General Information

Job title : PhD au LSPM/LiPhy

Location: Villateneuse/Grenoble
Contract type: Fixed-term contract CNRS section: 09 and 02
Contract duration: 3 years
Expected start date: 01.10.2023 Workload
Full time Salary: 2135€ gross monthly
Level of education required: Master's degree or equivalent
Supervisors: O.U. Salman, V. Lecomte
Experience required: None
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Missions

This project aims to build a bridge between the fundamental statistical mechanical and the application-driven mechanical engineering approaches to the study of semi-flexible fibrous network materials whose elasticity can switch from bending-dominated to stretching-dominated mode. The implied transition from bending (BE)- to stretching (ST)-dominated elastic response plays an important role in the mechanical behavior of cells and tissues and is interesting from the point of view of bio-mimetic engineering aimed at the development of new classes of materials. In particular, considerable efforts are presently devoted to the rationalization of the remarkable ability of the cytoskeleton to modify its elasticity mode depending on the tasks and external conditions. It was found that a continuous crossover between the two regimes takes the form of a highly heterogeneous coexistence between (BE) and (ST) dominated phases. Despite the successes in direct numerical modeling, the fundamental theoretical understanding of the BE-ST transition is still lacking. The development of a coarse-grained model of this phenomenon informed by fundamental physics will facilitate the continuum modeling of cellular scale phenomena and potentially advance the engineering design of highly promising artificial metamaterials with under-connected network architecture.

Activités

The first task will be to start from the simplest model [15,26] presenting, in one dimension, the mixed linear/non-linear stress-strain behavior to adapt it to the case of two-dimensional materials. The key problem will be here to identify the simplest model that still presents the features of interest in dimensions larger than one. This, together with understanding the bibliography, will span the first 9 months of the Ph.D.

The Ph.D. candidate will then apply the homogenization theory tools to obtain the material's macroscopic behavior and study the corresponding critical behavior of the BS transition. Once the zero-temperature zero-disorder case is well understood, the Ph.D. candidate will incorporate aspects present in realistic systems: (i) the role of space-time fluctuations of thermal and non-thermal origin (active fluctuations), and (ii) the impact of quenched disorder. For this, the Ph.D. candidate will resort to tools of statistical mechanics, both at the analytical level (Fokker–Planck evolution, path-integral representations) and numerical level (Langevin simulations). The finite-but-small temperature limit will be studied using small-noise theory, using the WKB (or Freidlin-Wenztell) approaches, that saddle-point expansion renders peculiarly amenable in a path-integral formulation. The Ph.D. candidate will then compare the obtained predictions to the behavior of more complex systems, by means of extended simulations, in order to ascertain if the theoretical predictions derived in simple models survive the presence of more realistic but complex features – and, depending on the obtained results, a comparison with experimental results will be performed.e.

Compétences

The candidates must hold a master's degree in mechanics or physics and possess general knowledge/skills in continuum mechanics, applied mathematics, and numerical modeling. Please provide a complete CV and a letter of recommendation.

Contexte de travail

The numerical work will be carried out at the LSPM laboratory, which has a strong interest in the development of analytical and numerical methods. The computing resources of the PMMH (and the CNRS) will be available for numerical studies. The nature of the doctoral project is mainly theoretical, but the student will be encouraged to follow the experiments carried out at the LIPhy (led by C. Verdier).

[1] O.U. Salman, L. Truskinovsky, Phys. Rev. E 100, 051001(R) (2019)
[2] Salman, O. U., L. Truskinovsky, JMPS, 154, 104517 (2021)