Deciphering mechanical homeostasis with FEM

Laboratory: Institut Lumière Matière, Lyon, France (link)

Contact: Nicolas Bain, nicolas.bain@univ-lyon1.fr (link)

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Scientific context When stretched, most elastic materials develop mechanical stresses. Independently of the material composition, a larger stretch usually produces larger stresses. In active materials such as living tissues, however, things can differ. For instance, **micrometric fibroblasts** in the extracellular matrix contract and relax, thereby maintaining nearly constant mechanical stresses over **centimetric scales**, even when the matrix is stretched [1, 2]. This phenomenon, called mechanical homeostasis, has been extensively studied in tissue equivalents, such as collagen gels seeded with living cells, and is understood as arising from the interplay between actuators that locally contract and a soft matrix that transfers forces over large distances (Fig. 1A) [2, 3]. The biological limitations of tissue equivalents, in which one cannot vary all parameters independently, however prevent a detailed comprehension of the underlying physics [1, 4, 5]. It is, for instance, very difficult to vary the matrix composition or the imposed stretch without changing how much the cells contract. **A precise comprehension of how local contractions propagate to the large scales in mechanical homeostasis is therefore still lacking, despite its potential use in soft robotics and tissue engineering.**

Missions In this project, we will conduct Finite Elements Simulations of local contractions inside homogeneous materials, and evaluate how stresses propagate as a function of material properties (Fig. 1B). We will use the software COMSOL, and put emphasis on understanding the link between material nonlinear properties and stress propagation. The results will be directly compared with ongoing experimental results.

Outlooks You will be using state of the art numerical analysis tools, and the expected results are likely to be published in a peer-reviewed international journal. The opportunity to continue as a Ph.D. student can be considered.

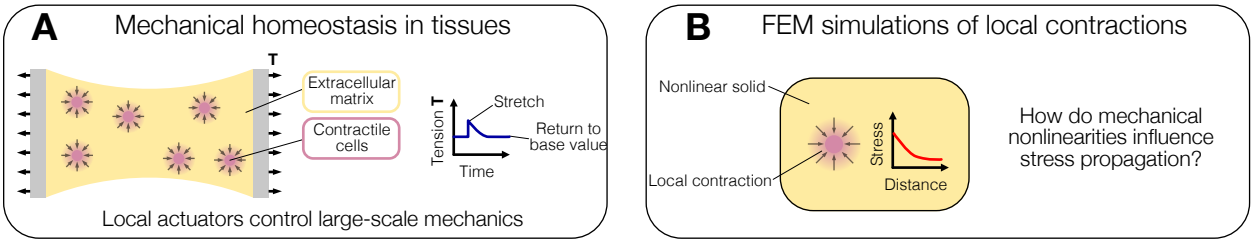

Figure 1: Project overview (A) In mechanical homeostasis, micrometric contractile cells control the macroscopic tension T in classical tissue equivalents. Upon external stretch, the macroscopic tension returns to a base value. (B) We will conduct Finite Elements simulations to evaluate how local contractions propagate in a nonlinear solid.

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