Job offer – Post-doctorate in Topological Mechanics
(*For non-French scientists only*)

Research Project Title: "Unraveling topological protection in nonlinear and disordered mechanical metamaterials"
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Reference Number of the Job Offer: IFI_CEF_26_07

Project description

- Keywords: Topological insulator, Topological protection, Metamaterial, Nonlinear wave, Disorder
- Context: Over the past decade, topological concepts have reshaped condensed matter physics by revealing symmetry-protected mechanisms that enable backscattering-immune edge transport. Their extension to phononic and mechanical systems has created new opportunities for controlling elastic waves through engineered lattice architectures. Topological mechanical metamaterials will provide the central platform for realizing geometry-controlled, robust wave manipulation with direct experimental relevance, offering potential applications in vibration isolation, wave guiding, impact mitigation, and signal transmission. However, most existing studies are restricted to linear, perfectly ordered, and conservative models, whereas practical mechanical structures inherently exhibit dissipation, nonlinear response, and unavoidable disorder arising from material imperfections and fabrication tolerances. These effects can substantially modify band topology, alter mode stability, and degrade or reshape topological protection. A systematic investigation of the interplay among nonlinearity, dissipation, disorder, and topology will therefore be essential for translating idealized theoretical predictions into reliable and functional mechanical devices.
- Abstract of the Research Project: The project aims to investigate the robustness and tunability of topological phases in mechanical metamaterials in the presence of controlled nonlinearity, engineered disorder, and dissipation. Although topological states are theoretically protected against perturbations, their behavior in realistic mechanical systems—characterized by nonlinear interactions, structural imperfections, and intrinsic damping—remains insufficiently understood. It is therefore crucial to determine whether corner, edge, and surface states maintain their spectral isolation, spatial localization, and dynamical stability when material losses and damping are explicitly incorporated. To address this, the project will develop nonlinear lattice models that systematically include dissipative effects, enabling analysis of spectral evolution, stability boundaries, and the persistence of topologically protected modes under varying disorders and nonlinear coupling strengths. The interplay among nonlinearity, disorder, and dissipation will be examined to identify parameter regimes in which topological modes remain robust, become destabilized, or transition to qualitatively new dynamical states. The study will also explore the constructive role of dissipation in amplitude-dependent control and selective stabilization of topological phases. Advanced numerical simulations employing high-performance computing will be integrated with a tunable experimental platform capable of systematically varying nonlinear characteristics, disorder distributions, and damping levels. Experimental validation will quantify wave localization, edge-state resilience, and topological phase transitions under realistic operating conditions. By explicitly incorporating dissipative mechanisms into both theory and experiment, the project will bridge the gap between idealized topological frameworks and deployable mechanical systems, establishing rigorous design principles for practically realizable topological phononic devices.
- Scientific Objective 1: To design and develop mechanical metamaterials incorporating diverse forms of nonlinearity, including onsite, intersite, and other functional nonlinear interactions, while explicitly accounting for material damping and dissipative effects. The study will systematically investigate how these nonlinear and dissipative mechanisms influence the emergence, persistence, and stability of topological corner, edge, and surface states, with the goal of enabling controlled tuning and amplitude-dependent modulation of topological phases that can be directly compared with experimental realizations.
- Scientific Objective 2: To engineer mechanical metamaterials with tailored disorder profiles, including random and chiral disorder, and to assess their influence on topological protection in the presence of damping and intrinsic losses. The objective is to establish strategies for precise control and stabilization of topological states through combined disorder and dissipation, identifying parameter regimes in which topological modes remain robust under realistic operating conditions and enabling meaningful experimental validation.
- Methodology and Timeline of the Project: The project will commence with a comprehensive numerical and experimental investigation of a one-dimensional lattice composed of coupled rotating elements. Intersite geometric nonlinearities

arising from large rotations will be explicitly incorporated, and tunability will be achieved by systematically varying the number and placement of connecting springs. Driven–damped simulations will be performed to examine amplitude-dependent spectral evolution, modal stability, and the persistence of topological states in the presence of dissipation. Disorder-induced topological transitions will be analyzed by introducing controlled variations in rotor inertia and spring stiffness, including both random and chiral disorder profiles. Experimental validation will be conducted using a vibration shaker for excitation and high-speed imaging to quantify rotational responses and mode localization. This first phase will be completed within 10 months of project initiation. The second phase will extend the investigation to two-dimensional nonlinear lattices supporting edge and corner states. Kagome, hexagonal, and square configurations will be constructed and analyzed through driven–damped simulations with adjustable geometric nonlinearities, engineered disorder, and controlled damping. Particular emphasis will be placed on identifying parameter regimes in which dissipative effects either preserve, destabilize, or selectively stabilize topological boundary modes. The study will further examine disorder-induced topological phase transitions and quantify the robustness of corner and edge states under realistic operating conditions. Extensive experiments will then be performed on assembled 2D lattices using rotary elements and vibration testing to demonstrate robust edge and corner states in disordered, nonlinear, and dissipative systems. The second phase will be completed within 10 months following the first stage.

Candidate profile

- Candidates can be all nationalities except French. In case of double nationality (French and another one), the candidate is not eligible. In the context of CEFIPRA, Indian candidates are preferred.

- Applicants for post-doctorate must have a PhD degree (or be in the process of obtaining one).

- No competence in French language is required.

- Candidate competences: The postdoctoral candidate should possess strong expertise in nonlinear dynamics, with a solid background in the analytical and computational modeling of nonlinear systems. Proven competence in solution methodologies, stability analysis, and bifurcation theory is essential. Familiarity with topological mechanics, phononic crystals, or mechanical metamaterials will be highly advantageous. The candidate should demonstrate the ability to conduct independent research while actively contributing to collaborative scientific efforts. Strong scientific writing skills, evidenced by peer-reviewed publications, together with the capacity to clearly articulate complex theoretical and computational concepts, are essential for the successful execution of the project.

- Candidate know-how: The candidate should have demonstrated experience in developing and implementing high-fidelity numerical codes for nonlinear differential equations, preferably using MATLAB, Python, or comparable scientific computing platforms. Practical expertise in applying computational tools to analyze stability, bifurcation behavior, and nonlinear wave phenomena in lattice systems is required.
- Expected starting date: 01-10-2026
- Expected duration: 20 months

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. One letter of recommendation from any Indian institution –mandatory- (max 2 pages)
vi. All should be submitted within 1 pdf file of no more than 10 pages.

Applications must be submitted through this Google Form selecting the appropriate reference number for the job offer.

Research Project Title as Submitted to CEFIPRA: "Unraveling topological protection in nonlinear and disordered mechanical metamaterials"

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:

The final selection is made by a dedicated selection committee of scientific experts after a pre-selection phase by the French principal investigator. Decisions will be transmitted by the Embassy of France to CEFIPRA.

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