Mechanics of microstructured media – Deterministic and Non-Deterministic approaches

Financial support : CDE, 18 months + teaching assistant position at FAU

Location : IRDL (UMR CNRS 6027)/ Université Bretagne Sud,
Centre de recherche Christiaan Huyghens, 56100 Lorient - France

Florida Atlantic University (FAU)
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Duration: 3 years - From September or October 2023 to August-September 2026.

Context: The work of the research team (PTR 5 of the IRDL Institute) focuses on the modeling of heterogeneous materials and structures. To take into account heterogeneities, microstructure scales into a nonlocal framework formulated from discrete models is introduced. An international collaboration has been initiated for the past ten years between Florida Atlantic University (FAU), USA, and Université Bretagne-Sud (UBS), France. Prof. Isaac ELISHAKOFF (FAU), Dr. Vincent PICANDET and Prof. Noël CHALLAMEL (UBS) propose to co-supervise a PhD student on stability and vibrations of periodic microstructures and equivalent non-local continuous media. The candidate will spend half the time at each of the two universities.

Objectives: The research project focuses on the study of discrete systems using the nonlocal mechanics of continuous media. One-dimensional lattices, such as discrete strings, bars or beams, can be equivalently simulated by one-dimensional non-local models. The two or three-dimensional generalization of such continuum modelling is much more recent, and has mainly focused on the behavior of microstructured plates or even three-dimensional lattices. The non-local or gradient-type laws that emerge from continualization procedures of such lattices are used to analyze the stability and the vibration of these so-called microstructured systems. Geometric and material non-linearities can also be taken into account at the micro scale, thus generating non-local or gradient non-linear higher order laws at the macroscopic scale. Most results in this area are based on orthogonal lattices. It is planned to generalize such an approach to hexagonal lattices, for engineering applications especially in the field of nanotechnologies.

Expectations: This research has applications in many areas especially when scale effect may be significant, with applications in both physics and in engineering sciences such as mechanics and/or civil engineering. The accurate modelling of damage phenomena in large scale structures (reinforced concrete for example) needs to take into account the effects of microstructure, that may significantly affect scale effects phenomena.

In the field of nanotechnology, the study of nanoscale structures requires the introduction of consistent structural models that include interatomic scale effects. More generally, a multi-scale structural analysis driven by the behavior of constituent materials at both the micro and the macro scale requires the formulation of specific laws that make the material and the structure interact through a non-local correspondence.

Key words

Lattice theory; Beam theory; Plate theory; Nonlocal mechanics; Asymptotic methods; Scale effects; Shear effects; Microstructured theories

Abstract: This project aims at a theoretical and numerical study of the mechanical behavior of 2D or 3D discrete periodic structures through a non-local modeling of an equivalent continuous medium.

Recent publications liked to the topic:

Elishakoff I., Pentaras D., Dujat K., Versaci C., Muscolino G., Storch J., Bucas S., Challamel N., Natsuki T., Zhang Y.Y., Wang C.M., Ghyselinck G., *Carbon nanotubes and nanosensors: vibrations, buckling and ballistic impact*, Wiley – ISTE, 2012.

Picandet V, Challamel N, *Bending of an elastoplastic Hencky bar-chain: from discrete to nonlocal continuous beam models*, Meccanica, 53,11–12:3083–3104, 2018

Wang C.M., Zhang H., Challamel N. and Pan W., *Hencky-Bar-Chain/Net for Structural Analysis*, World Scientific, 2020.

Picandet V., Challamel N.,*Nonlocality of one-dimensional bilinear hardening–softening elastoplastic axial lattices*, Mathematics and Mechanics of Solids, 25,2:475–497, 2020

Challamel N., Wang C.M., Zhang H. and Elishakoff I., *Lattice-based nonlocal elastic structural models*, in: Ghavanloo E., Fazelzadeh S.A. and Marotti de Sciarra F., Ed., *Size-dependent continuum mechanics approaches: Theory & Applications*, 1-50, Springer, 2021.

Expected skills and profiles:

- MSc in Mechanics - Civil Engineering - Theoretical Mechanics - Applied Mathematics
- Skills in modeling the mechanical behavior of materials, structural simulation
- Interest in theoretical, analytical and numerical approaches
- Theory of structures - beams, plates and shells

Application to be sent by e-mail before April 7, 2023 with the following documents

- Letter of motivation
- CV
- Copies of titles / diplomas and transcripts
- List of publications (if any)
- Recommendations (or contacts)

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