**Physics for Medicine Paris**
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# PhD position: AI-driven cardiac elastography

## Physics for Medicine, Paris

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## Context

Cardiac pathologies are often associated with increase stiffness of the heart wall, which can be measured using an ultrasound imaging technique named Shear Wave Elastography (SWE). This technique, which can provide quantitative maps of the local tissue elasticity, has already demonstrated strong diagnostic power in several pathologies. However, despite the 3D geometry of the heart, it has often been constrained to 2D measurements, providing incomplete biological information. SWE relies on the physics of ultrasound-triggered shear wave propagation, which occurs in the whole myocardial tissue. Because of the complex 3D geometry of the heart, and its inherent anisotropy, 3D SWE reconstruction remains a challenge today. Recently, Artificial Intelligence (AI) tools such as Deep Learning (DL) algorithms have emerged as a powerful strategy for diagnostic classification and prediction based on medical images. In particular, Physics Informed Neural Networks (PNNs) have demonstrated performance and robustness in solving complex image reconstruction algorithms. This PhD project aims to leverage the potential of AI tools applied to volumetric in-vitro and clinical data acquired with a new custom 3D SWE system, in order to provide a robust comprehensive diagnostic SWE tool for cardiac pathologies.

## Objectives

The two main objectives are the following:

- Develop a PINN for 3D shear wave velocity (SWV) estimation based on 3D elastic wave propagation
    - Integrate wave propagation equation into a DL framework
    - Integrate anisotropic elastic medium model
    - Train and validate with in vitro and in vivo data
    - Evaluate SWV variation during the cardiac cycle

- Build an AI-based diagnostic tool for cardiology, using multimodal data available on echography systems
    - Develop an AI model for classification of echography loops (videos)

- Integrate SWE data and Electrocardiogram (ECG) data
- Train/Validate on specific cardiac pathologies (HFpEF, cardiac amyloidosis and cardiomyopathies) using data from two clinical trials

The candidate will:

- Become familiar with the principles of Shear Wave Elastography and SWE data reconstruction
- Build an appropriate DL database using the existing in vitro and clinical data
- Propose, implement and validate DL models

We are looking for a candidate with a strong interest in AI and/or medical image analysis and/or ultrasound imaging, and solid knowledge of Matlab, Python and/or deep learning libraries.

Please send your CV and cover letter to beatrice.walker@espci.fr, clement.papadacci@inserm.fr and mathieu.pernot@inserm.fr