

## Research Opportunity at Institut Fresnel and IRPHE Internship in Non invasive analysis of the composition of Intervertebral Disks with PhotoAcoustics

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Applications are invited for an **internship** in **PhotoAcoustics and Biomechanics** at the *Institut Fresnel and IRPHE*, CNRS, Aix-Marseille University, Centrale Marseille, France.

→ **Background:** PhotoAcoustic Tomography (PAT) is a multiple wave tomographic imaging technique. It consists in illuminating the tissue with a pulsed laser source. Because of the presence of absorbing heterogeneities within the tissue (high vascularisation of the tissues, neoangiogenesis of the tumors, water content with near IR illumination, collagen ...), light is locally absorbed and dissipated into heat, microdilations appear and give birth to an acoustic wave that propagates through the tissue and can be measured with conventional ultrasonic transducers. Hence, in visible to mid infrared wavelength range, it potentially offers the possibility to couple high sensitivity to a wide variety of chromophores (haemoglobin, oxygen consumption, glucose, fat, water, ...) brought by the optical illumination and high spatial resolution thanks to the acoustic detection.

Intervertebral discs (IVD) are fibrocartilaginous organs that provide the linkage and mobility of the vertebrae of the spine. Healthy, they have a high water content, nearly 80% by volume, which diminishes with age thus decreasing intervertebral mobility and nutritional contributions to disc cells. Disc degeneration (DD) is thus a process in principle natural that continues throughout life but can, under the influence of various factors, accelerate suddenly and become pathological. Early detection of this pathology, at the first signs of back pain, is therefore of great interest to quickly establish effective treatments. We have recently shown the central role played in this pathology by the regulation of the water content of the IVD which proceeds from a delicate balance between mechanical stresses exerted by the adjacent vertebrae, electrochemical phenomena within the extracellular matrix (ECM) and the performance of the nutritional transport processes throughout the ECM. The multiphysical model developed makes it possible to estimate the viability of the organ but requires the knowledge of geometric, mechanical and physical properties of the IVDs to initialize the calculation. So, this study aims to evaluate the possibility of obtaining some of these data by PAT and then to elaborate a complete tool to assess the organ viability.

→ **Research program:** The internship (and the subsequent PhD study program) can contain two aspects that can be implemented separately according to the skills of the candidate:

- Experimentally, a collection of multi spectral data (700 -1000 nm) on excised animal intervertebral disks will be obtained from the photoacoustic setup at the Institut Fresnel (Da Silva et al. 2017).
- The signal will be post-processed in order to account for the experimental instrument response function.
- The filtered signal will be processed and unmixed in order to recover the water and collagen content in depth and then to proceed with the IVD computer modelling.
- An experimental study on the modifications of the PA signal when the IVD is subjected to controlled pressure will be conducted.

→ **Qualifications:** The project is highly multidisciplinary. Applicants must be in the last semester of a master-granting program in Bioengineering, Physics, Mechanics or other related areas of science and engineering. Applicants are expected to have a strong interest in working in a multi-disciplinary environment.

### References:

- Da Silva, et al., "Taking advantage of acoustic inhomogeneities in photoacoustic measurements," J. Biomed. Opt. 22(4), 041012 (2017).
- Chetoui M., Boiron et al (2018), Assessment of intervertebral disc degeneration-related properties using finite element models based on p H -weighted MRI data, Biomech Model Mechanobiol (2018), <https://doi.org/insis.bib.cnrs.fr/10.1007/s10237-018-1064-1>
- M. A. Chetoui, O. Boiron, A. Dogui, V. Deplano., Intervertebral disc nutrition modeling : use of MRI to assess initial parameters, 8th World Congress of Biomech., July 8-12 2018, Dublin.