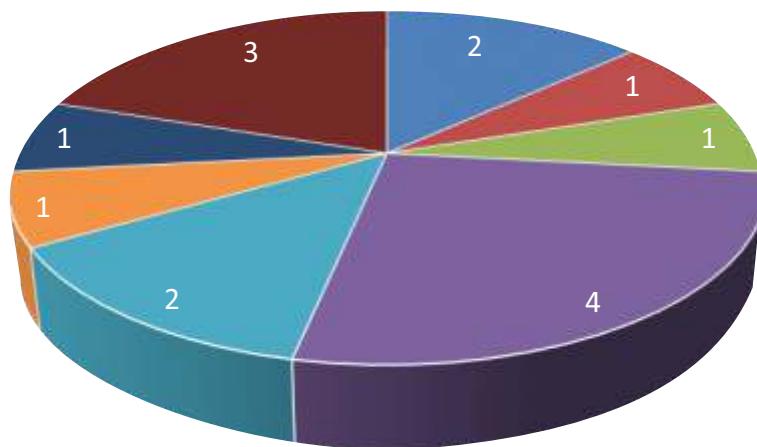


Figure 2: Area-wise Distribution of Proposals Considered by 65<sup>th</sup> SC under Thematic Call

### Area-wise distribution of proposals consider by SC General Areas

Figure 3: Area-wise distribution of proposals consider by 65<sup>th</sup> SC under General Areas Call

### New project intiatited area wise distribution



- Biological chemistry (chemistry for unravelling the biological process)
- Computer Science
- Earth and Planetary Sciences
- Life and Health Sciences
- Material Sciences
- Pure and Applied Chemistry

**Total = 15**

Figure 4: New project intiatited area wise distribution

### New Projects Commenced:

Project proposals undergo a system of intensive peer review by experts in India and France before being considered by the council. The Council evaluated the scientific merit of the proposals on the basis of comments from the referees and discussions amongst the members.



The thrust area-wise distribution of the proposals received and recommended for support during the year 2020-2021 is given in figures 2 and 3. From figures 2, 3, 4 and 5, it is prominent that the area of Life Health Sciences & Pure & Applied Physics continues to have a higher share of the proposals recommended whereas Life Health Sciences have a higher share of the proposals received.

A total of fifteen new projects were initiated during the year 2020-21 and figure 4 depicts the thrust area-wise distribution of projects commenced.

### **Ongoing Projects:**

A total of 57 projects are ongoing under the CSRP as on 31<sup>st</sup> March, 2021. 65<sup>th</sup> Meeting was held virtually. Therefore mid-term evaluations of projects were not able to evaluate the progress of midterm projects. Due to pandemic, and lockdowns various universities and labs were closed. Timelines of ongoing projects were delayed.

Therefore, only a total of 16 ongoing projects PIs had requested CEFIPRA for project extensions. The Council, in a view of prevailing pandemic conditions felt that it was justified to accept all requests for no additional cost extensions.

191 journal papers have been published from the completed projects in several national and international journals of repute.

Area-wise distribution is given at figure 5.

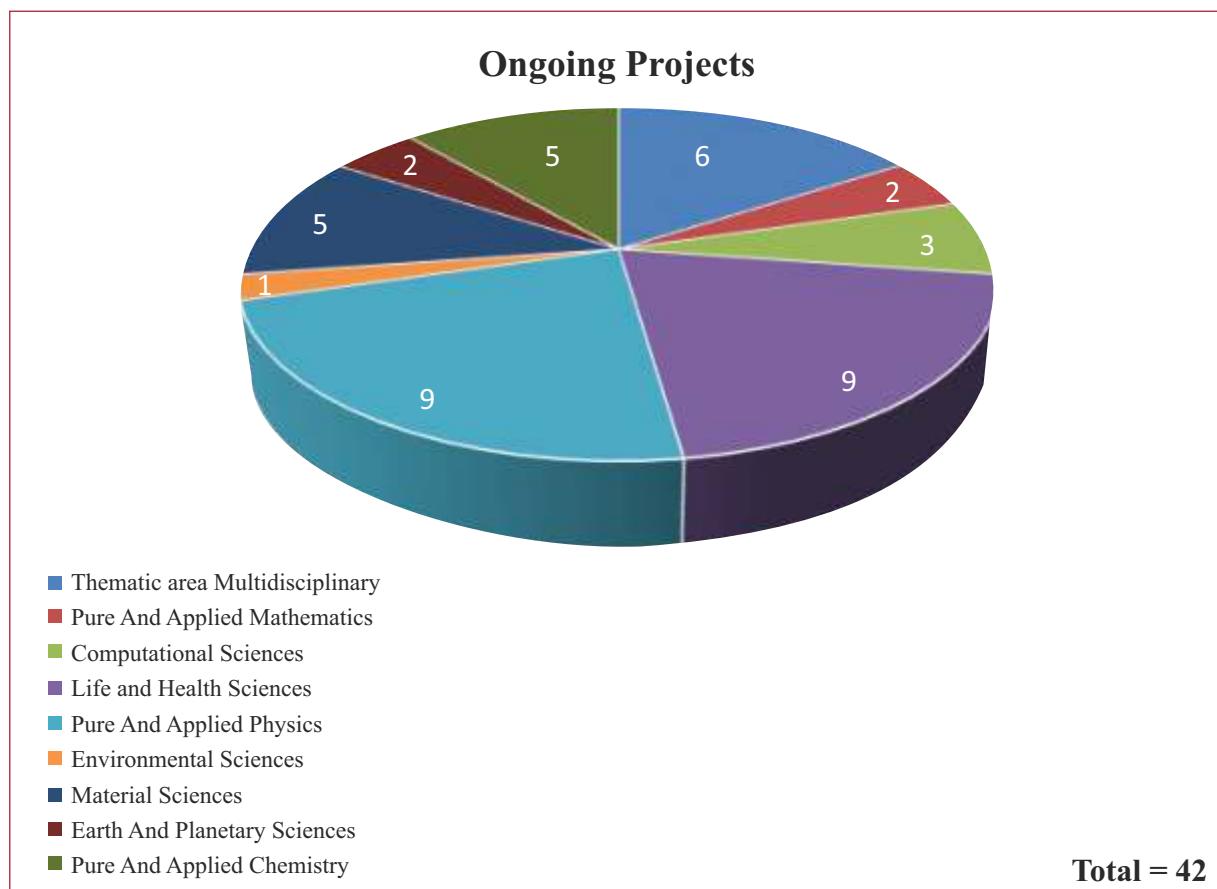


Figure 5: Area-wise Distribution of Ongoing Projects

### Completed Projects:

Nine projects, completed during the reported year, due to COVID-19 and lockdown various research and educational institutes were shut down. The Scientific Council was not able to grade them based on the achievements made vis-à-vis aims and objectives, however the number and quality of publications including joint publications and the scientific excellence of the research outputs were seen during the period. The members felt that it was necessary to have an interaction with PIs of completed projects for awarding a final grade. The area wise distribution is given at figure 6.

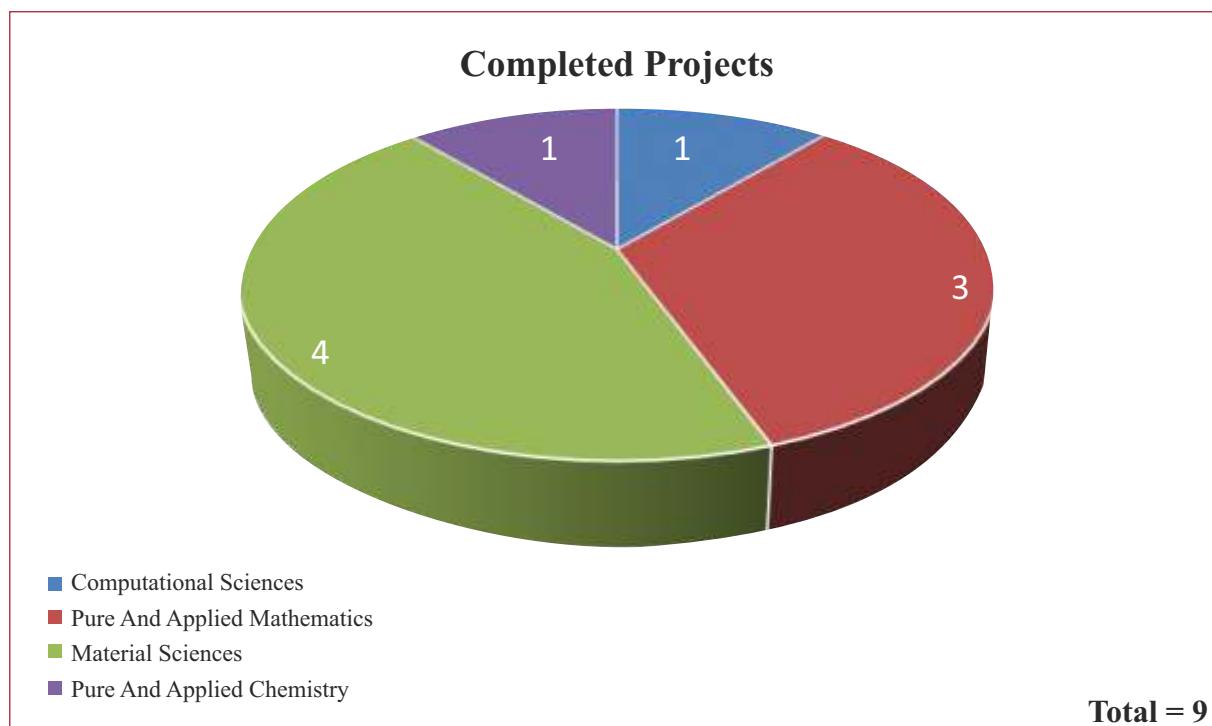


Figure 6: Area-wise Distribution of Completed Projects

The SC reviewed 5 proposals received for holding bilateral seminars/workshops. Based on the evaluation by Members and considering the importance of the topics of the proposed seminars, the SC recommended one proposal titled “French-Indian workshop on Novel Phases of Matter in Frustrated Magnets 2021” for support.

During the period, various seminars/workshops could not be organized due to the lockdown and restrictions on international travel related to the pandemic COVID19. The seminars proposed for holding in 2020 have been postponed to 2021/2022. However, one seminar on “Galactic and Extra Galactic Universe in the era of new generation Radio (SKA and pathfinders) and IR/Optical (MSE) facilities” was held during 22-26 March, 2021 through virtual platform. 116 participants from India and France attended the seminar.

A total of 144 persons as Human Resource Development (84 in India & 60 in France) were supported through training comprising of Doctoral and Post-Doctoral students along with few master students and 61 mobility/ exchange visits (34 from India to France and 27 from France to India) were supported (Figure 7) under 09 completed projects and 42 Ongoing Projects.

Centre facilitates exchange visits for researchers in one platform facilitation towards visa support, ticketing etc under joint projects funded by the Centre. It enhances the prospects for the scientists of our country to enter into the international scientific fold. However, due to pandemic restrictions in travel, mobility among the scientists and students were drastically reduced.

## ANALYSIS OF SCIENTIFIC ACTIVITIES

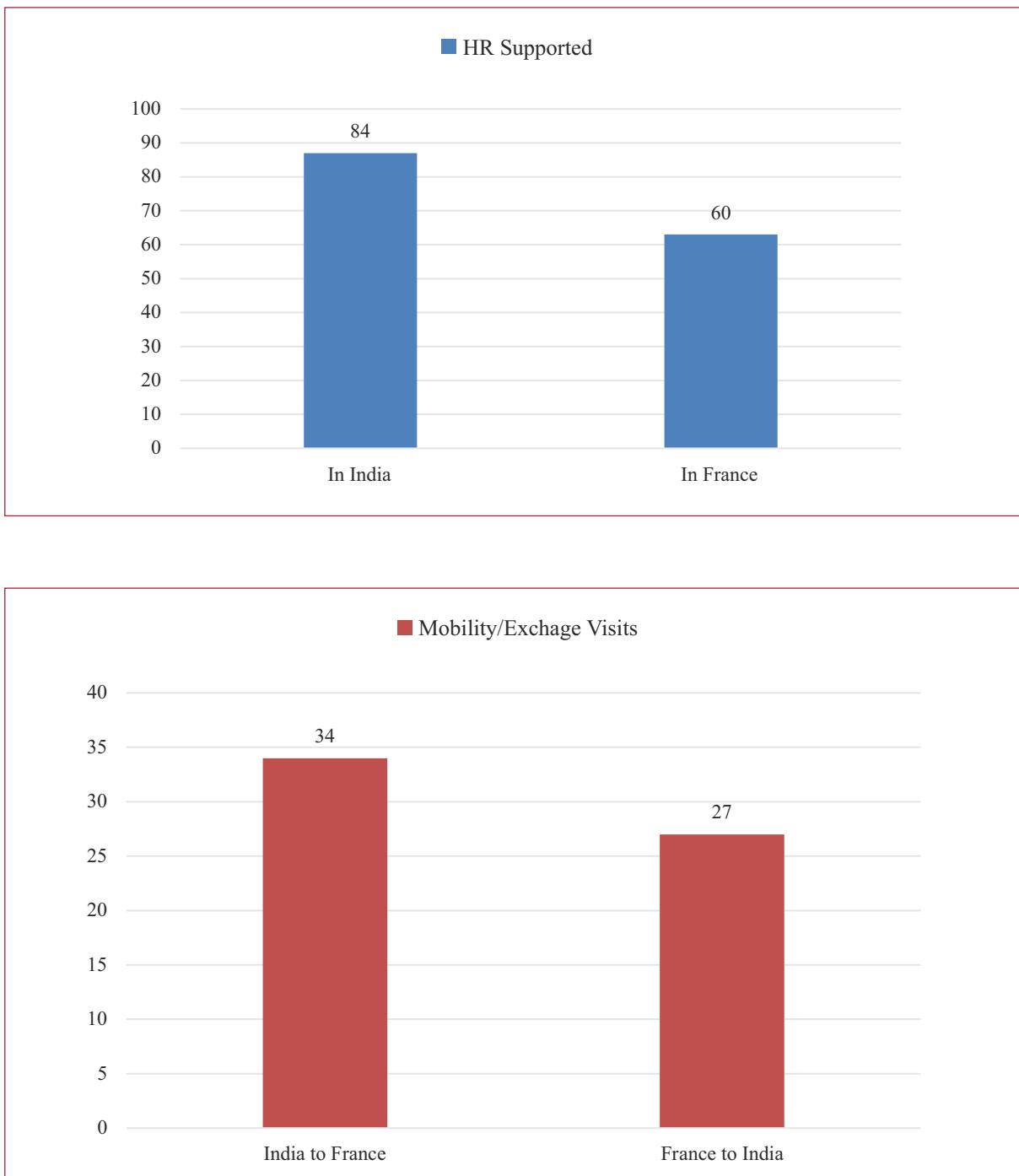


Figure 7: Outcomes in terms Exchange Visits and HR supported under completed projects.

Another important decision by the scientific council of CEFIPRA has been to ensure that each project supported by CEFIPRA has allocation for doctoral and post-doctoral positions in the relevant fields. The importance attached to human resource development through the programmes of the Centre has been a central tenant of its involvement.

## Publications (191) emanated from projects during 2020

During the year 2020, 191 papers were published in 77 CEFIPRA implemented projects as reported. CEFIPRA projects are supported across 12 subject areas/domains of science and technology. The “Pure and Applied Physics” domain that has 27 projects contributed the maximum number of 75 papers (39.27 %) followed by “Life and Health Sciences” with 38 papers and “Pure and Applied Chemistry” with 22 papers. A look at the average Impact Factors of these subject areas reveals that the “Pure and Applied Chemistry” area has the highest average Impact Factor of 7.807.

The joint publications and outcomes emerging from the projects supported by CEFIPRA under the CSRP cover major thrust areas and highlight the research achievements of Scientists/Researchers of the two countries. The Bibliometric Analysis which was conducted periodically shows that publications have resulted from the collaborative projects implemented under CSRP receiving a high number of citations qualitative scientific output. This clearly shows impactful research. CEFIPRA’s programme has also contributed towards skill development among young researchers.

CEFIPRA is actively involved in supporting the Indo-French Science, Technology & Innovation (ST&I) system through its various activities. The publications that have been obtained from the Scientific Collaborative Research Programme of CEFIPRA focus on academia-to-academia collaborations between Indian and French academic collaborators in various domains. The number of papers emanating from a project depends on several factors such as the nature of project, subject area of project, number of scientists and researchers working in the project, number of collaborators in the project and so on. The CEFIPRA supported projects have resulted in 191 publications during the year 2020. During the year 2020, 191 papers were published from 77 projects of CEFIPRA. It is seen that on an average, 2.48 research papers resulted from each of the 77 CEFIPRA projects.

Ongoing Project, “*Modelling and observing pulsars: from high energy to radio emission*” (Project code 5904-1) produced the maximum number of 12 papers. There are 20 projects that have produced four or more papers during 2020. Further, it is seen that nearly 70.16% of the papers were published from 28 projects. As a result of this collaboration, sixty nine out of 191 research papers (36.12%) are from 77 CEFIPRA Projects.

The open access movement is gathering momentum all over the world with more and more papers published in the open access domain, including open access journals and as APC based open access articles. It is seen that 135 CEFIPRA papers was published in open access mode during the year 2020.

## ANALYSIS OF SCIENTIFIC ACTIVITIES

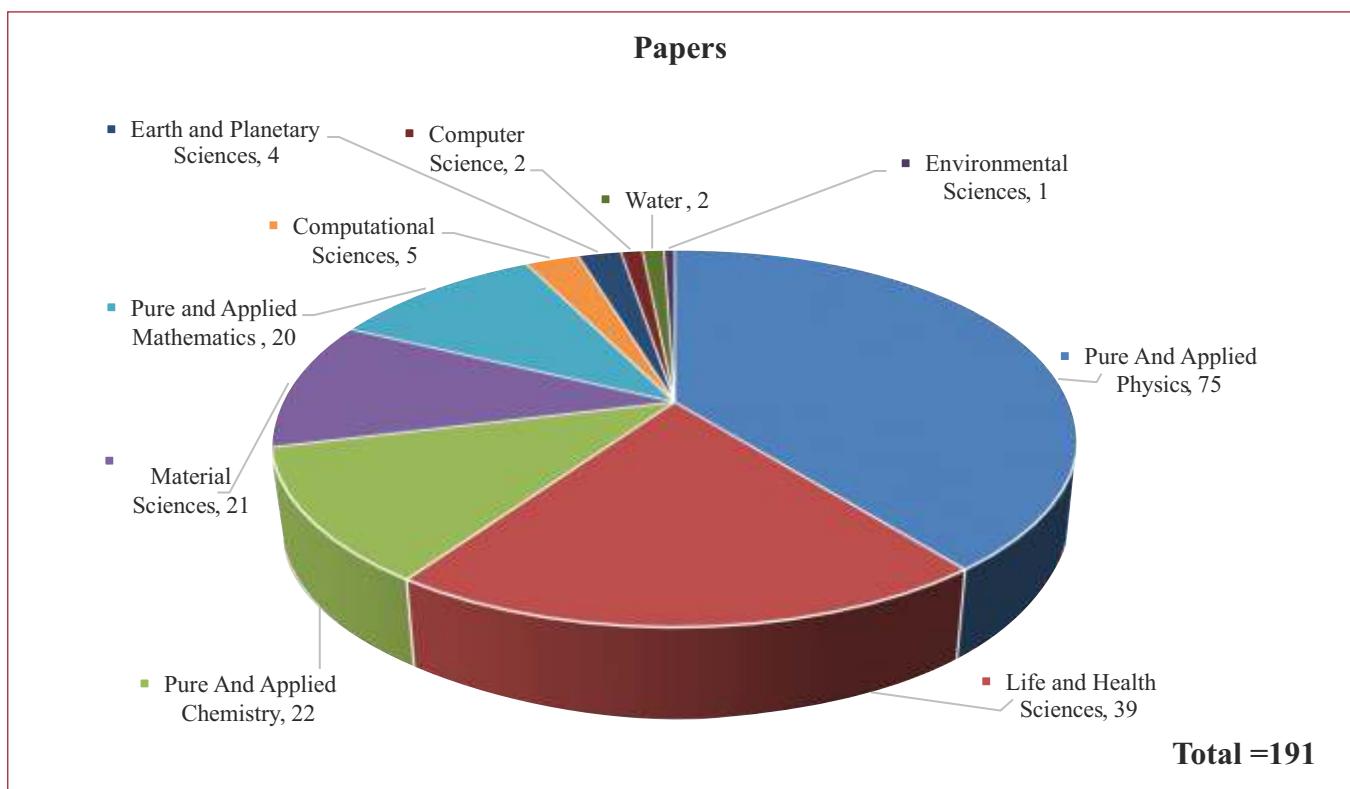


Figure 9: Thrust Area-wise Number of Publications Emanated from CSRP Projects

Number of papers based on domain/subject areas			
S. No.	Domain	No. of Projects	Papers
1	Pure And Applied Physics	27	75
2	Life and Health Sciences	15	38
3	Pure And Applied Chemistry	10	22
4	Material Sciences	10	21
5	Pure and Applied Mathematics	4	20
6	Computational Sciences	4	7
7	Earth and Planetary Sciences	3	4
8	Water	2	2
9	Environmental Sciences	1	1
10	Biotechnology	1	1
	<b>Total</b>	<b>77</b>	<b>191</b>

<b>Average Impact Factor based on domain/subject areas</b>				
<b>S. No.</b>	<b>Domain</b>	<b>No. of Projects</b>	<b>Papers</b>	<b>Avg-IF</b>
1	Pure And Applied Chemistry	10	22	7.807
2	Life and Health Sciences	15	38	6.713
3	Material Sciences	9	20	5.779
4	Pure And Applied Physics	27	75	5.017
5	Earth and Planetary Sciences	3	4	4.716
6	Environmental Sciences	1	1	3.663
7	Water	2	2	2.963
8	Computational Sciences	4	7	1.460
9	Pure and Applied Mathematics	4	20	1.436
10	Biotechnology	1	1	0

**No. of patents/new patents etc under CSRP****5105-2**

Patent filed "Non-canonical dithiol-based amino acid comprising at least one 2,3-/3,4-dimercaptopehnylalanines, method of synthesis and incorporation into peptides" Ref/patent Application No. 201931030030 (1/31715/2019-KOL).

**5303-2**

2 In progress: 'Title: Biocompatible phosphorus dendrimers in nanomedicine. Antitubercular/ antibacterial activities. Two patents have been completed: First dedicated to the development of anti-TB dendrimers, and the second in the oncology domain.

**5702-1**

1. V. S. Khandkar and M. K. Hanawal: Masking Host Identity on Internet: Encrypted TLS/SSL Handshake. Indian patent filed on 21st December 2020. Application no. 202021055538.
2. V. S. Khandkar and M. K. Hanawal: FairNet : Measurement setup for Detection Net neutrality Violations. Provisional Indian Patent filed on 6<sup>th</sup> November 2020. Application no. 202021048922.

### Significant Process Developed and it's Potential for Knowledge Forward Chain under Projects reported this year

#### Pure and Applied Physics

##### **Project No 5404-1**

Discovered universal dissociation mechanism for trapped alkali molecular ions, Demonstration of cold atoms lasing into cavity mode; New cooling mechanism for trapped ions has been demonstrated etc. The project is blue sky science and details of the Li-Li<sup>+</sup> calculations done both at RRI and LAC have in their own right been outstanding. However, there is no real product, beyond the human resource and technical exchange generated.

##### **Project No 5404-2**

Trained manpower generation was an important motto of this project. Huge developments in the theoretical front have taken place about the underlying layers of Nature which have not been experimentally revealed so far due to limitation in accelerator energy. The advancements took place in both conceptual and computational fronts, which would help experimentalists march into unexplored territory for verification of many predictions. The students and postdocs involved in this project got world class training in these aspects. The knowledge gathered in the process would add to important developments in Particle Physics and Cosmology.

##### **Project No 5504-1**

Construction of the wavelet graph:

- Mathematical graph based on the time-frequency-scale evolution plus matching pursuit algorithm. The analysis algorithm has been implemented, integrated to the source code of Coherent WaveBurst, and is freely available online
  - Wavegraph – <https://github.com/ecm0/wavegraph>
  - Coherent Waveburst – Wavegraph module  
<https://gitlab.com/gwburst/public/library/tree/public/tools/wavegraph>
- See also: <https://zenodo.org/record/3731701#.XocFZKaxVf4> – DOI:10.5281/zenodo.373170

##### **Project No 5604-1**

- Frontier research problems on modelling mechanical properties of amorphous solids. Developed a novel framework via coupling of mesoscale and microscopic models.
- Coarse-grained measurements from micro simulations → inputs for meso-model: coherent matching of response across micro and meso models.
- Analysing history-dependence of creep response. Mesomodel provides insight into residual stress formation via newly activated sites during stress relaxation following switch-off.

##### **Project No 5704-1**

Yielding in amorphous solids under cyclic shear deformation using extensive computer simulations. The achievements are of fundamental nature and add a lot of new information on the yielding transition, a subject that recently attracted a lot of attention.

##### **Project No 5804-1**

Discovery by Astro-Sat published in Nature Astronomy journal emanated from CEFIPRA supported project No. - 5804-1(<https://doi.org/10.1038/s41550-020-1173-5.>) from Kanak Saha et al.

**Project No 5804-2**

Development of a  $\mu$ -SQUID magnetometry setup at IIT -K with 1.3 Kelvin base temperature and up to 1 Tesla vector magnetic fields. This setup will be used to study different individual nano-magnetic particles and structures. We are working to further improve the noise figure by using magnetic and electromagnetic shielding so as to study non-ferromagnetic nano-particles.

**Project No 5804-3**

Developed a HI transport code with a mean-field treatment (meta-modeling) that can interpolate between EoS models. 2) Demonstrated the mass and charge of the evaporation residue in intermediate energy Ni+Ni collisions is a sensitive probe of the symmetry energy 3) Introduced the metamodeling in a sub-saturation equilibrium EoS model that fully accounts for the nuclear distribution at finite temperature. Revised the simplified liquiddrop approximation of the canonical multifragmentation model with an improved functional with surface properties optimized on experimental masses 5) Demonstrated, that the fractionation property of the liquidgas phase transition leads to very different isotopic ratios in equilibrium multi fragmentation, with respect to the predictions of the spinodal instability.

**Project No 5904-1**

Developed observational techniques for analysing pulsar data from radio and x-ray telescopes. In particular we developed softwares for analysing the polarization of radio pulsar data which is crucial for our project. Improved several spectral and discontinuous Galerkin codes to simulate force-free and radiative pulsar magnetospheres in 3D. Also developed a particle test code with the aforementioned master/engineer school student to properly address particle acceleration problems around strongly magnetized rotating neutron stars with realistic field strengths which place us at the forefront of particle dynamics in such environments.

**Material Sciences****Project No 5608-2**

Synthesis and crystal growth of known and novel heavy metal-based chalcogenide having zero/narrow band gap at the Fermi level. Successfully prepared Sb doped Bi<sub>2</sub>Te<sub>2</sub>Se single crystals were prepared using the direct reaction technique.

**Project No 5708-1**

Improved Fuel cell electrode-Raman and Transmission Electron Microscopy Studies of Dual Doped and Partially Unzipped Carbon Nanotubes for Energy Conversion Applications-Synthesis & characterization of Pt, Pt alloy NPs dispersed on highly active and stable.

Development of a novel high temperature stable tandem absorber of WAlN/WAlSiN/SiON/SiO<sub>2</sub> on various substrates with very high absorptance and low thermal emittance.

**Project No 5808-1**

Successfully fabricated Si/SiO<sub>2</sub> (native)/Ta (5 nm)/Pt (6 nm)/Co (tCo)/Ta (5 nm) and Si/SiO<sub>2</sub> (100 nm)/Ta (5 nm)/Pt (6 nm)/CoFeB (tCoFeB)/MgO (2 nm)/Ta (3 nm) series of samples in order to achieve perpendicular anisotropy (PMA). They have also stabilized the skyrmions in the thin films.

**Project No 5908-1**

Develop a novel metal carbide, oxide, oxynitride and oxide based spectrally selective high temperature solar absorber coating by sputtering process .

- Achieve coating's high selectivity ( $\alpha > 94\%$ ,  $\epsilon < 15\%$  at 82°C) and thermal stability (600°C in air: cyclic conditions) on superalloy and SS304 substrates-Nanolayered W/WAlSiN/SiON/SiO<sub>2</sub> tandem absorber with  $\alpha = 0.955$  and  $\epsilon = 0.10$  developed on SS304 substrates.
- Complete characterization of the coating carried out to understand its structure, microstructure and chemical composition.
- Ellipsometry data indicated gradient of R.I. along different layers, leading to very high absorption.

## Pure & Applied Chemistry

### Project No 5705-1

Synthesis of ligand and Pd and Ni complexes with pendent Brønsted bases. 2) Discovery of chemoselective C(sp<sub>2</sub>)–H bond sulfonylation.heteroatoms incorporated ionomer coated polymer wrapped CNT/graphene based catalyst support.

### Project No 5805-1

Three new families of modular chiral tridentate ferrocene-based ligands (PSP, PNN and PNP) have been developed. In all cases, the syntheses are efficient and both enantiomers of the ligands can be obtained in an enantiomerically pure form. These families of ligands are new and their reactivity in non-noble metal catalysis is worth to be developed.

### Project No 5905-1

- [BH<sub>3</sub>(SCHS)]<sup>-</sup> ion found to be a suitable precursor for the synthesis of trithia-diborinane and dithioformato metal complexes.[(Cp<sup>\*</sup>Ru){(η<sub>2</sub> SCHS)CH<sub>2</sub>S<sub>2</sub>(BH<sub>2</sub>)<sub>2</sub>} is the first structurally characterized trithia-diborinane complex of ruthenium where the central ring [CB<sub>2</sub>S<sub>3</sub>] adopts a chair confirmation.
- Synthesis of the various borinane complexes of group-8 heavier transition metal (i.e., ruthenium) from a dithioformato stabilized arachnodiruthenium pentaborane cluster was carried out.

## Mathematics & Computational

### Project No 5702-1

- Android and iOS app are developed for detection of net neutrality violations
- An android app developed for net neutrality detection.
- Available online at:<https://play.google.com/store/apps/details?id=com.iitb.fairn.et>

### Project No 5801-1

Study of several fundamental problems at the Interface of ergodic theory, geometry, and number theory were studied and progress was made on several problems involving:

1. Quadratic forms, in and around the famous Oppenheim conjecture.
2. Diophantine approximation, in the p-adic as well as geometric (in negative curvature) aspects.
3. Dynamical Systems concerning the study of their rotation numbers. In our approach an important role is played by the Diophantine properties of the parameters involved in the definition of the PL circle maps.

### Project No 5908-2

Training to know-how on 2D materials and specific techniques developed in IMPMC in France for these materials. He is being trained in clean room techniques and device fabrication. The Indian SPPU group has a strong background in testing of solar cells. The Indian group also has good hands and expertise on control synthesis of various 2D chalcogenide materials using different Physical and chemical methods.

### Project No 5902-1

1. Design of 60 GHz oscillator.
2. Design of sub sampling ADC for space applications.
3. Design of novel Phase Frequency Detector (PFD).
4. Design of an enhanced beam-scanning antenna using metasurface.

**Project No 6002-1**

Achieve Optimal efficiency trade offs for public-key broadcast encryption using bilinear maps and the Learning-With-Errors assumption which is the realization of optimal broadcast encryption schemes from pairings and lattices. The first such construction [AY20] obtained the best paper award at the Eurocrypt 2020 conference (Eurocrypt is one of the top-tier conferences in cryptography and it is highly competitive every year). This result stands out as it solves a problem that was open for many years in the context of broadcast encryption and ABE. Achievement #3 is also very important as it provides the best constructions to date of FE schemes for Turing machines. Recall that FE for Turing machines is very appealing as it avoids the limitations of the circuit model of computation, which requires a predetermined bound on the size of encrypted datasets.

**Project No 5903-1**

Non-autonomous control of animal growth by blood cells in Drosophila. 2. Metabolic control of systemic lipid homeostasis by blood cells. 3. Generation of blood specific driver lines. 4. Differential gene expression profile of blood cells from Drosophila embryo and larvae. 5. Established mass-spectrometric analysis of Drosophila larval blood cells, both circulating and from the lymph gland.

**Project No 5907-1**

Two field trips during dry (March 2019) and wet (August 2019) seasons to sample GW and surface water when available at the three studied locations: Mule Hole (forest), Berambadi (agriculture), Godavari estuary with implementation of monthly monitoring at the latest. (2) Measurements of basic biogeochemical parameters in most of the dry season samples (nutrients, cations and anions) and Bacterial activity in groundwater.

**Industry-Academia Research & Development Programme (IARDP)**

The 36<sup>th</sup> meeting of the Industrial Research Committee (IRC) was held on 29 May, 2020 through videoconferencing. A total of five proposals from various thematic areas [Internet of things (1), Oenology (1), Nutrition (1), Ophthalmology (1) and Affordable healthcare (1)] were evaluated by the expert panel members, out of which following three innovative projects were considered for support: Urinary metabolomics for monitoring Lysine sufficiency in malnourished infants receiving lysine fortified food (SupLys), 3-D binocular motor control in Strabismus before and after surgery(BMCS) Environmentally Benign Routes to Affordable Healthcare (EBRAH).

The thematic areas identified by Industrial Research Committee (IRC) for Seminars/workshops for the year 2020-2021 are Natural products & cosmetics, Nano toxicology and Smart & digital manufacturing.

Following are the salient achievements under some completed project under IARDP.

**PASAT**

“In addition, Knowledge-Product pathway had been catalyzed through two projects completed loop heat pipe for avionics and terrestrial applications, Piezoelectric Actuator Systems for Automotive, etc.

The technologies developed in this project include:

- Proposition of two motor designs based on piezoelectric actuators.
- Geometrical modelling of the necessary mechanical system design for automotive applications.
- Prototype development of the actuation system for two different configurations.
- Experimental analysis of the mechanical actuation system.
- Mathematical modelling and simulation of the piezoelectric actuators and inchworm motor
- Design of three adaptive, non-linear control algorithms for piezoelectric actuators with performance evaluation.

- Prototype development of high frequency amplifier driver circuit to actuate the inchworm motor under different control pulse test cases.
- Experimental analysis of the power electronics based electrical actuation system with car battery.
- Interfacing of Inchworm Motor in real time controller environment along with forward and reverse direction control.

Adaptive Voltage Dither Controller design for Nonlinear Piezoelectric Actuator Based on Spectral Analysis method  
Interfacing of Inchworm Motor in real time environment dspace1202 along with forward and reverse direction control  
Testing the actuation system test under high frequency (2kHz) 2 Patent.

### LOOPHEAT PIPE

Loop heat pipes (LHPs) which are passive thermal management systems that could ensure transport heat from a source to a sink at extremely low thermal resistance. Copper and Nickel wicks have been developed.

Optimization of Nickel wicks is in progress.

Loop heat pipe with Copper wicks has been performance tested. Some design issues due to higher heat leak from the evaporator to the compensating chamber have been identified and are being addressed. This will enhance the performance even further.

LHP at INSA Lyon has been made operational and an adsorber based anti-freezing system (patented by INSA) has been tested by the post doc scholar. This is importance from avionics application point of view.

The project, outcomes industrial capability was build-up for manufacturing specialized LHP wicks as per design guidelines and specifications of the industrial partners (Thales) (nominal power 60 W with maximum power of 100 W, with start-up load of 10 W). Working LHP thermo-mechanical demonstrators with specified high performance flat plate and cylindrical wick structures (both mono-porous and bi-porous; flat and cylindrical designs of copper and nickel) were fabricated and tested. This project explored innovative technologies to realise automotive seat motion based on the use of smart actuators in seating arrangement involving product line seat electronics. Piezoelectric actuation is a promising candidate for such systems but some challenges remain to be unlocked. A main challenge was to design a compact piezo actuator able to provide the required power to slide a standard automotive seat. This was accomplished with the minimum amount of motion transformation from the motor to the seat frame, keeping the cutting edge advantages of piezoelectric actuation devices. Developing the corresponding electrical amplifier driver circuit was also a challenge, as the voltage source available in car is a battery whereas the piezoelectric actuators operate at voltages near hundred volts besides being highly capacitive in nature.

### REDEFINE

Reactive programming and compilation for the REDEFINE manycore is completed in Jan. 21. Following major outcomes were achieved.

- 1) REDEFINE Functional Simulator
- 2) Heptagon language and back-end extension for OpenCL
- 3) Micro-Architectural support for High-Availability of NoC in REDEFINE
- 4) REDEFINE ISA Simulator

## Non-Core Programmes

Under the Non-Core Programmes, CEFIPRA acted as a facilitator for different programmes with Indian national funding agencies like Department of Science and Technology (DST) and Biotechnology Industry Research Assistance Council (BIRAC) with French funding agencies French Institute for Research in Computer Science and Automation (Inria) for collaborative research. During the year, two projects were completed in area of Applied Mathematics and Big Data which has yielded 17 publications and 13 visits from India to France and 10 from France to India.

Moreover, 19 projects are ongoing in the areas of Big Data (1), Cyber Security (1), Internet of Things (2), Distributed and Autonomous Systems (1), Applied Mathematics (1) & Machine Learning (3). Under these ongoing projects, 16 publications have been emanated and 13 visits from India to France and 12 from France to India. Further, 4 new projects have been initiated in Cyber-Physical Systems (2), Big Data (1) & Stochastic Optimization (1).

### DST-Inria-CNRS Programme

#### **Project-Study of Privacy, Accountability and Ownership in IoT**

- New primitive, Private Polynomial Evaluation, and validated the primitive with a formal security model, termed as security against Indistinguishable Chosen-Function Attack
- Proposed protocol makes it possible to hide a polynomial from a user while allowing the user to evaluate his/her data on this polynomial.

#### **Project-Looking Beyond Backpropagation in Deep Learning**

- Accelerate the optimization within single hidden layer neural networks.
- Classifying deep architectures in one go using modern computer architecture.

#### **Project-Modelling of Human Intention during Gait Rehabilitation**

- Novel technique for gait event identification.
- Fusion of gait sensor data for control.

#### **Project-Machine Learning for Network Analytics**

Reinforcement learning algorithms for learning threshold policies and Whittle index policies:

- Opinion shaping on networks.
- Analysis of content caching and delivery schemes.
- Dynamic urn models and their algorithmic applications.

#### **Project-Formal Verification of Autopilot Software for UAVs**

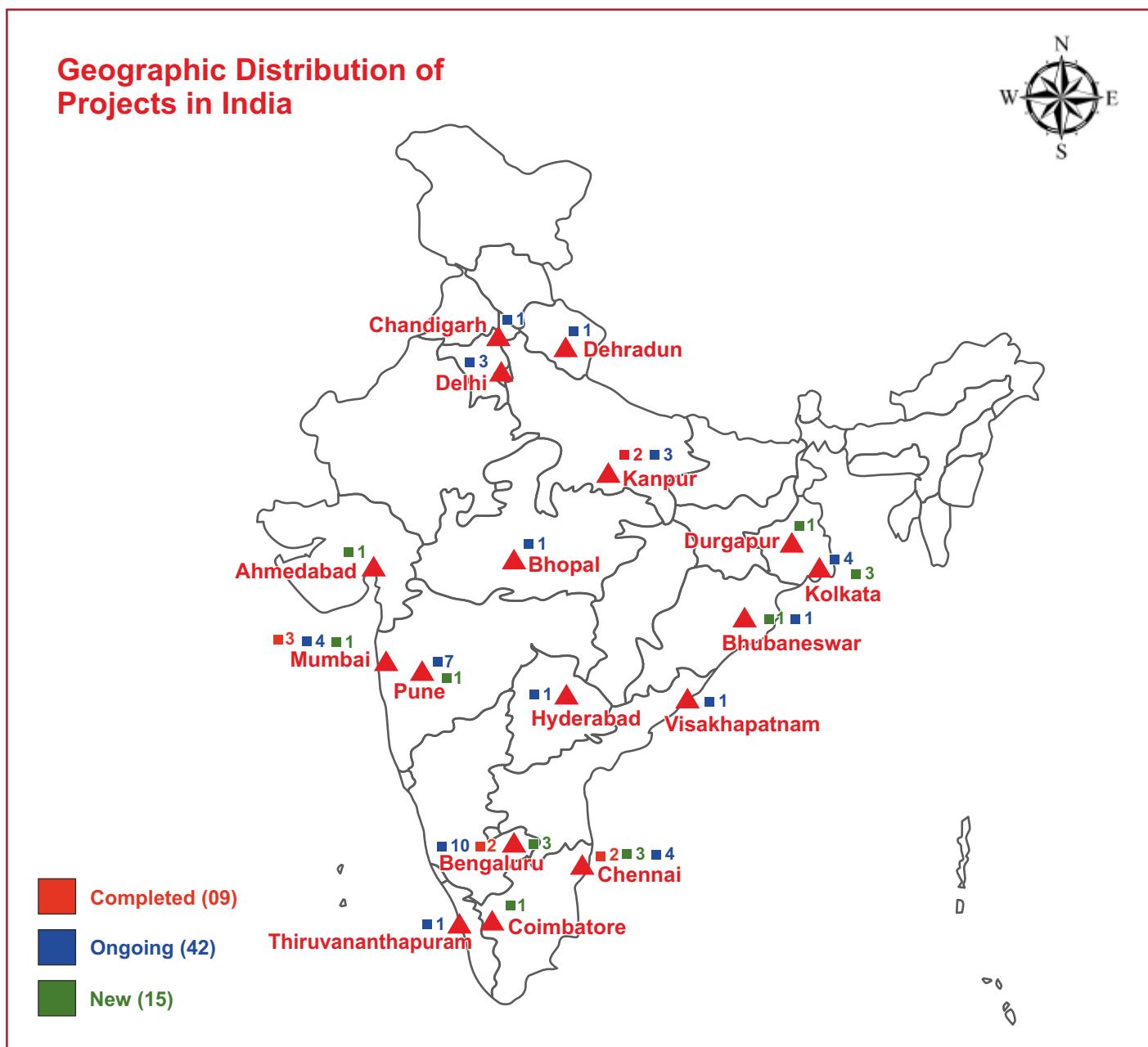
- Autopilot Software driven by Deep Neural Network.

#### **Project-FogCity: QoS Aware Resource Management for Smart Cities**

- Designed a QoS-aware resource bargaining scheme, named FogBarg, for resource management in fog networks.

# Geographic Distribution of Projects in India

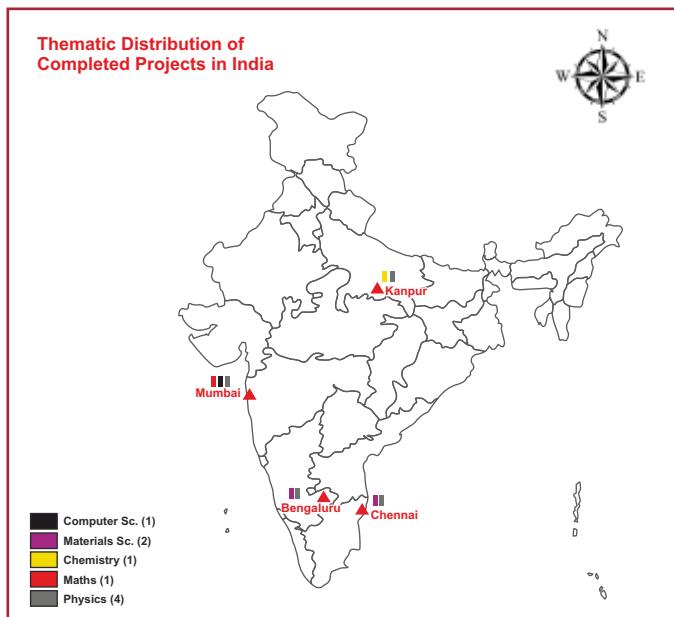
Map 1



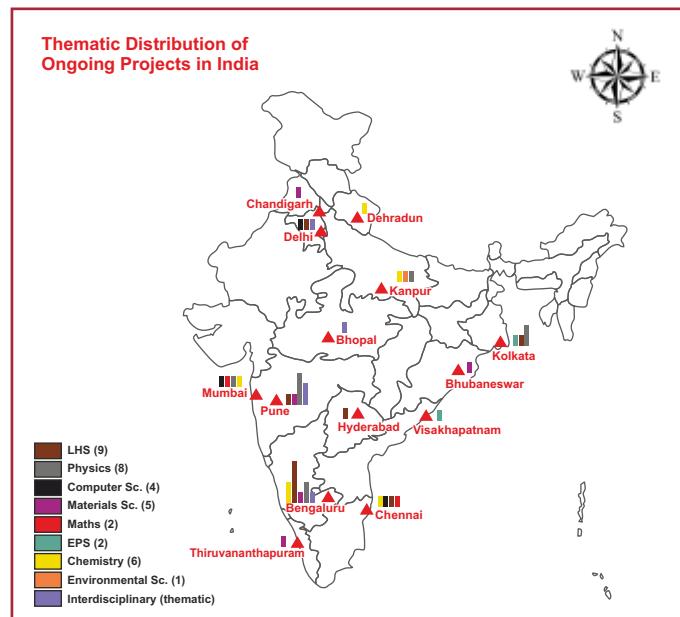
# Thematic Distribution of Projects in India

The following three Indian maps are showing the spatial heterogeneity with respect to completed (09) ongoing (42) and new initiated (15) Collaborative Scientific Research Projects of CEFIPRA in different subject domains.

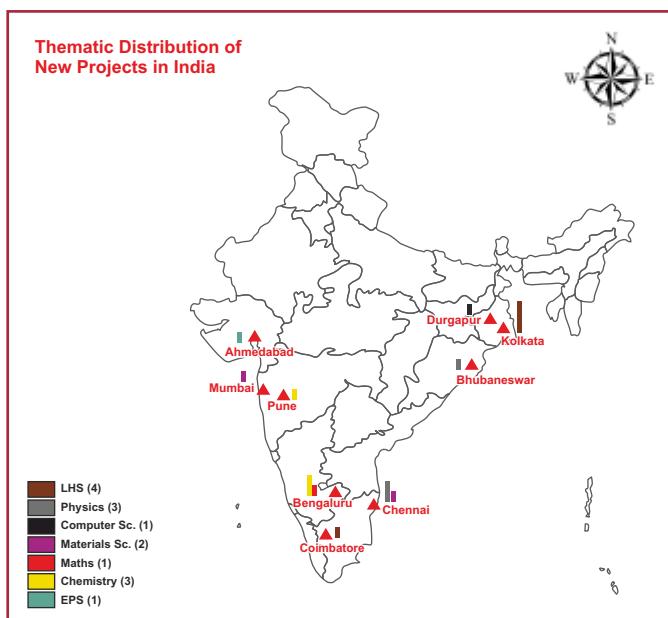
Map 2



Map 3

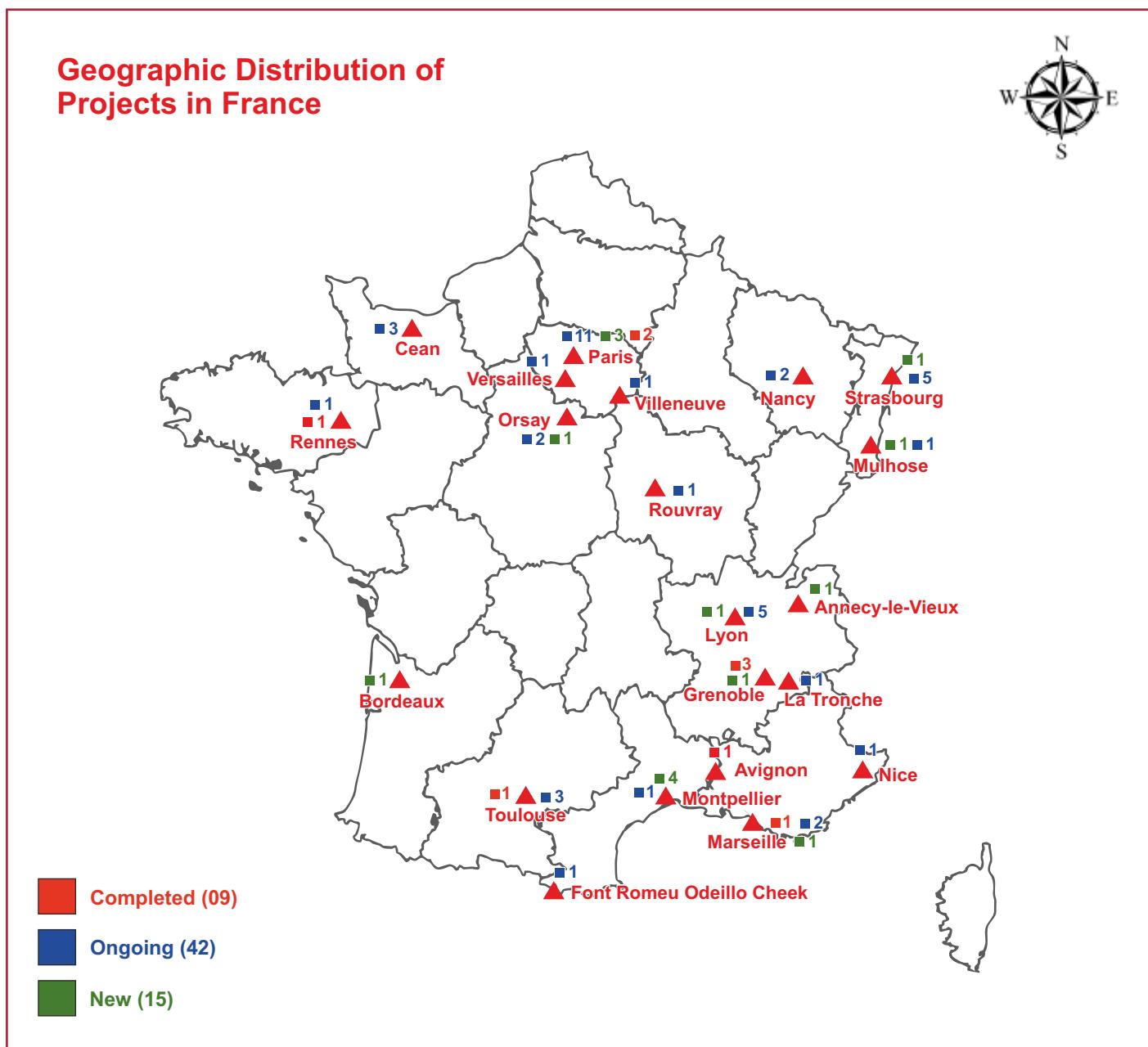


Map 4



# Geographic Distribution of Projects in France

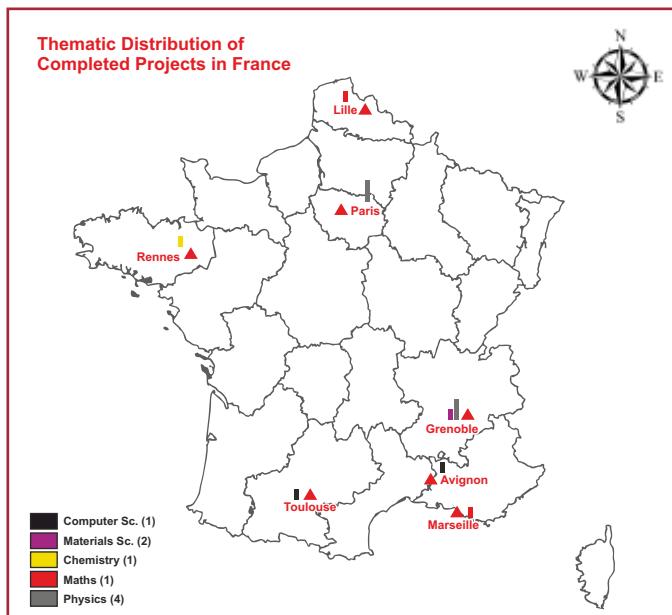
Map 5



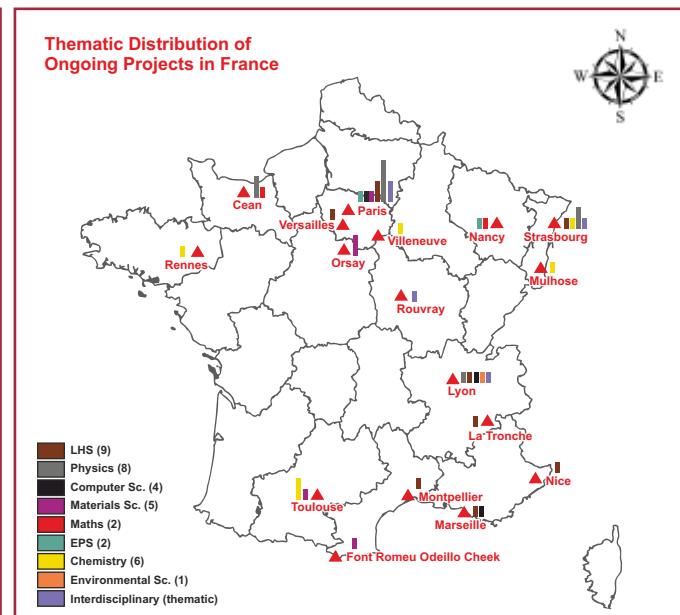
# Thematic Distribution of Projects in France

The following three French maps are showing the spatial heterogeneity with respect to completed (09) ongoing (42) and newly initiated (15) Collaborative Scientific Research Projects of CEFIPRA in different subject domains.

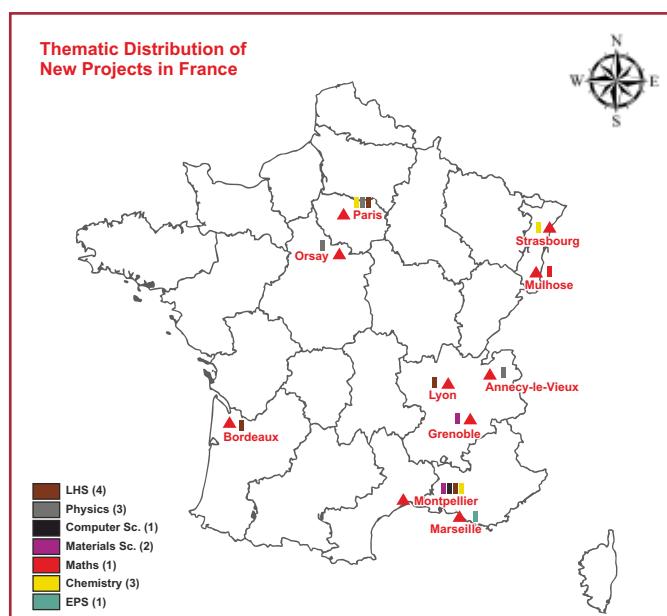
Map 6



Map 7



Map 8







## 7. CEFIPRA in Social Media

# Research from CEFIPRA projects in Social Media

**the pioneer**

Tuesday, 23 March 2021

**Sensor developed for identification of new cancer therapeutic drugs**

Sunday, 21 March 2021 | PNS | New Delhi

Researchers from inStem, Bangalore have developed the first tubulin nanobody - and use this for identification

**india EducationDiary.com**

NATIONAL NEWS SCIENCE & TECHNOLOGY

Scientists Develop Molecular Sensor That Will Aid Identifying New Drugs Of Therapeutic Value

**DST@50** Bharat vi Utkosh Bhawan DEPARTMENT OF SCIENCE & TECHNOLOGY

Home >> Scientists develop molecular sensor that will aid identifying new drugs of therapeutic value

**Scientists develop molecular sensor that will aid identifying new drugs of therapeutic value**

Researchers have recently developed a molecular sensor, which can identify new drugs by detecting how such

**The Statesman**

Tuesday, 23 March, 2021

Home / Features / Researchers develop molecular sensor that can identify cancer drugs

**Researchers develop molecular sensor that can identify cancer drugs**

Microtubules are part of the cytoskeleton, a structural network within the cell's cytoplasm, and they alter in response to several chemicals.

SNS Web | New Delhi | March 16, 2021 5:00 pm

A Strategy for screening binders against tubulin carboxy-terminal tails (CTTs)

CTTs of TUBA1A used for +ve and -ve screening:

Biotin-[<sup>33</sup>P]-GEGE-GEGE-GEGEY<sup>33</sup>] (-) Magnetic

# Electronic Media Coverage

**THE TIMES OF INDIA**

TOI Home City India World Business Tech Cricket IPL Sports Entertainment TV All Sections

Nisha Kalra's comment has been published

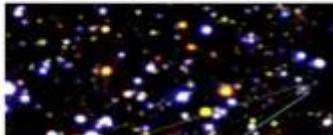
**Extreme UV light from galaxy detected by AstroSat can give important clue on Dark Ages: DST**

NEW DELHI: India's first multi-wavelength satellite AstroSat has detected extreme-UV (EUV) light from a galaxy 9.3 billion light-years away from Earth, uncovering an important clue on how the Dark Ages of the

**RMI** Research Matters

Research based news stories & highlights in science, engineering, technology & humanities in India

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**EET INDIA**

**Scientists Uncover Clue of How First EUV Light Appeared**

Article By : PIB Delhi

Category : Communications Date 2020-10-06 Comments (0)

**FOX EXCLUSIVE**

**Outrageous UV Light from Galaxy Recognized by AstroSat Can Provide Significant Insight on Dark Ages: DST**

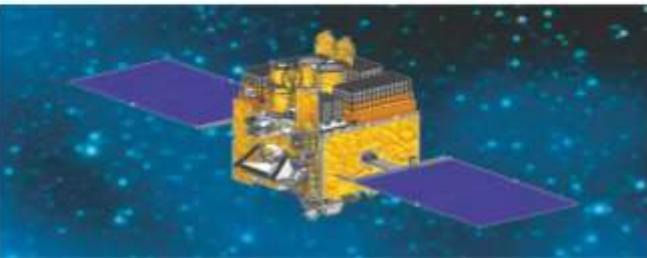
Shreya Ranjan Saturday, 3 October 2020, 14:04 IST Last updated Saturday, 3 October 2020, 16:08 IST

There are indeed many compelling stories of profound science resulting from India's active international collaborations in the frontier areas with over 40 countries: Prof Ashutosh Sharma, Secretary, DST



**AstroSat discovers tell-tale signs of cosmic evolution from a young, dynamic galaxy**

Debdipta Paul  
Read time: 4 min  
Bengaluru Aug 24, 2020, (Research Matters):





## 8. Indian and French Organizations

# Collaborative Scientific Research Projects

## INDIAN ORGANIZATIONS

<b>Indian Institute of Technology</b>	
1	Indian Institute of Technology Bombay
2	Indian Institute of Technology Delhi
3	Indian Institute of Technology Kanpur
4	Indian Institute of Technology Madras
<b>Universities</b>	
1	Jadavpur University
2	Jawaharlal Nehru University
3	Punjab University
4	Savitribai University
5	University of Calcutta
<b>Other Academic / Research Institutions</b>	
1	CSIR: Central Mechanical Engineering Research Institute Durgapur
2	CSIR: Indian Institute of Chemical Biology (IICB)
3	CSIR: Indian Institute of Petroleum Dehradun
4	CSIR: National Aerospace Laboratories
5	CSIR: National Institute for Interdisciplinary Science and Technology
6	CSIR: Institute of Genomics and Integrative Biology
7	CSIR:National Institute of Oceanography
8	DAE: Institute of Physics
9	Indian Association for the Cultivation of Sciences
10	Indian Institute of Information, Hyderabad
11	Indian Institute of Science
12	Indian Institute of Science Education and Research
13	Indian Statistical Institute
14	Institute for Stem Cell Biology and Regenerative Medicine
15	Institute of Mathematical Sciences
16	International Centre For Genetic Engineering and Biotechnology
17	International Centre for Theoretical Sciences
18	Inter-University Centre for Astronomy and Astrophysics
19	Jawaharlal Nehru Centre for Advanced Scientific Research
20	KMCH Institute of Health Sciences and Research
21	Physical Research Laboratory (PRL)
22	Tata Institute of Fundamental Research
23	Variable Energy Cyclotron Centre

# Industry Academic Research Projects

## INDIAN ORGANIZATIONS / INDUSTRIES

1	Center For Incubation, Innovation, Research And Consultancy(CIIRC)
2	CSIR- National Metallurgical Laboratory
3	CSIR-Central Mechanical Engineering Research Institute
4	Dr Hari Singh Gour Central University
5	Golden Star Technical Services
6	Indian Institute of Science
7	Indian Institute of Technology Kanpur
8	Jadavpur University
9	Mohanlal Sukhadia University
10	Morphing Machines Pvt Ltd
11	Samsung India R&D Institute
12	Sergusa Solutions Pvt. Limited
13	Tata Consultancy Services
14	Vellore Institute of Technology
15	Virchow Biotech Private Limited

# Targeted and Innovation Projects

## INDIAN ORGANIZATIONS / INDUSTRIES

1	Bihar Agricultural University, Sabour	8	Indian Institute of Technology Goa
2	Chennai Mathematical Institute	9	Indian Institute of Technology Kanpur
3	CSIR-Central Scientific Instruments Organisation	10	Indian Institute of Technology Kharagpur
4	Indian Institute of Science Bangalore	11	Indraprastha Institute of Information Technology, New Delhi
5	Indian Institute of Space Science and Technology	12	International Institute of Information Technology (IIIT-H)
6	Indian Institute of Technology Bombay	13	National Institute of Technology Silchar
7	Indian Institute of Technology Delhi		

# Collaborative Scientific Research Projects

## FRENCH ORGANIZATIONS

1	Center for Nanosciences and Nanotechnologies
2	Centre de recherche de l'Institut Curie
3	Centre de Recherche en Automatique de Nancy (CRAN)
4	Centre de Recherches Pétrographiques et Géochimiques (CRPG)
5	Centre des Sciences du Goût et de l'Alimentation, Dijon
6	Institut Albert Bonniot (IAB), Grenoble
7	Institut de Génétique et de Biologie Moléculaire et Cellulaire, ENSICAEN
8	Institut de Physique du Globe (IPGP)
9	Institut de Physique Nucléaire de Lyon
10	Institut National des Sciences Appliquées (INSA)
11	Institute for Electronics Microelectronics and Nanotechnology
12	Institute of Molecular Genetics of Montpellier, Montpellier
13	Laboratoire de Chimie de Coordination, Toulouse
14	Laboratoire de physique corpusculaire de Caen
15	Laboratoire des Symbioses Tropicales & Méditerranéennes (IRD)
16	Laboratoire Interdisciplinaire de Physique
17	Laboratoire Moléculaire Applications (Lima)
18	Laboratoire Procédés, Matériaux et Énergie Solaire (PROMES)
19	NEEL Institute, Grenoble
20	Observatoire de Paris

Universities	
1	ENSICAEN
2	Université d'Aix-Marseille
3	Université de Avignon
4	Université de Bordeaux
5	Université de Caen
6	Université de Nancy
7	Université de Paris-Sud
8	Université de Paul Sabatier
9	Université de Poitiers
10	Université de Reims Champagne-Ardenne
11	Université de Rennes
12	Université de Strasbourg
13	Université de Toulouse
14	Université Grenoble Alpes
15	Université Joseph Fourier, Orsay
16	Université Montpellier
17	Université Paris Diderot
18	Université Sorbonne
19	University Pierre and Marie Curie
Ecole	
1	Ecole Nationale Supérieure de Chimie de Paris
2	Ecole Nationale Supérieure de Chimie de Rennes
3	Ecole Normale Supérieure de Lyon, Lyon
4	Ecole Polytechnique-Centre de Physique Théorique
5	Ecole Supérieure de Physique et de Chimie Industrielle (ESPCI)
6	ENS de Lyon, Lyon



# Industry Academic Research Projects

## FRENCH ORGANIZATIONS / INDUSTRIES

1	Centrale Supelec
2	Centrale Supélec, Gif-Sur-Yvette
3	CETHIL, INSA Lyon
4	École Normale Supérieure, Paris
5	Faurecia / CentraleSupelec / Esigeclec GeePs, Gif-sur-Yvette
6	Inria

7	INSERM
8	Institut Mines Telecom
9	Span Diagnostics SAR
10	Terra Nova Development
11	Université de Bordeaux
12	Université Jean Monnet

# Targeted Projects

## FRENCH ORGANIZATIONS / INDUSTRIES

1	Aix-Marseille University
2	Institut national de recherche dédié au numérique (Inria)
3	IRMB Hôpital St Eloi, Montpellier
4	Laboratoire Bordelais de Recherche en Informatique
5	Laboratoire Informatique Gaspard Monge (LIGM)
6	Laboratory for Analysis and Architecture of System LAAS-CNRS
7	Las – Universite de Lille
8	Mnemosyne INRIA, Bordeaux

9	Université de Bordeaux
10	Université de Lille
11	Université de Paris-Est Marne-la-Vallée
12	Université de Rennes 1
13	Université Grenoble
14	Université Grenoble Alpes
15	Université Montpellier 2
16	Université Paris Diderot
17	Université Paul Sabatier



## 9. Financial Reports & Audited Accounts



# Financial Report for FY 2020-21

The CEFIPRA receives grants-in-aid of Euro 1.55m each from the Indian and French Governments annually. The nodal agency on the Indian side is the Ministry of Science and Technology and on the French side is the Ministry for Europe and Foreign Affairs. The grants-in-aid are released based on the budgetary projections made by the Centre and duly approved by the Governing Body of the Centre.

## a) Core Programmes

The grants-in-aid received from both the Governments are utilized towards expenditure, which is shared on equal basis on the following core programmes of the Centre:

- i) Collaborative Scientific Research Programme (CSRP)
- ii) Industry Academia Research and Development Programme (IARDP)
- iii) Seminars/Workshops
- iv) Others

During the year 2020-21, Rs 140.05 (0.44 million) and Rs.136.03 million (Euro 1.55 million) grants-in-aid were received from Government of India & Government of France respectively for the core programmes. The details of fund position for the last three years under the core programmes are given below in the **Table 1**.

**Table 1- Grants-in-Aid received from Government of India & Government of France for core programmes during FYS 2018-19, 2019-20 & 2020-21**

(Rs. in million)

Financial Year	Grant-in-aid received from Govt. of India		Grant-in-aid received from Govt. of France		Total Funds available
	C/F from last year	Grant received during the year	C/F from last year	Grant received during the year	
2020-21	20.46	140.05	144.68	136.03	Rs. 441.22 (Euro 5.02 million)
2019-20	71.13	35.00	109.24	121.11	Rs. 336.48 (Euro 4.30 million)
2018-19	67.78	145.72	43.16	124.24	Rs. 380.92 (Euro 4.90 million)

During the Financial Year 2020-21, one hundred thirty six (136) new collaborative scientific research project proposals (CSRP) and twenty (20) Industry Academia Research and Development project proposals (IARDP) were received.

Out of this thirty-seven proposal of CSRP was evaluated by the SC during its 65<sup>th</sup> meeting,

Ten (10) proposals were recommended to support and three (03) proposals of IARDP were recommended for support during the 36th IRC meeting in May 2020. However, the November meetings of SC and IRC were deferred due to the pandemic (Covid-19). The details of expenditure incurred during the year towards core activities are given below:

- i) **As of March 31 2021, sixty-eight (68) projects (including 15 new projects and 09 completed projects during the year) of CSRP were under implementation.** The core expenditure of the Centre towards collaborative scientific research projects is Rs. 175.82 (Euro 2.00 million). Various projects got delayed and extensions were granted due to pandemic Covid-19.
- ii) **As of March 31, 2021, 9 (2 new projects and 3 Completed projects during the year) of IARDP were under implementation.** Rs. 13.97 million (Euro 0.159 million) was spent on the Industry-Academia Research and Development Programme during the financial year. Various projects got delayed and extensions were granted due to pandemic Covid-19.
- iii) Seminars and workshops have always been used as a platform for enabling interactions between the scientific communities of the two countries. However, during the reported

period, Seminars/workshops could not be organized due to the lockdown and restrictions on international travel related to the Pandemic COVID-19. However, one seminar in the area of Astrophysics was held virtually. During the year, three (3) seminars/workshops were recommended. One in the 65th SC and two (2) in 36th IRC

- iv) Rest of the expenses of Rs. 52.59 million (Euro 0.599 million) are for expense on meetings of Governing Body, Scientific Council and Industrial Research Committee (Rs. 0.51/Euro 0.005 millions) as well as running expenses/expenses from Reserve fund (Rs. 52.08/Euro 0.585 million).

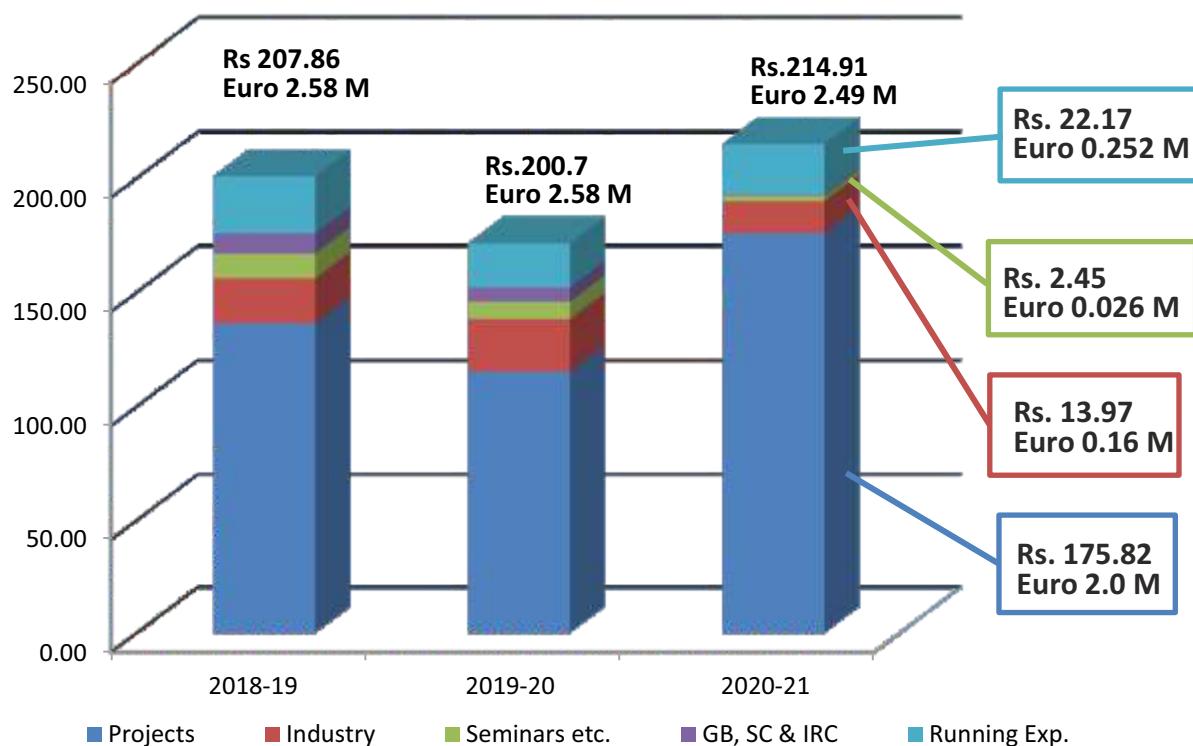
The details of the expenditure incurred by the Centre during the Financial Year 2020-21 for the core programmes, under various budget heads are given in the **Table 2 and Figure X**. A comparison with the previous three years has also been provided in **Table 2 and Figure Y**.

**Table 2: Expenditure incurred for the core programmes during the financial years 2018-19, 2019-20 & 2020-21**

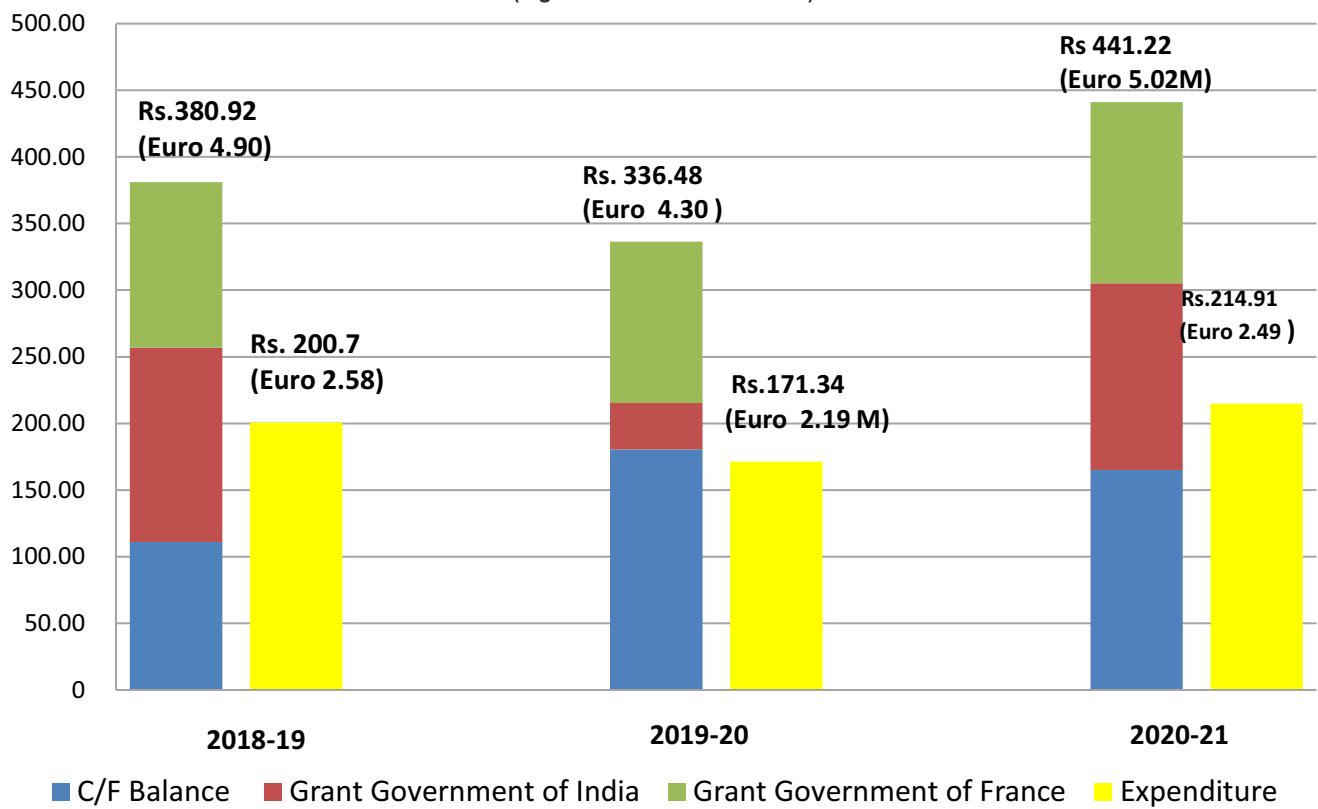
(Rs./Euro in million)

		2017-18		2018-19		2019-20	
	Budgetary Components	Expenditure Rs.	% of total	Expenditure Rs.	% of total	Expenditure Rs.	% of total
1.	Scientific Research Projects	136.42 (1.75 M Euro)	67.98%	115.19 (1.47 M Euro)	67.29%	175.82 (2.00 M Euro)	81.83%
2.	Industrial Research Projects	19.62 (0.25 M Euro)	9.79%	22.99 (0.29 m Euro)	13.41%	13.97 (0.16 M Euro)	6.50%
3.	Seminars & Workshops	10.52 0.135 M Euro)	5.24%	5.66 (0.075 M Euro)	3.30%	0.56 (0.006 M Euro)	0.26%
4.	General Scientific Expenses (activities like Publication of research papers, ESONN, SOLEIL Synchrotron Programmes, Lecture Series etc.)	0.290 (0.003 M Euro)	0.14%	1.95 0.02 M Euro	1.12%	1.89 0.02 M Euro	0.87%
5.	Governing Body, Industrial Research Committee & Scientific Council meetings	8.87 (Euro 0.114 M)	4.41%	6.25 (0.07 M Euro)	3.64%	0.50 (0.005 M Euro)	0.23%
6.	Running expenses of the Centre (Salaries, Office maintenance & Travel)	24.98* (Euro 0.33 M)	12.44%	19.26 (0.225 M Euro)	11.24%	22.177 (0.252 M Euro)	10.31%
	<b>TOTAL</b>	<b>200.7 (2.58 M Euro) @ 1Euro = 77.7024</b>		<b>171.34 (2.19 M Euro) @ 1 Euro= 78.16</b>		<b>214.91 (2.49 M Euro) @ 1 Euro= 87.767</b>	

**Figure X: Annual Expenditure Over the Years - Core Programmes**  
(Figures in Rs./Euro in Million)



**Figure Y: Fund Position v/s Expenditure - Core Programmes**  
(Figures in Rs./Euro in Million)



## b) Non-Core Programmes

As per earlier directives of the Governing Body of CEFIPRA, the Centre has initiated its activities for expansion beyond the core programmes and has undertaken a number of scientific programmes (including TDB programme which started during the Financial Year 2016-17), which are funded by various

organizations from India and France. The details of fund position and expenditure incurred for the non-core programmes during the financial year 2020-21 are given in the **Table 3A (Rs in million)**, **Table 3B (in Euro)**

**Table 3A - Non Core Programmes: Fund Position & Expenditure incurred during FY 2020-21 (Rs. In Million)**

(Rs. in million)

Non- Core Programmes : Fund Position & Expenditure incurred during Financial Year 2020-21												
S.No.	Funds Available		Received during the year			Total funds available during the year (a)	Expenditure during the year		Amount Adjusted during the Year (exchange fluctuation impact)	Total Expenditure (b)	Balance Available (a-b)	
			RECEIPTS	C/F Balance	Indian Side		Indian Side	French Side				
1	IFCAM(DST-CNRS)	16.30	7.50	-	-	23.80	19.91	-	-0.31	0.45	20.05	3.75
2	RAMAN CHARPAK FELLOWSHIP (DST-Fr.Embassy)	18.54	-	12.22	-	30.76	0.61	9.43	-0.27	7.30	17.08	13.68
3	DST-INRA PROJECTS	1.41	-	-	0.02	1.43	-	-	-0.03	-	-0.03	1.46
4	DST-Inria-CNRS PROJECTS	6.43	5.18	-	-	11.61	2.88	-	0.07	-	2.95	8.66
5	DST-ANR PROJECTS	-	-	-	-	-	-	-	-	-	-	-
6	BIRAC- FRENCH EMBASSY PROJECTS	10.99	-	-	0.08	11.07	-	-	-0.28	-	0.28	11.35
7	Indo-French Water Network	14.22	-	-	0.09	14.30	-	-	-0.42	-	-0.42	14.72
8	TDB Programee	0.23	1.20	-	0.04	1.41	1.16	-	-	-	1.16	0.31
9	BIRAC-BPI FRANCE	3.09	-	-	0.09	3.18	-	-	-	-	-	3.18
10	Economic Diplomacy	6.93	-	-	-	6.93	-	-	-0.20	-	-0.20	7.13
11	DST-CNRS Fellowship	2.06	3.84	-	-	5.90	3.39	-	-	-	3.39	2.51
<b>TOTAL</b>		<b>80.202</b>	<b>17.720</b>	<b>12.220</b>	<b>0.313</b>	<b>110.455</b>	<b>27.954</b>	<b>9.430</b>	<b>-1.429</b>	<b>7.751</b>	<b>43.706</b>	<b>66.749</b>

NOTE for 2020-21:

- (1) The C/F balances includes Programme Implementation charges and overhead charges and is after necessary adjustment required as per audited Financial Statement.
- (2) The Grants received from Indian Side and French side includes Programme Implementation and Overhead Charges.
- (3) Expenditure incurred during the year also includes expenses that have been met out of Programme Implementation and Overhead charges.

**Table 3B - Non Core Programmes: Fund Position & Expenditure incurred during FY 2020-21 ( Euro in Million)**

(Euro in Million)

Non Core Programmes : Fund Position & Expenditure incurred during Financial Year 2020-21												
S.No.	Funds Available	Received during the year				Total funds available during the year (a)	Expenditure during the year		Amount Adjusted during the Year (exchange fluctuation impact)	Amount refunded to DST/ Transferred to Group Farming	Total Expenditure (b)	Balance Available (a-b)
		RECEIPTS	C/F Balance	Indian Side	French Side		Indian Side	French Side				
1	IFCAM (DST-CNRS)	1,85,719	85,454	-	-	2,71,173	2,26,851	-	-3,555	5,127	2,28,423	42,750
2	RAMAN CHARPAK FELLOWSHIP(DST-Fr.Embassy)	2,11,241	-	1,39,232	-	3,50,473	6,996	1,07,444	-3,054	83,186	1,94,572	1,55,901
3	DST-INRA PROJECTS	16,055	-	-	251	16,326	-	-	-296	-	-296	16,612
4	DST-Inria-CNRS PROJECTS	73,262	59,020	-	-	1,32,282	32,814	-	798	-	33,612	98,670
5	DST-ANR PROJECTS	-	-	-	-	-	-	-	-	-	14,700	-
6	BIRAC- FRENCH EMBASSY PROJECTS	1,25,218	-	-	855	1,26,072	-	-	-3,190	-	-3,290	1,29,263
7	Indo-French Water Network	1,61,986	-	-	980	1,62,966	-	-	-4,751	-	-4,751	1,57,717
8	TDB Programee	2,621	13,673	-	456	16,749	13,217	-	-	-	13,217	3,532
9	BIRAC-BPI FRANCE	35,218	-	-	1,025	36,244	-	-	-	-	-	36,244
10	Economic Diplomacy	79,005	-	-	-	79,005	-	-	-2,233	-	-2,233	81,238
11	DST-CNRS Fellowship	23,471	43,752	-	-	67,223	38,625	-	-	-	-	38,625
	<b>TOTAL</b>	<b>9,13,806</b>	<b>2,01,898</b>	<b>1,39,232</b>	<b>3,566</b>	<b>12,58,503</b>	<b>3,18,502</b>	<b>1,07,444</b>	<b>-16,282</b>	<b>88,313</b>	<b>5,12,578</b>	<b>7,60,525</b>

NOTE for 2019-20:

- (1) The C/F balances and Programme Implementation charges and overhead charges and is after necessary adjustment required as per audited Financial Statement.
- (2) The Grants received from Indian Side and French side(IFCAM and Raman Charpak) includes Programme Implementation and Overhead Charges.
- (3) Expenditure incurred during the year also includes expenses that have been met out of Programme Implementation and Overhead charges.

### Financial Audit

The statutory audit of the accounts of the Centre was carried out by M/s. Nirbhaya & Associates, Sagar Plaza, Vikas Marg, New Delhi-110092. The accounting currencies of the Society are both Indian Rupee (INR) and Euro. Separate books of accounts are maintained for recording respective transactions occurring in INR and Euro currencies and accordingly separate Financial Statements i.e. Balance Sheet, Income & Expenditure and Receipts and Payments are drawn in respective currencies.

For presentation of INR accounts the grant received in Euro currency for core programme is converted into INR on the exchange rate prevailing on the date of transaction as declared by the Reserve Bank of India (RBI). The expenditure of the Centre for Core programmes and income and expenditure for Non-Core programmes are

converted on average rate determined on the basis of exchange rate prevailing on the date of opening bank balance and date of grant received. The Assets & Liabilities of Euro account are converted to INR at the rate prevailing on the Balance Sheet date, as declared by RBI, on 31<sup>st</sup> March of each Financial Year.

All INR accounts viz, the Income & Expenditure account, Balance Sheet and Receipt & Payment account of INR are translated to Euro on the basis of rate of exchange prevailing on the date of preparation of the Balance Sheet, as declared by RBI, on 31<sup>st</sup> March of the financial year.

The Auditors' Report with its attachments viz. Receipt & Payment Account, Income & Expenditure Account and Balance Sheet in terms of INR and Euro are given in the following pages.



INDEPENDENT AUDITOR'S REPORT

To The Governing Body of  
**Indo-French Centre for the Promotion of Advanced Research**  
Lodhi Road, New Delhi

**REPORT ON THE FINANCIAL STATEMENTS**

**Opinion**

We have audited the accompanying financial statements of **Indo-French Centre for the Promotion of Advanced Research, New Delhi**, which comprise the Balance Sheet as at March 31, 2021, the Statement of Income and Expenditure and the Receipt and Payment Account for the year then ended, and a summary of significant accounting policies and other explanatory information.

In our opinion and to the best of our information and according to the explanations given to us, the aforesaid financial statements give the information required by the Indian Law in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India.

- a) In the case of the Balance Sheet, of the state of affairs of the CEFIPRA as at March 31, 2021;
- b) In the case of Income and Expenditure Account of the surplus of Income over expenditure; and
- c) In the case of Receipts and Payments Account of the receipts and payments for the year ended on that date.

**Basis for opinion**

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

**Responsibilities of management and those charged with governance for the financial statements**

The management is responsible for the preparation of these financial statements in accordance with the accounting principles generally accepted in India, including the Accounting Standards issued by the Institute of Chartered Accountants of India and for such internal financial control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.



In preparing the financial statements, management is responsible for assessing the CEFIPRA's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Centre or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the CEFIPRA's financial reporting process.

**Auditor's responsibilities for the audit of the financial statements**

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

In making risk assessments, the auditor considers internal financial control relevant to CEFIPRA's preparation of the financial statements that give a true and fair view in order to design audit procedures that are appropriate in the circumstances.

**For NIRBHAYA & ASSOCIATES**

**Chartered Accountants**

**Firm Registration No. 016125N**

Ankesh  
Partner  
Membership No.550940



**Place : New Delhi**

**Date: 16-11-2021**

**UDIN: 21550940AAAASH9910**

**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH (IFCPAR)**

**SCHEDULE ANNEXED TO AND FORMING PART OF THE BALANCE SHEET, INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31<sup>ST</sup> MARCH, 2021**

**SCHEDULE-H**

**SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS**

**A. SIGNIFICANT ACCOUNTING POLICIES**

**1. OVERVIEW & BASIS OF PREPARATION**

- 1.1 IFCPAR/CEFIPRA has been created under a bilateral cooperation agreement between the Government of France and Government of India to promote, catalyse, strengthen and expand cooperation in advanced areas of Science, Technology and Innovation for the public good.
- 1.2 The IFCPAR/CEFIPRA has been registered under Societies Registration Act, 1860 and under section 12A of the Income Tax Act, 1961.
- 1.3 The financial statements have been prepared under historical cost convention and on accrual basis of accounting.

**2. Income Recognition**

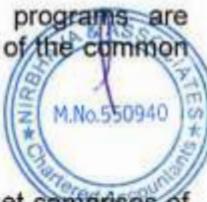
- 2.1 Grant due, in accordance with the bilateral agreement between Government of India and Government of France, and received during the year is recognized as Income.
- 2.2 Non-Core programs are administered on behalf of the granting agencies. Grants received for such programs are committed funds and expenses of these programs are directly charged to the respective grants received. The unutilised balance amount of non-core grants are shown under current liabilities in the balance sheet.

**3. Expenditure Recognition**

- 3.1 Grants to an awardee for research projects are recognized as expenditure to the extent of payment made to each awardee during the year. First year releases are made on the basis of approved budget and subsequent releases are made only on receipt of the statement of expenditure of the previous years.
- 3.2 Common costs incurred for implementation and management of non-core programs are apportioned to these programs on an estimated resource allocation basis at 25% of the common costs incurred by the Centre.

**4. Fixed Assets**

- 4.1 Fixed Assets are stated at cost less accumulated depreciation. The cost of an asset comprises of its purchase price and directly attributable costs of bringing the asset to working condition for its intended use.
- 4.2 All assets acquired for research projects remain with the institutions where the research work is carried on. The centre, has, however, retained the right to transfer these assets to other institutions, if so required, on the completion of the Project for which these assets were purchased. The expenditure incurred on those assets are accounted for in the Income and Expenditure account under the head "Research project". Assets purchased for non-core program are considered as Application of Fund and are charged to the respective grant as expenditure.



## **5. Depreciation**

5.1 Depreciation on fixed assets has been charged on written down value method at the rates prescribed under the Income Tax Rules, 1962.

## **6. Foreign Currency Transactions**

6.1 Grant received in foreign currency for Core Programs is converted into INR on the exchange rate prevailing on the date of transaction.

6.2 Grant received in foreign currency for Non-Core Programs, expenditure incurred for Core and Non-Core Programs and repatriation of funds are converted into INR on average rate.

6.3 Current Assets and Current liabilities except Non-Core Program balances are converted into INR on the exchange rate prevailing on the date of Balance Sheet.

6.4 IFCPAR, every year receives a fixed Grant in EURO account from France Government for carrying the core and non-core programmes for which separate books of accounts are maintained as part of Non-Integral Foreign Operation.

The Non-Integral Foreign operations have been incorporated in the Financial Statement of IFCPAR as per Para – 24 of AS-11 "The Effects of Changes in Foreign Exchange Rates" which is as follows:

### ***"Non-integral Foreign Operations***

*24. In translating the financial statements of a non-integral foreign operation for incorporation in its financial statements, the reporting enterprise should use the following procedures:*

*(a) the assets and liabilities, both monetary and non-monetary, of the non-integral foreign operation should be translated at the closing rate;*

*(b) income and expense items of the non-integral foreign operation should be translated at exchange rates at the dates of the transactions; and*

*(c) all resulting exchange differences should be accumulated in a foreign currency translation reserve until the disposal of the net investment."*

For practical reasons, an average exchange rate at the dates of receipt of grant-in-aid from France Government (in EURO) which is Rs. 87.767 / euro is used to translate income and expense items of a foreign operation.

The translation of the financial statements of a non-integral foreign operation results in the recognition of exchange differences amounting to Rs. - 4,03,201.23 (i.e.\*(85.92-87.767)) which has been recognised as "Foreign Currency Translation Reserve" under the head Liabilities in Balance Sheet.

## **7. Employee Benefits**

### **7.1 Gratuity & Pension**

The Centre has taken a policy with LIC of India for payment of Gratuity and Pension to employees who are eligible for such benefits.



## 7.2 Leave Encashment

Leave encashment is accounted for at the time of payment and no provision for the same is made in the books.

## B. NOTES TO ACCOUNTS:

### 1. Grant in Aid

- a) IFCPAR has received a sum of Rs. 14,05,00,000/- as Grant in Aid from Government of India, Ministry of Science and Technology, Department of Science and Technology during the year for normal core activity
  - b) IFCPAR has received a sum of Euro 15,50,000 as Grant in Aid from Government of France during the year for normal core activity.
  - c) IFCPAR has received a sum of Euro 1,40,000 and Rs.1,72,79,534/- as Grant in Aid during the year from Government of France and Government of India respectively during the year for non-core activity.
2. The Non-Core Expenditure of Programme Implementation and Overhead for the current financial year has not been transferred and will be transferred after the finalization of accounts.
  3. Contribution was made to LIC of India towards annual premium for Group Gratuity Accumulation Scheme maintained with LIC of India for the FY 2020-21 amounting Rs.4,63,703/. In respect of premium of pension the decision was made to pay the amount through Reserve and surplus account amounting to Rs 2,80,20,812/- which was paid through Reserve Account.
  4. Provision has not been made for leave encashment liability and the same is accounted for cash basis.
  5. The Centre was granted exemption from payment of Income Tax vide notification issued by CBDT dt. 15.11.2018 u/s 11(1) (c) of the Income Tax Act, 1961 valid upto Asst. Year 2018-19. Application for renewal of exemption u/s 11(1)(c) of the Income Tax Act, 1961 for AY 2020-21 has been submitted to CBDT. Application for F.Y 2021-22 will be filed in due course of time. Keeping in view the previous approvals given by CBDT, no provision of Income Tax has been made for FY 2020-21.
  6. During the year total ongoing projects were 68 and the total liability towards these projects as per sanctioned amounts aggregates to Rs.8,03,88,797/- for the Indian side and Euro 10,39,740/- for the French side at 31<sup>st</sup> March, 2021

For NIRBHAYA & ASSOCIATES  
Chartered Accountants  
Firm Registration No. 016125N

ANKESH  
Partner  
Membership No.550940  
Place : New Delhi  
Date : 16.11.2021  
UDIN:21550940AAAASH9910



*[Signature]*  
Simranjeet Singh  
Assistant Accounts Officer  
(SIMRANJEET SINGH)  
Assistant Accounts Officer  
Indo-French Centre for the  
Promotion of Advanced Research  
New Delhi

*[Signature]*  
Dr. Purnima Rupal  
Director  
Dr. PURNIMA RUPAL  
Director  
Indo-French Centre for the  
Promotion of Advanced Research  
5B, Ground Floor  
India Habitat Centre  
Lodhi Road, New Delhi-110 003

INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI Balance Sheet as at 31st March 2021					
INR Version					
I. Liabilities	SCH	Amount as on 31.03.2021		Amount as on 31.03.2020	
		Total Amount in INR		Total Amount in INR	
Reserve Fund	A	22,04,20,457.49	22,04,20,457.49	18,13,12,581.00	18,13,12,581.00
Core Programmes	B				
Current Liabilities					
Targeted Programmes					
IFCAM Project		37,52,680.43		1,63,07,882.43	
DST-ANR Projects		1,476.00		-	
DST-INRA Projects		14,66,007.55		14,17,874.00	
DST-INRIA Projects		86,61,457.00		64,26,960.00	
Raman Charpak Fellowship		1,37,09,573.94		1,85,47,521.97	
BIRAC French Embassy		1,13,46,922.32		1,09,91,804.88	
Economic Diplomacy R & D Programme		71,36,676.84		69,42,254.37	
BIRAC BPI France		31,86,382.00		30,96,001.00	
DST- ESSONN Fellowship		5,162.05		5,868.00	
DST-CNRS Fellowship		20,52,266.60		20,59,620.00	
Indo French Water Network		1,47,32,771.53		1,42,29,423.43	
Programme Implementation & Overhead	B		6,60,51,376.26		8,00,25,210.07
DST-ANR Projects		-		-	
DST-INRA Projects		-		-	
Raman Charpak Fellowship		2,50,493.94		2,98,273.00	
BIRAC French Embassy		-		-	
Indo French Water Network		3,11,638.00		2,28,030.00	
TDB Programme		-		-	
BIRAC BPI France		-		-	
DST-ESSONN Fellowship					
Expenses Payable	C		5,62,131.94		5,26,303.00
Salaries and Office Expenses Payable	C	39,155.00		6,10,137.00	
TDS Payable	C	68,428.00		36,528.00	
Seminar & Workshop	C	34,05,793.00		33,69,615.00	
GB/SC Expenses Payble				50,150.00	
Expenses on Publication					
Interest Payable to DST					
Sbi Core		21,94,334.00		11,68,963.00	
Raman Charpak Fellowship		7,54,578.00		8,85,911.00	
DST CNRS Fellowship		47,614.00		42,208.00	
DST Inria Fellowship		3,33,443.00		3,33,668.00	
IFCAM		1,22,979.00		1,63,238.00	
Group Farming	D		69,66,324.00		66,60,418.00
Grant-In Aid-2017-18			6,11,502.00		6,11,502.00
Foreign Currency Adjustment Account			-		-
Total Liabilities			62,20,651.77		89,55,390.00
			30,08,32,443.46		27,80,91,404.07

Accounting policies and notes to accounts are integral part of financial statements.

#### AUDITOR'S REPORT

As per our report of even date attached.

For NIRBHAYA & ASSOCIATES

Chartered Accountants

Firm Registration No.

(Ankesh)

Partner

Membership No.

Place : New Delhi

Date : 16.11.2021



(Simranjeet Singh)  
Assistant Accounts Officer  
**(SIMRANJEET SINGH)**  
Assistant Accounts Officer  
Indo-French Centre for the  
Promotion of Advanced Research  
New Delhi

Purnima Rupal  
(Dr. Purnima Rupal)  
Director

INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI Balance Sheet as at 31st March 2021					
				INR Version	
	SCH	Amount as on 31.03.2021		Amount as on 31.03.2020	
		Total Amount in INR		Total Amount in INR	
				INR Version	
<b>II. Assets</b>		<b>Amount as on 31.03.2021</b>		<b>Amount as on 31.03.2020</b>	
		<b>Total Amount in INR</b>		<b>Total Amount in INR</b>	
<b>Fixed Assets</b>					
<b>Cash &amp; Cash Equivalents</b>					
<b>Core Bank Balances</b>					
State Bank of India Account	E	8,74,26,882.50		2,44,72,058.95	
Union Bank of India Accumulated Reserve		2,72,66,425.00		5,48,02,261.00	
Union Bank of India		4,66,240.00		4,52,198.00	
Axis Bank Account		78,315.00		78,315.00	
State Bank of India (GPF) Account		10,28,059.00		14,55,934.00	
State Bank of India (Gratuity) Account		10,90,95,879.51		10,50,38,528.33	
CIC, Paris Account		22,53,61,801.01		18,62,99,295.28	
<b>Non Core Bank Balances</b>					
Union Bank of India - Raman Charpak Account		2,07,03,731.52		2,84,30,154.92	
Union Bank of India - DST INRIA Account		1,25,13,247.99		96,68,223.00	
Union Bank of India - DST INRA Account		7,30,456.00		7,08,458.00	
Union Bank of India - IFCAM Account		8,04,814.02		72,83,751.00	
Union Bank of India-DST ANR Account		49,787.73		48,287.73	
Union Bank of India-TDB Programme		17,63,529.10		12,05,242.90	
State Bank of India-IFWN		32,28,758.00		31,42,417.00	
State Bank of India-BIRAC		27,74,797.50		27,00,595.50	
State Bank Of India- BPI France		33,01,115.00		32,10,734.00	
Union Bank DST CNRS		26,91,231.78		23,80,521.58	
Union Bank Of India-ESONN		56,091.81		56,754.76	
<b>Current Assets</b>					
Seminars & Workshops	F	36,18,107.00		35,37,748.00	
Income Tax & TDS Receivable		1,79,719.00		1,91,225.00	
Other Deposits	F	69,31,472.00		87,18,838.00	
Tour Advances- Core		38,64,961.00		78,54,879.00	
Accrued Interest-IFCAM		23,213.00		66,432.00	
Accrued Interest-ESSONN		437.00		480.00	
Accrued Interest-ANR		368.00		392.00	
Accrued Interest-TDB		13,332.00		10,250.00	
Accrued Interest-Raman Charpak		1,53,331.00		2,92,167.00	
Accrued Interest-INRIA		1,00,701.00		85,707.00	
Acured Intersest CNRS		8,648.00		21,306.00	
Accrued Interest Accumulated Reserve		2,08,160.00		5,25,291.00	
Accrued Interest- INRA		5,403.00		5,735.00	
Accrued Interest-Core		3,449.00		3,661.00	
IIC Membership Fee Advance		1,99,538.00		1,59,300.00	
Electonic Project Proposal Management				4,90,875.00	
Cash -in-transit				-	
Security Deposit, Campus France, Paris		68,73,600.00		66,24,440.00	
<b>Total Assets</b>					
		2,21,84,439.00		2,85,88,726.00	
		<b>30,08,32,443.46</b>		<b>27,80,91,404.67</b>	

Accounting policies and notes to accounts are integral part of financial statements.

#### AUDITOR'S REPORT

As per our report of even date attached.

For NIRBHAYA & ASSOCIATES

Chartered Accountants

Firm Registration No. 016125N

(Ankesh)

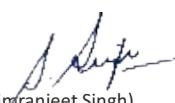
Partner

Membership No.550940

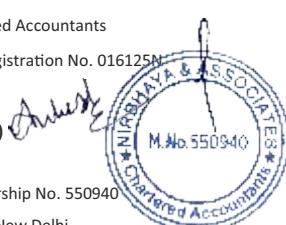
Place : New Delhi

Date : 16.11.2021



  
 (Simranjeet Singh)  
 Assistant Accounts Officer  
**(SIMRANJEET SINGH)**  
 Assistant Accounts Officer  
 Indo-French Centre for the  
 Promotion of Advanced Research  
 New Delhi

  
 (Dr. Purnima Rupal)  
 Director

INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI					
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st March 2021-CORE PROGRAMME					
Income	SCH	Amount as on 31.03.2021		INR Version	
		Total Amount in INR		Amount as on 31.03.2020	
		G		Total Amount in INR	
Grant-in Aid		14,05,00,000.00		3,50,00,000.00	
From Government of India		13,60,38,850.00		12,11,54,898.00	
Interest From Bank Accounts	H		27,65,38,850.00		15,61,54,898.00
Misc. Income			12,68,438.00		22,25,698.00
			3,504.00		8,480.00
<b>I. Total Income</b>			<b>27,78,10,792.00</b>		<b>15,83,89,076.00</b>
Expenditure	I				
Running Expenditure of the Centre		2,20,70,400.00		1,76,23,225.00	
Salaries and Office Expenses of the Centre		1,07,686.00		16,45,292.00	
Travel Expense		5,01,489.00		62,57,019.00	
GB/SC/IRC/SEP/Vision Group Expenses		2,80,20,812.00		-	
<b>Total Running Expenditure (A)</b>			<b>5,07,00,387.00</b>		<b>2,55,25,536.00</b>
Scientific Expenditure of the Centre		18,93,646.00		19,56,662.00	
General Scientific Expenses		19,03,58,009.00		14,38,65,410.00	
<b>Total Scientific Expenditure (B)</b>			<b>19,22,51,655.00</b>		<b>14,58,22,072.00</b>
<b>II. Total Expenditure(A+B)</b>			<b>24,29,52,042.00</b>		<b>17,13,47,608.00</b>
Excess of Income over Expenditure(I-II)	E	(8,47,761.00)	<b>3,48,58,750.00</b>		<b>(1,29,58,532.00)</b>
Depreciation		-		(7,02,106.00)	
Loss on Sale assets					
Prior period Items					
Exchange Rate Fluctuation( Repatriate Fluctuation difference )			<b>(8,47,761.00)</b>		<b>(7,02,106.00)</b>
<b>Balance of Surplus Funds</b>			<b>3,40,10,989.00</b>		<b>(1,36,60,638.00)</b>
Accounting policies and notes to accounts are integral part of financial statements.					
AUDITOR'S REPORT					
As per our report of even date attached.					
For NIRBHAYA & ASSOCIATES					
Chartered Accountants					
Firm Registration No. 016125N					
(Ankesh) 					
Partner					
Membership No. 550940					
Place : New Delhi					
Date : 16.11.2021					
					
					
(Simranjeet Singh)					
Assistant Accounts Officer					
<b>(SIMRANJEET SINGH)</b>					
Assistant Accounts Officer					
Indo-French Centre for the					
Promotion of Advanced Research					
New Delhi					
					
(Dr. Purnima Rupal)					
Director					

**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**  
**Schedules forming part of Income & Expenditure- Core Programme as At 31st March 2021**

				<b>Amount as on 31.03.2021</b>	<b>Amount as on 31.03.2020</b>
				<b>Transaction (INR)</b>	<b>Transaction (INR)</b>
				<b>Transaction (Euro)</b>	<b>Transaction (Euro)</b>
<b>Schedule G- Income Core Programme</b>					
<b>Grant in Aid</b>					
Government of India	14,05,00,000.00	-		14,05,00,000.00	3,50,00,000.00
Government of France	-	15,50,000.00		13,60,38,850.00	12,11,54,898.00
<b>Total Grant in Aid</b>	<b>14,05,00,000.00</b>	<b>15,50,000.00</b>		<b>27,65,38,850.00</b>	<b>15,61,54,898.00</b>
				<b>Amount as on 31.03.2021</b>	
<b>Schedule H- Interest from Bank Accounts</b>					
Union Bank of India Accumulated Reserve	12,18,780.00	-		12,18,780.00	21,32,433.00
State Bank of India	-	-		-	-
UBI-Bank	13,830.00	-		13,830.00	18,720.00
Axis Bank	-	-		-	27,073.00
State Bank of India-Gratuity Account	35,828.00	-		35,828.00	47,472.00
	<b>12,68,438.00</b>	<b>-</b>		<b>12,68,438.00</b>	<b>22,25,698.00</b>



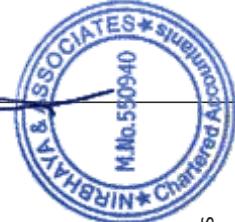
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**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Core Programme as At 31st March 2021**

				Amount as on 31.03.2020	
				Transaction (INR)	Transaction (EURO)
				Total Amount (INR)	Total Amount (INR)
Schedule -I	Expenditure Core Programme				
<b>I. Running Expenditure of the Centre</b>					
Salaries and Office Expenses of the Centre					
(A) Salaries	1,58,35,791.00	-	1,58,35,791.00	1,14,04,511.00	-
Less: Salaries for Non Core	-	-	-	-	-
<b>Total Salaries(A)</b>	<b>1,58,35,791.00</b>	-	<b>1,58,35,791.00</b>	<b>1,14,04,511.00</b>	-
<b>(B) Office Expenses</b>					
Communication Expenses	3,67,707.00	-	3,67,707.00	3,21,640.00	-
Conveyance Expenses	3,23,301.00	-	3,23,301.00	47,015.00	-
Repair & Maintenance	1,67,915.00	-	1,67,915.00	1,22,510.00	-
Electricity Expenses	5,09,078.00	-	5,09,078.00	85,590.00	-
Security Charges	4,75,267.00	-	4,75,267.00	3,01,612.00	-
Other Office Expenses	1,74,336.00	-	1,74,336.00	1,65,675.00	-
Bank Charges	4,786.00	4,353.04	3,86,839.00	5,313.40	5,095.00
Books & Periodicals	17,299.00	-	17,299.00	16,048.00	-
Canteen Expenses	73,390.00	-	73,390.00	54,838.00	-
Staff Welfare	1,19,165.00	-	1,19,165.00	53,240.00	-
Management Service	2,86,323.00	-	2,86,323.00	3,05,303.00	-
Printing and Stationary	88,449.00	-	88,449.00	1,10,658.00	-
Staff Car Expenses	1,42,644.00	-	1,42,644.00	1,38,950.00	-
Professional & Legal Expenses	1,07,380.00	-	1,07,380.00	3,18,600.00	-
Audit Fees	99,120.00	-	99,120.00	82,600.00	-
Maintenance Charges IHC	10,01,740.00	-	10,01,740.00	11,14,767.00	-
Maintenance Charges-Office Premises	2,72,914.00	-	2,72,914.00	3,33,030.00	-
Computer Software	21,830.00	-	21,830.00	1,770.00	-
Employees Insurance Premium	1,72,923.00	-	1,72,923.00	1,41,178.00	-



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**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Core Programme as At 31st March 2021**

		Amount as on 31.03.2020	
		Transaction (INR)	Transaction (EURO)
Recruitment Expenses	-	-	22,949.00
Advertisement Expenses	-	-	63,000.00
IIC Membership	1,59,300.00	-	1,35,700.00
Website Maintenance	3,37,328.00	1,59,300.00	2,87,049.00
Gratuity	4,63,703.00	3,37,328.00	1,08,713.00
Prior Period Expenses	-	4,63,703.00	10,16,082.00
Property tax	4,66,658.00	-	4,66,658.00
Office Expenses(B)	58,52,556.00	4,353.04	58,20,488.40
		62,34,609.00	5,095.00
			62,18,714.00
Total Salaries and Office Expense(A+B)	2,16,88,347.00	4,353.04	2,20,70,400.00
			1,72,24,999.40
			5,095.00
			1,76,23,225.00
(C) Travel Expenses			
Domestic Travel	1,07,686.00	-	1,07,686.00
International Travel	-	-	-
Total Travel Expenses (C)	1,07,686.00	-	1,07,686.00
(D) GB/SC/IRC/SEP/Vision Group Expenses			
Governing Body	1,36,904.00	-	1,36,904.00
Scientific Council	2,41,002.00	-	2,41,002.00
Industrial Research Council	-	-	-
Standard Expert Panel	10,000.00	-	10,000.00
Finance Sub-Committee	-	-	-
Other Office Meetings	1,13,583.00	-	1,13,583.00
Total GB/SC/IRC/SEP/Vision group Expenses (D)	5,01,489.00	-	5,01,489.00
			43,81,713.00
			23,993.17
			62,57,019.00



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**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Core Programme as At 31st March 2021**

		Amount as on 31.03.2020	
		Transaction (INR)	Transaction (EURO)
<b>(E) Office Expenses- Accumulated Reserve</b>			
Pension Premium to LIC	2,80,20,812.00	-	2,80,20,812.00
Network Projects	-	-	-
<b>Total Office Expenses- Accumulated Reserve (E)</b>	<b>2,80,20,812.00</b>	<b>-</b>	<b>2,80,20,812.00</b>
<b>II Scientific Expense of the Centre</b>			
<b>(A) General Scientific Expenses</b>			
Electronic Project Proposal Management	17,65,896.00	-	17,65,896.00
Scientific Publication	1,27,750.00	-	1,27,750.00
Cefipra Lecture Series	-	-	-
Other Scientific Expenses	-	-	(1,85,412.00)
<b>Total General Scientific Expenses (A)</b>	<b>18,93,646.00</b>	<b>-</b>	<b>18,93,646.00</b>
<b>(B) Research Projects/Seminar and Workshop</b>			
Seminars & Workshops	7,83,448.00	(2,520.93)	5,62,194.00
Research Projects	6,37,62,239.00	12,76,780.61	17,58,21,443.00
Industrial Research Projects	93,09,025.00	53,156.05	1,39,74,372.00
<b>Total Research Project/Seminar and workshop (B)</b>	<b>7,38,54,712.00</b>	<b>13,27,415.73</b>	<b>19,03,58,009.00</b>



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**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**  
**RECEIPT AND PAYMENT FOR THE YEAR ENDED ON 31st March 2021**

		Amount as on 31.03.2021		Amount as on 31.03.2020	
		Transaction in INR	Transaction in Euro	Transaction in INR	Transaction in Euro
<b>I. Receipts</b>					
<b>A. Balance Brought Forward</b>					
Union Bank of India Raman Charpak Account		2,84,30,154.92		2,09,08,820.48	
Union Bank of India DST INRA Account		7,08,458.00		6,84,866.00	
Union Bank of India DST INRA Account		96,68,223.00		70,51,920.64	
Union Bank of India IFCAM Account		72,83,751.00		1,19,061.82	
Union Bank of India-DST ANR Account		48,287.73		17,04,535.73	
Union Bank of India- Esson		56,754.76		54,556.76	
Union Bank Accumulated Reserve		5,48,02,261.00		5,27,25,716.48	
Union Bank of India-TDB		12,05,242.90		7,82,660.16	
State Bank of India Account		2,44,72,058.95		6,65,09,909.36	
Union Bank of India- CEFIPRA Account		4,52,198.00		4,37,139.00	
Axis Bank Account		-		8,17,916.00	
State Bank of India (Gratuity Fund) Account		14,55,934.00		15,17,175.00	
State Bank of India-BIRAC		27,00,595.50		26,18,248.50	
DST CNRS		23,80,521.00			
State Bank of India-IFWN		31,42,417.00		27,59,582.00	
State Bank of India GPF		78,315.00		78,315.00	
State Bnak of India-Birac BPI France		32,10,734.00		30,88,157.00	
CIC, Paris			12,68,497.00		9,60,957.93
<b>Total Opening Balance(A)</b>		<b>14,00,95,906.76</b>	<b>12,68,497.00</b>	<b>16,18,58,579.93</b>	<b>9,60,957.93</b>
<b>B. Grant Received and Interest Earned</b>					
i. Grant-in-aid Core Programmes					
Grant From Govt. of France		-	15,50,000.00	-	15,50,000.00
Grant from Govt. of India		14,05,00,000.00	-	3,50,00,000.00	-
Adavance Grant recived for Financial Year 2017-18		-	-	-	-
ii. Grant-in-aid Non Core Programmes					
Government of France		-	1,40,000.00	-	2,05,214.00
Government of India		1,60,73,743.00	-	4,58,69,980.00	-
TDB-Programme		12,05,791.00	-	10,84,242.00	-
iii. Interest from Bank Accounts(Net of TDS)					
State Bank of India		21,94,334.00	-	11,68,963.00	-
UBI-Bank		14,042.00	-	15,059.00	-
State Bank of India-Gratuity account		35,828.00	-	47,472.00	-
Union Bank of India - Raman Charpak Account		10,24,747.00	-	7,18,916.00	-
Union Bank Accumulated Reserve		15,35,911.00		20,76,544.00	
Union Bank of India - DST INRIA Account		3,18,449.00		3,01,111.00	
Union Bank of India - DST INRA Account		21,998.00		23,592.00	
Union Bank of India - IFCAM Account		1,66,198.00		97,834.00	
Union bank of India CNRS		60,272.00		20,902.00	
Union Bank of india-DST ANR Account		1,500.00		44,093.00	
State Bank of India Account-IFWN		86,341.00		91,272.00	
Union Bank of India-TDB		39,008.00		35,200.00	
State Bank of India Account-Birac		74,202.00		82,437.00	
State Bank of India BPI		90,381.00			
Axis bank Interest		-	-	27,073.00	-
Union Bank Of India-ESSONN		1,840.00		2,198.00	-
Cash in Transit		-		33,43,850.00	
iv. Misc.Income		3,504.00		8,480.00	-
v. Prior Period Items					
vi. Repatriation of Funds		2,28,22,738.00	(2,73,214.00)	1,57,24,880.00	(2,00,010.00)
vii. Income Tax Recoverable		11,506.00	-	1,55,965.00	-
<b>TOTAL (B)</b>		<b>18,62,82,333.00</b>	<b>14,16,786.00</b>	<b>10,59,40,063.00</b>	<b>15,55,204.00</b>
<b>TOTAL RECEIPTS(A+B)</b>		<b>32,63,78,239.76</b>	<b>26,85,283.00</b>	<b>26,77,98,642.93</b>	<b>25,16,161.93</b>



INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI RECEIPT AND PAYMENT FOR THE YEAR ENDED ON 31st March 2021					
	Amount as on 31.03.2021		Amount as on 31.03.2020		
	Transaction in INR	Transaction in Euro	Transaction in INR	Transaction in Euro	
<b>II. PAYMENTS</b>					
<b>(A) Running Expenses of the Centre</b>					
Salaries and office Expenses of the Centre	2,19,55,987.00	4,353.04	1,75,06,976.17	5,095.00	
Travel Expenses	1,07,686.00	-	12,94,420.00	4,489.15	
GB/SC/IRC/SEP/Vision Group Expenses	5,01,489.00	-	43,83,801.00	23,993.17	
Expenses from Reserve	2,80,20,812.00	-	-	-	
<b>Total Running Expenses(A)</b>	<b>5,05,85,974.00</b>	<b>4,353.04</b>	<b>2,31,85,197.17</b>	<b>33,577.32</b>	
<b>(B) Scientific Expenses of the Centre</b>					
General Scientific Expenses	18,93,646.00	-	19,63,018.00	-	
Research Projects/Seminar and Workshop	6,98,64,794.00	13,27,415.73	6,55,64,215.00	10,14,531.74	
<b>Total Scientific Expenses (B)</b>	<b>7,17,58,440.00</b>	<b>13,27,415.73</b>	<b>6,75,27,233.00</b>	<b>10,14,531.74</b>	
<b>(C) Other Payments</b>					
Non Core Programmes	2,57,55,177.86	1,07,450.68	3,09,90,118.00	1,99,861.31	
Non Core Programmes Programmed	22,61,839.00	-	29,36,049.00	-	
Implementation and Overhead charges	11,48,161.00	-	4,94,061.00	-	
Purchase of Assets Net of sales	1,00,61,377.00	-	25,50,395.00	-	
Interest refunded to DST	(76,211.00)	(23,674.34)	19,683.00	(305.44)	
Meeting Advance					
Other Deposit					
<b>Total Other Payments(C )</b>	<b>3,91,50,343.86</b>	<b>83,776.34</b>	<b>3,69,90,306.00</b>	<b>1,99,555.87</b>	
<b>TOTAL PAYMENTS(D=A+B+C)</b>	<b>16,14,94,757.86</b>	<b>14,15,545.11</b>	<b>12,77,02,736.17</b>	<b>12,47,664.93</b>	
<b>III. Cash &amp; Cash Equivalent</b>					
<b>Balance carried forward</b>					
Union Bank of India Raman Charpak Account	2,07,03,731.52	-	2,84,30,154.92	-	
Union Bank of India DST INRIA Account	1,25,13,247.99	-	96,68,223.00	-	
Union Bank of India DST INRA Account	7,30,456.00	-	7,08,458.00	-	
Union Bank of India IFCAM Account	8,04,814.02	-	72,83,751.00	-	
Union Bank of India-DST ANR Account	49,787.73	-	48,287.73	-	
Union Bank of India-TDB	17,63,529.05	-	12,05,242.90	-	
Union Bank of India Accumulated Reserve	2,72,66,425.00	-	5,48,02,261.00	-	
State Bank of India Account	8,74,26,882.50	-	2,44,72,058.95	-	
Union Bank of India-CEFIPRA Account	4,66,240.00	-	4,52,198.00	-	
Union Bank- DST ESONN Fellowship	56,091.81	-	56,754.76	-	
Union Bank DST CNRS Account	26,91,231.78	-	23,80,521.00	-	
Axis Bank Account	-	-	-	-	
State Bank of India (Gratuity Fund) Account	10,28,059.00	-	14,55,934.00	-	
State Bank of India - BIRAC French Embassy	27,74,797.50	-	27,00,595.50	-	
State Bank of India -IFWN	32,28,758.00	-	31,42,417.00	-	
State Bank of India-BIRAC BPI France	33,01,115.00	-	32,10,734.00	-	
CIC Paris		12,69,737.89			
State Bank Of India- GPF Account	78,315.00	-	78,315.00	-	
Exchange Rate Flctuation					
<b>TOTAL CLOSING BANK BALANCE (D)</b>	<b>16,48,83,481.90</b>	<b>12,69,737.89</b>	<b>14,00,95,906.76</b>	<b>12,68,497.00</b>	
<b>TOTAL PAYMENTS (C+D)</b>	<b>32,63,78,239.76</b>	<b>26,85,283.00</b>	<b>26,77,98,642.93</b>	<b>25,16,161.93</b>	

Accounting policies and notes to accounts are integral part of financial statements.

#### AUDITOR'S REPORT

As per our report of even date attached.

For NIRBHAYA & ASSOCIATES

Chartered Accountants

Firm Registration No. 01612 N

(Ankesh)

Partner

Membership No. 55094

Place : New Delhi

Date : 16.11.2021



(Simranjeet Singh)  
Assistant Accounts Officer

**(SIMRANJEET SINGH)**

Assistant Accounts Officer

Indo-French Centre for the

Promotion of Advanced Research

New Delhi

(Simranjeet Singh)

Assistant Accounts Officer

**(SIMRANJEET SINGH)**

Assistant Accounts Officer

Indo-French Centre for the

Promotion of Advanced Research

New Delhi

*Purnima Rupal*

(Dr. Purnima Rupal)

Director

INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st March 2021-NON CORE PROGRAMMES					
Income	SCH J	Amount as on 31.03.2021		Amount as on 31.03.2020	
			Total Amount in INR		Total Amount in INR
IFCAM Projects		75,00,000.00		2,20,97,126.00	
DST-ANR Projects		1,476.00		29,775.00	
DST-INRA Projects		21,666.00		23,416.00	
DST-INRIA Projects		51,88,766.00		86,32,857.00	
Raman Charpak Fellowship		1,22,87,380.00		2,59,42,400.00	
BIRAC French Embassy		74,202.00		82,347.00	
Indo French Water Network		86,341.00		91,272.00	
TDB Programmes		12,47,881.00		11,22,494.00	
BIRAC BPI France Programme		90,381.00		-	
DST CNRS		33,84,977.00		52,37,123.00	
DST- ESONN Fellowship		1,797.00		1,962.00	
<b>Total Income</b>			<b>2,98,84,867.00</b>		<b>6,32,60,772.00</b>
<b>Expenditure</b>	K				
IFCAM Projects		1,99,12,135.00		1,33,76,994.00	
DST-ANR Projects		-		(16,73,060.00)	
DST-INRA Projects		-		-	
DST-INRIA Projects		28,80,769.00		46,68,383.00	
Raman Charpak Fellowship		1,00,93,131.00		2,42,54,856.00	
BIRAC French Embassy		-		13,51,230.00	
Indo French Water Network		-		(15,01,646.00)	
TDB Programmes		11,64,273.00		11,84,322.00	
BIRAC BPI France Programme		-		1,888.00	
DST CNRS		33,92,330.40		31,77,503.00	
DST- ESONN Fellowship		5,002.95		-	
<b>Total Expenditure</b>			<b>3,74,47,641.35</b>		<b>4,48,40,470.00</b>
<b>Balance of Surplus Funds</b>					
IFCAM Projects		(1,24,12,135.00)		87,20,132.00	
DST-ANR Projects		1,476.00		17,02,835.00	
DST-INRA Projects		21,666.00		23,416.00	
DST-INRIA Projects		23,07,997.00		39,64,474.00	
Raman Charpak Fellowship		21,94,249.00		16,87,544.00	
BIRAC French Embassy		74,202.00		(12,68,883.00)	
Indo French Water Network		86,341.00		15,92,918.00	
TDB Programmes		83,608.00		(61,828.00)	
BIRAC BPI France Programme		90,381.00		(1,888.00)	
DST CNRS		(7,353.40)		20,59,620.00	
DST- ESONN Fellowship		(3,205.95)		1,962.00	
<b>Total Balance of Surplus Funds</b>			<b>(75,62,774.35)</b>		<b>1,84,20,302.00</b>

Accounting policies and notes to accounts are integral part of financial statements.

#### AUDITOR'S REPORT

As per our report of even date attached.

For NIRBHAYA & ASSOCIATES

Chartered Accountants

Firm Registration No. 016125N

**Partner**

Membership No.550940

Place : New Delhi

Date :16.11.2021



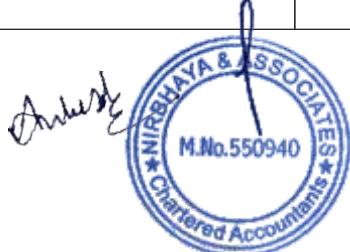
(Simranjeet Singh)

Assistant Accounts Officer  
**(SIMRANJEET SINGH)**  
 Assistant Accounts Officer  
 Indo-French Centre for the  
 Promotion of Advanced Research  
 New Delhi

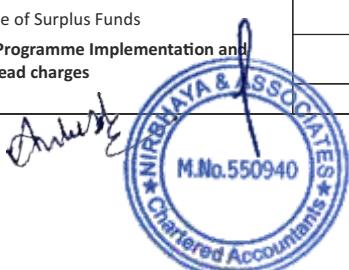
*Purnima Rupal*  
 (Dr. Purnima Rupal)

Director

INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI Schedules forming part of Balance Sheet as At 31st March 2021						
	Amount as on 31.03.2021			Amount as on 31.03.2020		
Schedule B- Targetted Programmes	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
<b>IFCAM Projects</b>						
Opening Balance-Project Release	86,27,672.85	92,750.00	1,63,07,882.43	16,60,816.85	27,536.00	33,43,476.43
Balance of Surplus Funds	(1,24,12,135.00)	-	(1,24,12,135.00)	36,23,006.00	65,214.00	87,20,132.00
Repatriation of Funds	63,14,318.00	(73,214.00)	-	33,43,850.00	-	-
Funds In Transit	-	-	-	-	-	-
Foreign Currency adjustment	-	-	-	-	-	-
Adjustment during the year	-	-	-	-	-	-
Total IFCAM Projects	<b>25,29,855.85</b>	<b>19,536.00</b>	<b>38,95,747.43</b>	<b>86,27,672.85</b>	<b>92,750.00</b>	<b>1,20,63,608.43</b>
Less: Programme Implementation & Overhead	-	-	-	-	-	-
Less: amount refunded to DST	4,55,709.00		4,55,709.00			-
Foreign Currency fluctuation			3,12,642.00			42,44,274.00
<b>Balance for Project Releases</b>	<b>20,74,146.85</b>	<b>19,536.00</b>	<b>37,52,680.43</b>	<b>86,27,672.85</b>	<b>92,750.00</b>	<b>1,63,07,882.43</b>
<b>DST- ANR Projects</b>						
Opening Balance- Project Release	-	-	-	11,23,886.00	-	11,23,886.00
Balance of Surplus Funds	1,476.00		1,476.00	17,02,835.00	-	17,02,835.00
Prior Period Items	-	-	-	5,46,680.00	-	5,46,680.00
Total DST-ANR Projects	<b>1,476.00</b>	-	<b>1,476.00</b>	<b>33,73,401.00</b>	-	<b>33,73,401.00</b>
Less: Programme Implementation & Overhead	-	-	-	-	-	-
Less: Amount Refunded To DST			-	33,73,401.00		33,73,401.00
<b>Balance for Project Releases</b>	<b>1,476.00</b>	-	<b>1,476.00</b>	-	-	-
<b>DST- INRA Projects</b>						
Opening Balance	7,14,193.00	8,498.00	14,17,874.00	6,90,777.00	8,498.00	9,17,129.00
Balance of Surplus Funds	21,666.00	-	21,666.00	23,416.00	-	23,416.00
Adjustment for Core Programme	-	-	-	-	-	-
Prior Period Items	-	-	-	-	-	-
Adjustment for Non Core Programme	-	-	-	-	-	-
Repatraition of funds	-	-	-	-	-	-
Gain/(Loss) on Repatraition of Funds	-	-	-	-	-	-
Total DST-INRA Projects	<b>7,35,859.00</b>	<b>8,498.00</b>	<b>14,39,540.00</b>	<b>7,14,193.00</b>	<b>8,498.00</b>	<b>9,40,545.00</b>
Less: Programme Implementation & Overhead	-	-	-	-	-	-
Foreign Currency fluctuation			26,467.55			4,77,329.00
<b>Balance for Project Releases</b>	<b>7,35,859.00</b>	<b>8,498.00</b>	<b>14,66,007.55</b>	<b>7,14,193.00</b>	<b>8,498.00</b>	<b>14,17,874.00</b>
<b>DST- INRIA Projects</b>						
Opening Balance	64,26,960.00	-	64,26,960.00	47,51,296.00	-	47,51,296.00
Balance of Surplus Funds	23,07,997.00	-	23,07,997.00	39,64,474.00	-	39,64,474.00
Adjustment during the year	(73,500.00)	-	(73,500.00)	-	-	-
Adjustment from DSt-INRA	-	-	-	-	-	-
Total DST-INRIA Projects	<b>86,61,457.00</b>	-	<b>86,61,457.00</b>	<b>87,15,770.00</b>	-	<b>87,15,770.00</b>
Less: Programme Implementation & Overhead	-	-	-	-	-	-
Less: Amount Refunded To DST			-	22,88,810.00		22,88,810.00
<b>Balance for Project Releases</b>	<b>86,61,457.00</b>	-	<b>86,61,457.00</b>	<b>64,26,960.00</b>	-	<b>64,26,960.00</b>



INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI Schedules forming part of Balance Sheet as At 31st March 2021						
	Amount as on 31.03.2021			Amount as on 31.03.2020		
<b>Schduele B- Targetted Programmes</b>						
<b>Raman Charpak Fellowship</b>	<b>Amount (INR)</b>	<b>Amount (Euro)</b>	<b>Total Amount in INR</b>	<b>Amount (INR)</b>	<b>Amount (Euro)</b>	<b>Total Amount in INR</b>
Opening Balance	2,07,13,429.00	(26,156.56)	1,85,47,521.97	1,49,11,010.00	30,306.44	1,75,82,977.00
Balance of Surplus Funds	-	32,549.32	21,94,249.00	61,00,692.00	(56,463.00)	16,87,544.00
Foreign Currecy Fluctuation	(6,14,941.00)	-	-	-	-	-
Repatriation of funds	-	-	-	-	-	-
Adjustment during the year	3,62,975.00	-	-	-	-	-
Amount refunded to DST	(73,01,155.00)	-	(73,01,155.00)	-	-	-
Total Raman Charpak Fellowship	<b>1,31,60,308.00</b>	<b>6,392.76</b>	<b>1,34,40,615.97</b>	<b>2,10,11,702.00</b>	<b>(26,156.56)</b>	<b>1,92,70,521.00</b>
Less: Programme Implementation & Overhead	-	-	-	2,98,273.00	-	2,98,273.00
Less: Interest refunded to DST	-	-	-	-	-	-
Foreign Currency fluctuation	-	-	2,68,957.97	-	-	(21,65,907.03)
Balance for Project Releases	<b>1,31,60,308.00</b>	<b>6,392.76</b>	<b>1,37,09,573.94</b>	<b>2,07,13,429.00</b>	<b>(26,156.56)</b>	<b>1,85,47,521.97</b>
<b>Birac French Embassy</b>						
Opening Balance	35,23,080.00	90,196.00	1,09,91,804.88	34,40,733.00	1,07,484.00	1,10,20,995.00
Balance of Surplus Funds	74,202.00	-	74,202.00	82,347.00	(17,288.00)	(12,68,883.00)
Foreign Currency Fluctuation	-	-	-	-	-	-
Adjustment during the year	-	-	-	-	-	-
Total Birac French Embassy	<b>35,97,282.00</b>	<b>90,196.00</b>	<b>1,10,66,006.88</b>	<b>35,23,080.00</b>	<b>90,196.00</b>	<b>97,52,112.00</b>
Less: Programme Implementation & Overhead	-	-	-	-	-	-
Foreign Currency fluctuation	-	-	2,80,915.44	-	-	12,39,692.88
Balance for Project Releases	<b>35,97,282.00</b>	<b>90,196.00</b>	<b>1,13,46,922.32</b>	<b>35,23,080.00</b>	<b>90,196.00</b>	<b>1,09,91,804.88</b>
<b>Economic Diplomacy R &amp; D Programme</b>						
Opening Balance	17,73,126.00	62,424.94	69,42,254.37	17,73,126.00	62,424.94	59,18,008.00
Total Economic Diplomacy R & D programme	<b>17,73,126.00</b>	<b>62,424.94</b>	<b>69,42,254.37</b>	<b>17,73,126.00</b>	<b>62,424.94</b>	<b>59,18,008.00</b>
Less: Programme Implementation & Overhead	-	-	-	-	-	-
Foreign Currency fluctuation	-	-	1,94,422.47	-	-	10,24,246.37
Balance for Project Releases	<b>17,73,126.00</b>	<b>62,424.94</b>	<b>71,36,676.84</b>	<b>17,73,126.00</b>	<b>62,424.94</b>	<b>69,42,254.37</b>
<b>India France Water Network</b>						
Opening Balance	31,42,417.00	1,33,892.15	1,42,29,423.43	26,35,117.00	1,20,002.46	1,10,31,799.00
Balance of Surplus Funds	86,341.00	-	86,341.00	5,07,300.00	13,889.69	15,92,918.00
Adjustment for core programme	-	-	-	-	-	-
Transfer from Indo France Tech Sumit	-	-	-	-	-	-
Foreign Currency Fluctuation	-	-	-	-	-	-
Total India France water Network	<b>32,28,758.00</b>	<b>1,33,892.15</b>	<b>1,43,15,764.43</b>	<b>31,42,417.00</b>	<b>1,33,892.15</b>	<b>1,26,24,717.00</b>
Less: Programme Implementation & Overhead	-	-	-	-	-	-
Foreign Currency fluctuation	-	-	4,17,007.10	-	-	16,04,706.43
Balance for Project Releases	<b>32,28,758.00</b>	<b>1,33,892.15</b>	<b>1,47,32,771.53</b>	<b>31,42,417.00</b>	<b>1,33,892.15</b>	<b>1,42,29,423.43</b>
<b>TDB Programme</b>						
Opening Balance	2,28,030.00	-	2,28,030.00	2,89,858.00	-	2,89,858.00
Balance of Surplus Funds	83,608.00	-	83,608.00	(61,828.00)	-	(61,828.00)
<b>Total Programme Implementation and Overhead charges</b>	<b>3,11,638.00</b>	<b>-</b>	<b>3,11,638.00</b>	<b>2,28,030.00</b>	<b>-</b>	<b>2,28,030.00</b>



INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI Schedules forming part of Balance Sheet as At 31st March 2021						
	Amount as on 31.03.2021			Amount as on 31.03.2020		
Schedule B- Targetted Programmes	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
<b>Birac BPI France Programme</b>						
Opening Balance	30,96,001.00	-	30,96,001.00	30,97,889.00	-	30,97,889.00
Balance of Surplus Funds	90,381.00	-	90,381.00	(1,888.00)	-	(1,888.00)
Total Birac French Embassy	<b>31,86,382.00</b>	-	<b>31,86,382.00</b>	<b>30,96,001.00</b>	-	<b>30,96,001.00</b>
Less: Programme Implementation & Overhead	-	-	-			-
Balance for Project Releases	<b>31,86,382.00</b>	-	<b>31,86,382.00</b>	<b>30,96,001.00</b>	-	<b>30,96,001.00</b>
<b>DST - ESONN Fellowship</b>						
Opening Balance	5,868.00	-	5,868.00	3,906.00	-	3,906.00
Balance of Surplus Funds	(3,205.95)	-	(3,205.95)	1,962.00	-	1,962.00
Total Esson Fellowship	<b>2,662.05</b>	-	<b>2,662.05</b>	<b>5,868.00</b>	-	<b>5,868.00</b>
Prior Period items	2,500.00	-	2,500.00			-
Less: Amount refunded to DST			-			
Balance for Project Releases	<b>5,162.05</b>	-	<b>5,162.05</b>	<b>5,868.00</b>	-	<b>5,868.00</b>
<b>DST - CNRS</b>						
Opening Balance	20,59,620.00		20,59,620.00			
Balance of Surplus Funds	(7,353.40)		(7,353.40)	20,59,620.00		20,59,620.00
Total of DST CNR	<b>20,52,266.60</b>		<b>20,52,266.60</b>	<b>20,59,620.00</b>	-	<b>20,59,620.00</b>



Rupal.

**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**  
**Schedules forming part of Balance Sheet as At 31st March 2021**

				Amount as on 31.03.2021	Amount as on 31.03.2020	
		Transaction in INR	Transaction in Euro	Total Amount in INR	Transaction in INR	Transaction in Euro
<b>Schedule A</b>						
<b>Reserve Fund-Core Programmes</b>						
Opening Balance B/f	9,21,63,147.01	11,04,770.73		18,13,12,581.60	8,74,21,955.41	13,86,316.17
Balance of Surplus Funds	1,48,57,489.00	2,18,231.23		3,40,10,989.00	(5,28,95,379.40)	5,01,891.56
Adjustment for Currency Fluctuation				50,96,886.89	4,44,62,086.00	(5,83,427.00)
Interest refunded To DST					(25,50,395.00)	8,88,192.00
Transfer of Funds Current Year	1,65,08,420.00		(2,00,000.00)		1,57,24,880.00	(2,00,010.00)
<b>Balance c/f to next year</b>	<b>12,35,29,056.01</b>	<b>11,23,001.96</b>		<b>22,04,20,457.49</b>	<b>9,21,63,147.01</b>	<b>11,04,770.73</b>

				Amount as on 31.03.2021	Amount as on 31.03.2021	
		Transaction in INR	Transaction in Euro	Total Amount in INR	Transaction in INR	Transaction in Euro
<b>Schedule D</b>						
<b>Foreign Currency Adjustment Account</b>						
Opening Balance	-	-		89,55,390.00	-	-
Less: Reversal of Previous Year Adjustment	-	-		(23,31,537.00)	-	-
Less: Current Year Adjustment				(4,03,201.23)		
<b>Balance carried forward to next year</b>				<b>62,20,651.77</b>	<b>-</b>	<b>89,55,390.00</b>
(As per the accounting policy for adjustment of foreign currency transactions the difference arising on Balance sheet date due to conversion of Euro to INR is passed in the Balance Sheet and no effect is given in the Profit & Loss Account)						



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INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI Schedules forming part of Balance Sheet as At 31st March 2021						
	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Transaction in INR	Transaction in Euro	Total Amount in INR	Transaction in INR	Transaction in Euro	Total Amount in INR
<b>Schedule C</b>						
<b>1) Salaries &amp; Office Expenses Payable</b>						
Other Office expenses				5,002.00		5,002.00
Electronic Proposal Management Charges	37,800.00	-	37,800.00	5,59,220.00		5,59,220.00
Professional Expenses Payable	1,355.00	-	1,355.00	37,800.00		37,800.00
Communication Expenses				8,115.00		8,115.00
<b>Total Salaries &amp; Office Expense Payable</b>	<b>39,155.00</b>	<b>-</b>	<b>39,155.00</b>	<b>6,10,137.00</b>	<b>-</b>	<b>6,10,137.00</b>
<b>Duties &amp; Taxes</b>						
On Professional Services	9,450.00	-	9,450.00	23,600.00		23,600.00
On Contractors	8,124.00	-	8,124.00	1,566.00		1,566.00
TDS on GST	50,854.00		50,854.00	11,362.00		11,362.00
<b>Total Duties &amp; Taxes</b>	<b>68,428.00</b>	<b>-</b>	<b>68,428.00</b>	<b>36,528.00</b>	<b>-</b>	<b>36,528.00</b>
<b>Seminar &amp; Workshops Liability</b>						
Seminar on Medical Robotics (11-171)	1,08,510.00		1,08,510.00	1,08,510.00		1,08,510.00
Seminar on New Frontiers	1,23,000.00		1,23,000.00	1,23,000.00		1,23,000.00
Seminar on New Trends in Chemistry (11-138)	2,88,000.00		2,88,000.00	2,88,000.00		2,88,000.00
Seminar on Organic Semiconductor(11-139)	2,75,400.00	3,820.00	6,03,614.00	2,75,400.00	3,820.00	5,91,717.00
Seminar on Repair Recombination	2,12,837.00	-	2,12,837.00	2,12,837.00		2,12,837.00
Seminar on Evolutionary Developmental		1,320.00	1,13,414.00		1,320.00	1,09,303.00
Seminar on Metagenomic		3,288.00	2,82,505.00		3,288.00	2,72,264.00
Seminar on Airthmetic Geometry	-	3,188.00	2,73,913.00		3,188.00	2,63,984.00
Seminar on ocean Technology			14,00,000.00		14,00,000.00	14,00,000.00
<b>Total Seminar &amp; Workshop Liability</b>	<b>24,07,747.00</b>	<b>11,616.00</b>	<b>34,05,793.00</b>	<b>24,07,747.00</b>	<b>11,616.00</b>	<b>33,69,615.00</b>

INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI Schedules forming part of Balance Sheet as At 31st March 2021						
	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Transaction in INR	Transaction in Euro	Total Amount in INR	Transaction in INR	Transaction in Euro	Total Amount in INR
<b>Schedule F- ADVANCES</b>						
<b>Seminar &amp; Workshops</b>						
Seminar on Application of Structured Biology	-	-	-	-	-	-
Seminar on processing	8,05,200.00	-	8,05,200.00	8,05,200.00	-	8,05,200.00
Registrar,Bharatnat University	5,96,000.00	-	5,96,000.00	5,96,000.00	-	5,96,000.00
Tata Institute of Fundamental	-	-	-	-	-	-
Seminar on Catlysis by Design Using NMR	-	13,482.00	11,58,373.00	-	13,482.00	11,16,384.00
Seminar on Plasticity, Rheology and Nonlin	-	12,320.00	10,58,534.00	-	12,320.00	10,20,164.00
<b>Total Seminar &amp; Workshop Advances</b>	<b>14,01,200.00</b>	<b>25,802.00</b>	<b>36,18,107.00</b>	<b>14,01,200.00</b>	<b>25,802.00</b>	<b>35,37,748.00</b>
<b>Other Deposit</b>						
India Habitat Centre	-	-	-	-	-	-
Rent-Director Residence	21,951.00	-	21,951.00	21,951.00	-	21,951.00
Cellular Connection	6,515.91	-	6,516.00	6,515.91	-	6,516.00
GB/SC/IRC Advance	12,366.00	8,993.60	7,85,096.00	22,820.00	8,993.60	7,67,540.00
Internet Charges				74,098.00		74,098.00
Campus France	-	71,022.86	61,02,284.00	-	94,697.20	78,41,449.00
Other Advances	14,198.00	-	14,198.00			
Cash Imprest	1,427.00	-	1,427.00	7,284.00	-	7,284.00
<b>Total Other Deposit</b>	<b>56,457.91</b>	<b>80,016.46</b>	<b>69,31,472.00</b>	<b>1,32,668.91</b>	<b>1,03,690.80</b>	<b>87,18,838.00</b>



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INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI  
SCHEDULES FORMING PART OF THE BALANCE SHEET AS AT 31st March 2021

Schedule- E Fixed Assets

S.No	Particulars	Rate	GROSS BLOCK			Depreciation for the year	Adjustment	Total	NET BLOCK	
			Opening Balance	Additions during the year	Sold/Written off during the year				Balance as on 31-03-2021	Balance as on 31-03-2020
1	CAR	0.15	6,04,763.00	5,274.00	6,04,763.00	4,66,896.00	20,680.00	4,87,576.00	1,17,187.00	1,37,867.00
2	FURNITURE & FIXTURE	0.10	12,44,065.00	34,200.00	12,15,867.00	4,47,958.00	76,527.00	5,24,485.00	6,91,382.00	7,96,107.00
3	OFFICE EQUIPMENT	0.15	45,19,306.00	59,111.00	46,12,617.00	30,34,750.00	2,34,115.00	32,68,365.00	13,43,752.00	14,84,536.00
4	COMPUTER	0.40	23,58,597.00	10,49,576.00	34,08,173.00	21,85,907.00	2,78,991.00	24,64,888.00	9,43,275.00	1,72,690.00
5	LAND & BUILDING	0.10	1,47,71,284.00	1,47,71,284.00	1,35,19,737.00	1,25,155.00	11,921.00	1,36,44,892.00	11,26,392.00	12,51,547.00
6	PHOTOCOPIER	0.15	1,52,250.00	1,52,250.00	72,775.00	16,85,958.00	12,39,957.00	84,696.00	67,554.00	79,475.00
7	TELEPHONE SYSTEM	0.15	16,85,958.00	59,111.00	10,89,050.00	2,64,50,912.00	66,900.00	13,06,257.00	3,79,101.00	4,46,001.00
	Previous Year		2,48,37,307.00	-	3,300.00	33,472.00	2,09,67,980.00	8,14,289.00	-	2,17,82,269.00
						1,95,41,757.00	2,48,40,607.00	5,99,741.00	-	46,68,643.00
										1,87,70,113.00

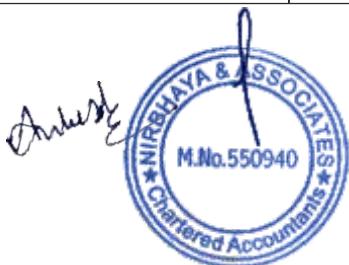


Rupali:

**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Non Core Programme as At 31st March 2021**

Schedule- J Income- Non Core Programme	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
<b>IFCAM Projects</b>						
Grant In Aid	74,00,000.00	-	74,00,000.00	1,69,00,000.00	65,214.00	2,19,97,126.00
Programme Implementation and Overhead	1,00,000.00	-	1,00,000.00	1,00,000.00	-	1,00,000.00
Bank Interest	-	-	-	-	-	-
<b>Total IFCAM Projects</b>	<b>75,00,000.00</b>	<b>-</b>	<b>75,00,000.00</b>	<b>1,70,00,000.00</b>	<b>65,214.00</b>	<b>2,20,97,126.00</b>
<b>DSt- ANR Projects</b>						
Grant In Aid	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
Bank Interest	1,476.00	-	1,476.00	29,775.00	-	29,775.00
<b>Total DST-ANR Projects</b>	<b>1,476.00</b>	<b>-</b>	<b>1,476.00</b>	<b>29,775.00</b>	<b>-</b>	<b>29,775.00</b>
<b>DSt- INRA Projects</b>						
Grant In Aid	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
Bank Interest	21,666.00	-	21,666.00	23,416.00	-	23,416.00
<b>Total DST-INRA Projects</b>	<b>21,666.00</b>	<b>-</b>	<b>21,666.00</b>	<b>23,416.00</b>	<b>-</b>	<b>23,416.00</b>
<b>DSt- INRIA Projects</b>						
Grant In Aid	45,38,766.00	-	45,38,766.00	79,82,857.00	-	79,82,857.00
Programme Implementation and Overhead	6,50,000.00	-	6,50,000.00	6,50,000.00	-	6,50,000.00
Bank Interest	-	-	-	-	-	-
<b>Total DST-INRIA Projects</b>	<b>51,88,766.00</b>	<b>-</b>	<b>51,88,766.00</b>	<b>86,32,857.00</b>	<b>-</b>	<b>86,32,857.00</b>
<b>Raman Charpak Fellowship</b>						
Grant In Aid	-	1,40,000.00	1,22,87,380.00	1,40,00,000.00	1,40,000.00	2,49,42,400.00
Programme Implementation and Overhead	-	-	-	10,00,000.00	-	10,00,000.00
Bank Interest	-	-	-	-	-	-
<b>Total Raman Charpak Fellowship</b>	<b>-</b>	<b>1,40,000.00</b>	<b>1,22,87,380.00</b>	<b>1,50,00,000.00</b>	<b>1,40,000.00</b>	<b>2,59,42,400.00</b>
<b>Birac French Embassy</b>						
Grant In Aid	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
Bank Interest	74,202.00	-	74,202.00	82,347.00	-	82,347.00
<b>Total Birac French Embassy</b>	<b>74,202.00</b>	<b>-</b>	<b>74,202.00</b>	<b>82,347.00</b>	<b>-</b>	<b>82,347.00</b>
<b>Indo french Water network</b>						
Grant In Aid	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
Bank Interest	86,341.00	-	86,341.00	91,272.00	-	91,272.00
<b>Total Indo French Water Network</b>	<b>86,341.00</b>	<b>-</b>	<b>86,341.00</b>	<b>91,272.00</b>	<b>-</b>	<b>91,272.00</b>
<b>TDB Programme</b>						
Grant In Aid	-	-	-	-	-	-
Programme Implementation and Overhead	12,05,791.00	-	12,05,791.00	10,84,242.00	-	10,84,242.00
Bank Interest	42,090.00	-	42,090.00	38,252.00	-	38,252.00
<b>Total TDB Programme</b>	<b>12,47,881.00</b>	<b>-</b>	<b>12,47,881.00</b>	<b>11,22,494.00</b>	<b>-</b>	<b>11,22,494.00</b>
<b>BIRAC BPI France Programme</b>						
Grant In Aid	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
Bank Interest	90,381.00	-	90,381.00	-	-	-
<b>Total BIRAC BPI France Programme</b>	<b>90,381.00</b>	<b>-</b>	<b>90,381.00</b>	<b>-</b>	<b>-</b>	<b>-</b>



INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI

Schedules forming part of Income & Expenditure- Non Core Programme as At 31st March 2021

Schedule- J Income- Non Core Programme	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
DST- ESONN Fellowship	-	-	-	-	-	-
Grant In Aid	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
Bank Interest	1,797.00	-	1,797.00	1,962.00	-	1,962.00
<b>Total ESONN Fellowship</b>	<b>1,797.00</b>	-	<b>1,797.00</b>	<b>1,962.00</b>	-	<b>1,962.00</b>
DST CNRS						
Grant In Aid	30,84,977.00	-	30,84,977.00	49,37,123.00	-	49,37,123.00
Programme Implementation and Overhead	3,00,000.00	-	3,00,000.00	3,00,000.00	-	3,00,000.00
Bank Interest	-	-	-	-	-	-
<b>Total Birac French Embassy</b>	<b>33,84,977.00</b>	-	<b>33,84,977.00</b>	<b>52,37,123.00</b>	-	<b>52,37,123.00</b>



**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Non Core Programme as At 31st March 2021**

Schedule-K Expenditure Non Core Programme	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
<b>IFCAM Projects</b>						
Project Expenses & Bank Charges	1,98,12,135.00	-	1,98,12,135.00	1,32,76,994.00	-	1,32,76,994.00
Programme Implementation and Overhead	1,00,000.00	-	1,00,000.00	1,00,000.00	-	1,00,000.00
<b>Total IFCAM Projects</b>	<b>1,99,12,135.00</b>	-	<b>1,99,12,135.00</b>	<b>1,33,76,994.00</b>	-	<b>1,33,76,994.00</b>
<b>DST- ANR Projects</b>						
Project Expenses & Bank Charges	-	-	-	(16,73,060.00)	-	(16,73,060.00)
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total DST-ANR Projects</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>(16,73,060.00)</b>	<b>-</b>	<b>(16,73,060.00)</b>
<b>DST- INRA Projects</b>						
Project Expenses and Bank Charges	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total DST-INRA Projects</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>DST- INRIA Projects</b>						
Project Expenses & Bank Charges	22,30,769.00	-	22,30,769.00	40,18,383.00	-	40,18,383.00
Programme Implementation and Overhead	6,50,000.00	-	6,50,000.00	6,50,000.00	-	6,50,000.00
<b>Total DST-INRIA Projects</b>	<b>28,80,769.00</b>	<b>-</b>	<b>28,80,769.00</b>	<b>46,68,383.00</b>	<b>-</b>	<b>46,68,383.00</b>
<b>Raman Charpak Fellowship</b>						
Project Expenses & Bank Charges	6,14,941.00	1,07,450.68	1,00,45,565.00	81,97,581.00	1,96,463.00	2,35,53,129.00
Programme Implementation and Overhead	47,566.00	-	47,566.00	7,01,727.00	-	7,01,727.00
<b>Total Raman Charpak Fellowship</b>	<b>6,62,507.00</b>	<b>1,07,450.68</b>	<b>1,00,93,131.00</b>	<b>88,99,308.00</b>	<b>1,96,463.00</b>	<b>2,42,54,856.00</b>
<b>Birac French Embassy</b>						
Project Expenses	-	-	-	-	17,288.00	13,51,230.00
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total Birac French Embassy</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>17,288.00</b>	<b>13,51,230.00</b>
<b>Indo french Water network</b>						
Project Expenses & Bank Interest	-	-	-	(4,16,028.00)	(13,889.69)	(15,01,646.00)
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total Indo French Water Network</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>(4,16,028.00)</b>	<b>(13,889.69)</b>	<b>(15,01,646.00)</b>
<b>TDB Programme</b>						
Programme Implementation and Overhead	11,64,273.00	-	11,64,273.00	11,84,322.00	-	11,84,322.00
<b>Total TDB Programme</b>	<b>11,64,273.00</b>	<b>-</b>	<b>11,64,273.00</b>	<b>11,84,322.00</b>	<b>-</b>	<b>11,84,322.00</b>
<b>BIRAC BPI France Programme</b>						
Project Expenses & Bank Charges	-	-	-	1,888.00	-	1,888.00
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total BIRAC BPI France Programme</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1,888.00</b>	<b>-</b>	<b>1,888.00</b>



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**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Non Core Programme as At 31st March 2021**

<b>Schedule-K Expenditure Non Core Programme</b>	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
DST- ESONN Fellowship						
Project Expenses & Bank Charges	5,002.95		5,002.95			-
Programme Implementation and Overhead		-	-		-	-
Total DST Esson Fellowship	<b>5,002.95</b>	-	<b>5,002.95</b>		-	-
DST CNRS						
Project Expenses & Bank Charges	30,92,330.40		30,92,330.40	28,77,503.00		28,77,503.00
Programme Implementation and Overhead	3,00,000.00		3,00,000.00	3,00,000.00		3,00,000.00
Total DST CNRS	<b>33,92,330.40</b>		<b>33,92,330.40</b>	31,77,503.00		31,77,503.00
Economic Diplomacy						
Project Expenses & Bank Charges	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
Total Birac French Embassy	-	-	-	-	-	-



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**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Non Core Programme as At 31st March 2021**

Schedule-K Expenditure Non Core Programme	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
<b>IFCAM Projects</b>						
Project Expenses & Bank Charges	1,98,12,135.00	-	1,98,12,135.00	1,32,76,994.00	-	1,32,76,994.00
Programme Implementation and Overhead	1,00,000.00	-	1,00,000.00	1,00,000.00	-	1,00,000.00
<b>Total IFCAM Projects</b>	<b>1,99,12,135.00</b>	-	<b>1,99,12,135.00</b>	<b>1,33,76,994.00</b>	-	<b>1,33,76,994.00</b>
<b>DST- ANR Projects</b>						
Project Expenses & Bank Charges	-	-	-	(16,73,060.00)	-	(16,73,060.00)
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total DST-ANR Projects</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>(16,73,060.00)</b>	<b>-</b>	<b>(16,73,060.00)</b>
<b>DST- INRA Projects</b>						
Project Expenses and Bank Charges	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total DST-INRA Projects</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>DST- INRIA Projects</b>						
Project Expenses & Bank Charges	22,30,769.00	-	22,30,769.00	40,18,383.00	-	40,18,383.00
Programme Implementation and Overhead	6,50,000.00	-	6,50,000.00	6,50,000.00	-	6,50,000.00
<b>Total DST-INRIA Projects</b>	<b>28,80,769.00</b>	<b>-</b>	<b>28,80,769.00</b>	<b>46,68,383.00</b>	<b>-</b>	<b>46,68,383.00</b>
<b>Raman Charpak Fellowship</b>						
Project Expenses & Bank Charges	6,14,941.00	1,07,450.68	1,00,45,565.00	81,97,581.00	1,96,463.00	2,35,53,129.00
Programme Implementation and Overhead	47,566.00	-	47,566.00	7,01,727.00	-	7,01,727.00
<b>Total Raman Charpak Fellowship</b>	<b>6,62,507.00</b>	<b>1,07,450.68</b>	<b>1,00,93,131.00</b>	<b>88,99,308.00</b>	<b>1,96,463.00</b>	<b>2,42,54,856.00</b>
<b>Birac French Embassy</b>						
Project Expenses	-	-	-	-	17,288.00	13,51,230.00
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total Birac French Embassy</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>17,288.00</b>	<b>13,51,230.00</b>
<b>Indo french Water network</b>						
Project Expenses & Bank Interest	-	-	-	(4,16,028.00)	(13,889.69)	(15,01,646.00)
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total Indo French Water Network</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>(4,16,028.00)</b>	<b>(13,889.69)</b>	<b>(15,01,646.00)</b>
<b>TDB Programme</b>						
Programme Implementation and Overhead	11,64,273.00	-	11,64,273.00	11,84,322.00	-	11,84,322.00
<b>Total TDB Programme</b>	<b>11,64,273.00</b>	<b>-</b>	<b>11,64,273.00</b>	<b>11,84,322.00</b>	<b>-</b>	<b>11,84,322.00</b>



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**INDO-FRENCH CENTRE FOR THE PROMOTION OF ADVANCED RESEARCH, NEW DELHI**

**Schedules forming part of Income & Expenditure- Non Core Programme as At 31st March 2021**

Schedule-K Expenditure Non Core Programme	Amount as on 31.03.2021			Amount as on 31.03.2020		
	Amount (INR)	Amount (Euro)	Total Amount in INR	Amount (INR)	Amount (Euro)	Total Amount in INR
BIRAC BPI France Programme			-			
Project Expenses & Bank Charges			-	1,888.00		1,888.00
Programme Implementation and Overhead		-	-	-	-	-
<b>Total BIRAC BPI France Programme</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1,888.00</b>	<b>-</b>	<b>1,888.00</b>
DST- ESONN Fellowship			5,002.95			-
Project Expenses & Bank Charges	5,002.95		5,002.95			-
Programme Implementation and Overhead		-	-	-	-	-
<b>Total DST Esson Fellowship</b>	<b>5,002.95</b>	<b>-</b>	<b>5,002.95</b>	<b>-</b>	<b>-</b>	<b>-</b>
DST CNRS			30,92,330.40			28,77,503.00
Project Expenses & Bank Charges	30,92,330.40		30,92,330.40	3,00,000.00	3,00,000.00	28,77,503.00
Programme Implementation and Overhead		-	-	-	-	3,00,000.00
<b>Total DST CNRS</b>	<b>33,92,330.40</b>	<b>-</b>	<b>33,92,330.40</b>	<b>31,77,503.00</b>	<b>-</b>	<b>31,77,503.00</b>
Economic Diplomacy			-			-
Project Expenses & Bank Charges	-	-	-	-	-	-
Programme Implementation and Overhead	-	-	-	-	-	-
<b>Total Birac French Embassy</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>



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Sr. No.	Project No.	Name of the Equipment purchased	Date of Released	Amount in (Rs.)
		Opening as per Notes to Accounts given in Annual Report -(2015-16)		4,66,08,787.00
1	5504-2	HPz840 & EMC Storage	21.01.2016	8,00,000.00
2	5504-3	Roller Block/Diff Drive RH Metric, Back Illuminated EMCCD iXon, different capacity convex lenses and silica+Meniscus lenses	07.05.2016	49,35,500.00
		Precision XYZ, Nanopositioning system, recommended controller digital multi-channel piezo controller		
3	5505-2	Recycling type preparative HPL Flash Chromatography system with accessories, Low freezer refrigerator with accessories	11.05.2016	20,55,000.00
4	5601-1	MacBook-1	21.04.2017	86,900.00
5	5603-1	Inverted Research Fluorescent and Phase contrast research Microscope	21.10.2016	24,23,000.00
6	5604-1	Apple Imac 27inch Retina 5K quad-core i5 3.5GB/8GB/1TB Fusion/AMD M290X, 3x Dual CPU 12 core node, with infiny bank network for data storage, 8 GPU cards	13.01.2017	40,00,000.00
7	5604-2	12.9" inch Ipad Pro WiFi258GB Space Grey, 1 PMC593FEB, Pad APP-SUP software	27.11.2017	1,51,612.00
8	5604-3	Oscilloscope and Pulse Generator	21.10.2016	45,74,666.00
9	5605-1	Titrando Titrators	17.11.2016	10,79,706.00
10	5607-1	Lenovo workstation, Team Data and Processing Server	21.10.2016	10,18,490.00
11	5608-2	Hall measurement system, High Pressure Cell	20.12.2016	19,95,532.00
12	5703-2	Upgradation of Microscope	03.04.2017	10,16,892.00
13	5704-1	24 core x 4 computer nodes, Rotaevaporator & Kugelrohr	05.04.2017	25,25,776.00
14	5705-1	Rotaevaporator & Kugelrohr Distillation Unit, Microscope	05.04.2017	14,40,000.00
15	5803-1	Computer workstation, Incubator shaker	22.12.2017	7,30,916.00
16	5804-1	Apple Macbook, Work Station (12 cores Zenon Processor)	22.12.2017	4,18,676.00
17	5804-2	Data acquisition system (ADWIN-Gold), Liquid Helium dewar with level sensor, SQUID based low temp amplifier	10.11.2017	25,30,000.00
18	5805-1	Diacel chiral column, Rota evaporator	02.08.2017	9,99,975.00
19	5808-1	Lock-in amplifier, Probe station for Kerr microscopy	20.12.2017	21,71,313.00
20	5904-1	Laptop, BAY NAS and Hard Disk	18.12.2018	1,71,533.00
21	5904-2	Laptop, Printer, Data storage	18.12.2018	3,91,028.00
22	5905-1	Microscope, Photoreactor, Ultrachill Cooler	02.11.2018	14,74,190.00
23	6005-2	Hydrogen Generator, Fume Hood, Mass flow controller, Spectrometer, Desktop	25.05.2019	15,66,511.00
24	6007-1	Nikon Stereozoom Microscope JPY 541589, Brunton make Axis Pocket, 21.5 inch New I-mac with Retina, Dremel Microdrill, Gramin Gps, Metter Toledo	22.05.2019	6,26,927.00
25	6008-1	CCD, Spectrophotometer including source and computer, High energy ball milling, Light measurement system, Microwave digestion system, Reduction tube furnace including Vacuum pump	29.03.2019	30,41,673.00
26	6103-1	Arabidopsis Growth Chamber	29.03.2019	16,00,000.00
27	6104-2	Cryostat With electric ports	29.03.2019	16,09,750.00
28	6105-1	Rotavapor R-300 System and Accessories	29.04.2019	5,63,340.00
29	6109-1	Auto Titrator	29.03.2019	9,97,540.00
30	62T4-1	Freezer	27.02.2020	70,000.00
31	62T5-1	CMOS Camera	11.05.2020	5,04,100.00
32	62T9-1	HPC Computer Cluster nodes, Workstation for PhD & Workstation for Post Doc	02.03.2020	15,19,583.00
33	6301-1	Laptops	21.07.2020	2,56,948.00
34	6305-1	Rotatory evaporator, Stirrers & Vaccum Pumps	21.07.2020	8,00,000.00
35	6307-1	Peristaltic pump	17.07.2020	4,04,800.00
36	6308-1	GPU Workstation	18.09.2020	3,50,000.00
37	6308-2	Phytolithography	27.07.2020	14,00,000.00
38	64T4-1	Laptops and workstation	24.03.2021	15,90,955.00
		<b>Total</b>		<b>10,05,01,619.00</b>





# CEFIPRA

Indo-French Centre for the  
Promotion of Advanced Research

Centre Franco-Indien pour la  
Promotion de la Recherche Avancée

Indo-French Centre for the Promotion of Advanced Research/ Centre Franco-Indien pour la Promotion de la Recherche Avancée (CEFIPRA) is a model for international collaborative research in advanced areas of Science & Technology. The Centre was established in 1987 being supported by Department of Science & Technology, Government of India and the Ministry for Europe & Foreign Affairs, Government of France. CEFIPRA is actively involved in supporting Indo-French Science, Technology & Innovation system through various activities. Collaborative Scientific Research Programme focuses on Academia-to-Academia Collaborations between Indian and French Academic Collaborators in various domains. Industry Academia Research & Development Programme emphasizes to develop the linkage between Industry and Academia from France and India. Dedicated mobility support programmes of CEFIPRA provide exposure to young researchers of the working, social and cultural environment of the partnering country. Targeted Programmes of CEFIPRA provide platform for Indian and French National Funding Agencies to implement programmes for specific areas. Innovation programmes through PPP mode are the programmes where industries join hands with CEFIPRA as a funding partner for supporting R & D in defined priority areas.



For further information, please contact:

**Director**

**Indo-French Centre for the Promotion of Advanced Research (IFCPAR)/  
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