Master 2 Internship

Title: Contactless Rheology of living cells

Type: experimental and theoretical

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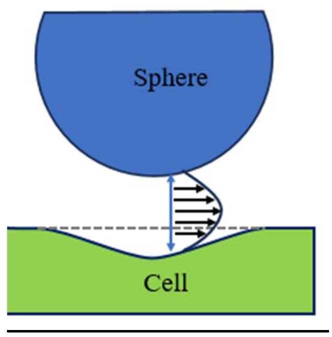
Project: Mechanical properties of soft objects are of great interest for many emerging applications including surface coatings, photonics, microelectronics, biosensors and biology. The mechanical properties of cells are assisting and guiding all their functions at different scales, including adhesion, migration, differentiation, proliferation and trafficking inside the cytoplasm.

Methods like tensile or bending tests and direct indentation are commonly used for the characterization of soft materials. The Atomic Force Microscope (AFM) is a widely spread device for the measurements of the mechanical properties of cells. AFM probes, with known shapes, are used as nano-indenters for applying normal and localized compression on living cells. However, sample damage and probe contamination may also occur during this physical probe-cell contact.

Elastohydrodynamic (EHD) interactions between a vibrating sphere and a soft sample in a liquid environment provide a new and precise method to assess mechanical properties without contact. At small liquid-gap thickness between the sphere and the soft sample, the vibration of the sphere generates a hydrodynamic stress field that might be large enough to deform the object, and in turn perturb the flow, leading to an EHD coupling.



Based on this coupling, new tools were developed to probe the mechanical properties of soft interfaces without contact. Recently we have measured without contact the surface tension of microbubbles without contact for different surfactants concentrations (1). We have also measured the mechanical properties of polydimethylsiloxane (PDMS) samples over a large range of frequencies (2).

In this project, we will extend our previous approaches to living cells, using an AFM colloidal probe method. Interestingly, the cell-sphere interaction, and its evolution with the cell-probe distance will provide us a simple, non intrusive assay of their complex viscoelasticity. Thanks to the adaptation of the resonance frequency of the cantilever with the rigidity of the cell, very soft (mammalian) and stiffer (yeast) cells will be compared. This work will be performed in collaboration two teams of the Institut de Biochimie et de Génétique Cellulaire and Chimie des Biomembranes et Nano-objets laboratories.

References:

1) V .Bertin et al; Phys. Rev. Research 3 (3), L032007(2021)
2) Z. Zhang et al;, Phys. Rev. Applied 17, 064045 (2022).