

M2 Internship proposal – ERC project

Laboratory: Institut Langevin (1 rue Jussieu, 75005, Paris)

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Internship title: Development of a Retinal Digital Twin to model scattering and phase contrast retinal imaging

This Master 2 internship is part of the ERC project MIRACLE-AD, led by Pedro Mecê at the Institut Langevin. The project aims to unravel the mechanisms of neurovascular coupling (NVC) — the process linking neuronal activity to local blood flow regulation — whose early dysfunction is considered one of the earliest hallmarks of Alzheimer's disease (AD). Since the retina is the only optically accessible part of the central nervous system, it provides a unique opportunity to study NVC at the cellular level.

Recently, the group led by Pedro Mecê has developed an advanced optical imaging technique for cellular-resolution retinal imaging: the Adaptive Optics Rolling-Slit Ophthalmoscope (AO-RSO). This system can capture high-speed phase-contrast images over a wide field of view, enabling the visualization of individual red blood cells and vessel walls — key elements for investigating vascular responses in NVC.

However, the origin of the phase contrast remains partially understood, which limits the ability to optimize imaging parameters for different retinal features (Figure 1). Understanding the underlying scattering mechanisms is thus essential for improving image contrast and interpretability.

Internship objectives:

The goal of this internship is to develop a **Retinal Digital Twin** to study the origin of phase-contrast retinal imaging. The intern will contribute to the following objectives:

1. Develop a Retinal Digital Twin using **Monte Carlo simulations**.
2. Investigate the influence of different imaging parameters on image contrast.
3. Validate the findings using the existing AO-RSO imaging system.
4. Determine an optimal imaging configuration to maximize contrast for red blood cell imaging.

This work will involve close collaboration with researchers, engineers, clinicians, and PhD students from the **Institut Langevin** and the **Paris Eye Imaging Group** at the **Quinze-Vingts National Ophthalmology Hospital** (Paris).

Part of the internship will take place at Quinze-Vingts, where the imaging data required for NVC studies will be acquired.

Internship duration: M2: 5-6 months

Possibility to continue in a PhD program: Yes.

How to apply? Interested applicants should send a **motivation letter** and a **CV** including the names of two references.

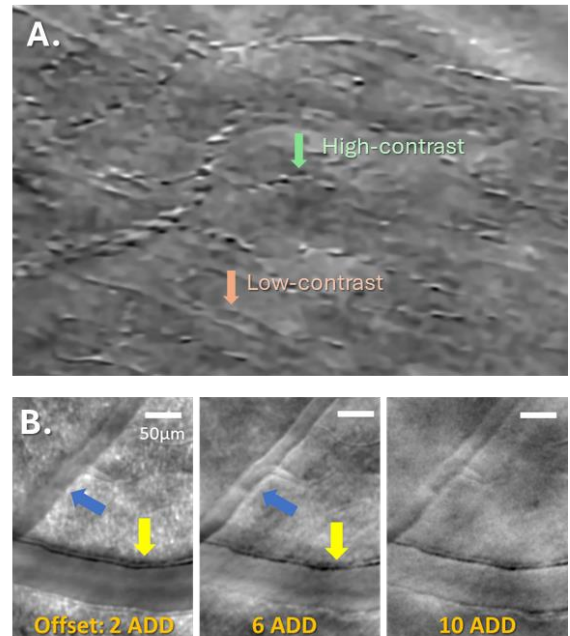


Fig. 1: A) Red blood cells imaging in the living human retina. Red blood cells present different image contrast across the field-of-view. B) The change of image parameters affects differently the contrast of different retinal features.