AMBASSADE DE FRANCE EN INDE
Liberté Égalité Fraternité

CEFIPRA

INSTITUT FRANÇAIS India

Job offer –Post-doctorate in
High Pressure Synthesis of Quantum Materials

Research Project Short Title as Submitted to CEFIPRA: "Exploring New qUantum MatERiAls from exTremE conditions (ENUMERATED)"
Principal Investigator Contact: "Dr. Angel M. Arevalo-Lopez**,** angel.arevalo-lopez@univ-lille.fr", Université de Lille - Centrale Lille
Reference number of the Job Offer: IFI_CEF_24_02

Project description

- **Keywords:** High pressure synthesis, multiferroics, perovskites, spintronics, spin liquids, superconductors

- **Context:**

  The search for novel materials with exciting properties in condensed matter physics and chemistry has been intense since the discovery of the high T_C cuprate superconductors. Since then, every major materials discovery (CMR and spintronics, multiferroics, iron chalcogenides, photovoltaics, topological insulators, nickel superconductors, etc.) has been accompanied by a flood of related compositions, structures, or compounds with similar properties. Moreover, the use of high pressure provides access to transient species that are not attainable at ambient conditions, and it is also a source for materials with unexpected properties. This project will concentrate efforts on discovering multiferroics, spintronics, superconductors, and spin liquids using large-volume high-pressure techniques. These techniques open a new phase space that remains relatively unexplored to date. This project will simultaneously pursue, in a joint effort via synthesis, characterization, and DFT calculations, based on high-pressure cation-ordered perovskite compounds and metal chalcogenides.

- **Abstract of the Research Project:**

  Quantum materials are solids with exotic physical properties, arising from the quantum mechanical behaviour of their constituent electrons. Examples include the aforementioned superconductors, complex magnets or topological materials. These materials can lead to many novel technologies, including faster computers, fault tolerant quantum computers, improved optical sensors or levitating trains. Thus, there is an ever-increasing demand for new generation technologies based on quantum effects as the correlation or entanglement of multiple quantum states, *e.g.* in a quantum computer. The discovery of exotic states based on spin-orbit coupling (SOC) or fluid-like states in superconductors and quantum spin liquids (QSLs) or topological effects as bond-directional Kitaev exchange were fuelled by the 2016 Physics Nobel Prize "for theoretical discoveries of topological phase transitions and topological phases of matter". In this context, the **ENUMERATED** (**E**xplore **N**ew q**U**antum **M**at**ER**i**A**ls from extreme con**D**itions) project aims to synthesize new quantum materials such as multiferroics, spintronics, superconductors and spin liquids via high-pressure and high-temperature reaction conditions. In order to understand the relationship between the chemical composition, structural details and physical properties that governs their quantum behaviour. **ENUMERATED** will use a combined computational and experimental design approach. Moderate-, medium- and high- pressure synthesis techniques (pressure-vessels and large-volume presses) will be used to obtain the materials. Computational design and insight will be obtained through density functional theory (DFT) calculations. The expected results are the identification, preparation and complete characterization of several new quantum materials based on high-pressure cation ordered perovskite compounds and metal chalcogenides.

- **Scientific Objectives of the Project:**

  1) To synthesize new quantum materials such as multiferroics, spintronics, superconductors, and spin liquids via high-pressure and high-temperature synthesis, establish their structures, and determine their properties. 2) To unravel the relation between chemical and structural features of a material assisted by first-principles calculations.

- **Methodology and Timeline of the Project:**

  The organizational, experimental, and theoretical work of **ENUMERATED** is separated in three main interacting work packages. **1)** Synthesis and primary characterization (powder/single crystal laboratory X-ray diffraction). **2)** Complete characterization, for the successful synthesis a microstructural (TEM) and large-scale central facilities studies (Synchrotron and Neutron diffraction) will be performed along with physical properties characterization (magnetometry, calorimetry, dielectric measurements, etc). **3)** DFT simulations to calculate *e.g.* exchange couplings, single-ion and exchange anisotropy. These will be coupled with Monte Carlo simulations for estimating transition temperatures. These tasks will be pursued in the **20 months** of the position as:

Candidate profile

- Only Indian candidates or candidates with a research experience in India are eligible; French candidates are not eligible
- Applicants for post-doctorate must have a PhD degree (or be in the process of obtaining one) in physics, chemistry, materials science or a related field.
- No competences in French language is required
- Candidate competences: Interpretation of diffraction data (Single crystal and/or powder data). Interpretation of magnetization and calorimetry data.
- Candidate know-how: Expertise in solid-state synthesis, characterization using powder/single-crystal diffraction (Rietveld/structure solution). Understanding of large-volume press techniques is desirable. The successful candidate is expected to be able to work in both independent and collaborative group environments.
- Expected starting date: **01-09-2024** but may be adjustable

How to candidate ?

Documents to be provided :

i. A cover letter (reasons for the candidature, professional project …) max 2 pages
ii. A copy of the master's degree or a proof of the program followed (and expected date of end) OR A copy of the PhD degree or a proof of the PhD program followed (and expected date of defense) max 1 page
iii. A copy of results for previous scholarship (max 3 pages)
iv. International curriculum vitae (max 2 pages)
v. Two letters of recommendation: one from any Indian institution and one from the French institution planned to host the candidate –mandatory- (max 2 pages)
vi. All should be submitted within 1 pdf file of no more than 10 pages.

Applications should be submitted to the following email address: msi@ifindia.in mentioning the reference number of the Job offer clearly.

Research Project Title as Submitted to CEFIPRA: "Exploring New qUantum MatERiAls from exTremE conditions (ENUMERATED)"

Candidates are requested to contact the French scientific principal investigator of the project before submission. A recommendation letter from the scientific principal investigator is mandatory.

Benefits:

- Monthly allowance of 2400 euros for Post-Doc
- Travel allowance
- University fee
- Carte de séjour fee
- Campus France management fee
- Registration to the French social security scheme

Selection process:

Selection is made by a dedicated selection committee of at least 4 persons. Decisions will be transmitted by the Embassy of France to CEFIPRA. **No consideration will be given for candidates with no recommendation letter from the French institution.**

Criteria for applicants' selection:

Academic excellence

- Excellence of the Academic background, Academic records, Honors, Letters of support, Participation to international research projects, exchange programmes and conferences.

Motivation and qualities

- Academic maturity: appropriation of the thesis project (stakes and contexts) • Quality of the presentation (oral expression, skills for synthesis, English level) • Maturity of the professional project: capacity to project her/himself within five years in terms of career development.

About CEFIPRA:
Indo-French Center for the Promotion of Advanced Research (CEFIPRA/IFCPAR) is an Indian body which promotes scientific cooperation between France and India in advanced fields of Science and Technology. It is supported by the Department of Science and Technology, Government of India and the Ministry of Europe and Foreign Affairs of the French government.