M2 internship proposal with PhD funding

Volumetric optical imaging of viscoelasticity for scoliosis and cancer observation

General information

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Scientific description

For a few years, it has become clear that the mechanical properties of cells and extracellular matrix are one of the key actors of the physiology and pathophysiology of biological tissues. Mechanical forces can modify cell organization, signalling, and fate. Moreover, pathological cell states (e.g. tumor cells) can modify the viscoelastic properties of their surrounding microenvironment. More recently, a coupling between mechanical and electrical forces was proposed to be a driver for action potentials and neuronal activity. Performing a precise quantitative measurement of viscoelastic properties of cells and their surrounding scaffold is therefore of major interest for fundamental biology as well as for medical diagnosis.

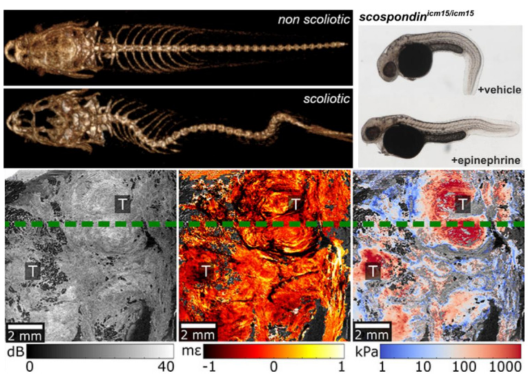

Figure 1: **Main applications targeted by the project.** Zebrafish with idiopathic scoliosis will be investigated in order to understand the upoming of the spine torsion. Mechanical properties of biopsies will be also evaluated to refine tumor diagnosis.

Nonetheless, there is no imaging technique already fully able to perform quantitative measurements of the rheological properties of tissues at the cellular scale. **In this project, we propose to develop 3D label free optical measurement of viscoelastic properties in thick biological tissues at the cellular scale, and combine this measurement with the evaluation of the surrounding cells physiology.** The overall project will follow three main objectives: Develop new tools to increase the spatial resolution of quantitative viscoelasticity measurements in thick tissues, combine these tools with label free evaluation of tissue physiology, and apply these tools to specific biomedical questions.

The VISCO project is built upon the technique of static and dynamic full field optical coherence tomography (FF-OCT), invented at the Institut Langevin. Such microscope has so far enabled to measure the organization of the extracellular matrix at the submicron scale and to measure the cell shape and physiology without label or sample modification. During the project, the main technological optical development is to propose a new version of this technique to allow fast volumetric measurements. First, volumetric FF-OCT will enable to record the 3D architecture of biological tissues at a faster rate by two orders of magnitude. Second, it will allow the fast measurement of 3D displacement maps, with phase measurement enabling the measurement of subresolution axial displacements, which is at the core of the viscoelasticity measurement. Together, this will offer a unique label-free 3D characterization of biological tissues at the cellular scale, combining architectural, physiological, metabolic, and mechanical information in a few minutes enabling the longitudinal study of all these properties together.

The project specifically targets two applications with this new technology. First, the project aims to improve anatomopathology diagnosis to characterize tumoral breast samples. Second, it aims to evaluate how muscle elastic properties are affected in a zebrafish model of idiopathic scoliosis.

Expected skills

The project is mainly experimental, and will involve the development of a new optical microscope, as well as an experimental sequence to provide mechanical stimulation and detection. General knowledge in physics, and programming are expected, as well as strong interest for the the biophysics interface.