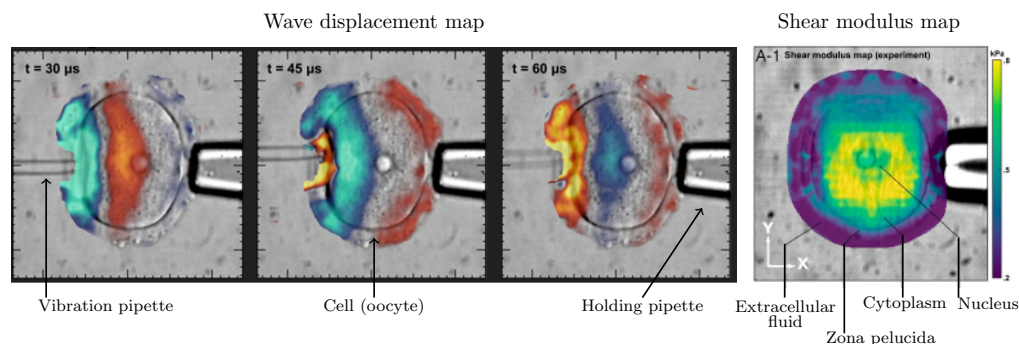


Bubble-induced contactless microelastography of biological cells

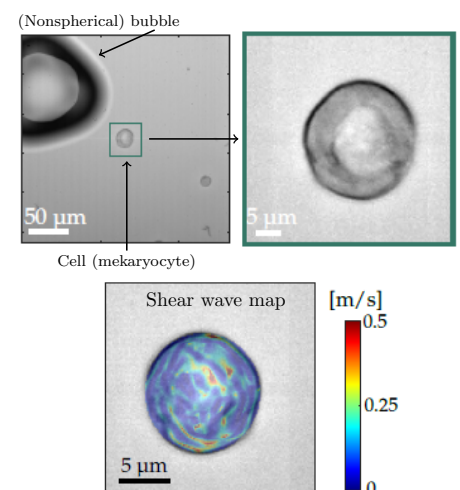
Postdoctoral fellowship

Context and preliminary work

In wave physics, uncorrelated vibrations could be exploited using noise correlation tools to reconstruct images of a medium. By using a high-frequency vibration, a high-speed tracking device, and a reconstruction technique based on temporal correlations of travelling waves, it is possible to map the elasticity of tissues or organs. Measuring the elasticity of tissues is primordial in the aim of assessing the pathological state of an organ for instance, by probing the change of stiffness in comparison to a healthy sample. Coupling optical microscopy to the elastography technique allowed in 2018 to perform a significant scale change by detecting the propagation of shear waves into a single biological cell [1]. The measurement of the cell elasticity at the micrometer scale, called microelastography, allows mapping internal cell structures, and thus represents a tractable option for interrogating biomechanical properties of diverse cell types.



The cell microelastography technique has been performed using oocytes ($\sim 100 \mu\text{m}$ diameter) attached to a micro-pipette and excited by another one on the opposite side. Such a contacting excitation disturbs the behavior of the cell membrane and make complex the automatization of the process. These drawbacks have been recently raised by using a unique oscillating bubble that shakes a single biological cell of smaller size ($\sim 30 \mu\text{m}$ diameter). This bubble can oscillate spherically or non-spherically depending on the driving pressure amplitude [2]. Coupling sensitive optical microscopy to elastography technique revealed that shear waves propagate in the cell allowing the mapping of its elasticity for micrometric cell size [3].



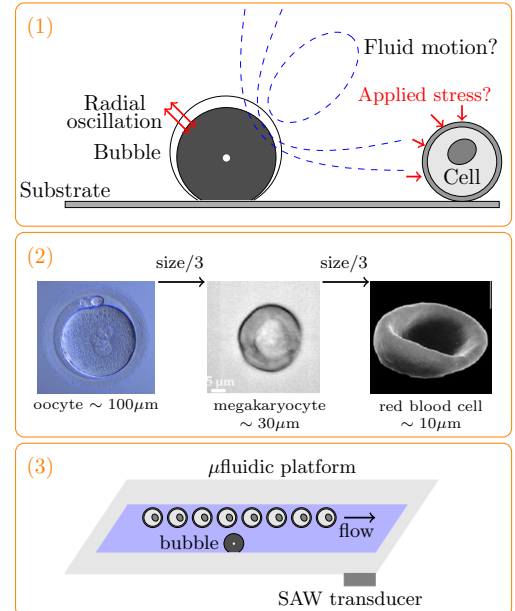
Problematics

While the proof-of-concept of the microelastography technique has been performed, (i) the mechanisms underlying the bubble-mediated wave generation within the cells are still unknown, (ii) the cell size needs to be decreased to the common size of cancerous cells and (iii) a microfluidic platform allowing large data processing on various cell lines must be designed.

Work program

The objective of the postdoctoral project is to advance in the understanding of the mechanisms leading to shear wave propagation within micrometric single biological cells using a contactless vibrating body : the acoustic bubble. One of the challenge is to fasten the acquisition process of the cell elastography technique, in order to make reproducible and to broaden the application of this technique to smaller cells, to various cell lines and to differentiate cancerous cells versus intact ones. These investigations will be performed in a threefold program :

1. The interaction between a single oscillating bubble and a single micrometric cell will be determined at the acoustic timescale, quantifying cell deformation, the surrounding fluid motion, the scattered pressure field from the bubble that can oscillate spherically or along shape oscillations.
2. The second challenge consists in decreasing the size of the investigated cells : after oocyte ($100\mu\text{m}$ diameter) and megakaryocyte ($30 - 40\mu\text{m}$), optimization of the optical setup must be handled in order to investigate red blood cells, with a characteristic size less than $10\mu\text{m}$.
3. The third challenge is the design of a microfluidic platform including a stably, wall-attached, oscillating bubble in the vicinity of which a train of biological cells flows. Fast and repetitive measurements will be performed along a huge number of cells for a given cell line.



Laboratory

The work program will be performed at the Laboratory of Therapeutic Applications of Ultrasound (LabTAU, Lyon, France), in collaboration with the Laboratory of Fluid Mechanics and Acoustics (LMFA, INSA Lyon, France).

Supervision

— Claude INSERRA, LabTAU, Associate Professor (HdR), claud.inserra@inserm.fr

Profile and Application

The candidate should have academic knowledge in one or several disciplinary fields related to the project : acoustics, applied physics, fluid mechanics, microfluidics. Please contact Claude Inserra with a resume and letter of motivation for applying to the position. The fellowship can start as soon as November 2026, for a duration of 1 to 2 years, depending on the experience of the candidate. The salary is imposed by the INSERM policy for recruiting non-permanent researchers (minimum of 55.7k€/year for a young researcher with an experience less than 2 years after PhD completion).

Bibliography

1. P. Grasland-Mongrain, A. Zorgani, S. Nakagawa, S. Bernard, L. Gomes Pain, G. Fitzharris, S. Catheline, G. Cloutier. *Ultrafast imaging of cell elasticity with optical microelastography*. PNAS, **115**(5), 861-866, 2018.
2. M. Fauconnier, C. Mauger, J.C. Bera, C. Inserra. *Nonspherical dynamics and microstreaming of a wall-attached microbubble*. J. Fluid Mech., **935**, A22, 2022.
3. G. Laloy-Borgna, M. Fauconnier, C. Inserra, S. Catheline. *Contactless, bubble-mediated microelastography of a single biological cell*, in preparation.