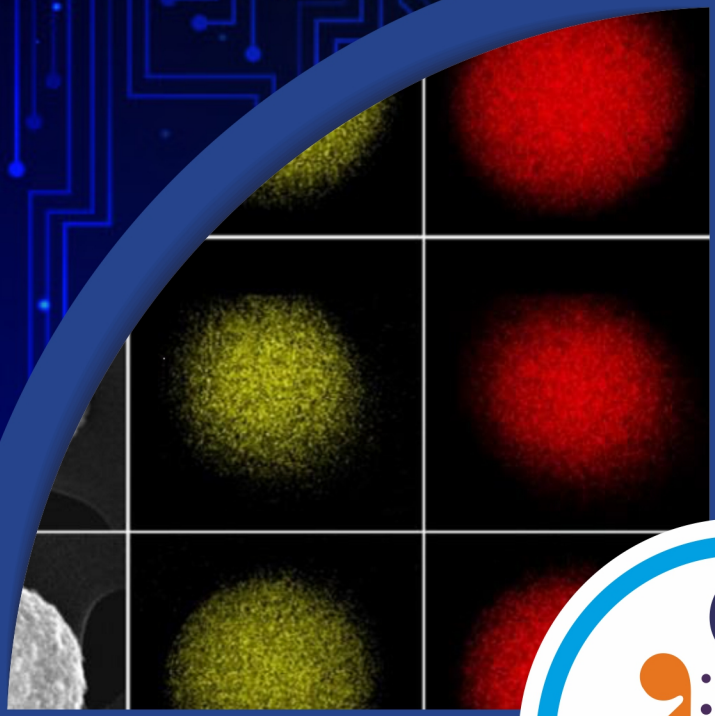
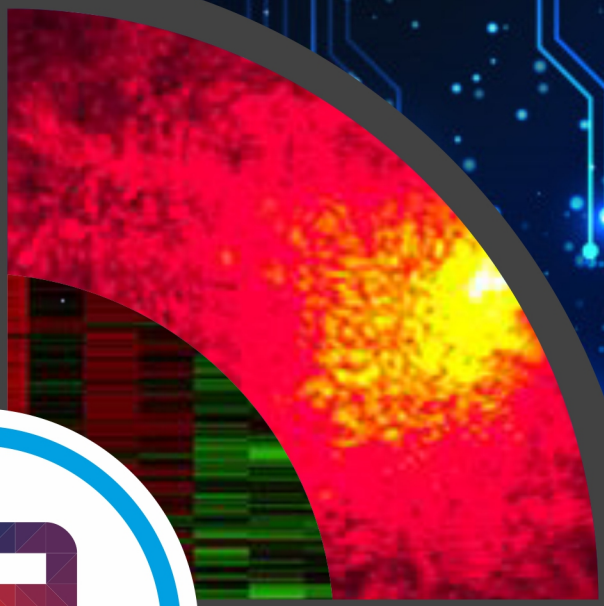
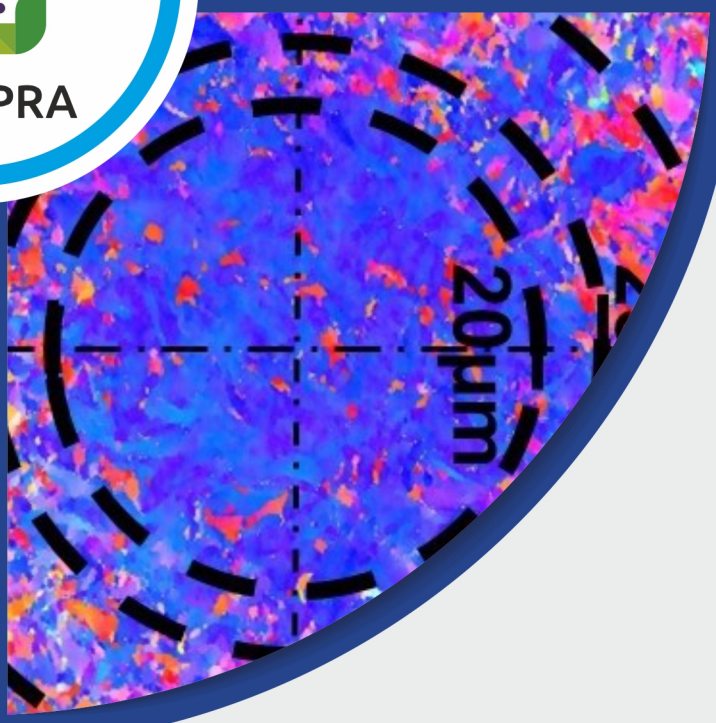




CEFIPRA

ANNUAL REPORT 2021-22



Indo-French Centre for the Promotion of Advnaced Research

Centre Franco-Indien pour la Promotion de la Recherche Avancée

CEFIPRA

Annual Report
2021-22

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

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

From the Director

I take pride in sharing that CEFIPRA, in spite of present health and sanitary restrictions due to the pandemic around the world, accomplished its mandated charter successfully without making any compromise in the performance and enthusiasm on the S&T activity front. We gratefully acknowledge with gratitude the cooperation and encouragement of all our patrons and stakeholders in India as well as in France in meeting our goals.

During the year, CEFIPRA supported 44 new Indo-French projects in the areas of phytochemical production, block-chain geotechnical engineering, synthetic aperture sonar imaging, acoustics metamaterials, neuro-inflammation, life & health sciences, water & agriculture, marine biology & ecology and chemical & synthetic biology. These wide-ranging innovative projects submitted by Indo-French team of researchers envisage providing solutions to various societal problems by advancing the knowledge like study of a molecular and cellular mechanisms, by improving diagnosis and treatment of diseases, studying ocean environment by climate change, improving crop productivity through microbial technologies, developing a numerical framework to estimate star formation rates, designing novel assays for measuring in cell distribution and stability, creating a nontoxic bio-implant for clinical applications etc.

In its continued support to Sustainable Development Goals (SDGs), CEFIPRA would be facilitating interactions among Indian and French scientists by way of joint workshops in the areas of hydrodynamics of groundwater, chemistry-biology interfaces in healthcare, disruptive nano-photonics and advanced aerospace materials. The aim is to harvest the strength of networking stakeholders to yield knowledge linkages & build forward the knowledge chain by facilitating exchange of domain expertise, innovative ideas and technological knowhow between selected groups.

CEFIPRA also organized high impact workshops on Artificial Intelligence (AI), 25-26 November 2021 in the 3rd edition of Indo-French Knowledge Summit. These workshops envisioned specific fields of application of AI in Healthcare and Sustainable Agriculture. The popularity of these scientific events organized by the Centre was evident from the response of scientists, researchers, academicians, policy makers and other professionals in the organized programmes.

This year CEFIPRA also had the privilege to welcome the Co-Chairs of CEFIPRA, Dr. M. Ravichandran, Secretary, Ministry of Earth Sciences (MoES) and the then Secretary (Additional Charge) of Department of Science and Technology (DST), Government of India and Mr. Matthieu Peyraud, Director of Department of Culture, Education, Research and Networking, Ministry of Europe & Foreign Affairs (MEAE), Government of France. During this meet, the members of French and Indian delegations held constructive discussions on various aspects of ST&I collaboration between India and France under the Centre's platform.

CEFIPRA is now gearing up to work under the New Secretary, DST Dr. Srivari Chandrasekhar's able leadership to further enhance the Indo-French ST&I collaboration. He is one of the leading active members of the Indo-French science ecosystem in his various capacities.

I would like to place my sincere appreciation/gratitude to my predecessor, CEFIPRA team and our stakeholders for successfully accomplishing the activities of CEFIPRA I look forward to my association with CEFIPRA with the resolution to strengthen the core competency and expanding the mandate of the Centre towards dynamic S&T cooperation.

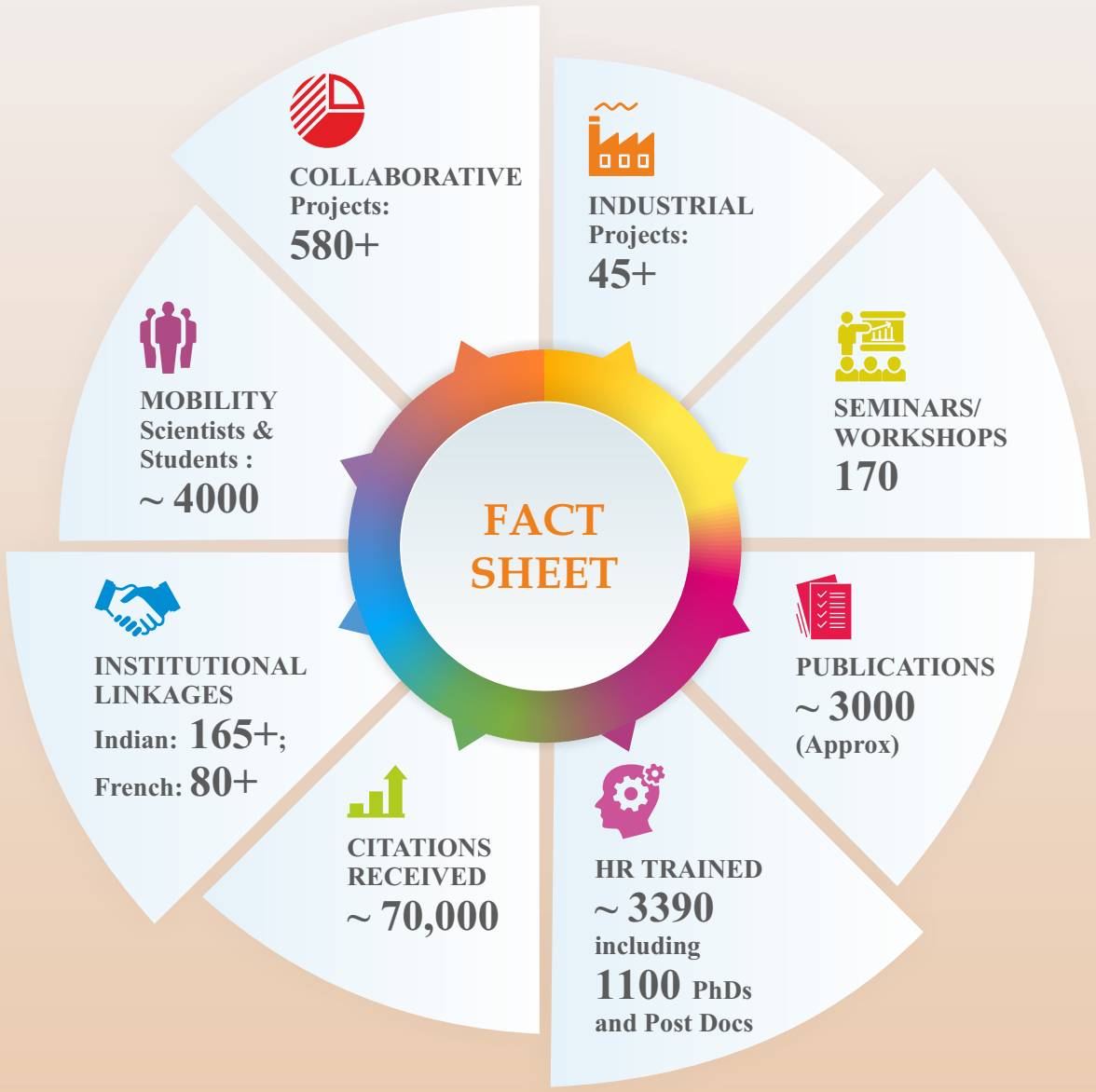
Prof. Nitin Seth
Director, CEFIPRA

Contents

CEFIPRA

1. Overview & Activities of the Centre

A seamless journey over three decades - At a Glance



The year under review….

During the year 2021-22, 34th meeting of Governing Body (GB) held on 13 April, 2021 virtually wherein members provided guidance on the various programmes/ activities of the Centre.

Further, 66th and 67th meetings of the Scientific Council (SC) were held on 14-16 June, 2021 and 10-13 January, 2022 respectively through videoconferencing. During both the meetings, a total of 186 proposals were considered for evaluation (18 from thematic areas and 168 from general areas). The Scientific Council recommended 37 proposals (4 from thematic and 33 in general areas) for support.

The new recommended projects were in the areas of Pure and Applied Mathematics (2), Computational Science (3), Earth and Planetary Science (2), Life and Health Science (6), Pure and Applied Physics (6), Pure and Applied Chemistry (6), Environmental Science (1), Biotechnology (1) and Materials Science (6). While, the above were in General Areas (33), more projects were supported in Thematic Areas (4) such as Host-Microbe-Interactions In Health and Agriculture (2), Marine Biology and Ecology (1) and Chemical & Synthetic Biology (1).The support was further continued for 56 ongoing projects. Further, 21 projects were also completed during this period and 66 publications in SCI journals have emanated from the projects supported under this programme.

CEFIPRA organized 37th Industrial Research Committee meetings virtually during 7-8 Jan, 2022. IRC considered 13 Industry-academia preselected proposals and two seminar proposals. However, IRC recommend seven new Indo-French Industrial-Academia projects on Technology Readiness Level and scientific merit in the advanced areas like Phytochemical production, Blockchain Geotechnical Engineering, Synthetic Aperture Sonar images, Acoustics Metamaterials, Materials Engineering, Neuroinflammation. These wide-ranging industries centric and innovative projects submitted by Indo-French team of researchers envisage providing the industrial/academic partners an enhanced competitiveness at the international level.

CEFIPRA would also be facilitating interactions among Indian and French scientists and technologist by way of joint workshop in the area of Advanced Aerospace Materials.

The Industrial Research Committee (IRC) of CEFIPRA met on 24 March, 2022, to carry out a detailed evaluation of all the completed projects and progress of ongoing projects. Investigators from 5 completed + 4 ongoing projects were invited to make their presentations.

Seminars/Workshops originally planned for Financial Year 2020-21 & 2021-22 could not be organized due to COVID-19 Pandemic. However, as per the directives of Governing Body, CEFIPRA organized workshops on Artificial Intelligence (AI) in Healthcare and Sustainable Agriculture, 25-26 November, 2021 at the Indo-French Knowledge Summit 3.

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 (i) DST-Inria-CNRS Programme under which 13 projects are ongoing. Till, 2021, 24 projects supported (6 ongoing + 18 completed). The 8th Call for proposals of 2021 in areas of Artificial Intelligence, Cybersecurity &Signal Processing. Expert Committee met on 6 December, 2021 and 3 proposals recommended for support. Further, the meeting for review of ongoing projects were held on 15 March, 2022. (ii) DST-CNRS; Targeted programme was launched in the areas of a) Biodiversity, Ecosystems and Human-environment interactions, b) Detector and theory developments in nuclear and particle physics and c) Engineering and Systems Sciences in the year 2018 and 4 projects are ongoing under the programme.

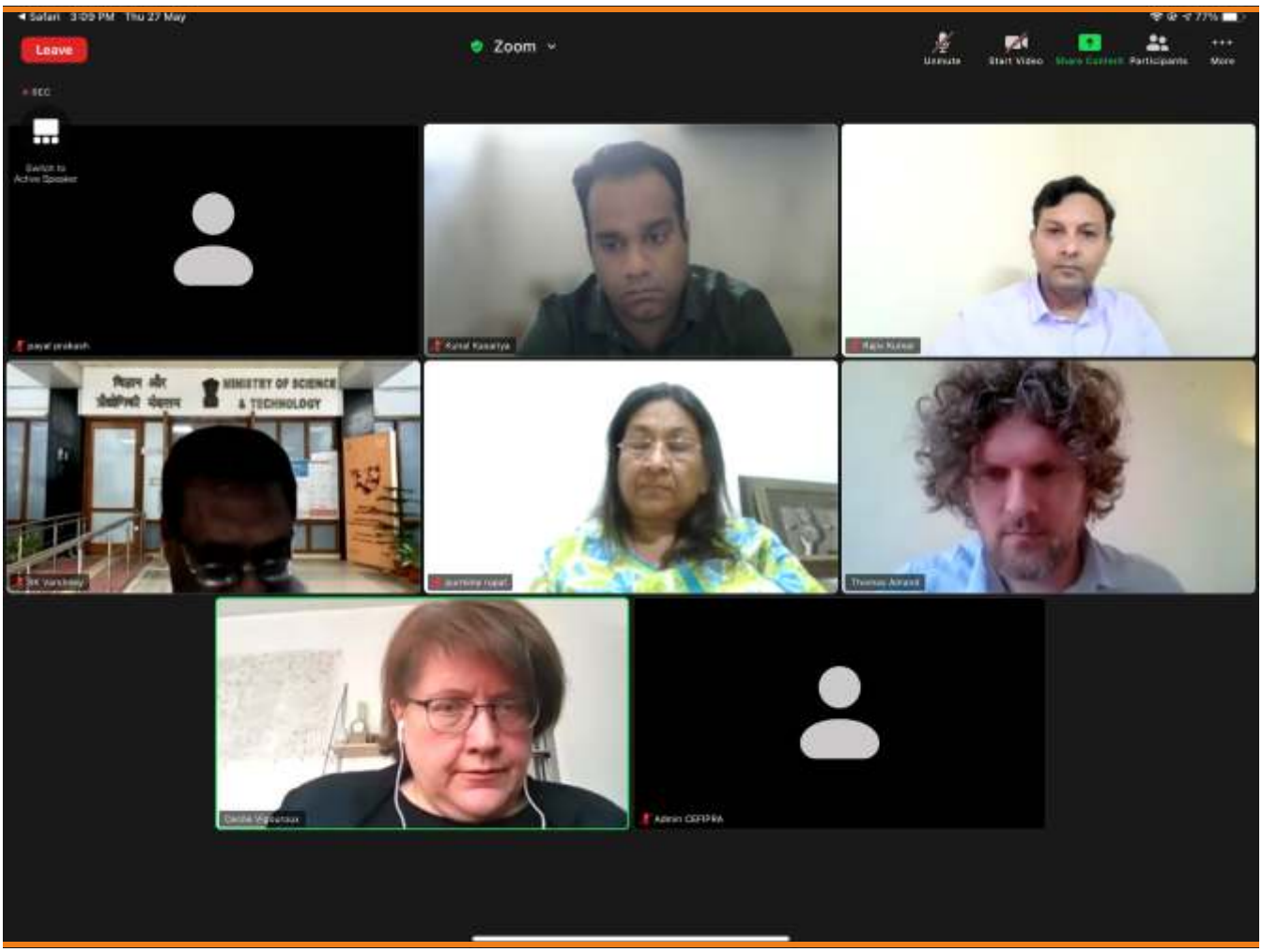
In order to strengthen human resource development, the Call for Applications for Raman-Charpak Fellowship- 2022 was launched in February, 2022 with the extended deadline of 15 May, 2022.

Under the, Indo-French Centre for Applied Mathematics (IFCAM) Programme, 18 projects are ongoing and CEFIPRA facilitated the mobility support for the visitors.

Under the CEFIPRA Annual Lecture Series, the speaker for 7th lecture was finalized. The 7th Annual lecture series will be delivered by a eminent French Scientist in India in Sept./Oct., 2022.

The 34th GB, in its meeting on 13 April, 2021, approved the launch of two High Impact Scientific Research Networks with an aim to provide a mechanism to support and connect the best of Indo-French groups that have worked in the past. It was recommended that only two areas where past outcomes have been excellent should be included. Accordingly, 66th Scientific Council identified two domains for cooperation viz. 'One Health' & 'Data Science'.

Targeted Programmes



DST-INRIA-MoU extended

CEFIPRA facilitated the "Targeted Programmes" between Department of Science & Technology (DST), Govt. of India and Institut National de Recherche en Informatique et en Automatique (Inria), Govt. of France to support collaborative scientific research in the field of Information & Communication Science and Technology (ICST) for the benefit of the Indian and French scientific community.

Dr. Cécile Vigouroux, Head International, Inria, Mr. S. K. Varshney, Adviser & Head, International Cooperation, DST and Dr. Purnima Rupal, Director, CEFIPRA met virtually on 27 May, 2021 to discuss the renewal of collaboration under the DST-Inria Programmme. It was mutually decided to extend the MoU for another five years. The areas identified mutually for 8th Call for Proposals 2021/22 for collaborative research grant are *Artificial Intelligence*, *Cybersecurity* and *Signal Processing*. CEFIPRA would be implementing these projects from Indian side.

Expert Committee Meeting under DST-Inria Targeted Programme

6 December, 2021

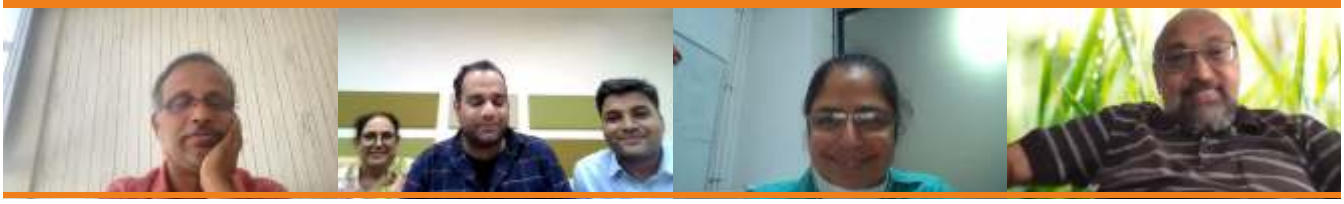
The virtual meeting of the Expert Committee (Indian Side) of DST-Inria Targeted Programme under Indo-French Programme in Information and Communication Science & Technology (ICST) was held on 6 December, 2021. The Committee evaluated the proposals received under the 8th Call.

A total 07 proposals were received under the three domains - Artificial Intelligence, Cybersecurity and Signal Processing of ICT were received out of which three were recommended from experts.

All proposals were peer-reviewed and comments of reviewers are highlighted in agenda for consideration by experts. Jointly selected proposals will be funded in India by DST through CEFIPRA and in France by Inria (for Inria Research Team).

Expert Commiee Meeting for Review under DST-Inria/CNRS Targeted Programme

15 March, 2022



Expert Committee meeting was held on 15 March, 2022 to review progress of ongoing and final review of completed projects under Department of Science and Technology (DST) and Institut National de Recherche en Informatique et en Automatique (Inria) under DST-Inria/CNRS Targeted Programme. A total of 8 projects (7 ongoing and 1 completed) in sub areas of Information and Communication Science & Technology ICT (Big Data, Computer science for Biology and Life Sciences, Artificial Intelligence, Cyber Physical Systems, ICT and Applied Mathematics. The Committee also reviewed completed projects which were graded as Excellent, Very Good & Good, on basis of their scientific merit & quality of the consortium and good synergies between the partners. The investigators during their presentations highlighted the achievements/outcomes/work done with reference to original objectives. These projects highlighted the various outcomes like study efficient techniques for quantitative verification of cyber-physical systems, and develop efficient algorithms for models of such systems that involve time and/or randomness. In another project Investigators highlighted the work to create a theoretical framework which could accommodate multiplayer decision making and uncertainties together both in static and dynamic settings etc.

CEFIPRA

2. Governance & Guidance

Meeting with Co-Chairs of CEFIPRA

10 November, 2021

CEFIPRA welcomed **Dr. M. Ravichandran**, Co-Chair & Secretary DST (Additional Charge) & MoES and **Mr. Matthieu Peyraud**, French Co-Chair, Ministry for Europe & Foreign Affairs, Government of France on 10 November, 2021. Sh. Sanjeev K Varshney, Advisor & Head, International Cooperation Division, DST, GoI and Dr. Nicolas Gherardi, Deputy Counsellor for Education, Science and Culture, Embassy of France in India were also present. The other members of French delegation from Ministry for Europe & Foreign Affairs were Mr. Thibaut Dutruel, Officer at University and Scientifc partnership, Mr. Eric Chevreul, Advisor to the Asia Director and Mr. François-Xavier Mortreuil, Attaché for Scientific and Academic Cooperation, Bangalore. A video showcasing CEFIPRA's journey of more than three decades was presented to the members.

Invited PIs of CSRP & IARDP praised the CEFIPRA team for their support. The members of the two sides addressed & noted the concerns/suggestions made by some PIs regarding the projects being funded.

Bienvenu, Dr. S. Chandrasekhar
(as the new Indian Co-Chair of Governing Body of CEFIPRA)

A very warm welcome to the new Indian Co-Chair of the Governing Body of CEFIPRA - Dr. Srivari Chandrasekhar, Secretary, Department of Science and Technology, Government of India.

Dr. Chandrasekhar was the Director of the Indian Institute of Chemical Technology (IICT) sine 2015. He is a renowned synthetic organic chemist and has made significant contributions in diverse areas of organic chemistry with special emphasis on chiral chemistry, total synthesis of biologically active natural products and pharmaceutical products. He has received several accolades including Eminent Scientist Award for contributions in the field of Chemistry from for his contributions in synthetic organic chemistry with special focus on the synthesis of complex molecules from natural sources and innovative, practical approaches to pharmaceuticals of current interest to industry.

Dr. Srivari Chandrasekhar was the lead Principal Collaborator from Indian Institute of Chemical Technology (IICT), Hyderabad along with Ecole Nationale Supérieure de Rennes for the CEFIPRA supported project on 'Misoprostol' which was an orally active synthetic prostaglandin E1 (PGE1) analog essential medicine. The project developed innovative technology which successfully reduced the cost of production. Dr. Chandrasekhar also guided the activities of CEFIPRA as a member of the Governing Body. CEFIPRA also has the honour of having been associated with him for various other networking activities. CEFIPRA is looking forward to work under his able leadership and further enhance the Indo-French ST&I colloboration.

Adieu...

CEFIPRA bid farewell to Director, Dr. Purnima Rupal as she completed her tenure and joined back CSIR, headquarters. The event was graced by the presence of various dignitaries and officials from the Department of Science and Technology, Ministry of Science and Technology, French Embassy in India. Among the guests present were Dr. Ashutosh Sharma, Former. Secretary, Department of Science and Technology (DST) and Indian Co-Chair of CEFIPRA, Mr Sanjeev K Varshney, Head ICD, DST; Mr Emmanuel LEBRUN-DAMIENS, Counsellor for Education, Science & Culture, Dr Didier Radisson, Attaché for Scientific and Academic Cooperation, Delhi and founder Director of CEFIPRA, Mr. PGS Mony.

CEFIPRA family will forever cherish the leadership and guidance of Dr Purnima Rupal and wishes her success and happiness in both her professional & personal journey!

A very warm welcome to Prof. Nitin Seth, as the new Director of Indo-French Centre for the Promotion of Advanced Research (IFCPAR/CEFIPRA). Dr. Seth is affiliated as Professor and Head of the Centre for Trade Facilitation and Logistics (CTFL), Indian Institute of Foreign Trade (IIFT), New Delhi.

Dr. Nitin Seth
Director, CEFIPRA

66th Scientific Council Meeting

14-16 June, 2021

CEFIPRA represents the scientific interests of both nations and supports high quality research groups through joint IndoFrench research projects in advanced areas of science & technology. CEFIPRA recently organized its Sixty-sixth (66) meeting of the Scientific Council (SC) which was held from 14-16 June, 2021. A total of 98 proposals were received under two Calls, of which 19 were received under the call ending Jan, 2021 (14 thematic & 5 general areas) & 75 under the call ending July, 2020. Out of which 20 projects of Indo-French groups were approved in the areas of Host-Microbe Interactions in Health, Water & Agriculture, Marine Biology and Ecology & Chemical & Synthetic Biology etc. Some of the expected outcomes of these Indo-French projects are to provide solutions of various societal problems by advancing the knowledge like study of a molecular and cellular mechanisms aiming to improve diagnosis and treatment of neurodevelopmental disorder, alterations caused in ocean environment by climate change, improving crop productivity through microbial technologies, developing a numerical framework to estimate star formation rates, designing novel assays for measuring in cell distribution and stability, creating a nontoxic bio-implant for clinical applications etc. Scientific Council also recommended workshops/seminar addressing Sustainable Development Goals (SDGs), in the areas of hydrodynamics of groundwater and chemistry-biology interfaces in healthcare. In areas of 'One Health' & 'Data Science', CEFIPRA will be launching its Call to connect excellent research groups from India & France. Such an intervention is expected to yield knowledge linkages & knowledge forward chain by facilitating exchange of domain expertise, innovative ideas and technological knowhow between selected groups.

67th Scientific Council (SC) Meeting

10-13 January, 2022

Under CSRP call a total of 88 proposals were received under July 2021 deadline and Council evaluated 41 preselected proposals during SC meetings. CEFIPRA' Scientific Council recommended 17 new Indo-French projects in the areas like Pure & Applied Physics, Biotechnology, Materials Science, Pure & Applied Mathematics, Computational Sciences, Pure & Applied Chemistry, Life & Health Sciences, Earth & Planetary Sciences and Environmental Sciences during the 67th meeting of the Scientific Council (SC) held virtually during 10-13 January, 2022. These wide-ranging innovative projects submitted by Indo-French team of researchers envisage providing solutions to various societal problems by advancing the knowledge. CEFIPRA would also be facilitating interactions among Indian and French scientists by way of joint workshop in the area of disruptive nano-photonics.

37th Industrial Research Committee Meeting

10-13 January, 2022

CEFIPRA organized 37th Industrial Research Committee meetings virtually during 7-8 January, 2022. IRC considered 13 Industry-academia preselected proposals and two seminar proposals. However, IRC recommend seven new IndoFrench Industrial-Academia projects on Technology Readiness Level and scientific merit in the advanced areas like phytochemical production, Block chain Geotechnical Engineering, Synthetic Aperture Sonar images, Acoustics Metamaterials, Materials Engineering, Neuroinflammation. These wide-ranging industries centric and innovative projects submitted by Indo-French team of researchers envisage providing the industrial/academic partners an enhanced competitiveness at the international level. CEFIPRA would also be facilitating interactions among Indian and French scientists and technologist by way of joint workshop in the area of Advanced Aerospace Materials.

Review meeting under IARDP

24 March, 2022

The Industrial Research Committee (IRC) of CEFIPRA met 24 March, 2022, to carry out a detailed evaluation of all the completed projects and progress of ongoing projects. Investigators from 5 completed + 4 ongoings were invited to make their presentations.

CEFIPRA

3. Seminars / Webinars

Virtual Meetings

Virtual meet with startups Director, CEFIPRA delivered an invited talk on opportunities for Indo-French Industry-Academia Partnership on 30 April, 2021- during the program for online incubators meet organized by International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad. The networking through this incubation meet will lead to further joint collaborations in applied research with the active involvement of industry.

Progress Review Meeting – PPMB: First Progress review meeting (internal) of Project "PPMB" Commercial pigment production by microalgae under IARDP (Industry-Academia) was organized on 28 May, 2021. This multi - disciplinary project deals with the electro-compatible extraction of pigments from microalgae using pulsed electric fields.

35th STIP Forum Lecture: This Online Science, Technology and Innovation th Policy (STIP) Forum lecture was delivered on 25 May by Dr. Amitava Banerjee, Associate Professor in Clinical Data Science, University College London (UK) and Honorary Consultant Cardiologist, University College London. The topic was COVID-19: Urgent Need Beyond the ICU, the hospital, and the Short-Term and session was Chaired by Prof. K Srinath Reddy, President, Public Health Foundation of India (PHFI).

Women in S&T: Challenges & opportunities in emerging context

16 - 18 August, 2021

Dr. Purnima Rupal, Director, CEFIPRA was invited as a panelist in a special session on 'Women in S&T: Challenges and opportunities in emerging context' chaired by Prof. Rohini Godbole, IISc Bangalore. She highlighted the need for networking, authenticity & communication of ideas for leadership roles. This session was a part of three day National Conference (virtual) on "Science and Technology in India: A Historical Introspection with a Contemporary Perspective" organized by CSIR-NIScPR during 16-18 August, 2021.

Knowledge Summit-3 (KS3)

24-26 November, 2021

Inauguration & Plenary Session

Knowledge Summit (KS) is a bilateral forum dedicated to scientific and academic cooperation between India and France. The 3rd Knowledge Summit focused on research and scientific activities. The main objective was to promote the tools and methods for better structuring our cooperation, and its alignment to the current reforms. It is an opportunity for our respective countries to underline the success of our scientific collaboration, to draw some new leads of joint research work and also to discuss and exchange ideas on global challenges that had to be tackled. The First edition was organized to identify the priority areas in research and innovation, whereas the second edition was an attempt to formulate concrete strategies for the execution of joint action involving both Academia and the Industry.

Inaugural Session

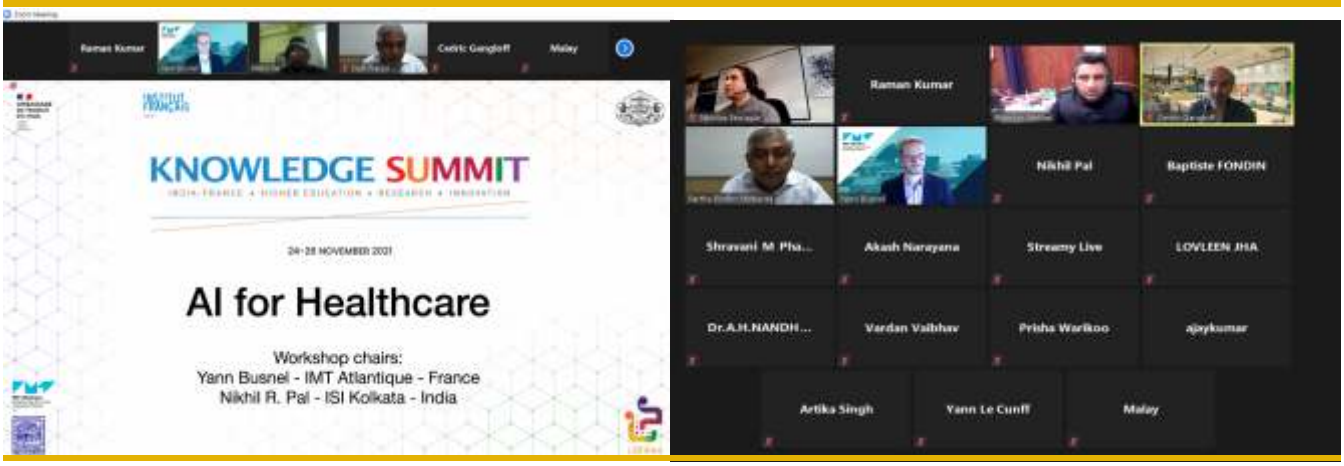
The 3 edition of Knowledge Summit was an online event inaugurated by Shri Dharmendra Pradhan, Hon'ble Minister of Education, Govt. of India, H.E. Mrs. Frédérique Vidal, Hon'ble Minister of Higher Education, Research and Innovation, Govt. of France, Dr M. Ravichandran, Secretary, Ministry of Earth Sciences and Department of Science & Technology, Govt. of India and Prof Nitin R Karmalkar, Vice Chancellor, Savitribai Phule Pune University, Pune, on 24 November, 2021.

Plenary Session

A plenary session on "Indo- French Scientific Cooperation" had Prof K. Vijayaraghavan, Principal Scientific Advisor, Govt. of India, Dr Purnima Rupal, Director, CEFIPRA and Dr Nicolas Gherardi, Deputy Counsellor for Education, Science and Culture, Embassy of France in India as panelists.

During Knowledge Summit 3, CEFIPRA partnered with French Embassy & Institut Francais in India (IFI) and organized workshops on Artificial Intelligence (AI) for Sustainable Agriculture and Healthcare, 25-26 November, 2021.

Workshops on Artificial Intelligence (AI) in Healthcare and Sustainable Agriculture



CEFIPRA organized **workshops on Artificial Intelligence (AI), 25-26 November, 2021 at the Indo-French Knowledge Summit 3. These workshops envisioned specific fields of application of AI in Healthcare and Sustainable Agriculture**.

The two-day workshop on Artificial Intelligence for Healthcare (AIH) was moderated by, Prof. Yann Busnel, IMT Atlantique, IRISA, France and Prof. Nikhil Pal, ISI Kolkata, India during 25-26 November,, 2021 with a focus on diagnostic assistance for health workers in rural or peri-urban areas, and on the sensitive issue of collecting and protecting health data.

There were eight speakers including three medical doctors, scientists from startup companies and researchers from renowned University. The following points emerged from the discussion over the two days: Any successful AI system for healthcare demands a large volume of reliable and labeled (annotated) data, which most often are not available. The abundance of missing data, unstructured nature and heterogeneous characteristics of the data pose a real challenge to develop practically useful AI/ML based healthcare applications. All the talks were technically very rich. Some of the talks focused on development of AI systems to reduce the cost of diagnosis, some focused on reducing the hazards and / or use of invasive techniques associated with diagnosis, some talked about development of light-weight and less data-hungry AI/ML algorithms, several emphasized on how to address the issues with real-life healthcare data and design useful AI/ML system on that; while majority of the speakers directly and indirectly indicated the need for having better accuracy in diagnosis and comfort of the patients. Last but not least, the issue of trust in AI was raised: practitioners and patients do not trust AI. It is essential that they start believing in the decision support process via AI. One way to solve this is to bridge the gap between discipline and AI experts: It is emphasised on building AI solutions on what and how we do instead of blind methods applied to databases. Prospective thematic areas emerged for the future:

1. Less data hungry and light-weight AI/ML algorithms and architecture.
2. Affordable rural healthcare support with AI/ML.
3. Explainable AI/ML for healthcare.
4. Interoperability between health data warehouses, which works in silo only.
5. Making Health Data a Reality: engineer point of view (stress feature selection, CNN architectures, deep and federated learning deployment, etc.).

Workshops on Artificial Intelligence (AI) in Healthcare and Sustainable Agriculture

The Workshop on the contributions of AI to Sustainable & Precision Agriculture, was coordinated by Prof Pascal Weil from France and Prof Utpal Garain from India. In total, thirteen speakers presented their research studies during the two workshop days. The speakers were from diverse fields like Agronomy, Plant Science, Computer Science, Mathematics, Statistics, and Social Science. Two were from start-up companies (one from an Indian spin off and the other one from a French start-up). Apart from the speakers several participants attended the workshop and joined the discussion in the focus area of irrigation management & chemical inputs, and strategies of farmers for transport and the marketing of their productions. Within the scope of AI for agriculture, the following are important thrust areas.

1. Solutions based on image or remote sensing analysis (e.g. plant, pest or crop identification, yield estimates, monitoring of the welfare of farm animals).
2. Solutions based on heterogeneous data, mixing e.g. image, video, weather patterns or forecast, water management data, market information.
3. Solutions based on robotic intervention, for monitoring or for labour-intensive tasks for which labour is hard to find.
4. Interdisciplinary studies evaluating the accessibility of proposed solutions for farmers (on different sorts of farms) and the impact of these solutions, both at the local level and at broader scales. The involvement of social scientists would be essential in such studies.

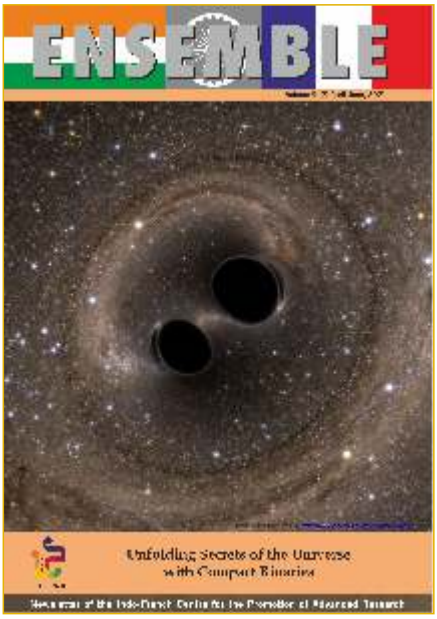
International workshop organized at the end of the project

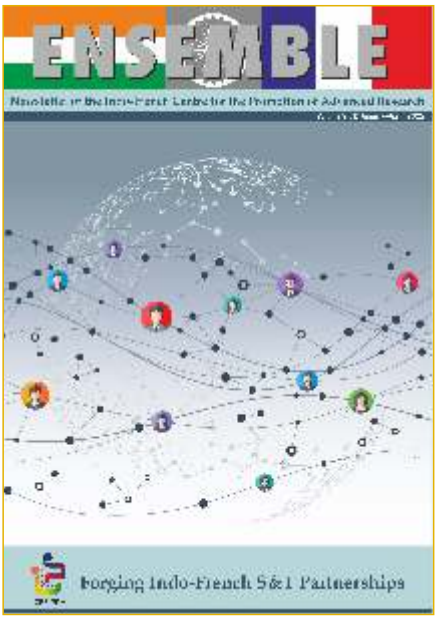
The international workshop "Virtual Symposium on organometallic chemistry and catalysis", co-organized by the two teams and featuring 12 distinguished speakers from India, France, Spain and Germany over three days (8-10 December, 2020) attracted over 850 registrations from > 100 different institutions worldwide

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 2021-22.

These editions highlighted Indo-French collaborative projects Forging Indo-French S&T Partnerships,Indo-French Scientific Collaboration for Sustainability & Innovation and Unfolding Secrets of the Universe with Compact Binaries. These newsletters also showcase research achievements of CEFIPRA supporting projects Gravitational wave searches from compact binary mergers using wavegraph.Economics of Networks and Queues and Host-Virus Interactions and Antibody Therapy for Japanese Encephalitis.





CEFIPRA

4. Brief Reports of Research Projects

A. Collaborative Scientific Research Programme

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**

Background

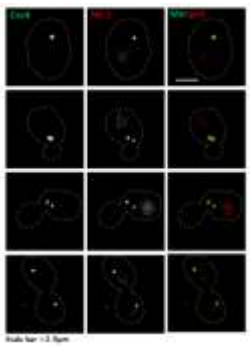
In this project, it is proposed to identify novel regulators and their role in maintaining genome integrity in C. *albicans*. To this aim, first a collection of C. *albicans* over-expression strains will be generated by transforming an existing collection of over-expression plasmids for ~5000 C. albicans 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.

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. albcians* 96-well plate transformation protocol from the Frenchlab, 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.

Principal Collaborators

Kaustuv Sanyal
Jawaharlal Nehru Centre for Advanced Scientific Research Bangalore

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

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:

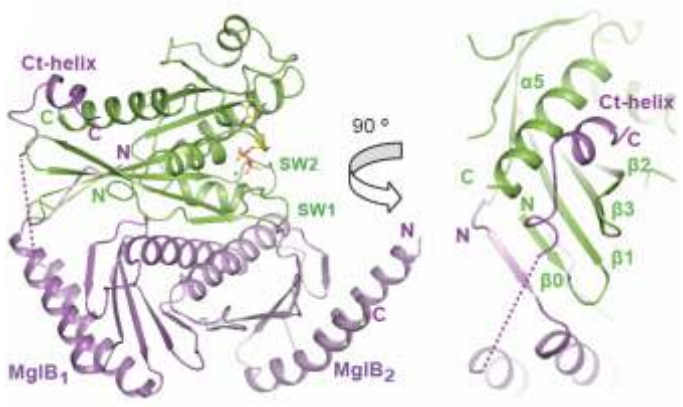
- the role of the GTPase MglA and MglB in driving the oscillations
- the role of the bacterial cytoskeleton MreB in positioning the motility complexes
- how FrzCD senses the signal that modulates the frequency of oscillation

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 DNAreceptor-bound complexes has been achieved
- Analysis of MglA and B oscillations in multicellular contexts and their role in 2 the formation of multicellular patterns is ongoing



Crystal structure of MglAB complex highlighting the Cterminal 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
Pune

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

Life & Health Sciences

Project No. 5803-2 | **Jan. 2018 to Dec. 2021**

Background

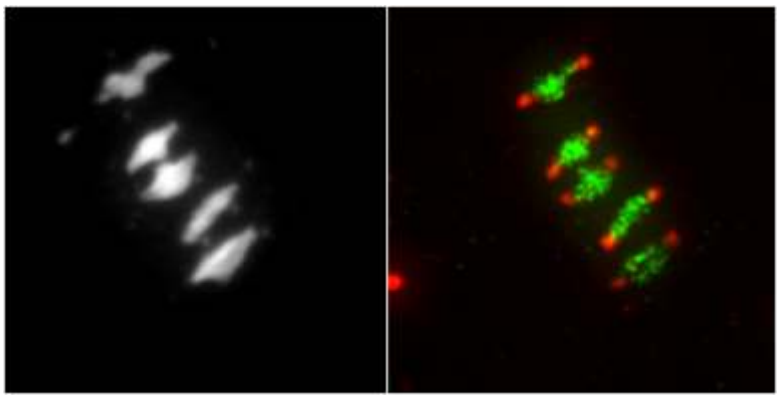
Proper distribution of chromosome at mitosis and meiosis is crucial to preserve genome integrity, prevent aneuploidy and carcinogenesis. Control of chromosome segregation during cell division requires precise temporal control of the activity of Separase the protein that cleaves Cohesin, the protein complex 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.

Objectives

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

Knowledge Generated/Products Developed

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



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).

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 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~1 to z~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~1 to z~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

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**

Background

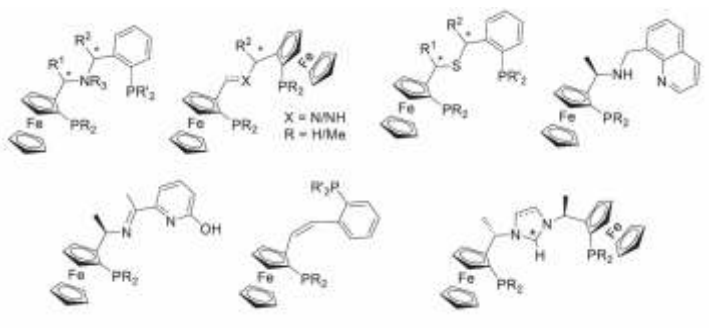
The aim of the project is to develop new efficient catalytic systems based on inexpensive first row transition metals for asymmetric transformations of unreactive substrates via activation by dehydrogenation. For this purpose, various chiral ferrocene-based metal complexes will be used with cobalt, iron 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 diastereoisomerically 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.

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 waschecked 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
- Nanotracks were prepared via EBL to study the skyrmion current induced dynamics and the threshold current density is significantly low (0.8 A/m2) than previous reports



Schematic representation of some targeted planar-chiral ligands

Principal Collaborators

Basker Sundararaju
Indian Institute of Technology Kanpur

Rinaldo Poli
Laboratoire de Chimie Coordination (LCC) Tolouse

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

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 fabricatedSi/SiO_2(native)/Ta (5 nm)/Pt (6 nm)/Co (t_Co)/Ta (5 nm) and Si/SiO_2(100 nm)/Ta (5 nm)/Pt (6 nm)/$Co_{40}Fe_{40}B_{20m}$ (t_{CFB})/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/$Co_{40}Fe_{40}B_{20}$/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 nanotracks with different width for transport measurements of skyrmions using EBL. The widths of track are 1 m and 3 m. Dynamics (nucleation, propagation) studies are beginning
- iDMI constant has been quantified for the Pt/CoFeB/MgOusing BLS. Also, PIs have investigated the dependency of iDMI on FM thickness. The linear dependency of iDMI with $1/_{tCFB}$, t_{CFB}= thickness of CoFeB, confirms its interfacial nature. The observed iDMI value varied in between 0.44-0.56 mJ/ $m^2$for Pt/CoFeB/MgO
- PIs have quantified iDMI first time in Bi_2Se_3/CoFeB/Ta thin films by BLS, where Bi_2Se^3 is a topological insulator. This opens some perspectives of new materials for skyrmions, with an expected increased sensitivity to current induced dynamics

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

Subhankar Bedanta
National Institute of Science Education and Research Bhubaneswar

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

Hematopoiesis and metabolism

Life And Health Sciences

Project No. 5903-1 | **Aug. 2018 to Jan. 2022**

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.

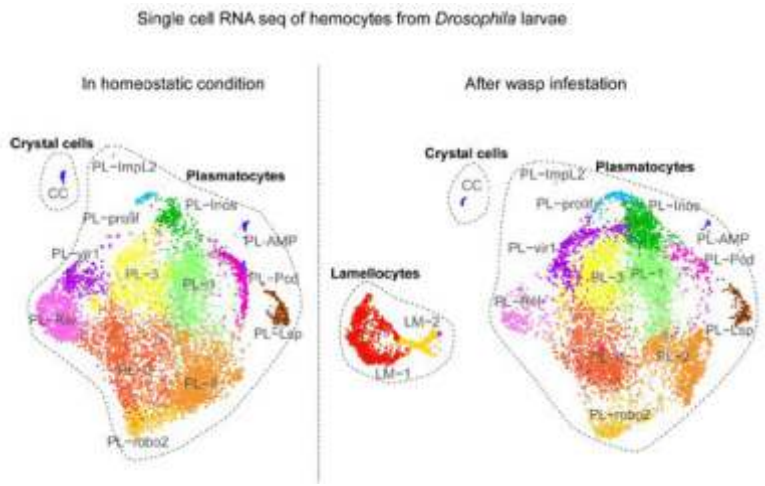
A conclusive understanding of hematopoiesis and metabolic homeostasis in animal physiology will be obtained by employing metabolic approaches along side developing genetic tools to precisely modulate embryonic and definitive hematopoietic cells. Finally, it is proposed to investigate the relevance of 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.

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



Hemocyte populations identified by single cell RNA-seq

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

Pre-evolutionary processes in autocatalytic RNA networks

Multi Disci (Physics, Chemistry, Biology)

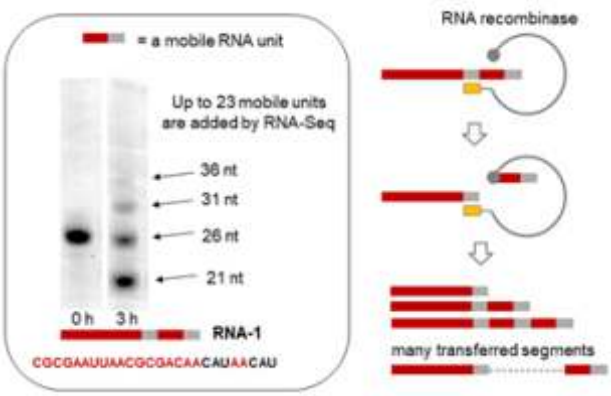
Project No. 5904-3 | **May 2018 to Apr. 2021**

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 bar-coding 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

Sandeep Krishna
National Centre for Biological Sciences
TIFR
Mumbai

Philippe NGHE
Laboratoire de Biochimie
Ecole Supérieure de Physique et de 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

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

Material Sciences

Project No. 5908-1 | **Sept. 2018 to Sept. 2021**

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

Harish Bharsilia
Surface Engineering Division
CSIR-National Aerospace Laboratories
Bangalore

Audrey Soum-Glaude
Laboratoire Procédés, Matériaux et Énergie Solaire (PROMES)
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

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 WAlN/WalSiN/SiON/SiO_2 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 under the microstructure and optical properties
- Thermal stability studies carried out till 700ºC in air and vacuum. Coating stable up to 700ºC 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-CNRSOdeillo/France (left) and its sample holder mounted with CSIR-NAL Bangalore sample (right)

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 SK(C). The user can apply this key to any ciphertext 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
Computer Science and Engineering
Indian Institute of Technology-Madras
Chennai

Benoit Libert
Ecole Normale Superieure 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

Nuclear structure at the extreme of isospin and spin

Pure & Applied Physics

Project No. 5604-4 | May 2017 to Apr. 2022

Background

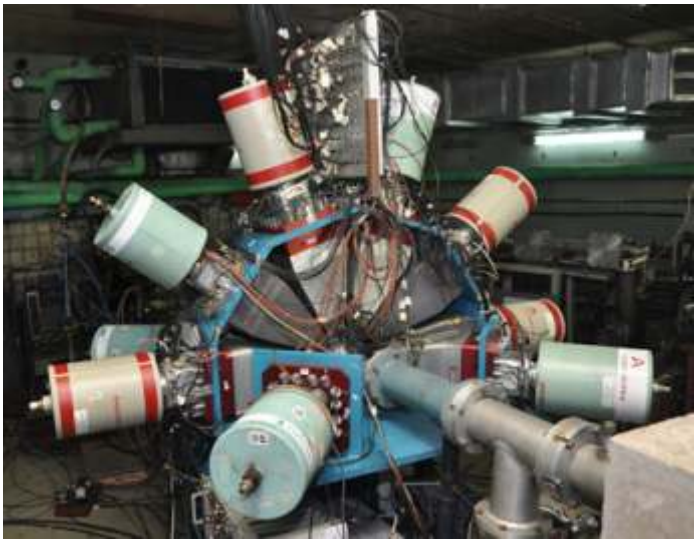
The project addresses an open question,viz., how do the internal properties of the complex many-body quantum system, the nucleus, evolve when there is animbalance of neutron to protons (compared stable nuclei) AND simultaneously undergoing fast rotation. Studies have shown the presence of new phenomena 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 13282Sn126. 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.

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 131Xe, 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

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

Life and Health Sciences

Project No. 5703-1 | **May 2017 to Apr. 2022**

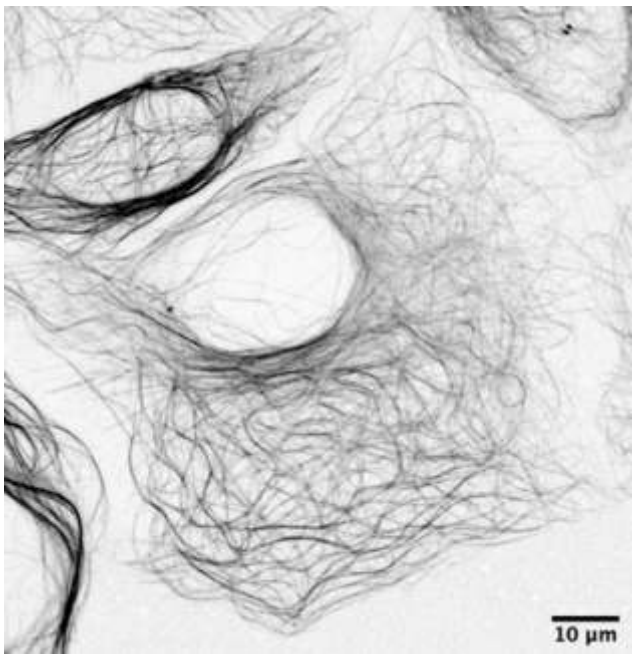
Objectives

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.

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 variablity 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

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

Pure & Applied Physics

Project No. 5804-3 | **Feb. 2018 to Sept. 2022**

Background

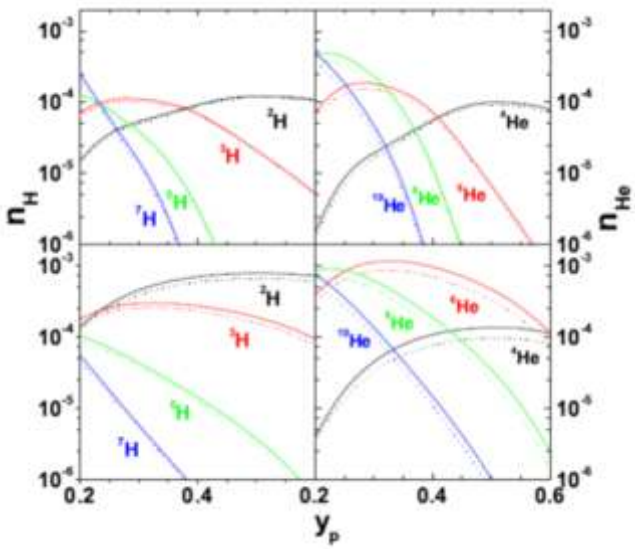
Nuclear clusters are abundantly formed in heavy ion collisions and believed to compose the dense matter in the universe that characterizes the cores of supernovae and the inner crust of neutron stars. Both aspects are the manifestation of the same physical phenomenon, namely the liquid-gas phase transition 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.

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



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

Principal Collaborators

Gargi Chaudhuri
Variable Energy Cyclotron Center
Kolkata

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

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

Computational Sciences

Project No. 5902-1 | **Jul. 2018 to Jul. 2022**

Objectives

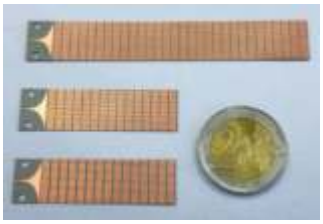
- To design the 60 GHz antenna system that will be able to scan in 2-dimension the roomto be monitored
- To design the radar transmitter and receiver with frequency scanning capabilities in 65nm UMC Technology
- To operate the radar in order to estimate its accuracy and its robustness

Revised objectives, if any

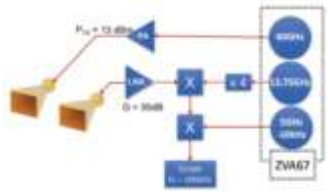
- To design the radar transmitter and receiver with frequency scanning capabilities in 40 nm TSMC Technology (As validated model are not available in 65 nm UMC for 60 GHz design, especially for inductor)

Knowledge Generated/Products Developed

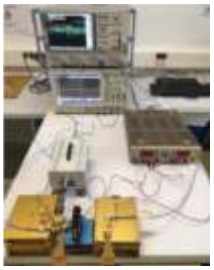
- Design of oscillator is done for 60 GHz and achieved approx. 3 GHz bandwidth
- Frequency of oscillators is 57.06 GHz to 59.9 is achieved
- Design of an enhanced beam-scanning antenna using metasurface
- A specification of the transreceiver has been finalized with the help of literature survey and experiment 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

Modelling and observing pulsars: from high energy to radio emission

Pure & Applied Physics

Project No. 5904-1 | **Jun. 2018 to Jun. 2023**

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.

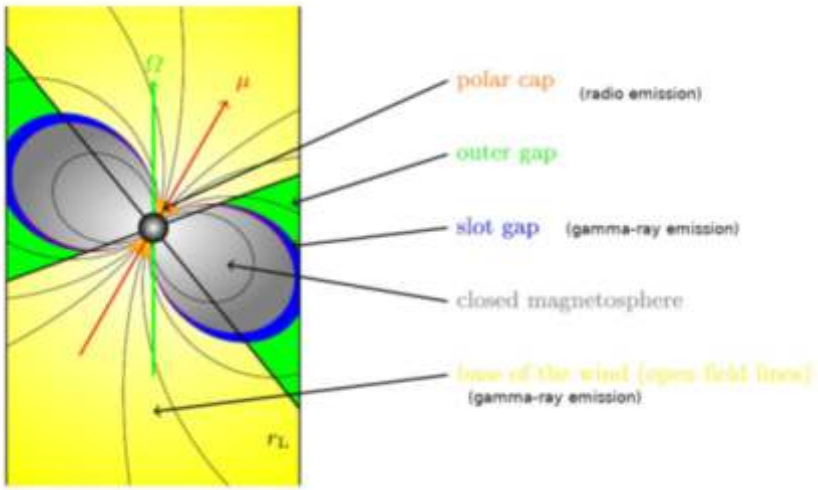
The radio pulse shape, its polarization and spectral properties suggest that pulsar emission arises from regions of open dipolar field lines. Pulsar radio emission is highly linearly polarized and in several pulsars the linear polarization position angle exhibits a S-shaped traverse.

Objectives

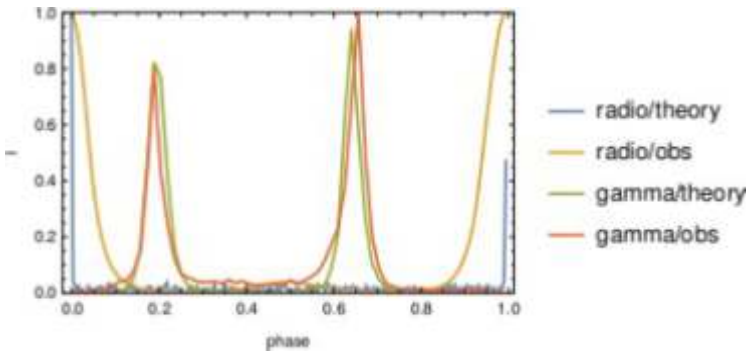
- Analysing existing radio and X-ray data
- Computing equilibrium configurations of the pulsar magnetosphere
- Interpreting results in the light of multipolar fields within the magnetosphere

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

Principal Collaborators

Dipanjan Mitra
National Centre for Radio Astrophysics (TIFR)
Pune

Jérôme Petri
Université de Strasbourg
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

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

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

K Sridhar
Azim Premji University
Bangalore

Giacomo Cacciapaglia
CNRS/IN2P3 Researcher,
Institut de Physique Nucléaire de Lyon
Université Lyon 1
Lyon

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

Boron-controlled CO_2 reduction

Pure & Applied Chemistry

Project No. 5905-1 | May 2018 to Apr. 2022

Background

Due to the increasing level of CO_2 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_2 by transferring hydride(s) to the electrophilic central carbon atom of CO_2. On another hand, the Lewis acidity of the borane moiety has been used in ambiphilic compounds to activate CO_2. 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_2 will be investigated in detail.

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

Principal Collaborators

Sundargopal Ghosh
Department of Chemistry, Office 317
Indian Institute of Technology-Madras
Chennai

Sebastien Bontemps
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

Objectives

- To get benefited from both the Lewis acid and the hydride donor ability of boron-based reagent to activate and transform Co_2
- 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_2 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,$[(Cp^*Ta)_2(\mu,\eta^2:\eta^2\text{-}B_2H_5)(\mu\text{-}H)(\kappa^2,\mu\text{-}S_2CH_2)_2]$, from the reaction of $[Cp^*TaCl_4]$ with $LiBH_4\cdot THF$ followed by addition of S_2CPPh_3has been demonstrated
- Synthesis of B-H activatedruthenium complexes and ruthenium silyl complexes from borane and hydrosilane activation by κ^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_2 under different reaction conditions will be explored
- Synthesis and structuralcharacterization of various novel rhenium – diborane(6) species, $[\{(OC)_4Re\}\{Re(CO)_3\}_2(\mu_3\text{-}\eta^2:\eta^2:\eta^2\text{-}B_2H_6)(\mu\text{-}H)]$, $[\{(OC)_4Re\}_2\{Re(CO)_3\}(\mu_3\text{-}\eta^2:\eta^2:\eta^1\text{-}B_2H_6)(\mu\text{-}H)]$ and $[\{(OC)_4Re\}_2(\mu\text{-}\eta^2:\eta^2\text{-}B_2H_6)]$with diverse coordination modes of the $[B_2H_6]^{2-}$ 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_2 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_2 reversibly
- New (PBP)borate pincer type ligands $Li[R_2B(C_6H_4\text{-}P^iPr_2)_2]$ (R_2= $(Ph)_2$, 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 notisolatednor-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 Nh_4+, NO_2-, NO_3- concentrations and of $\delta^{15}N$ & $\delta^{18}O$ of NO_2^- and NO_3^-, $\delta^{15}N$ of $NH4^+$

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 on-going complementary surveys from different labs in France and India adding advanced isotopic tools and expertise on C, N, Si, Ca, Sr, H_2O 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
CSIR-National Institute of Oceanography (Regional Centre)
Visakhapatnam

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

2D Materials for novel nano electronic device applications

Material Sciences

Project No. 5908-2 | Aug. 2018 to Jul 2022

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 (In_2Se_3)have beensynthesized 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 In^2Se^3 display n-type photocurrent densities of 0.15 mA cm^{-2} simulated solar irradiation. PIs have also synthesized lead free inorganic $K_3Bi_2I_9$ 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 ~2 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 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

Sandesh R Jadkar
Savitribai Phule Pune University
Pune

Abhay Shukla
Institut de minéralogie, Physique des Matériaux 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

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

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

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*. 59th 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 (Netgcoop), 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

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

Sukumar Srikant
Systems and Control Engineering,
CRNT building,
Indian Institute of Technology-Bombay
Mumbai

Irinel Constantin Morarescu
Centre de Recherche en Automatique de Nancy (CRAN), UMR7039
Université de Lorraine
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

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

Life and Health Sciences

Project No. 6003-1 | **Apr. 2019 to Mar. 2023**

Background

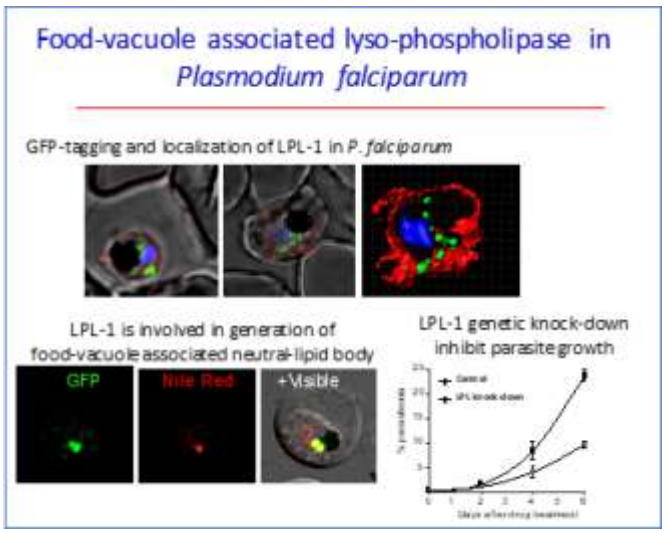
Apicomplexa is a phylum of obligate intracellular parasites, including major pathogenic parasites such as *Plasmodium spp.* and *Toxoplasma gondii*, causative agent of malaria and toxoplasmosis, respectively. There is no vaccine against these diseases and appearances of multi-drug resistant strains, 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.

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 Mohmmed
International Centre for Genetic Engineering and Biotechnology
New Delhi

Cyrille Yan Botté
Institut Albert Bonniot (IAB)
Grenoble

Publications

- No. of publications in SCI journals: 2
- 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 & 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: 1

Mobility Support

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

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

Pure & Applied Physics

Project No. 6004-1 | **Feb. 2019 to Jan. 2024**

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 maturating 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

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:

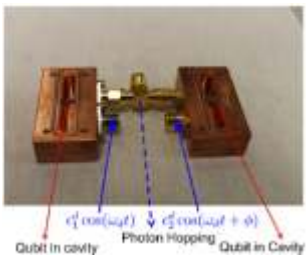
  A. Dey, M. Kulkarni, Phys. Rev. Res. 2, 042004, Rapid Communications (2020), "Emergence of chaos and controlled photon transfer in a cavity-QED network"

  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"

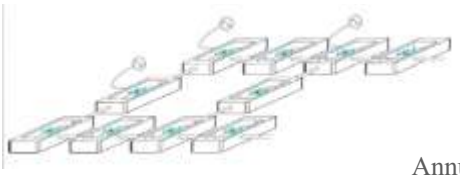
  A. Dey, M. Kulkarni, Phys. Rev. A 101, 043801 (2020), "Engineering indefinitely long-lived localization in cavity-QED arrays"

  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 Laboratoy 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_2 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/TiO2, MoS2 or SiNW/TiO2/MoS2 composites for enhanced CO2 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. CO2 adsorption is of highest concern during the CO2 reduction process because CO2 reduction kinetics is highly correlated to the CO2 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 CO2 through CO2-M bond and thus enhance the adsorption of CO2 on its surface

Knowledge Generated/Products Developed

- Synthesis of Ni/NiO grafted Co(II) complex at CSIR-IIP
- Synthesis of silicon nanowires SiNW) and MoS2 supported SiNW at IEMN, France
- Modification of SiNW and MoS2/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_2, MoS_2 or SiNW/TiO_2/MoS_2 composites as semiconductors support for grafting of metal complexes for enhanced CO_2 adsorption and its simultaneous conversion to high value chemicals such as formic acid, formates, methanol via photo-electrochemical conversion route using visible light. CO_2 adsorption is of highest concern during the CO_2 reduction process because CO_2 reduction kinetics is highly correlated to the CO_2 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_2 through CO_2-M bond and thus can enhance the adsorption of CO_2 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_2 reduction.

Principal Collaborators

Suman Lata Jain
CSIR-Indian Institute of Petroleum
Dehradun

Rabah Boukherroub
Institute for Electronics Microelectronics and Nanotechnology
Villeneuve dAscq

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

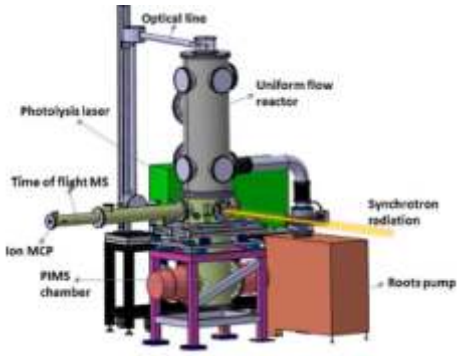
The project aims to uncover the detailed nucleation mechanisms and the associated rates through the exploration of elementary reaction steps. The investigation will be carried out with the help of supersonic flow reactors associated with mass and optical spectrometers and with free jets combined to a FTWM spectrometer. The focus will be put on the nucleation enhancement of prototype molecules (e.g. H_2O) 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.

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

Principal Collaborators

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

Ludovic Biennier
Institut de Physique de Rennes (UMR UR1-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

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 Gorumahishani-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

Material Sciences

Project No. 6008-1 | **Apr. 2019 to Mar. 2023**

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^2) fully flexible blue LEDs will be optimized. CSIR-NIIST will work on the synthesis of nanophosphors with high QE. Especially, a novel concept for nanosphorphor 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

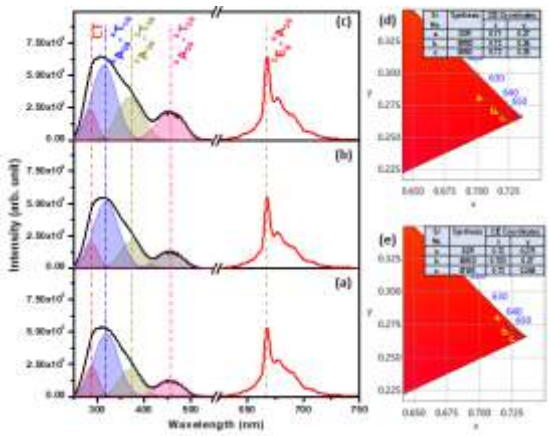
Objectives

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 Li3RbGe8O18:Mn4+, Mg2+ nanophosphors
- Synthesis of YAG: Ce3+ 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

Computational Sciences

Project No. 6102-1 | **Apr. 2019 to Mar. 2023**

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.

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

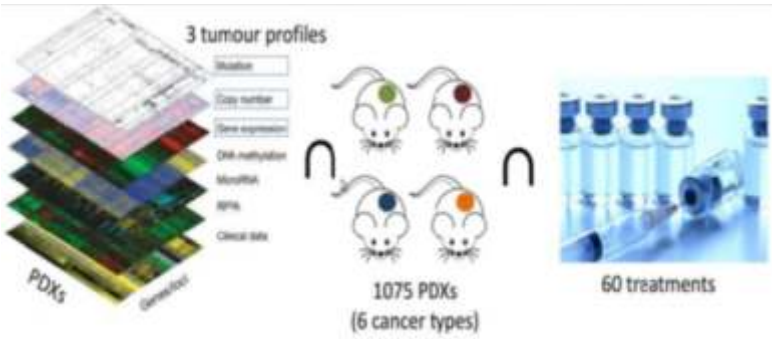
Objectives

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



How mechanical conflicts contribute to organ shape reproducibility in plants

Life & 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 cellcell 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, 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 ontogenic 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 ontogenic 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

Life and Health Sciences

Project No. 6103-2 | **May 2017 to Nov. 2022**

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.

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)

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

Turbulent flows in equilibrium

Pure & Applied Physics

Project No. 6104-1 | **Jun. 2019 to Dec. 2023**

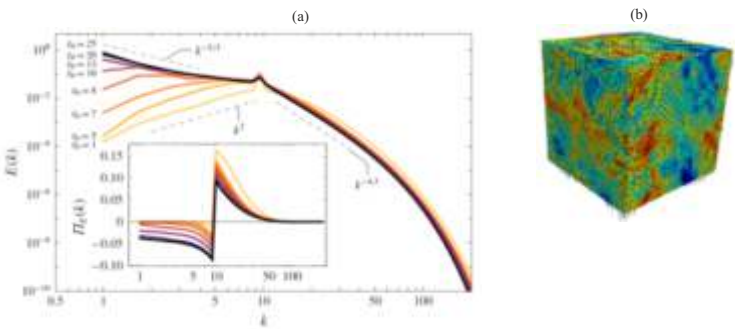
Objectives

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 Superieure
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 & 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 opto-electronic 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 heterostrcutures for novel electronic and opto-electronic 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_2

ROYCE (diveRsity Oriented sYnthesis of Complex hEterocycles)

Pure & Applied Chemistry

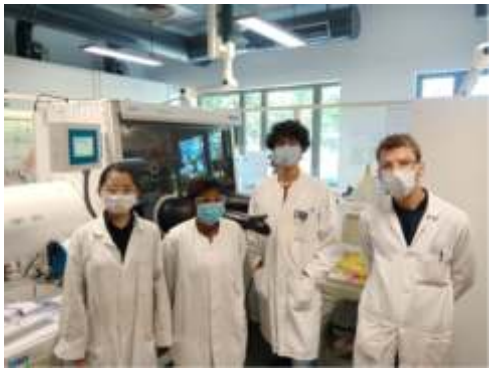
Project No. 6105-1 | Aug. 2019 to Jul. 2024

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 Switerzland.
- 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 8th, 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

Material Sciences

Project No. 6108-1 | **Apr. 2019 to Apr. 2022**

Background

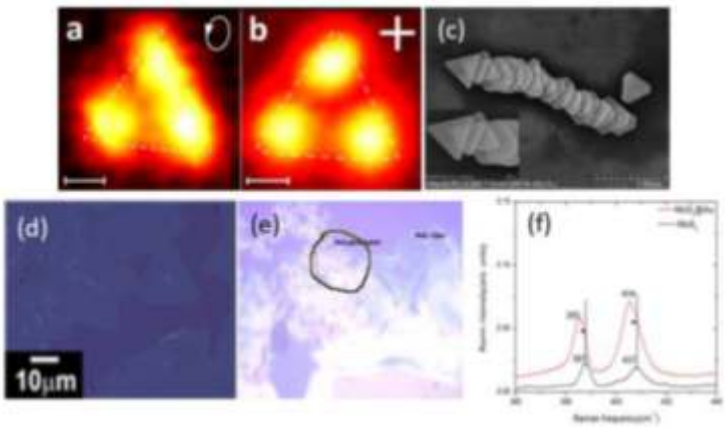
This collaboration aims at exploiting the spatial and spectral addressability of SP modes borne by ultrathin 2D metallic crystals to locally trigger (1) nonlinear luminescence of excitons in monolayer transition metal dichalcogenides (TMD) and (2) chemical reactions by thermal activation or hot electron 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.

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 MoS2
- Fabricated MoS2@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



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_2 grown on SiO_2/Si substrate. (e) Optical image of Hybrid nanostructures: MoS_2@Au on SiO_2/Si substrate. (f) Raman spectra of MoS_2@Au 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

Chromium isotopes as tracers of environmental contamination and remediation

Environmental Sciences

Project No. 6109-1 | **May 2019 to Apr. 2022**

Objectives

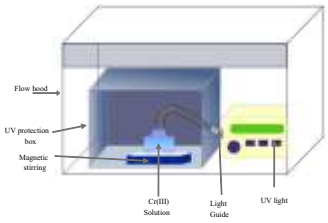
PIs have decided to modify one of the objectives of this project in light of the results we obtained during the first part of this project. Initially PIs had planned to work on Cr isotope as an environmental tracer using both mass dependent fractionation (MDF) and mass independent fractionation (MIF). 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



Experimental setup with a UV light to produce Cr(VI) from a Cr(III) solution

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 release Cr in the enviroment 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 MnO2 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

Host-Microbe-Interactions in Health & Agriculture?

Project No. 62T4-1 | **Feb. 2020 to Jan. 2023**

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 Superieure
Paris

Publications

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

Mobility Support

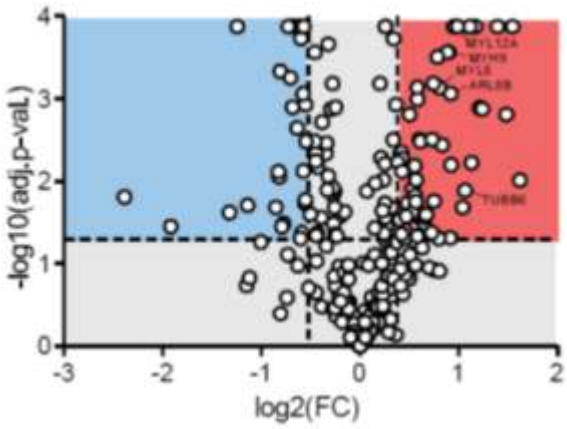
- India to France: Nil
- France to India: Nil

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**

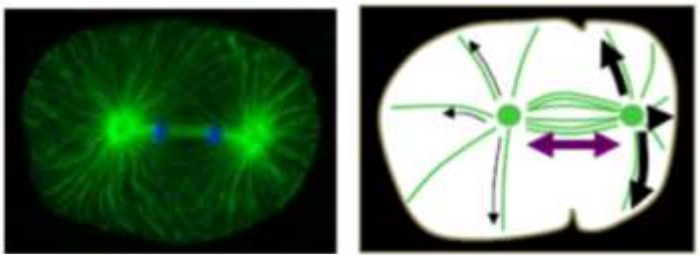
Objectives

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 spinde in 10 selected species;
  - i) Exploring evolutionary changes in spindle dynamics using in sillico 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) microcopy (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

Multifunctional Materials and The Underlying Science

Project No. 62T8-1 | **Feb. 2020 to Sept. 2023**

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_2, SnS_2, Bi_2Se_3, 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_6 and GdB_6), wide band gap semiconductor (HfO_2) 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

Objectives

- To develop and optimize novel field emitters due to Si nano needles coated with ultra-thin layer of rare earth hexaborides (LaB_6 and GdB_6), and wide band gap semiconductor (HfO_2). 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 LaB6 and GdB6 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 LaB6 nanotips with and without laser illumination

Q-Walker: programmable quantum dynamics simulator

Exotic States of Materials and Quantum Criticality

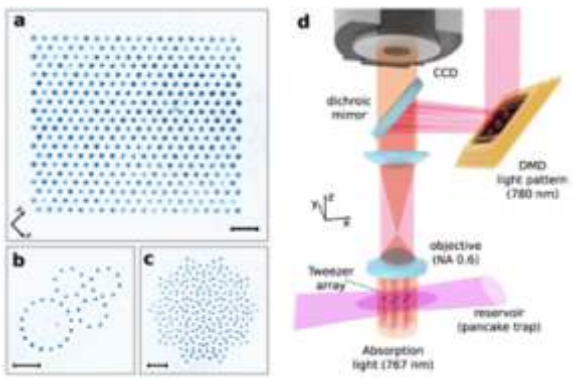
Project No. 62T9-1 | **Mar. 2020 to Aug. 2022**

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 ultra-cold 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

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 (2H , 13C and/or 15N) 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.

Principal Collaborators

Jayanta Haldar
Jawaharlal Nehru Centre for Advanced Scientific Research Bangalore

Burkhard Bechinger
UMR CNRS 7177
Institut de Chimie 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

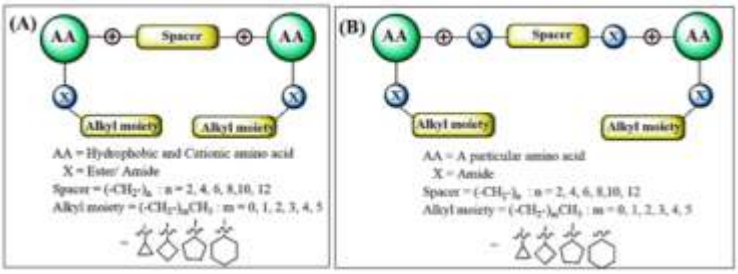
Objectives

- To develop amino acid based cationic small molecular AMP mimetics and test their in-vitro antibacterial activity and toxicity
- 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
- To synthesize isotope labelled lead compounds and study their detailed membrane active and anti-biofilm mechanism of action through solid-state NMR
- To study the detailed membrane active and antibiofilm mechanism of action through spectroscopic, light scattering and microscopic techniques

Knowledge Generated/Products Developed

- A library of 19 molecules was synthesised. Their in-vitro antibacterial activity and toxicity was evaluated, and a lead molecule was identified
- Biological characterisation of the lead molecule, including antibiofilm activity, and resistance frequency estimation was performed
- Isotope labelled lead compounds are being synthesised to study their detailed mechanism of action. Solid-state NMR spectroscopic investigations of lipids in the presence of a selection of compounds
- Detailed mechanism of action through fluorescence spectroscopy was performed, and membrane permeabilization and depolarization was seen. Solid-state NMR studies of membranes

A lead molecule has been identified through extensive structure activity analysis, and detailed preclinical biological investigations, covering the various aims of the project, along with additional aims, have been performed for the lead molecule. Similarly, other lead molecules developed through similar studies have been studied for their membrane-active mechanism of action, through NMR, and dye leakage study



Schematic of proposed molecular design

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

Biological Chemistry

Project No. 62T10-2 | **Jul. 2020 to Jun. 2023**

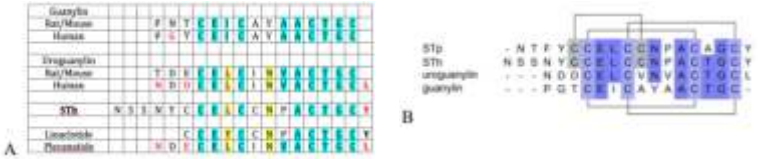
Objectives

- 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 diseaseassociated mutations in GC-C

Knowledge Generated/Products Developed

- Synthesis of six labeled model peptides: Four fluorescent uroguanylin peptides delivered to India for analysis. Peptides stable during shipment as tested by HPLC
- Peptides tested for receptor binding using radiolabeled receptor binding assays. All peptides bound to GC-C with a log order lower affinity than the native ST peptide. Peptides tested on both human and mouse receptor preparations
- Peptides tested for their ability to elicit cGMP production in cell lines expressing both human and mouse receptor. All peptides were active
- C5-ST peptide tested on cells using confocal imaging to monitor in vivo binding. Peptides bound to native receptor in intact cells
- Established organoid cultures from the mouse small intestine which respond by swelling on administration of ST peptide

Work going according to plan except for the break due to closure of laboratories during Covid. We have bioactive fluorescently labeled peptides that can now be tested in cellulo and in vivo



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

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. We 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.

Principal Collaborators

Sandhya S Visweswariah
Indian Institute of Science
Bangalore

Laurence A Mulard
Institut Pasteur
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

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

Biological Chemistry

Project No. 62T10-3 | **Mar. 2020 to Feb. 2023**

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 theoligomerization of the Abeta peptide. Then, these tools will be used to follow Cu events, iii) at physiological relevant concentrations (nM to low µM) 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

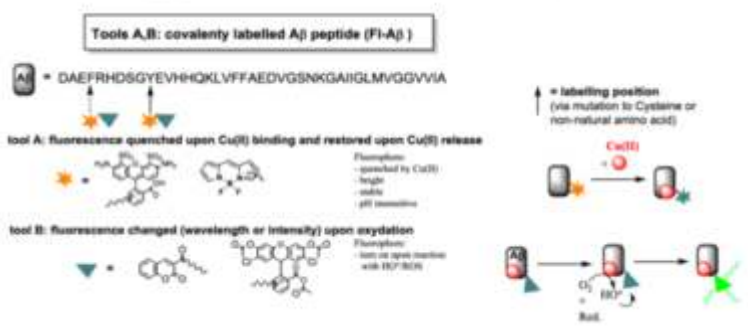
Objectives

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



Exploring the role of DNAse1L3in obesity-associated metaflammation and type 2 diabetes

Life and Health Sciences

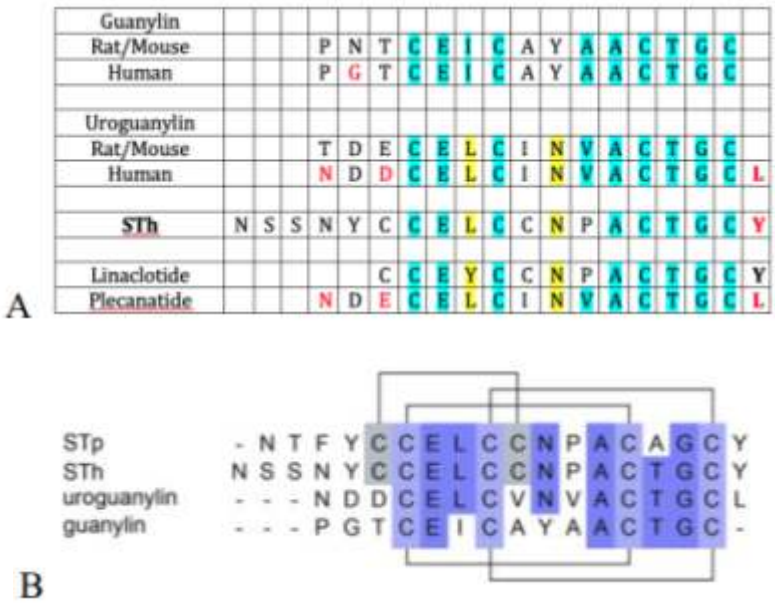
Project No. 6203-1 | **Mar. 2021 to Feb. 2024**

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

Knowledge Generated/Products Developed

- Series of online talks about:
  a) Introduction to Leavitt path algebra ®. Basu)
  b) Deformation theory (A. Naolekar)
  c) Groebner basis (A. Makhlouf)
  d) Noncommutative Groebner basis (A. Makhlouf)
  e) Deformation Theory of LPA (A. Naolekar)
  f) Deformations of path algebras with quivers and relations (A. Mandal)
- Compute Derivations of the family Lk(1,n) of Leavitt path algebras (paper under preparation)
- Preprint 1: Bialgebra and Hopf algebra structures of Leavitt path algebras.
- Working on Double Poisson structure of Leavitt path algebras
- Working on algebraic structures of Hochschild cohomology of bound quiver algebras



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

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
Indian Institute of Chemical Biology
Kolkata

Patrick Olivier Blanco
Bordeaux University
CNRS UMR 5164
Bordeaux

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

On the cohomology and deformations of leavitt path algebras and applications

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.

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

Knowledge Generated/Products Developed

- Introduction to Leavitt path algebra (R. Basu)
- Deformation theory (A. Naolekar)
- Groebner basis (A. Makhlouf)
- Noncommutative Groebner basis (A. Makhlouf)
- Deformation Theory of LPA (A. Naolekar)
- Deformations of path algebras with quivers and relations (A. Mandal)

Compute Derivations of the family Lk(1,n) of Leavitt path algebras

Principal Collaborators

Anita Naolekar
Indian Statistical Institute
Bangalore

Abdenacer Makhlouf
Université de Haute-Alsace
Mulhouse

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

Signalling for Real-time Control in the Smart Grid

Pure and Applied Mathematics

Project No. 6301-2 | Apr. 2021 to Mar. 2024

Objectives

Electricity grids are undergoing wide-ranging transformations due to the introduction of renewable generation, rooftop solar and distributed wind generation, affordable storage devices, and communication links between grid operators, generators and consumers. The aim of this proposal is to develop a signalling architecture that exploits communication between the electric grid and supply/demand in order to control the variability of consumption and production in real time at a lower cost. We consider signalling problems in three directions: demand response, predictability of intermittent renewable generation, and storage management. In each situation, we will develop incentive mechanisms based on the theory of optimal contracts or on game theory with incomplete information, and in particular on the idea of Bayesian persuasion

Background

Electricity grids are undergoing wide-ranging transformations due to the introduction of renewable generation, rooftop solar and distributed wind generation, affordable storage devices, and communication links between grid operators, generators and consumers. The goal of this proposal is the development of a signalling architecture that harnesses the communication between a balancing authority and the supply/demand with the aim of controlling variability in real time in a cost effective manner. The project will address challenges along three directions: Signalling architecture for renewable generation: The grid operator faces the dilemma of promoting renewable generation by dispatching as much of it as possible, and at the same time ensuring predictability in the schedule. The outcome of this direction would be joint signalling strategies for storage and DR, and for storage and renewable generation. We first consider the case where truthful revelation and obedience can be ensured by either by a legal contract or due to ownership. When obedience cannot be assumed, we will again adopt the paradigm of Bayesian persuasion to design signals such that they induce obedience.

Principal Collaborators

Ankur A. Kulkarni
Indian Institute Of Technology, Bombay Mumbai

Rene Aid
Universite Paris 9 Dauphine 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

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

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

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

Knowledge Generated/Products Developed

- Customizing microscopy setup to do both Interference Reflection Microscopy (IRM) as well as Total Internal Reflection Fluorescence (TIRF) microscopy
- Correlative microscopy of caveolae and membrane fluctuations.
- Understanding how actin -membrane interaction by ezrin can affect caveolae stability
- Establishing strategy to quantify response to local tension variation using intracellular tension and membrane excess area estimation.
- Using micropatterning to alter mechanical niche and find effect on tension set-point

Understanding the mechanism of crack-entry adapted root nodule symbiosis

Life and Health Sciences

Project No. 6303-2 **Oct. 2020 to Sep. 2023**

Objectives

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

Knowledge Generated/Products Developed

- The Aeschynomene evenia symbiotic subtilase AeSBT5 is specifically expressed during plant cell infection by Bradyrhizobium sp. (observation of transgenic roots transformed with ProAeSBT5:GUS:GFP construct); Cloning of 2 others reporter gene constructs ProAeSBT3:GUS:GFP and ProAeSBT9:GUS:GFP are ongoing
- The nodulation-related activation of an actinorhizal plant SBT (Cg12) is conserved in A. evenia and Arachis hypogaea
- A ProCg12:EPI construct is done; first in planta inhibitor assays suggest that SBTs have a negative impact on nodules inception
- A 35S:AeSBT5:mTurquoise construct is synthesized for subcellular localization of AeSBT5
- Expression profiles of Aspartate proteases expressed during the progress of symbiosis in Arachis hypogaea has been investigated

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 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.

Principal Collaborators

Maitrayee Dasgupta
Calcutta University
Kolkata

Fabienne Cartieaux
Institut de Recherche
Pour le Développement
Montpellier

Publications

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

Mobility Support

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

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 proto-type 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

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

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

Knowledge Generated/Products Developed

- Established mouse models of diabetes by treatment with a mixture of EDCs at doses equivalent to human exposure
- Establishment of type-2 diabetes (T2D) Bio-banking
- Standardized the faecal collection protocol and so far collected 197 T2D samples

We are in the process of understanding the molecular pathogenesis of diabetes during different etiology i.e., high fat diet and endocrine-disrupting chemicals. We have focused on both host and gut microbiota physiology in relation with endogenous glucose production, and more specifically intestinal gluconeogenesis. We recently finalized a study addressing the relationship between intestinal gluconeogenesis and the gut microbiota composition and function, not completely related with the present proposal, but useful in its further development (Vily-Petit et al, Sci Rep 2022). This knowledge generation may pave the way for development of products focused on gut microbiota or host glucose pathways, like probiotics, targeted therapy, etc., for better glycaemic control in diabetes population

Human Guided Impedance Control of Cobotic Arm

Computer Science

Project No. 6304-1 **Mar. 2021 to Mar. 2024**

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

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.

Principal Collaborators

Soumen Sen
CSIR Central Mechanical Engineering Research Institute
Durgapur

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

Publications

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

Mobility Support

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

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 Mar. 2025

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.

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

Principal Collaborators

Manimala Mitra
Institute of Physics
Bhubaneswar

Genevieve Belanger
CNRS -Lapth
Grenobl

Publications

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

Mobility Support

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

Novel Non-Perturbative Approaches to Strongly Coupled QCD Matter

Pure and Applied Physics

Project No. 6304-3 | Oct. 2020 to Sept. 2023

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

Knowledge Generated/Products Developed

New methods in effective theories via semi-holography, technique to compute out-of-equilibrium correlation functions in many-body systems via holography, technique for computing hybrid quasinormal modes of a black hole interacting with a perturbative system at the asymptotic boundary relevant for study of non-Markovian open quantum systems

- Developed a novel effective semiholographic theory for non-Fermi liquids which can reproduce transport properties of strange metals including linear-in-T resistivity over a wide range of temperatures
- Confirmed our model data which predicts universal properties of the spectral function and Planckian dissipation with a universal scattering time with experimental data

  (Both 1 and 2 would be relevant for study of cold dense QCD matter but should have broader impact on the field of applied holography and effective theories of non-Fermi liquids..)
- Proposed by Crossley, Glorioso and Liu; significantly, we have computed the out-of-equilibrium Schwinger-Keldysh correlation functions of the hydrodynamic attractor via holographic methods

This breakthrough is key to attain our objectives but should also have broader impact on the study of many body systems out of equilibrium

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.

Principal Collaborators

Ayan Mukhopadhyay
Indian Institute of Technology- Madras
Chennai

Giuseppe Policastro
Laboratoire de Physique
Theorique de l'Ecole Normale Superieure
Paris

Publications

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

Mobility Support

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

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

Life and Health Sciences

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.

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

Knowledge Generated/Products Developed

- First comprehensive study of ultracold atomic systems in the framework of low-momentum effective interactions
- For the ultracold Fermi gas, effect of pairing was included via Hartree-Fock Bogoliubov (HFB) formalism and perturbative corrections up to third order were computed with Bogoliubov many- body perturbation theory (BMBPT)
- Cutoff dependence of the Bertsch parameter for ultracold atoms was studied as a check of convergence. Convergence within BMBPT has been reached in the BCS region. In the unitaryregion, our Bertsch paramter estimate is close to recent experimental determinations
- HFB implemented for pure neutron matter with general non-local low-momentum interaction
- BMBPT corrections for pure neutron matter implemented up to second order

Principal Collaborators

Sunethra Ramanan
Indian Institute of Technology- Madras Chennai

Michael Urban
Institut de Physique Nucleaire (IPN) Orsay

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

Discovery and understanding of new glycosylation methods

Pure and Applied Physics

Project No. 6305-1 **Aug. 2020 to Sep. 2023**

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 CF3 or =CF2 groups and their use via C-F activation processes to provide new entries for selective and efficient glycosylation reactions

Knowledge Generated/Products Developed

- Initial mechanistic studies using ESI- MS
- Elaboration of more suitable substrates for mechanistic studies
- Improved synthesis of alkynyl glycosyl carbonates
- Activation of Alkynyl Ester Glycosides by Gold-catalysts
- Xylosides as efficient chiral auxiliaries in heterocycle synthesis

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.

Principal Collaborators

Hotha Srinivas
Indian Institute of Science Education and Research Pune
Pune

Florian Jaroschik
Institut Charles Gerhardt Montpellier
Ecole Nationale Supérieure de Chimie de Montpellier
Montpellier

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

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 N2 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 Indian and France, opening new research avenues in the most unknown oceanic basic.

Objectives

- Inter-seasonal and inter-basin comparison a) Environmental settings and core parameters b) Cyanobacterial vs. non-cyanobacterial N_2 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

Principal Collaborators

Arvind Singh
Physical Research Laboratory (PRL)
Ahmedabad

Mar Benavides
French National Research Institute for Sustainable Development (IRD)
Mediterranean Institute of Oceanography (MIO)
Marseille

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

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

Material Sciences

Project No. 6308-1 **Oct. 2020 to Sep. 2023**

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 divide 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

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.

Principal Collaborators

Prita Pant
Indian Institute of Technology Bombay
Mumbai

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

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

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 crystalsand 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 bringin 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 Ir5+ has an intrinsic magnetic order. Spin transport measurements will be carried out to probe the magnetic phases as a function of oxygen content in PIO and 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.

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-ay absorption and emission spectroscopy, Raman, high resolution TEM)
- Understanding of the quantum correlation effects from above mentioned studies in hitherto unexplored iridates

Knowledge Generated/Products Developed

- Thin films were successfully grown using PLD and magneto-transport studies were done on thus grown film
- The weak-localization arising in SrIrO3 films with the reduction in the O2 stoichiometry variation in the film were studied
- Optimized the deposition conditions for the SrCoO2.5 films following the preparation of phase pure target using quenching technique
- Magnetic transport was done on the heterostructure films to study the interface effects
- Angle dependent measurements were done on the heterostructure to understand the magnetic anisotropy

Principal Collaborators

M S Ramachandra Rao
Indian Institute of Technology Madras
Chennai

Werner Paulus
University of Montpellier
Montpellier

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

Developing novel oxygen carriers for chemical looping combustion using substitutional chemistry of mixed phases

Science for Sustainability

Project No. 64T2-1 | Oct. 2021 to Sep. 2024

Background

Chemical looping combustion (CLC) is a two-step process where in the first step an oxygen carrier (usually a metal oxide) is reduced using a fuel (methane, syngas, coal feed or organic biomass). This reduced oxygen carrier is re-oxidized using either air, CO_2 or H_2O depending upon the requirement and available resources. Clearly, the heart of CLC technology is the oxygen carrier – the solid, able to store and deliver the oxygen atom - and this project deals with developing novel oxygen carriers with (a) high oxygen storage capacity (OSC), (b) Low temperature reducibility, (c) fast oxygen release and capture property, and finally (d) thermal and chemical stabilities. The proposed oxygen carrier will be based upon the substitutional chemistry in mixed phases, a poorly explored concept to date. Here, one (or more) dopant(s) will be substituted in place of atoms of the host, which results in drastically different reactivity and chemical properties. French and Indian PIs already studied substitution of mixed oxides, and they demonstrated that it can enhance the oxygen storage capacities, while reducing the activation temperatures. Kinetics and reversibility are the additional properties which needs to be studied considering the importance of the rates of discharge and recharge of the carrier, are well as their stability during several hundreds of cycles. New oxygen carriers will be developed considering all the mentioned criteria. General objective concerns the production of energy from this process; therefore, oxygen carriers should be able to give partially oxidized product while they reduced, while re-oxidation could be done using CO_2 or H_2O to produce CO or H_2.

Principal Collaborators

Sudhanshu Sharma
Indian Institute of Technology Gandhinagar

Sebastien Royer
Université de Lille 1, UCCS
UMR 8181 CNRS
Lille

Objectives

- Synthesis of substituted metal oxides with high OSC (use of orthogonal experience plan to minimize the number of synthesis while determining the impact of each parameter among dopant nature, content, nature of the host on the OSC characteristics including the stability of the performances)
- Measure of Oxidation/Reduction cycles (O2/H2) (rate and capacity) over 10 pre-selected synthesized compositions (from objective 1). Issued key values are: rate of immediate reducibility and degree of reversibility; rate of prolonged reducibility (5 pulses) and degree of reversibility
- Measurement of CLC activity and stability upon prolonged use of 3 selected compositions, with quantification of H2 produced and CO produced by using H2O or CO2 during reoxidation step

High precision Chronology of refractory Inclusions from primitive chondrites

Earth And Planetary Sciences

Project No. 6407-1 | Jul. 2021 to Jun. 2024

Principal Collaborators

Kuljeet Kaur Marhas
Physical Research Laboratory
(Department of Space)
Ahmedabad

Yves Marrocchi
Centre de Recherches
Pétrographiques et Géochimiques
Nancy

Objectives

- Mineralogical and petrographic characterization of meteorite samples
  - Establish a detailed petrographic, chemical and microstructural survey of CAIs and AOAs from least altered carbonaceous and ordinary chondrites
- Chronology of formation of refractory inclusions
  - Establish a detailed and comprehensive 26Al-26Mg chronology of formation of primordial solids
- Formation conditions of refractory inclusions
  - Perform systematic measurements within CAIs and AOAs to determine the initial abundances of the extinct radioactivities 10Be (10Be &'8594; 10B, t1/2 = 1.5 Ma), 41Ca (41Ca &'8594; 41K, t1/2 = 0.1 Ma) and 44Ti (44Ti &'8594; 44Ca, t1/2 = 49 days)

Background

Refractory inclusions found in primitive meteorites are ancient solids formed at high temperature during the first few millions years of the early Solar System. They are key witnesses of the protoplanetary disk evolution from the formation of tiny condensates to the accretion of planetary embryos. In spite of numerous studies and significant improvements during the last decades, the message carried by these solids is still not clearly understood. This project will address the questions of the conditions of formation and evolution of the Solar System by combining state-of-the-art isotopic measurements with physical models of the protoplanetary disk. To do so, it is proposed to first establish a detailed petrographic, chemical and microstructural survey of refractory inclusions from the least altered carbonaceous and ordinary chondrites. Thanks to the unique analytical abilities of the Secondary Ion Mass Spectrometer (SIMS) 1280 HR2 (Nancy, France), PIs will perform systematic measurements within CAIs and AOAs to determine the initial abundances of the extinct radionuclides10Be (10Be &'8594; 10B, t1/2 = 1.5 Ma), 41Ca (41Ca &'8594; 41K, t1/2 = 0.1 Ma) and 44Ti (44Ti &'8594; 44Ca, t1/2 = 49 days). These results will allow us to provide both a quantitative and chronological estimate of the irradiation conditions that prevailed in the protoplanetary disk. In addition, the chronology of formation of CAIs and AOAs will be established via a detailed and comprehensive 26Al-26Mg characterization. Since high precision 26Al-26Mg dating will be performed using the SIMS 1280 HR2 recently coupled with the new Radio-frequency ion source, the proposed approach allows studying objects that were beyond reach so far and thus avoiding any sampling bias. On completion, this project will provide important constraints on the timing of dust formation and the irradiation conditions that prevailed during the evolution of the protoplanetary disk.

Exploring the Asian pollution signature in the upper troposphere/ lower stratosphere using medium duration balloon flights

Environmental Sciences

Project No. 6409-1 **Sep. 2021 to Aug. 2024**

Background

Over the past decades, rapid economic growth in Asia has had major impacts on atmospheric composition with potential consequences on the Southeast Asian Monsoon, a source water to 1/3 of the world population. The monsoon generates a transport pathway for pollution to the reach the upper atmosphere that can affect climate, stratospheric ozone and the hydrological cycle. Remote sensing measurements from satellites have revealed enhanced pollution levels at high altitudes, in the form of particulate matter within a very large anticyclonic area from Eastern Mediterranean Sea to Western China and encompassing India, so called the Asian Tropopause Aerosol Layer (ATAL). The goal of this work in the frame of a PhD thesis will be to study the nature, origin, and evolution of the ATAL using balloon-borne measurements, satellite observations and numerical simulations. Space-borne observations will provide a unique and continuous aerosol dataset to quantify the aerosol burden and variability during the monsoon season. They will be validated during ongoing existing balloon field campaigns, taking place in India since 2014. Numerical simulations will be performed to study the formation mechanism and origin of the ATAL. The overall objectives of PhD will be to: - Study the physical, chemical and optical properties of aerosols using a unique and valuable strategy using balloon-borne measurements over upper troposphere/lower troposphere (UTLS) region, in India - Compare and validate satellite observations with balloon measurements, and - Investigate Indian and Asian remote emission sources and aerosol formation/evolution processes using numerical simulation.

Principal Collaborators

Neeraj Rastogi
Physical Research Laboratory (Department of Space) Ahmedabad

Gwenael Berthet
Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E/CNRS), Chambon La Foret Orléans

Objectives

- To identify the mechanisms behind the formation of a layer of pollution particles present during the Indian monsoon season at high altitude and trapped in the monsoon anticyclone
- The properties of these particles in terms of nature, concentration, size and evolution will be determined by balloon observations in India, which are particularly unique and novel. The core of this work will be carried out within the framework of a PhD thesis

HI/CO gas Interaction, non-thermal emission in CLusters of GalaxieS (HI-CLoGS)

Pure and Applied Physics

Project No. 6504-3 | Jan. 2022 to Jan. 2025

Principal Collaborators

Nirupam Roy
Indian Institute of Science
Bangalore

Alexandre Marowith
Laboratoire Univers et Particules
Montpellier

Objectives

- Particle acceleration mechanisms, fluctuations in the power spectrum due to dense cluster environment and magnetic field evolution in the ICM
- Evolution of galaxies in extreme cluster conditions, quenching of their star formation activity, and AGN feedback
- Interaction of hot ionized and cold gas in galaxies within the clusters and the evolution of atomic and molecular cold gas reservoirs of star formation in cluster galaxies at $0 < z < 0.3$. Further, PIs will search for the faint star-forming distant radio galaxies lensed behind the clusters up to $z \sim 5$, via using the available data as a byproduct of this project

Background

Clusters of galaxies are the largest gravitationally bound structures in the universe with 1000s of galaxies held in the heated gaseous environment of the intra-cluster medium (ICM), which also shows the presence of rare cold gas, diffuse non-thermal emission and magnetic field at different spatial scales. Massive clusters can be used as gravitational lenses to magnify and probe the properties of a rare and faint population of distant galaxies lying at their background. The goal of HI-CLoGS proposal is to provide a breakthrough view, in PIs understanding of clusters and their galaxy population, in context with the (i) origin of rare non-thermal diffuse emission from their ICM, (ii) magnetic field studies in cluster environment over different spatial scales, (iii) abundance of cold gas within their environment, (iv) interaction of radio jets of the cluster galaxy population with their ICM and, (v) physical properties of the unexplored population of faint distant radio-emitting galaxies found behind the cluster environment, using new-generation high resolution (milliarcsec scale) and sensitivity (micro-Jy level) observations. The collaborators will address above goals by using the new proprietary data, from the new state-of-the-art world-class radio facilities like- LOw-Frequency ARray, Australian Square Kilometre Array Pathfinder (ASKAP)- WALLABY and up-graded Giant Metrewave Radio Telescope - a Square Kilometre Array (SKA) pathfinders. Further, using multi-wavelength data available within the collaboration from IR (IRAM, ALMA) and Optical (HST, MUSE, WEAVE - a new-spectroscopy survey instrument operational in late 2020 covering the LOFAR sky) facilities, PIs will study the correlation between dark and baryonic matter interaction in clusters, spectral and polarization properties of the radio galaxy hosts, the interaction of warm-cold gas within their environment and their evolution with the redshift. This will provide a complete scenario of the formation and evolution of large-scale structures, nearby to primordial radio galaxies, the evolution of magnetic fields at different spatial scales, and radio-mode feedback in clusters over cosmic timescales.

How to trace Metallo-drugs in living cells? Development of fluorescent chemical tools

Pure and Applied Chemistry

Project No. 6505-1 | Mar. 2022 to Mar. 2025

Background

The objective of this proof-of concept study is to set-up methods for tracking the stability, localization, and speciation of manganese based anti-oxidants (MnAOs) in living cells using a library of novel fluorescent Mn(II) ion probes with a range of metal binding affinities using confocal microscopy. C. Policars lab (ENS) has been designing catalytic MnAOs as superoxide dismutase mimics to treat inflammation associated oxidative stress (OS). In order to translate MnAOs as therapeutics we need to address: How many drug molecules reach the cellular target? What is the in cell stability of MnAOs? Where are MnAOs localized in cells? A. Dattas lab (TIFR) has been working on solving coordination chemistry challenges to develop Mn(II) selective cell-permeable fluorescent sensors. The groups propose to combine their unique complimentary expertise to target MnAOs to specific intracellular locations relevant to increased OS and evaluate their in cell stability constants and localization using Mn(II) sensors. Once successfully tested in MnAOs the concept will be applicable to any metallo-drug leading to a new paradigm in inorganic cellular chemistry in evaluation of drug efficacy.

Principal Collaborators

Ankona Datta
Tata Institute of Fundamental Research (TIFR)
Mumbai

Clotilde Sarah Policar
Ecole Normale Supérieure
Paris

Objectives

The specific objectives of the proposal are:

1 Chemical design: Developing cell-permeable and organelle-targeted MnAOs and fluorescent Mn(II) probes

- MnAOs design and physico-chemical characterization out of any cellular context (ENS, France)
- Design of a series of Mn(II) selective cell-permeable and organelle targeted sensors/probes and photo-physical characterization out of any cellular context (TIFR, India)
- Competition titrations between MnAOs and probes to generate a stability constant calibration ruler that will be used to determine the localization and stability of MnAOs in cells in objective 2 (ENS, France and TIFR, India)

2 Evaluation: Designing, optimizing, and applying novel assays to measure the in cell distribution and stability of MnAOs using the Mn(II) probes

- In cell evaluation of MnAOs (ENS, France)
- In cell evaluation of Mn(II) probes (TIFR, India)
- Development of in cell fluorescence based assays for determining the concentration, distribution, and speciation of MnAOs in live cells (TIFR, India and ENS, France)
- Implementation in a high content screening (HCS) to characterize MnAOs, from this project or from the literature, in cells (ENS France and TIFR, India)

Synchronization and spatio-temporal rhythms in an ensemble of active droplets

Pure and Applied Chemistry

Project No. 6505-2 | Jan. 2022 to Jan. 2025

Principal Collaborators

Punit Parmananda
Indian Institute of Technology-Bombay Mumbai

Véronique Pimienta
Laboratoire des Intéractions Moléculaires et Réactivité Chimiques et Photochimiques Toulouse

Objectives

- To investigate the collective dynamics and more specifically the synchronization phenomena of two active drops (DCM and pentanol) on an aqueous surfactant solution of CTAB
- To understand the modes of coupling in the system in the presence of multiple drops by varying the nature of the drop and so the related interactions (repulsive or attractive) with a single system
- To bring a clear picture on the key processes at play in each situation by determining the contribution of purely hydrodynamic interactions in the collective motion and related pattern formation

Background

The study of collective behavior is associated with diverse phenomena among which synchronization plays a crucial part. It is the phenomenon which is encountered in various fields of science and engineering and also in social studies. It is based on mutual interactions of individual species or entities. This exchange of information is what terms as coupling. Thus the synchronization has different manifestations depending on the underlying coupling mechanisms. From bacterial colony to humans, synchronization can be observed in a wide variety of system sizes. Few examples include synchronized flashing of fireflies, the synchronized occurrence of menstrual cycles among human females while living in close proximity, synchronous clapping of audiences in a theatre, synchronization of the biological clocks of living beings with the environmental factors e.g. illuminance. To witness the phenomena, firstly, a suitable mode of coupling needs to be chosen and secondly, the critical coupling strength should be determined. In an ensemble of oscillators or entities, a transition from desynchronized to the synchronized state takes place beyond that critical coupling strength. When the coupling strength starts to increase beyond that critical value, the system starts to form synchronized clusters which increase in numbers or in size as the coupling strength increases further. Now, in a system, an exchange of information (i.e. coupling) can take place in different ways. Finding a suitable coupling mechanism to control the spatio-temporal dynamics in an ensemble of self-propelled droplet, is a challenging task and needs to be performed carefully. The system at hand offers extremely promising properties that will allow us to compare the activity of multiple drops showing opposite properties in a geometry allowing the gradual modification of the interaction strength. Thus, to address the synchronization phenomena in an active droplet system, it needs a nonlinear perspective with the knowledge of surface-tension driven instabilities in relation with the physicochemical chemical properties of the system. Thus the accomplishments of the planned objectives in this project require collaborative efforts from nonlinear physicists and chemists with the expertise in self-propelled objects and soft matter. The academic backgrounds of both the PIs satisfy the requirements well. Also, the experimental systems for the proposed study are already functional.

Spatiotemporal control over signalling between artificial micro-compartments with a reversible coacervate glue

Materials Science

Project No. 6508-1 | Mar. 2022 to Mar. 2025

Background

Synthesizing materials with life-like properties would offer unprecedented means to tackle key societal challenges. The design and construction of cell-inspired microcompartments capable of integrated functions represents a promising step in this direction. An alternative strategy to increase the functional capabilities of these smart micromachines is to distribute multiple functions into specialized compartments able to communicate with each other via chemical signaling. However, it remains highly challenging to control the positioning of artificial microcompartments so as to draw a quantitative picture of their interactions. The aim of this project is to achieve precise manipulation of enzymatically active microcompartments to quantitatively study chemical signaling. Their approach relies on the use of stimuli-responsive coacervates produced by liquid-liquid phase separation as a selective and reversible glue to control (i) positioning of compartments on a substrate via reversible adhesion and motion, and (ii) reversible compartment clustering via coacervate-based wetting. PIs will modulate the distance and positional configuration between compartments with high spatiotemporal resolution and quantitatively study chemical signaling with enzyme cascade reactions. This interdisciplinary project represents a unique opportunity to couple our complementary expertise on coacervate and compartment design, and will involve experimental approaches at the interface of material science, soft matter, colloids, and the emerging fields of synthetic biology and systems chemistry. The expected outcomes will mark a stepping-stone towards the development of populations of artificial compartments with controllable collective behaviours and symbiotic relationships. Ultimately, the fine characterization and regulation of chemical signaling between artificial compartments is expected to inspire the design of a new generation of functional colloidal materials with life-like properties.

Principal Collaborators

Veera V. V.S.P.K. Bosukonda
Indian Institute of Technology- Roorke Roorkee

Nicolas Martin
CNRS, Univ. Bordeaux
Centre de Recherche Paul Pascal Bordeaux

Objectives

- To design of photo-responsive coacervates to modulate adhesive interactions between microcompartments and substrates to allow selective manipulation and positioning, and hence study of positiondependent chemical signaling
- To allow microcompartments to control their adhesion to the substrate via local pH changes based on enzymatic reaction hosted by them, and develop symbiotic relationships.
- To design light-responsive coacervate droplets for the selective and reversible clustering of microcompartments in suspension via wetting, and achieve reaction channelling
- To demonstrate self-mediated compartment clustering and reaction channelling based on enzyme-driven assembly/disassembly of pH-responsive coacervates

Role of viral and host factors in circulative transmission of tomato begomoviruses by the whitefly *Bemisia tabaci*

Principal Collaborators

Vipin Hallan
CSIR-Institute of Himalayan Bioresource Technology Palampur

Mikhail M Pooggin
PHIM
(Plant Health Institute of Montpellier)
Montpellier

Objectives

- Elucidate a composition of virus transmission complex present in plant phloem and ingested by the whitefliy *Bemisia tabaci* fed on tomato plants infected with the monopartite and bipartite begomoviruses economically important for both France and India
- Validate the function of insect proteins implicated in virus circulation in and transmission by the whitefly *Bemisia tabaci*
- Investigate begomovirus replication in the whitefly *Bemisia tabaci* and its impact on virus persistence and transmission efficiency
- Explore the role of small RNAs (sRNAs) and RNA interference (RNAi) in plant-virus-whitefly interactions and virus transmission
- Employ a virus-induced gene silencing (VIGS) approach based on a disarmed begomoviral satellite to validate the roles of viral and host factors in virus circulation and persistence in whitefly and transmission to new plant, with an ultimate goal to develop new strategies for control of viral disease spread at the transmission step

Host-Microbe Interactions In Health, Water & Agriculture

Project No. 66T01-1 | **May. 2022 to May. 2025**

Background

Transmission of plant viruses by insect vectors is a complex phenomenon involving viral, plant and insect factors. Begomoviruses (mono or bipartite ssDNA viruses, genus Begomovirus, family Geminiviridae) are major pathogens of crop plants worldwide. They are exclusively transmitted by the whitefly *Bemisia tabaci* in a persistent-circulative manner, such that once ingested from the plant phloem through the whitefly stylet, virions pass to the midgut, cross to the hemolymph, and move into the primary salivary glands, where they are egested back to plant with salivary secretions. Little is know about components of virus transmission complex that besides virions (circular ssDNA encapsidated by viral coat protein) may contain other viral or host proteins and nucleic acids which may play a role in circulation and persistence in the insect vector. The most predominant and damaging B. tabaci biotypes causing begomoviral epidemics worldwide are Middle East Asia Minor 1 (MEAM1) and Mediterranean (MED). Contrary to previous reports, most recent evidence indicates that the monopartite tomato yellow leaf curl virus replicates in the salivary gland cells of MEAM1 flies and the replication enhances transmission efficiency and persistence of this virus. In plant cells, begomoviruses replicate via rolling circle and recombination-dependent mechanisms generating circular ssDNA genomes and linear concatemeric dsDNA, respectively, and thereby evade small (s) RNA-directed RNA interference (RNAi) and gene silencing-based antiviral defences. Begomovirus replication in whitefly raises questions on the mechanism(s) of replication and the induction of the insect defences based RNAi and innate immunity and on insect defense evasion and/or suppression by viral proteins.

Engineering rhizosphere microbiota for enhanced resistance to plant disease and human pathogens through compost amendment

Host-Microbe Interactions In Health, Water & Agriculture

Project No. 66T01-2 | **Mar. 2022 to Mar. 2025**

Background

Rhizosphere, a microbial hotspot, is also a favorite system for pathogenic microorganisms, including human pathogens, due to the abundance of nutrients and possibility of interactions with other. In fact dual pathogenicity (on plants and humans) of pathogens like Bacillus cepacia, Pseudomonas aeruginosa etc has also been reported. The term Human Pathogens on Plants (HPOPs) has been recently coined for such microbes Manure from animal waste has proven to be a source for various pathogens, and antibiotic resistant bacteria. Hence organic farming may increase the risk of contamination by human pathogens thereby imposing health risk. In view of this, the proposal aims to first map Indian arable land, compost samples and plants rhizospheres for occurrence of human pathogens, followed by developing strategies for curbing their microbial load. Also, risk assessment of such a mitigation strategy will be performed in terms of its effect on microbial community structure and function in the interplay Plante/Microbiome/Pathogen. This will be performed with tomato as model crop and *Listeria monocytogenes* and *Klebsiella pneumoniae* as model pathogens, using state-of-art molecular microbiology tools, besides the traditional tools of enumeration. Engineering soil microbial communities with adequate plant growth promoting bacterial consortium in tomatos rhizosphere could be an integrated strategy for enhancement of crop yield, and protection against contamination by pathogenic bacteria. To the best of their knowledge this will be a pioneering study establishing not just the significance of compost as a source of two important human pathogens *Listeria monocytogenes* and *Klebsiella pneumoniae*, but also to attempt latters control in a green sustainable manner using plant probiotics. Also, by gaining a thorough understanding of the mechanism by which the plant probiotics serve as barrier to human pathogens, the study will open up venues for employing similar strategies for other pathogens and crops.

Principal Collaborators

Shilpi Sharma
Indian Institute of Technology-Delhi
New Delhi

Pascal Piveteau
Institut national de recherche pour l'agriculture, l'alimentation et l'environnement, (Inrae) Transsform
Ur Opaale
Rennes

Objectives

- Mapping of composts and fields (rhizospheres of tomato plants) in Delhi and NCR for abundance of *L. monocytogenes* and *K.pneumoniae*
- Screening and characterization of PGPR from compost samples and rhizosphere of tomato, as inhibitors of *L. monocytogenes* and *K.pneumoniae*
- Understanding the mechanism of action of inhibition
- Application of the consortium to bring down the load of pathogens and study of the impact of inoculation of the consortium on pathogen load and total bacterial community in the interplay Plante/Microbiome/Pathogens

CEFIPRA

4. Brief Reports of Research Projects

B. Industry Academia Research & Development Programme

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

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.

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
  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

Indian Partners

Swati Bandyopadhyay
Jadavpur University
Kolkatta

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

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 hydromamic 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

Stéphane Pellet-Rostaing
ICSM UMR 5257 – CEA/CNRS/UM/ ENSCM
site de Marcoule
30207 Bagnols sur Cèze

Christian Louis Thomas
Terra Nova Development
Lille

Publications

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

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

Domain: Immunology | **May 2018 to Apr. 2022**

Background

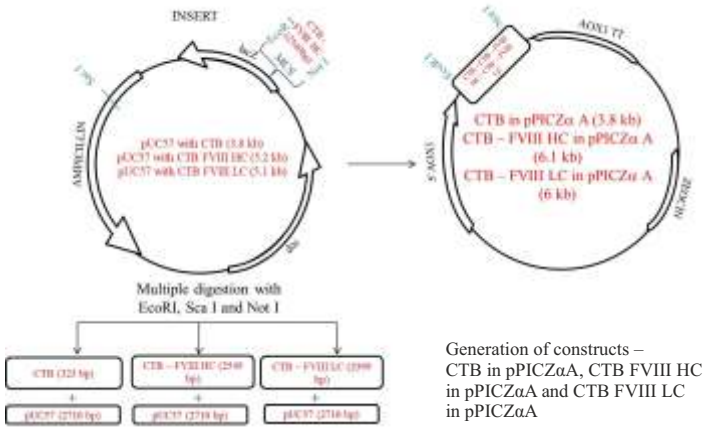
Development of anti-factor VIII (FVIII) antibodies (FVIII inhibitors) is a major concern during FVIII replacement therapy for patients with hemophilia A. Mucosal administration of recombinant FVIII fragments produced from plants blocks the production of FVIII inhibitors. However, this technology may 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.

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



Generation of constructs – CTB in pPICZαA, CTB FVIII HC in pPICZαA and CTB FVIII LC in pPICZαA

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
Equipe 16 INSERM UMRS 1138 Centre de Recherche des Cordeliers Paris

Daniela Balvay
R&D Director, SPAN Diagnostics S.A.R.L. Parc Technologique des Rives de l'Oise, 60280 Venette

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

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 (>> 1mAh/cm2)
- 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

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 Supã©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

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

Domain: Biotechnology | Sep 2020 to Aug 2023

Background

Biotechnological production of carotenoid from microalgae is slowly developping 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

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

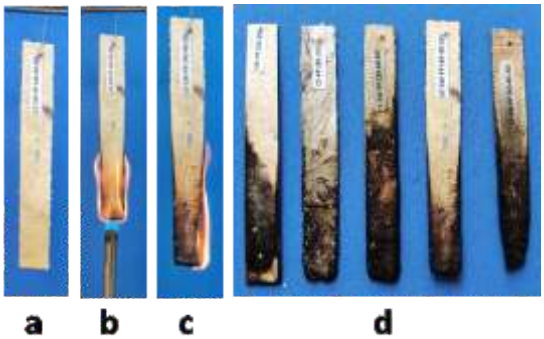
- The regulation of the carotenoid production by microalgae under stress: the optimization of the carotenoid production by the microalgae will be studied using biochemical, transcriptomic and proteomic and stress physiology analyses (O1.2.). Using the data, the regulatory circuits controlling the carotenoid 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.)

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

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.

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 Boy
64660 ASASP
NFP,Aquitaine,
Pau

Environmentally Benign Routes to Affordable Healthcare

Background

Healthcare expenditure worldwide amounts to ~7699 billion USD (2016 data) and amounts to ~10% GDP. The expenditure is higher in USA where it reaches ~17% of GDP. As science advancements have helped in finding cure for many diseases, for management of health patients have to take some medicines for longer periods or for life time. These medicines are required every day and contribute a substantial amount to healthcare. Any reduction in cost of these molecules will directly benefit the system and the saved money can be utilized in other important projects. This proposal plans to develop technologies that will help in reduction of number of steps, improve the yields and avoid the step of resolution for getting pure, single enantiomer. Today nearly 56% of the approved drugs are chiral and are marketed as single enantiomer or diastereomer. The pharmaceutical industry solves the problems of manufacturing single isomer mostly by following the route of chiral resolution at some stage of synthesis. This creates the problem of generating a substantial amount of unwanted isomer which adds to the waste and impacts the environment. The collaborators from India and France have a substantial amount of expertise in developing new synthetic routes for chiral complex molecules which will avoid the step of resolution. The molecules chosen are Nebivolol (β-blocker), Aliskiren (renin inhibitor), Sitagliptin (treatment of diabetes type 2) and Esketamine (for treatment resistant depression).

Indian Partners

Prathama S Mainkar
Indian Institute of Chemical Technology, Andhra Pradesh
Hyderabad

Sarma Vbns Bugga Sai
Life Sciences Limited
Hyderabad

French Partners

Janine Cossy
ÂCole Supã©Rieure De Physique Et De Chimie Industrielle (Espci),Ile-De-France
Paris

Domain: Healthcare | **Sep. 2021 to Aug. 2024**

Objectives

- To synthesize and demonstrate the processes for drug molecules employing environmentally benign routes which will help in bringing down the costs of the medicines thereby making the healthcare affordable
- Scale-up Studies for all four drug molecules
- To carry out feasibility studies to convert batch-processes into continuous flow processes towards zero effluent generation
- To avoid use of metal catalysts wherever possible to save the precious metals. (To replace precious metals like palladium with abundantly available non-toxic metals)
- To generate mild reaction conditions

Knowledge Generated/Products Developed

- New processes for the selected drug molecules will be demonstrated to the industry for manufacturing
- Industry partners, both Indian and French will utilize the knowledge generated for manufacturing
- Flow processes and new methods will reduce the environmental impact and result in effluent reduction
- Metal use will be minimized in case, cheap earth abundant metals will be used and milder reaction conditions will be employed for the processes
- Cost-reduction in the process will result in decrease in the burden of the healthcare system
- Tech pack will be delivered to industry partners

SupLys : Urinary metabolomics for monitoring Lysine sufficiency in malnourished infants receiving lysine-fortified foods

Domain: Nutrition | **Oct. 2021 to Sept. 2024**

Objectives

- Preclinical development of non-invasive biomarkers for lysine deficiency - To investigate the effect of Lysine supplementation on metabolomic biomarkers identified in Lysine deficient rats
- Clinical validation of biomarkers in human children - To validate the lysine deficiency biomarkers identified in preclinical studies in 6-11y old stunted malnourished children
- Development of high-quality lysine-fortified Food product - Innovative development of food product based on plant materials available in India and adapted to the constraints tied to the Lysine malnutrition
- Efficacy of lysine-fortified food Products – Investigate, optimize and validate the effect of the developed product on preclinical and clinical studies in 6-11y old for lysine supplementation in malnourished and stunted children using growth, functional muscle evaluation, and previously developed metabolomic biomarkers

Knowledge Generated/Products Developed

The pre-clinical study, has been done. Following analysis

- The rat's body weight gain and length were reduced by a lysine deficiency. The lean body mass follows the same way and was reduced by the lysine deficiency
- To compensate the adverse effect of the deficiency, lysine deficient rats increased their food intake relatively to their body weight, which lead to a higher energy intake
- To compensate their higher energy intake, lysine deficient rats increased their total metabolic rate, by increasing their resting metabolic rate without modifying their activity metabolic rate or cost of activity
- The increase in energy expenditure was not effective enough to compensate the higher energy intake, as the lysine deficient rats had a higher adiposity (without difference of fat mass, but a lower body weight)

Background

In India, a large portion of population is vegetarian and mainly consumes cereal proteins (63% of all proteins) - rice, wheat, millet. But cereal proteins, meet some problems both in term of quantity, with a low protein content, and of quality, with low lysine content and low digestibility. The cereal-based Indian diet raises the question of lysine sufficiency for children, and there is a need to develop lysine-fortified food solutions, using locally available Indian plant sources and easily adapted to local eating and traditional culinary habits. The industry partners are involved in the development of sustainable and nutritionallyadapted high-quality foods. They will develop well-balanced lysine-fortified foods easily accessible for lysine-deficient Indian children populations. In order to monitor lysine status during refeeding, non-invasive methods that can be applied in protein-deficient or growth faltering populations are needed. Such non-invasive "omics" methods are developed by the two academia partners and will be used to evaluate the developed lysine-fortified foods.

Indian Partners

Anura Kurpad
St. John's Research Institute
Bangalore

Sarita Devi
St. John's Research Institute
Bangalore

French Partners

Daniel Tomé
AgroParisTech, INRA
Université Paris-Saclay
Paris

Dalila Azzout- Marniche
AgroParisTech, INRA
Université Paris-Saclay

3-D binocular motor control in Strabismus before and after surgery

Background

Strabismus affects 3-4% of children. The major consequence of misalignment of the eyes is definite loss of bi-foveal fused vision. Beyond this, such misalignment may affect body scheme representation, vestibular function and postural control. Eye movements themselves show poor binocular coordination of the saccades and poor vergence with multiple saccade intrusions. Deficits reduce following strabismus surgery, presumably due to natural neuroplasticity. We aim to do a large scale study of binocular eye movements (saccades, vergences and combined eye movements) and postural control in children with strabismus, before and after strabismus surgery. We also aim to implement a neuro-rehabilitation paradigm using REMOBI technology (developed in the CNRS lab IRIS, University Paris Descartes) and evaluate further improvements on sensory bi-ocular vision, body posture and vestibular function.

Domain: Ophthalmologist **Sept. 2021 to Aug. 2024**

Objectives

- To investigate the effect of strabismus surgery on:
  - Binocular coordination of saccades, fixation stability and postural control
  - Quality of vergence eye movements
  - Quality of saccade-vergence eye movements
  - Quality of postural control while fixating or making active vergence movements
- To investigate effect of neuro-rehabilitation after strabismus surgery on eye movements and postural control

Knowledge Generated/Products Developed

- Provide scientific evidence that eye movement neuro-rehabilitation can enhance benefits from strabismus surgery
- Enhance integrative health approach: surgery-eye movement neuroplasticity and posture evaluation in strabismus.
- Train clinicians, researchers, engineers, and post-docs to innovative technologies: organize pluri-disciplinary workshops
- Build a unique databank on eye movement and posture measures in treated and untreated strabismus
- Obtain an applicative patent of the REMOBI&AIDEAL technology for strabismus

Indian Partners

Rohit Saxena
AIIMS
New Delhi

French Partners

Zoi Kapoula
CNRS, Iris Lab
Paris

Jacques Lemains
Orasis
Paris

CEFIPRA

4. Brief Reports of Research Projects

C. Targeted Programmes

Modelling of human intention during gait rehabilitation

Completed Project

Nov. 2017 to Apr. 2021

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.

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

Principal Collaborators

Neelesh Kumar
Principal Scientist,
Biomedical Instrumentation Unit,
CSIR-CSIO
Chandigarh

Ahmed Chemori
CNRS Research Scientist,
LIRMM CNRS /
University of Montpellier 2
Montpellier

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

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
Indian Institute of Technology Kanpur

Goran Frehse
Laboratoire Verimag
Université Grenoble Alpes
Grenoble

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

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.

Efficient quantitative verification

Ongoing Project

Sep. 2018 to Dec. 2022

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 undegraduate 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 is 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.

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

Principal Collaborators

S. Akshay
Indian Institute of Technology Bombay
Mumbai

Loïc Hélouët
SUMO Team, INRIA CR1
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)

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

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

Vikas Vikram Singh
Indian Institute of Technology Delhi

Abdel Lisser
Laboratoire de Recherche en Informatique (LRI) Université Paris Sud Paris

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

FOGCITY: QoS-aware resource management for smart cities

Ongoing Project

Aug. 2018 to Jul. 2021

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)

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

Principal Collaborators

Sudip Misra
Indian Institute of Technology Kharagpur

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

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

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

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 lauch 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.

Principal Collaborators

J. Indu
Department of Civil Engineering
Indian Institute of Technology
Bombay

Stephane CALMANT
Directeur de Recherche, Geophysicien
Institut de Recherche pour le Developpement
UMR 5566 LEGOS
OMP/LEGOS, Toulouse

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

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

Ongoing Project

Jan. 2020 to Jan. 2023

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 beneficiates, however, from encouraging preliminary results obtained by the French and Indian partners.

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 IIST team has developed suitable method for lysing the exosome and releasing the protein
- The IIST 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

Principal Collaborators

Palash Kumar Basu
Associate Professor
Dept. of Avionics
Indian Institute of Space Science & Technolog
Thiruvananthapuram

Anne-Marie Gué
Directrice de Recherche CNRS
LAAS-CNRS
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

France-India Group for High Technology Equipments at Colliders

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 HLLHC. 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 HLLHC. 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

Somnath Choudhury
Indian Institute of Science
Bangalore

Yves SIROIS
Directeur de Recherche de Classe Exceptionnelle (DRCE),
LLR École polytechnique
Palaiseau

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 HLLHC. 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(1016 GeV) or of quantum gravity at the Planck scale O(1019 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.

Deep Summarization Evaluation

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.

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

Partha Pakray
Assistant Professor (Gr-II)
Department of Computer Science & Engineering
National Institute of Technology Silchar
(NIT Silchar)
Silchar

Benoit Favre
Associate Professor (Maître de Conférences)
Département informatique et interactions,
Aix-Marseille University, Laboratoire
d'Informatique et Systèmes UMR 7020 / CNRS
Marseille

Publications

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

Design Automation for Intelligent Vision Hardware in Cyber

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

Sharad Sinha
Assistant Professor
Indian Institute of Technology (IIT)
Goa

Olivier Sentieys
INRIA and University Rennes 1
(INRIA Project Team: CAIRN)
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

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

Data Collection for Smart Crop Management

Ongoing Project

Mar. 2021 to Feb. 2024

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.

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

Principal Collaborators

Chandan Kumar Panda
Department of Extension Education,
Bihar Agricultural University,
Sabour
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

Ongoing 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

Raju Surampudi BAPI
International Institute of Information Technology (IIIT-H), Hyderabad
India

Nicolas P. ROUGIER
Mnemosyne INRIA
Bordeaux Sud-Ouest,
France

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

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-flip 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.

CEFIPRA

CEFIPRA

5. Analysis of Scientific Activitites

CEFIPRA is committed to aligning its scientific programmes with trends in the research world and the priorities of stakeholders.

The Core Programme of the Centre like Collaborative Scientific Research Programme (CSRP), Industry-Academia Research & Development Programme (IARDP) and Seminar/Workshop are funded by the two nodal agencies from Indian side it is the Ministry of Science and Technology and on the French side it is the Ministry for Europe and Foreign Affairs for quality collaborative research in advanced areas of S&T.

The Non-Core Programmes are funded by National Funding agencies of India and France with the aim to foster the Indo-French collaboration in scientific research for targeted areas. In these activities CEFIPRA's role is as a catalyst, facilitator and enabler to reach out to scientific communities with emphasis on developing systematic linkages to support and implement these programmes.

These Indo-French collaborative projects facilitated the scientific institutions & scientists via providing opportunities for transfer of technologies/products/processes/publications/patents/ joint PhDs /joint labs. CEFIPRA over a period of three decades has been playing an active role between the two scientific communities in promoting the emergence of collaboration and mobility in both directions.

Supported activities of the Centre during the reported period enabled more than three hundred participants from Indian and French institutes for knowledge-sharing on science and technology in the areas of current relevance. Moreover, these interactions among scientists and technologists of the two nations develop close links, strengthen and enhanced student and faculty exchanges and promoting collaborative research. Thus Centre has made significant contributions in terms providing plenty of opportunity in creating futuristic networks, greater interaction and linkages opportunities for academia & industries of both nations and enhancing research skills as well as capacity building of young researcher through its dedicated student mobility programmes. The Centre thus has achieved its mandate through its core activities reciprocating in knowledge generation in S&TI including scientists achieved fruitful results for societal benefits.

Core Programmes

Every year CEFIPRA supported projects have been making a great impact through their compelling outcomes. During the reported period, these programmes enhanced the institutional linkages to more than thirty five. The key to the success of these core programmes is the importance of a bottoming up approach and productive collaboration of scientists, inclusion of industries and R&D labs in their programs which has further added value to their competitiveness and creating awareness for both countries.

Collaborative Scientific Research Programme

In the year 2021-22, thirty seven new projects were recommended under the Collaborative Scientific Research Programme (CSRP) of CEFIPRA while forty nine projects were ongoing from the previous years, out of which ten were completed during the reported period. During two calls in the year 2021-22, CEFIPRA had received 186 new proposals. The Centre reviewed 98 and 88 new proposals in its 66th and 67th Scientific Council (SC) meetings respectively. Out of these proposals, thirty seven were recommended for support. A total of 14 ongoing projects were reviewed during mid-term of the project cycle in the areas of Computational Science (2), Life & Health Sciences (2), Pure & Applied Chemistry (3), Pure & Applied Physics (3), Pure & Applied Mathematics (2), Earth & Planetary Sciences (1), Environmental Sciences (1) Figure 1, depicts the status of total number of CEFIPRA projects implemented w.e.f. from 1 April, 2021 to 31 March, 2022.

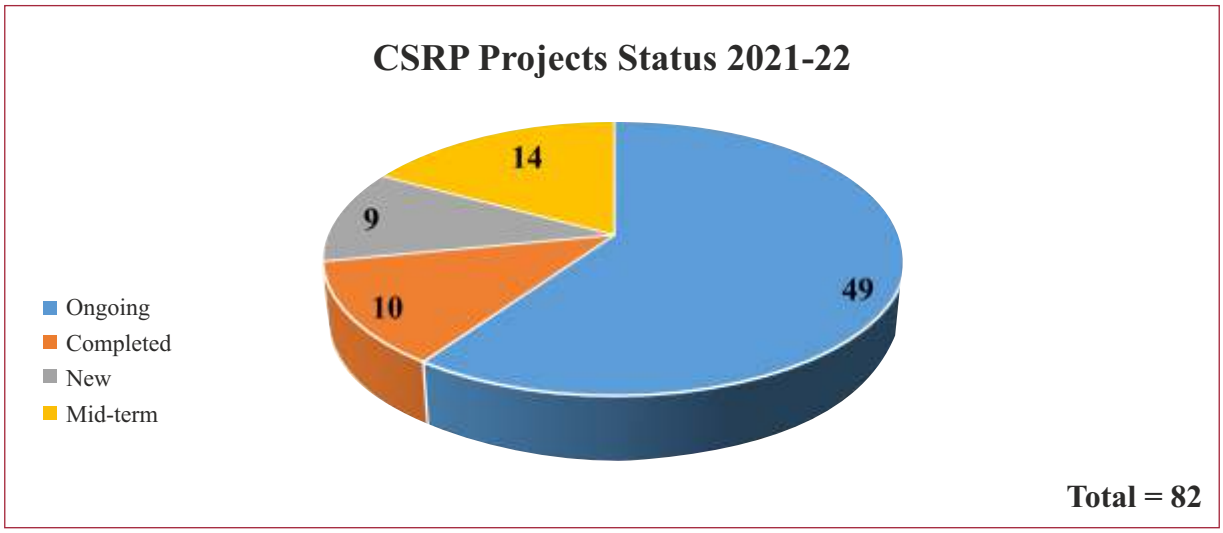


Figure 1: Status of CEFIPRA Projects implemented w.e.f. 1 April, 2021 - 31 March, 2022 under Collaborative Scientific Research Programme

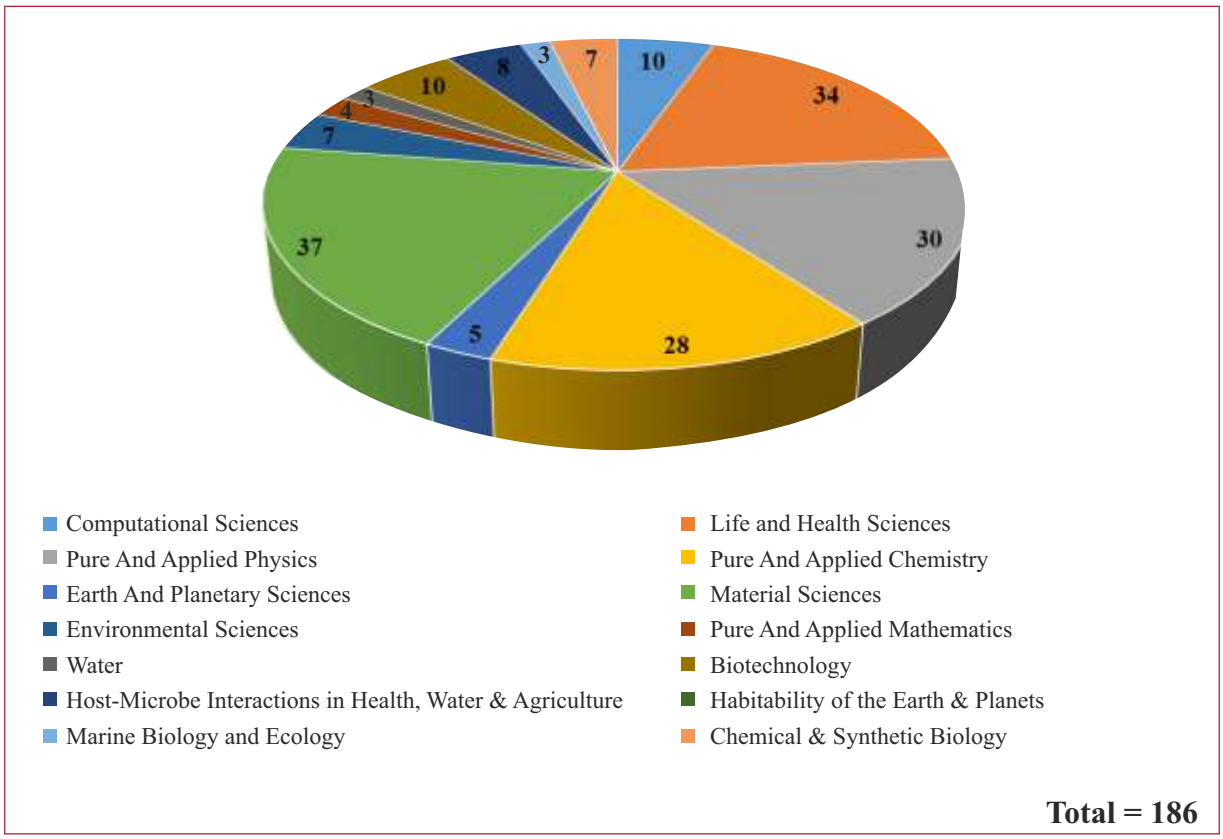


Figure 2: Area-wise Distribution of New Proposals considered during the year 2021-22

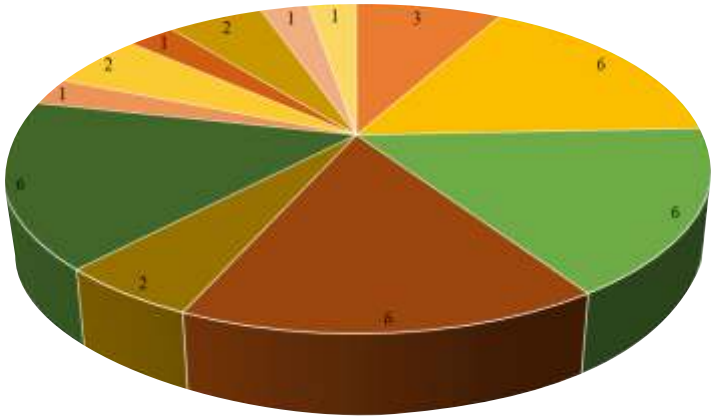


Figure 3: Area-wise Distribution of Projects Recommended in 66th and 67th Scientific Council (SC) Meetings

New Projects Commenced:

The Council evaluated the scientific merit of the 186 new proposals on the basis of comments from the referees and discussions amongst the members. As a result, the Scientific Council in its 66th and 67th meetings recommended 37 proposals for support. The thrust area-wise distribution of the proposals received and recommended for support during the year 2021-22 is shown in figures 2 and 3. From the figures 2, 3 and 4, it is evidence that the area of Life & Health Sciences, Pure & Applied Chemistry and Pure & Applied Physics and Materials Science continues to have a higher share of the proposals recommended whereas Materials Science area have a higher share of the proposals received.

Ongoing Projects:

As on 31 March, 2022, forty nine projects (excluding nine new projects started) were under implementation at various Indian and French research Institutes. During the two Scientific Council meetings, the members carefully monitored the midterm progress of 14 ongoing projects and suggested corrective measures for smooth operation of projects. In figure 5, an area-wise distribution of these ongoing projects is depicted.

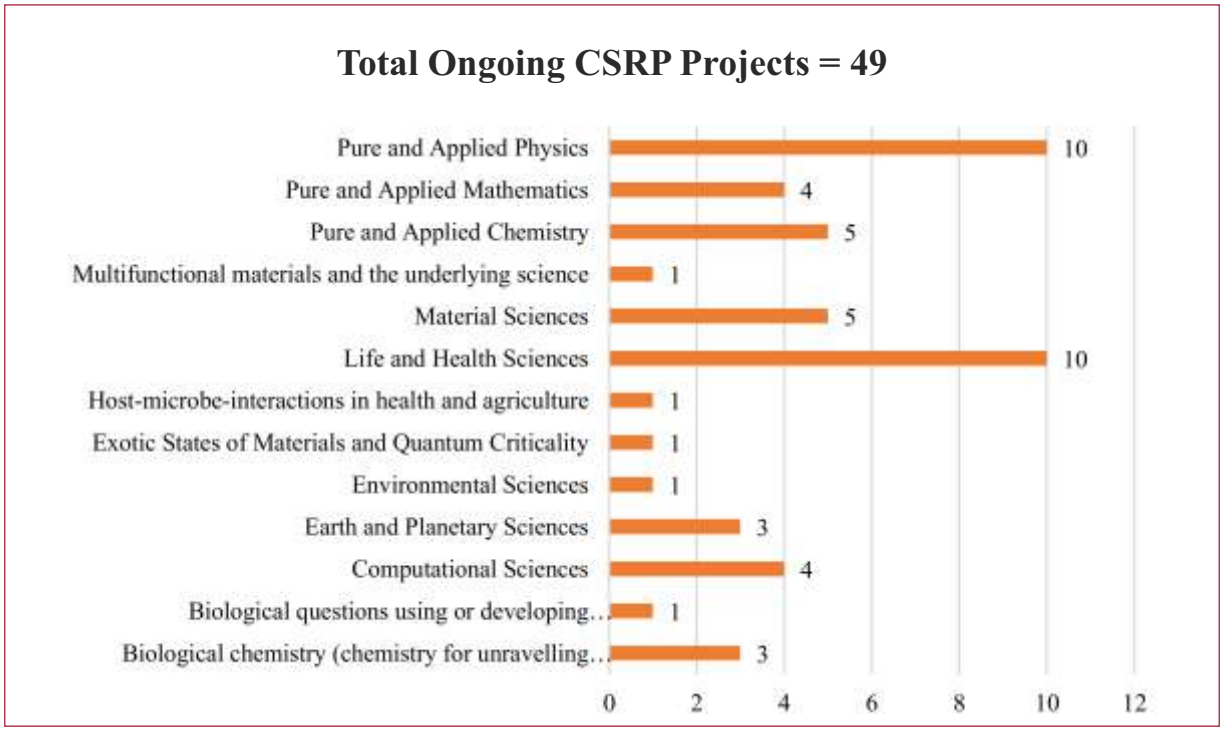


Figure 4: Area-wise Distribution of Ongoing Projects

Completed Projects:

During the reported year, ten projects were completed. The ten projects were from the areas of Life & Health Sciences (4), Materials Science (2) and one each from Pure & Applied Physics, Pure & Applied Chemistry, Computational Sciences and Multidisciplinary domain.

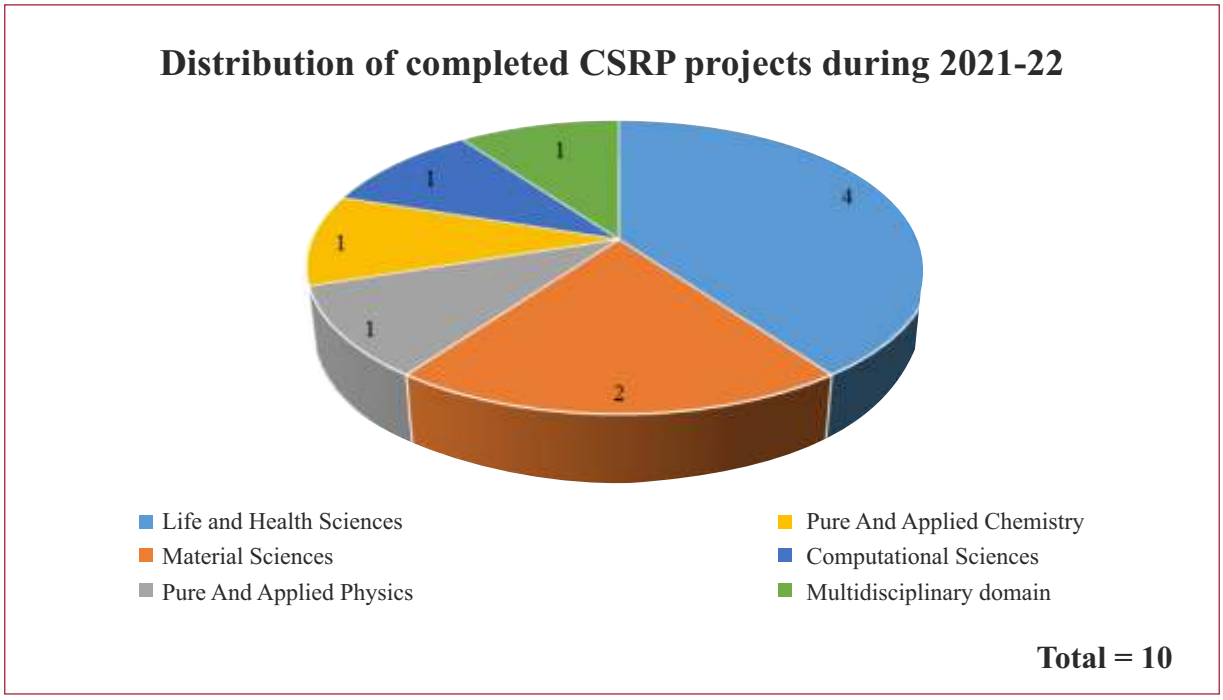


Figure 5: Area-wise Distribution of Completed Projects

Under these 10 completed projects, a total of 46 doctoral and post-doctoral students (28 in India & 18 in France) were supported in various labs in India and France. 78 mobility/exchange visits (42 from India to France and 36 from France to India) were facilitated (Figure 6 & 7) under these completed projects.

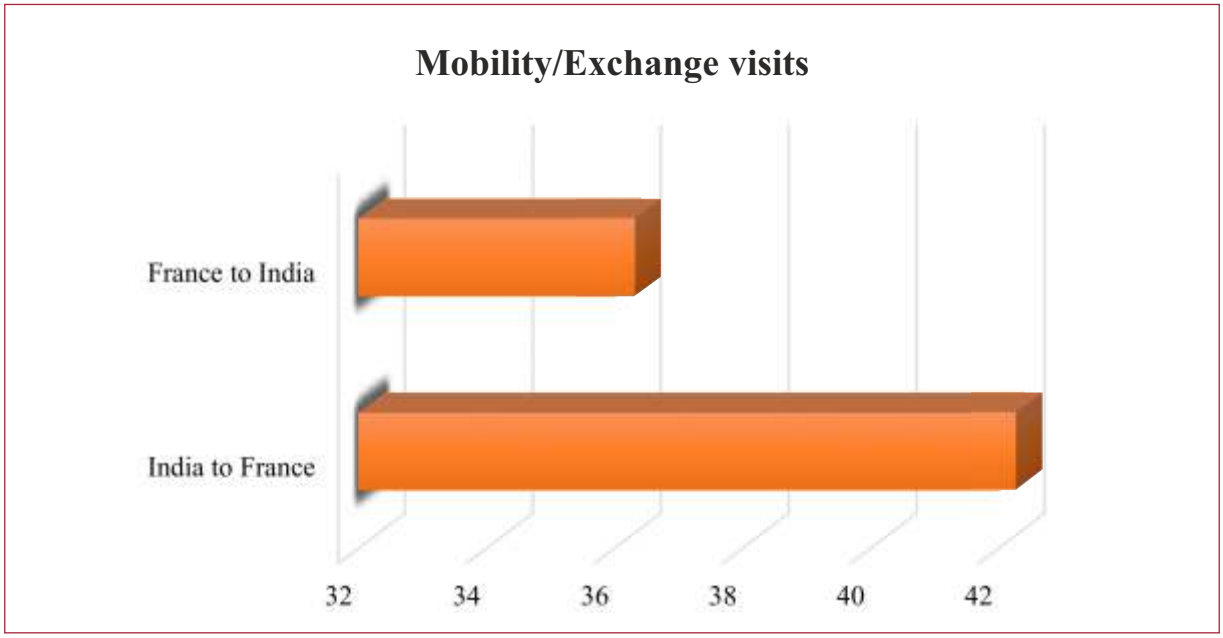


Figure 6: Outcomes in terms of Exchange Visits under completed projects

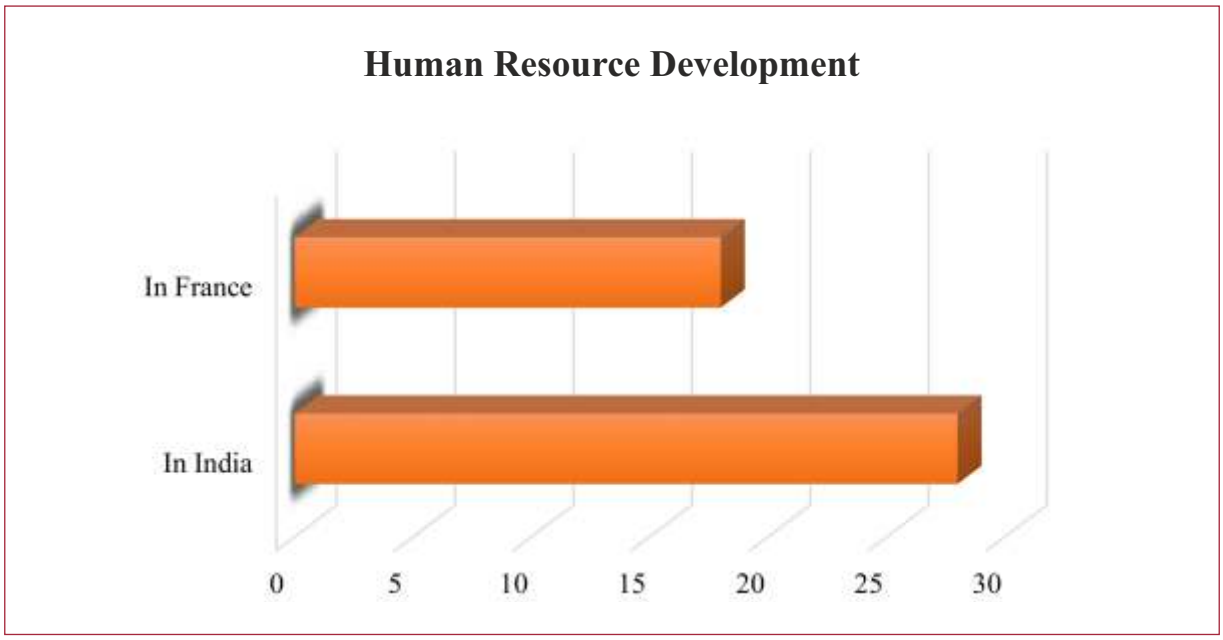


Figure 7: Outcomes in terms of HR supported under completed projects

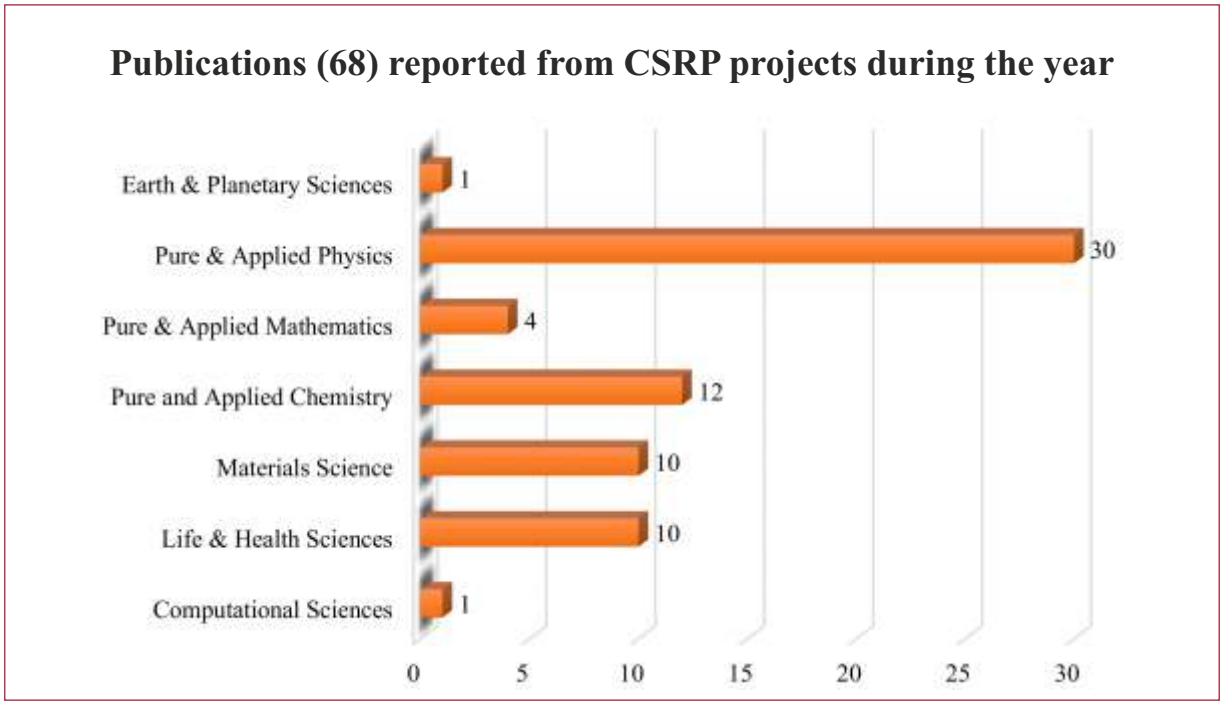


Figure 8: Thrust Area-wise Number of Publications Emanated from CSRP Projects

The CSRP projects have resulted in 68 publications during the year 2021-22. The list is indicative not exhaustive. The areas of Pure & Applied Physics, Life & Health Sciences, Pure & Applied Chemistry and Materials Sciences(Figure 8) are having the highest share of publications. These research publications have been published in reputed peer-reviewed journals such as *Biomedicines, Nature Cell Biology, Frontiers in cell and Development Biology BMC Biology, Life Science Alliance, Nature Communication, Current Biology, Frontiers in Immunology, Molecular Plant-Microbe Interaction, Applied Energy Material, Solar Energy Materials and Solar Cell, Solar Energy, Solid State Electrochemistry, J Mater Sci: Mater Electron, Chemistry—A European Journal, Applied Materials Today, Dalton Transactions, Nanomaterials, Coordination Chemistry Reviews, Organometallics, Chem.Comm., Inorganic Chemistry, Journal of Organometallic Chemistry, The Journal of Physical Chemistry A, Proceedings of the Royal Society, Journal of Noncommutative Geometry, Proc. London Math. Soc., Integral Equations and Operator Theory, Royal Astronomical Society, Physical Review Applied, The European Physical Journal A, Journal of Physics G: Nuclear and Particle Physics, Physical Review C, Astronomy Astrophysics, The Astrophysical Journal, Astronomy Astrophysics, Royal Astronomical Society, Life, Fluids, Physical Review Fluids, Journal of Fluid Mechanics, Journal of High Energy Physics, Physical Review D, Journal of High Energy Physics, Physical Review A and The European Physical Journal Special Topics*.

The projects based on sum of impact factor study are given as follows:

The number of papers emanating from a project depends on several factors such as the nature of the project, the subject area, number of scientists and researchers working in the project, number of collaborators in the project and so on. It is seen that on an average, 2.26 research papers resulted from each of the CEFIPRA projects. The project, "Modelling and observing pulsars: from high energy to radio emission" (Project code 5904-1) produced the maximum number of publications (10).

The most number of 5 CEFIPRA papers were published in the *Royal Astronomical Society* (Impact Factor: 5.287). These 5 papers were published from 2 projects. The Impact Factors of journals represent the quality of the journals. The Average Impact Factor of the journals in which CEFIPRA Papers have been published in 2021 is 6.35.

Project No.	Title of the Project	No. of Publications	Sum Impact Factor	Average Impact Factor
5703-1	Control of microtubule dynamic instability by the tubulin code	1	28.824	28.82
6003-1	Membrane Biogenesis in Apicomplexa parasites: Trafficking and recycling lipid sources for membrane remodelling as drug targets against malaria and toxoplasmosis	3	26.94	8.98
6103-1	How mechanical conflicts contribute to organ shape reproducibility in plants	1	10.83	10.83
6103-2	The genomic and evolutionary landscape of azole resistance in budding yeast	1	14.92	14.92
6203-1	Exploring the role of DNAse1L3 in obesity-associated metaflammation and type 2 diabetes	1	7.561	7.56
5908-1	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	2	13	6.5
5908-2	2D Materials for novel nano electronic device applications	3	10.361	3.45
6008-1	Nanowire white LEDs based on innovative nano-phosphors	4	24.58	6.14
5805-1	Novel Chiral First row Transition Complexes for Asymmetric Catalysis via Activation of inert C-H and C-Heteroatom bonds	2	22.96	11.48
5905-1	Boron-controlled CO2 reduction	7	49.5	1.07
6101-1	Maximal abelian subalgebras in operator algebras	4	7.78	1.945
5804-3	Phase transitions in sub-saturation nuclear matter and applications to core-collapse supernova and nuclear experiments	4	14.42	3.605
5904-1	Modelling and observing pulsars: from high energy to radio emission.	10	56.03	5.603
5904-3	Pre-evolutionary processes in autocatalytic RNA networks	3	25.84	8.61
6104-1	Turbulent flows in equilibrium	3	8.87	2.95
6304-2	Beyond Standard Model Physics with Neutrino and Dark Matter at Energy, Intensity and Cosmic Frontiers	3	24.67	8.22
6304-3	Novel Non-Perturbative Approaches to Strongly Coupled QCD Matter	2	15.24	7.62
6304-4	Pairing in neutron-star matter with renormalization-group based low-momentum interactions	2	5.42	2.71

Table 1: Some of the Completed Projects Based on Sum of Impact Factors

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

Project No 62T10-1

A library of 19 molecules was synthesised. Their in-vitro antibacterial activity and toxicity was evaluated, and a lead molecule was identified. A lead molecule has been identified through extensive structure activity analysis, and detailed preclinical biological investigations, covering the various aims of the project, along with additional aims, have been performed for the lead molecule. Similarly, other lead molecules developed through similar studies have been studied for their membrane-active mechanism of action, through NMR, and dye leakage study.

Project No. 62T10-2
Synthesis of six labeled model peptides: Four fluorescent uroguanylin peptides delivered to India for analysis. Peptides stable during shipment as tested by HPLC.

Established organoid cultures from the mouse small intestine which respond by swelling on administration of ST peptide.

Project No. 62T5-1
PIs have developed a software and deposited in the OpenSource community for single-particle tracking and analysis of viscosity from differential interference contrast (DIC) microcopy (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).

The experimental team has overcome an important technical obstacle by improving a protocol to generate CRISPR-Cas9 based transgenics in non- model species (manuscript in preparation). PIs are now in a situation to generate transgenic lines in several species in order to follow cytoskeleton dynamics with GFP reporters.

Project No. 62T9-1
A method for probing Rydberg quantum simulators via 2D spectroscopy in the microwave domain.

Project No. 62T4-1
PIs have identified a role for ARL8B in lysosome mediated triglyceride turnover in human macrophages. PIs have been able to ascribe this to the ability of ARL8B to localize to both the lipid droplet and lysosome, and identified structural requirements in ARL8B for lipid droplet localization. Importantly, the steady state abundance and size of macrophage lipid droplets is regulated by this process. Therefore, this may be critical in mobilization vis-à-vis storage of fatty acids upon challenges such as infection with intracellular pathogens such as *M. tuberculosis* and in atherosclerosis progression. The findings made so far in this project are a necessary first step in this direction.

Life and Health Sciences

Project No. 6003-2
High-throughput smFISH and in vitro assay for P-body targeting techniques have been developed.

A conserved choreography of mRNAs at centrosomes reveals a localization mechanism involving active polysome transport. 2020, Nat. Comm, accepted. Safieddine, A., Coleno, E., Traboulsi, A., Kwon OS., Lionneton, F., Georget, V., Robert, MC., Gostan, T., Lecellier, C., Salloum, S., Chouaib, R., Pichon, X., Le Hir, H. , Zibara, K., Peter, M, Bertrand, E. Preprint available at BioRxiv 2020.09.04.282038; doi: https://doi.org/10.1101/2020.09.04.282038.

Project No 6303-3
The process of understanding the molecular pathogenesis of diabetes during different etiology i.e., high fat diet and endocrine-disrupting chemicals. PIs have focused on both host and gut microbiota physiology in relation with endogenous glucose production, and more specifically intestinal gluconeogenesis. PIs recently finalized a study addressing the relationship between intestinal gluconeogenesis and the gut microbiota composition and function, not completely related with the present proposal, but useful in its further development (Vily-Petit et al, Sci Rep 2022). This Impactful research may pave the way for development of products focused on gut microbiota or host glucose pathways, like probiotics, targeted therapy, etc., for better glycaemic control in diabetes population

Project No. 6203-1
Self-Nucleic Acid Sensing: A Novel Crucial Pathway Involved in Obesity-Mediated Metaflammation and Metabolic Syndrome, A. Ferriere, P. Santa, A. Garreau, P. Bandopadhyay, P. Blanco, D. Ganguly, V. Sisirak, Front. Immunol. 11 (2021) 1–8. https://doi.org/10.3389/fimmu.2020.624256.

Material Sciences

Project No 6008-1
Optimized synthesis process for synthesizing nanosized germanite phosphors.

Pure and Applied Chemistry

Project No 6305-1
1. Developed a new method for the synthesis of glycosyl carbonates.
2. Synthesized several benzyl carbonates in order to understand the elusive intermediate in the silver assisted gold-catalysed activation of alkynes.

Pure and Applied Physics

Project No.6304-4
Computer codes for HFB + BMBPT calculations in cold atoms and pure neutron matter.

Project No. 6304-3
New methods in effective theories via semi-holography, technique to compute out-of-equilibrium correlation functions in many-body systems via holography, technique for computing hybrid quasinormal modes of a black hole interacting with a perturbative system at the asymptotic boundary relevant for study of non-Markovian open quantum systems.

Industry-Academia Research & Development Programme (IARDP)

Four projects were ongoing during the reported period in the areas of Biowool, Pigments, e-Textile and Hemophilia. During the year, one IRC meeting was organized wherein four ongoing projects and five completed projects were reviewed.

Out of seventeen new research proposals and one seminar proposals considered, Committee recommended support for seven new project proposals in the advanced areas like Phytochemical production, Blockchain Geotechnical Engineering, Synthetic Aperture Sonar images, Acoustics Metamaterials, Materials Engineering, Neuroinflammation. The Committee also recommended a joint workshop proposal in the area of Advanced Aerospace Materials.

The five completed projects (WEEE, REDEFINE, PACKMARK, PASAT and Loop Heat Pipe) were evaluated during the reporting period. The performance index of PASAT and Loop Heat Pipe projects was graded on the achievements made vis-à-vis aims and objectives, and the technical comprehensive research outcomes of these projects.

Following are the salient achievements under WEEE: 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 Electronic Equipments) WEEE.

- The process developed under has the potential for commercialization
- Energy efficient processing of magnet waste
- Selective extraction of rare earths
- The first time that EDTA type ligands are used as hydrophobic extractants High extraction capacity from HCl, HNO3, Aqua regia High selectivity REE/(Fe, B, Co, Ni…) Low selectivity Nd/Pr/Dy
- Process development for recovery of rare earths from spent NdFeB magnet-
- Two process approaches were investigated :
- RE recovery from spent NdFeB magnet by oxidation roasting & acid leaching
- RE recovery from spent NdFeB magnet by chlorination roasting & water leaching
- Industries shown interest in process (Tata Motors, Regen Power Tech. Pvt. Ltd.)
- 6 SCI Publication
- 4 Patents filed
- 2 Publication & 11 Conference paper/ presentations
- 1 Visit from India to France (Sep, 2019)

Following are the salient achievements under PACKMARK-Development of New Anti Counterfeit Printing Techniques for Medicine Packaging:

The interactions between the Indian Industrial Partners and the two Academic Partners were very good and fruitful, and beneficial not only for the PackMark project but also for Sergusa Solution Pvt. Ltd.

An experimental research such as the one done in this project requests a huge number of samples printed with various printers. Unfortunately, we had only access to few printers to perform our tests and comparisons, nevertheless it was sufficient to do the proof of concept of methods/solutions proposed (TRL4).

Before exploiting these solutions (TRL4 => TRL8), some other tests and experiments should be done at larger scale in relevant environments, that is to say in a printing company such as Sergusa Solution Pvt. Ltd. This could be done without the help of the Principal Investigators, as they already transfer the knowledge necessary for the implementation of these solutions to this company.

Product/ technology developed:
Several anti-counterfeit printing solutions have been developed and could be commercialized. But some other developments must be done in relevant conditions before reaching this objective;

Patent :
- One Patent published co-authored by the IPC and FPC (other patents could have been submitted);
- 11 publications published (+3 presentations in national/international conferences) (Each JSR published a paper co-authored by the IPC and FPC).

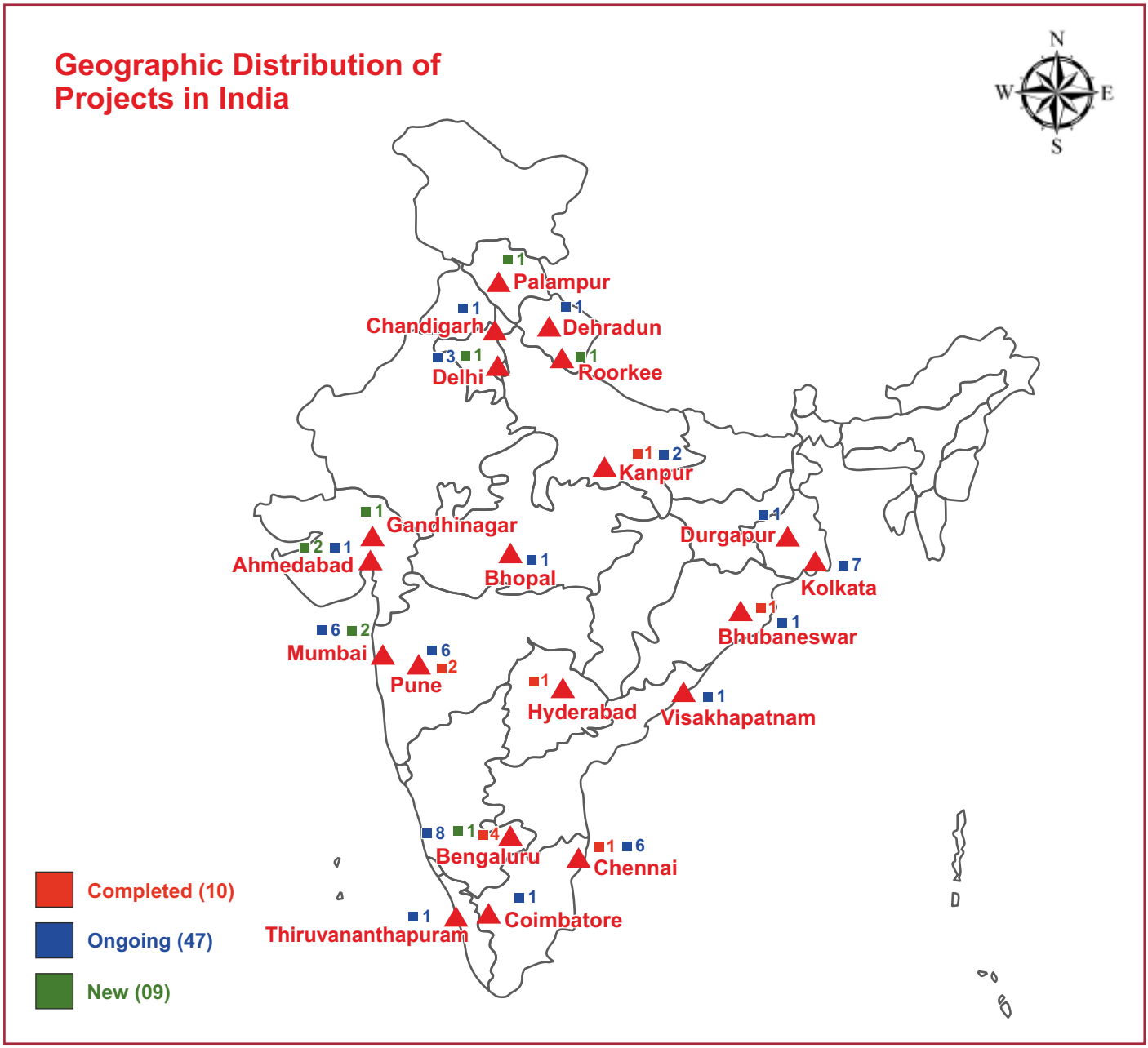
Non-core Programmes

Under the Non-Core Programmes, CEFIPRA acted as a facilitator for various programmes with Indian national funding agencies like Department of Science and Technology (DST) and with French funding agencies French Institute for Research in Computer Science and Automation (Inria) for collaborative research.

During the reported period, under DST-Inria targeted programme, one projects were completed and 5 ongoing projects areas of Applied Mathematics and Big Data, resulting in 19 publications. In addition, 11 visits from India to France and 13 from France to India were also undertaken. However, 6 projects under DST-CNRS are ongoing. Under these ongoing projects, 19 research papers have been published and 13 visits from India to France and 12 from France to India have been performed.

Geographic Distribution of Projects in India

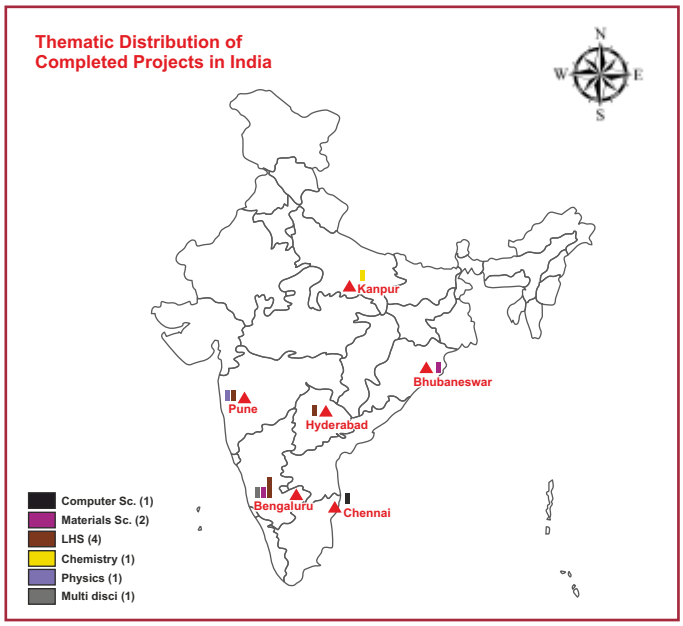
Map 1



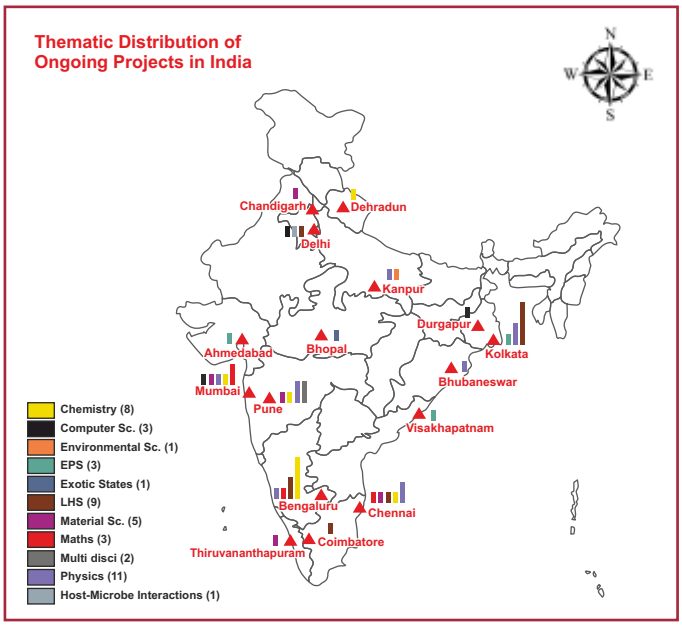
Thematic Distribution of Projects in India

The following three Indian maps are showing the spatial heterogeneity with respect to completed (10) ongoing (47) and new initiated (09) Collaborative Scientific Research Projects of CEFIPRA in different subject domains.

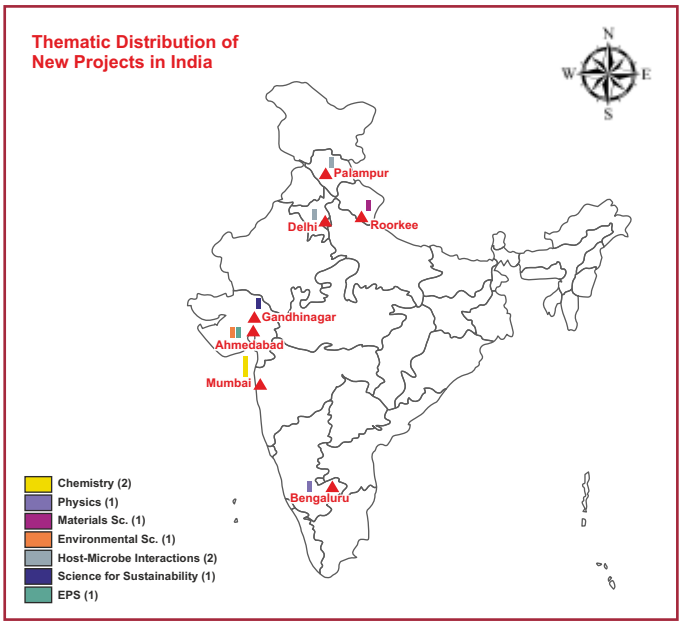
Map 2



Map 3

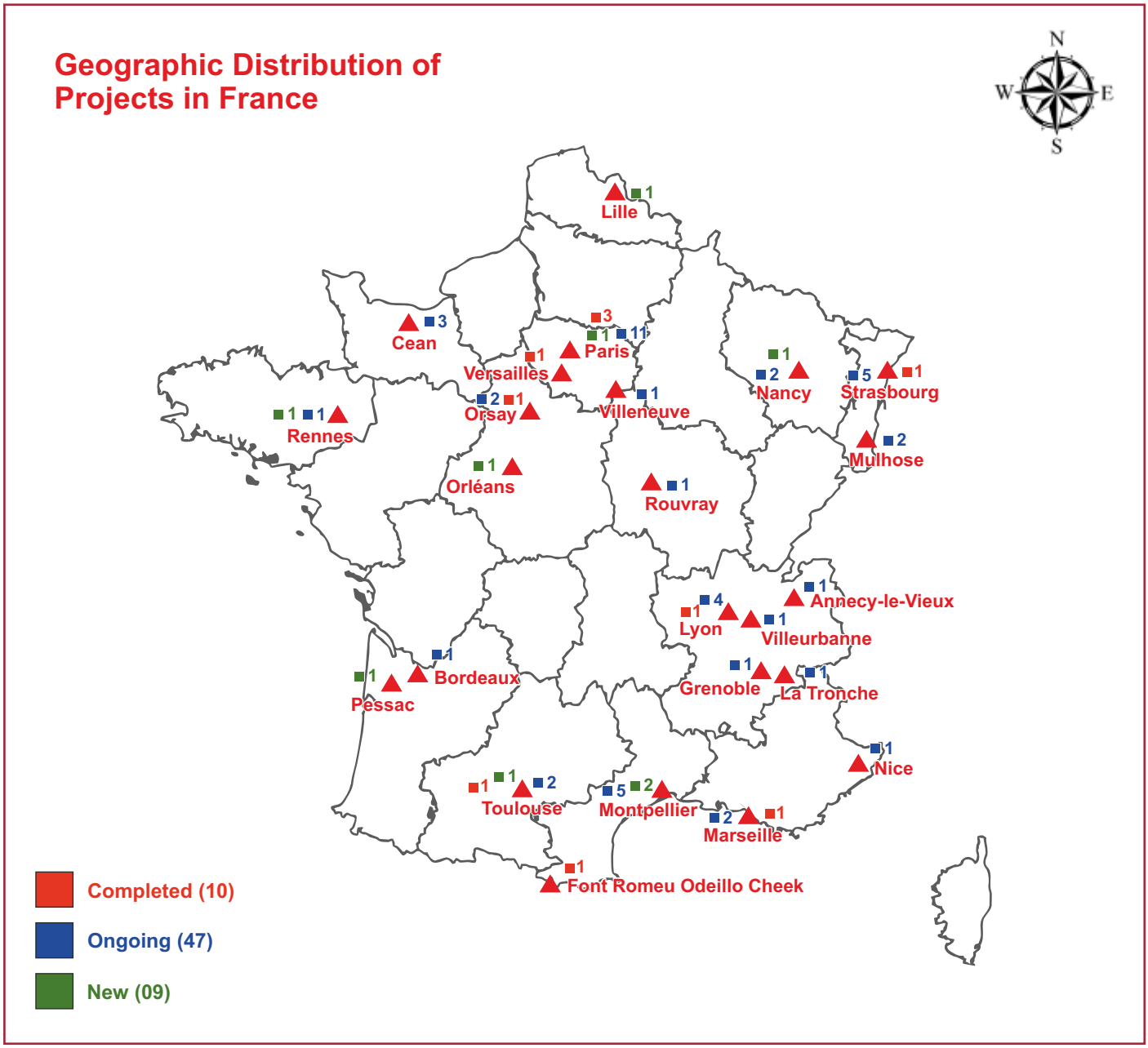


Map 4



Geographic Distribution of Projects in France

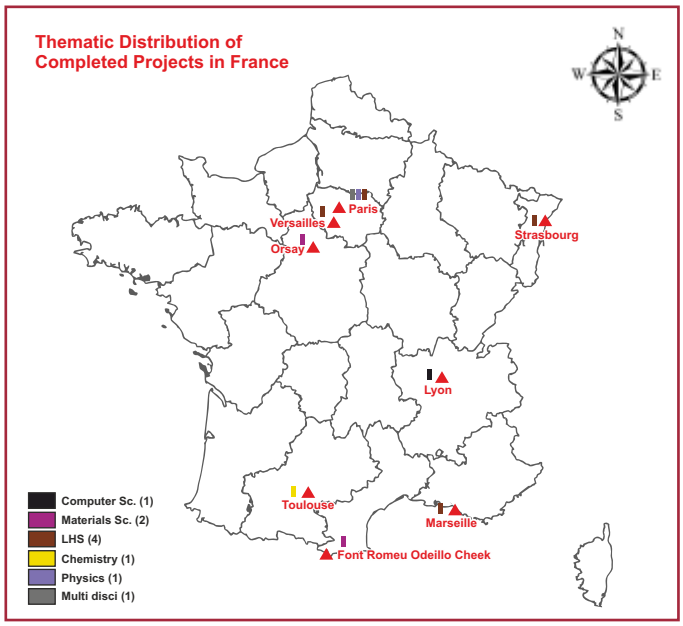
Map 5



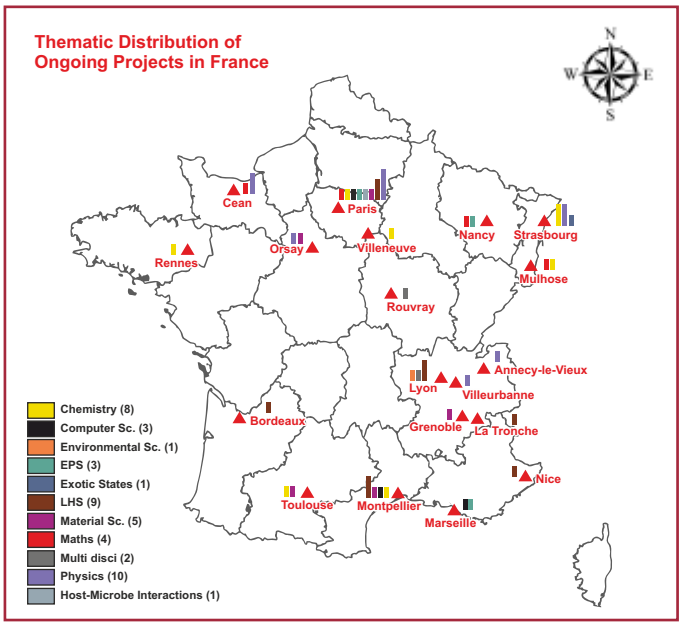
Thematic Distribution of Projects in France

The following three French maps are showing the spatial heterogeneity with respect to completed (10) ongoing (47) and newly initiated (09) Collaborative Scientific Research Projects of CEFIPRA in different subject domains.

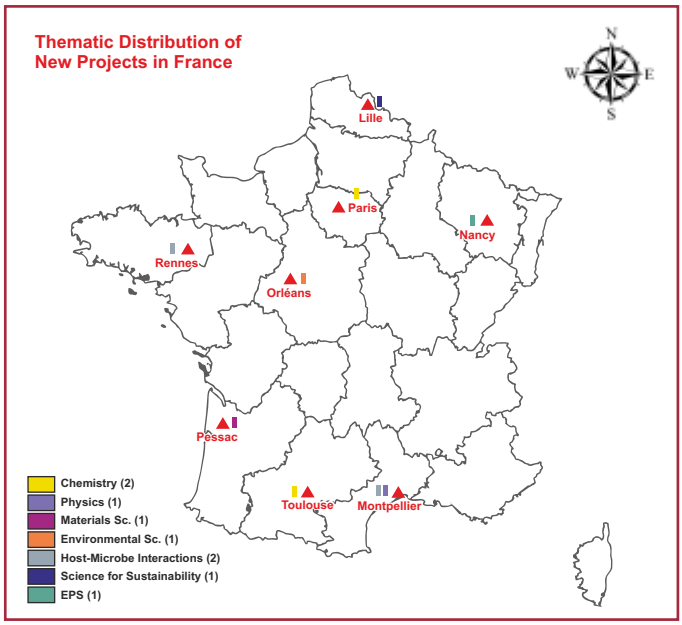
Map 6



Map 7



Map 8



CEFIPRA

6. Indian and French Organizations

Collaborative Scientific Research Projects

INDIAN ORGANIZATIONS

Indian Institute of Technology	
1	Indian Institute of Technology Bombay
2	Indian Institute of Technology Delhi
3	Indian Institute of Technology Gandhinagar
4	Indian Institute of Technology Kanpur
5	Indian Institute of Technology Madras
6	Indian Institute of Technology Roorkee
Universities	
1	Jadavpur University
2	Jawaharlal Nehru University
3	Punjab University
4	Savitribai University
5	University of Calcutta
6	University of Pune
Other Academic / Research Institutions	
1	CSIR: Centre for Cellular & Molecular Biology
2	CSIR: Central Mechanical Engineering Research Institute Durgapur
3	CSIR: Indian Institute of Chemical Biology (IICB)
4	CSIR: Institute of Himalayan Bioresource Technology, Kangra
5	CSIR: Indian Institute of Petroleum Dehradun
6	CSIR: National Aerospace Laboratories
7	CSIR: National Institute for Interdisciplinary Science and Technology
8	CSIR:Institute of Genomics and Integrative Biology
9	CSIR:National Institute of Oceanography
10	DAE: Institute of Physics
11	Indian Association for the Cultivation of Sciences
12	Indian Institute of Information, Hyderabad
13	Indian Institute of Science
14	Indian Institute of Science Education and Research
15	Indian Statistical Institute
16	Institute for Stem Cell Biology and Regenerative Medicine
17	Institute of Mathematical Sciences
18	International Centre For Genetic Engineering and Biotechnology
19	International Centre for Theoretical Sciences
20	Inter-University Centre for Astronomy and Astrophysics
21	Jawaharlal Nehru Centre for Advanced Scientific Research
22	KMCH Institute of Health Sciences and Research
23	National Centre for Radio Astrophysics
24	National Institute of Science Education and Research (NISER)
25	Physical Research Laboratory (PRL)
26	Tata Institute of Fundamental Research
27	Variable Energy Cyclotron Centre

Industry Academic Research Projects

INDIAN ORGANIZATIONS / INDUSTRIES

1	All India Institute of Medical Sciences
2	Center For Incubation, Innovation, Research And Consultancy(CIIRC)
3	CSIR: Indian Institute of Chemical Technology
4	CSIR: National Metallurgical Laboratory
5	Dr Hari Singh Gour Central University
6	Jadavpur University
7	Mohanlal Sukhadia University
8	Nutrivita, New Delhi
9	Sai Life Sciences Limited
10	Samsung India R&D Institute
11	Sergusa Solutions Pvt. Limited
12	St. John's Research Institute
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
2	Chennai Mathematical Institute
3	CSIR-Central Scientific Instruments Organisation
4	Indian Institute of Science Bangalore
5	Indian Institute of Space Science and Technology
6	Indian Institute of Technology Bombay
7	Indian Institute of Technology Delhi
8	Indian Institute of Technology Goa
9	Indian Institute of Technology Kanpur
10	Indian Institute of Technology Kharagpur
11	Indraprastha Institute of Information Technology, New Delhi
12	International Institute of Information Technology (IIIT-H)
13	National Institute of Technology Silchar

Collaborative Scientific Research Projects

FRENCH ORGANIZATIONS

1	Cancer Research Centre of Marseille, INSERM
2	Center for Nanosciences and Nanotechnologies
3	Centre de recherche de l'Institut Curie
4	Centre de Recherche en Automatique de Nancy (CRAN)
5	Centre de Recherches Pétrographiques et Géochimiques (CRPG)
6	Centre de Recherches Pétrographiques et Géochimiques (CRPG)
7	Centre D'Élaboration de Matériaux et D'Études Structurales (CEMES)
8	Centre des Sciences du Goût et de l'Alimentation, Dijon
9	CNRS Institut de Chimie de Strasbourg
10	CNRS: French National Research Institute for Sustainable evelopment (IRD)
11	CNRS: University Claude Bernard Lyon1
12	Grand Accélérateur National d'Ions Lourds (GANIL)
13	INRA Plant Biology and Breeding Lyon
14	Institut Albert Bonniot (IAB), Grenoble
15	Institut Charles Gerhardt Montpellier
16	Institut Curie
17	Institut de Génétique et de Biologie Moléculaire et Cellulaire
18	Institut de Génétique et de Biologie Moléculaire et Cellulaire, ENSICAEN
19	Institut de Physique du Globe (IPGP)
20	Institut de Physique Nucleaire (IPN)
21	Institut de Physique Nucléaire de Lyon
22	Institut de Recherche
23	Institut National des Sciences Appliquées (INSA)
24	Institute for Electronics Microelectronics and Nanotechnology
25	Institute for Research on Cancer and Ageing of Nice (IRCAN)
26	Institute of Molecular Genetics of Montpellier, Montpellier
27	Laboratoire de Biologie et Modélisation de la Cellule (LBMC)
28	Laboratoire de Chimie de Coordination, Toulouse
29	Laboratoire de physique corpusculaire de Caen
30	Laboratoire des Symbioses Tropicales & Méditerranéennes (IRD)
31	Laboratoire Interdisciplinaire de Physique
32	Laboratoire Moléculaire Applications (Lima)
33	Laboratoire Procédés, Matériaux et Énergie Solaire (PROMES)
34	NEEL Institute, Grenoble
35	Observatoire de Paris
36	Pour le Développement, Montpellier

Universities	
1	ENSICAEN
2	Université d'Aix-Marseille
3	Université de Bordeaux
4	Université de Caen
5	Université de Haute-Alsace, Mulhouse
6	Université of Lille
7	Université de Lyon
8	Université de Nancy
9	Université de Paris-Sud
10	Université de Paul Sabatier
11	Université de Poitiers
12	Université de Reims Champagne-Ardenne
13	Université de Rennes
14	Université de Strasbourg
15	Université de Toulouse
16	Université Grenoble Alpes
17	Université Joseph Fourier, Orsay
18	Universite Montpellier
19	Université Paris Diderot
20	Université Sorbonne
21	University Pierre and Marie Curie
Ecole	
1	Ecole Nationale Supérieure de Chimie de Montpellier
1	Ecole Nationale Supérieure de Chimie de Paris
2	Ecole Nationale Supérieure de Chimie de Rennes
3	Ecole Normale Superieure 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	Centre national de la recherche scientifique, CNRS
2	École Normale Supérieure, Paris
3	École supérieure de physique et de chimie industrielles de la Ville de Pari (ESPCI)
4	Eye Analytics & Rehabilitation Innovation Technologies
5	Inria
6	INSERM
7	Institut National De La Re-cherche Agronomique (INRA)
8	Laboratoire Hubert CURIEN
9	Marcoule Institute for Separation Chemistry (ICSM)
10	NUTRISET Group
11	Orasis-EAR
12	Span Diagnostics SAR
13	Terra Nova Development
14	Université de Bordeaux
15	Université Jean Monnet

Targeted Projects

FRENCH ORGANIZATIONS / INDUSTRIES

1	Aix-Marseille University
2	Institut national de recherche dédié aunumérique (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	Univrsité Paul Sabatier

CEFIPRA

Indo-French Centre for the Promotion of Advnaced Research

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.

CEFIPRA

For further information, please contact:
Director
Indo-French Centre for the Promotion of Advanced Research (IFCPAR)/
Centre Franco-Indien pour la Promotion de la Recherche Avancée (CEFIPRA)
5B, Ground Floor, India Habitat Centre, Lodhi Road, New Delhi - 110 003, India
Tel: 011 2468 2251, 2468 2252, 2463 3567
E-mail: director.office@cefipra.org ; Website: www.cefipra.org