

MASTER 2

SINGLE-CELL CHARACTERIZATION IN MICROFLUIDIC ENVIRONMENTS USING HOLOGRAPHIC OPTICAL TWEEZERS

Laboratory: Transfer-Interface-Mixing (TIM) group, TBI – Toulouse Biotechnology Institute (INSA Toulouse, CNRS, INRAE)

Location: Toulouse, France

Duration: 5-6 months

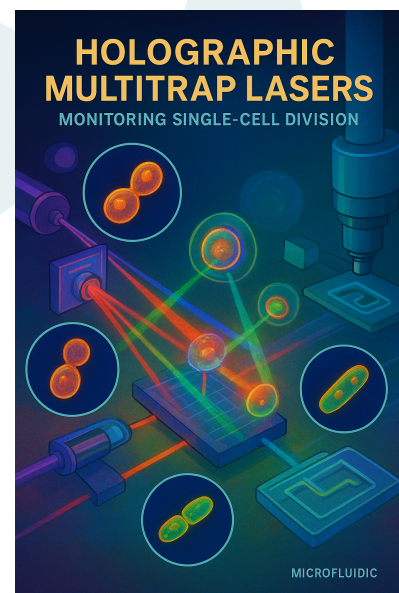
Level: Master 2 (or equivalent engineering degree)

Start date: January 2026 (flexible)

Supervisor: Mickaël Castelain – mickael.castelain@insa-toulouse.fr

Framework: SCUBA Project (2026–2029) ANR-25-CE51-7100-01

Possibility to continue as a PhD starting October 2026



CONTEXT

Modern bioprocesses rely on a precise understanding of cell-environment interactions to optimize yield, robustness, and product quality. Yet, at the industrial scale, imperfect mixing in bioreactors generates fluctuating microenvironments (in pH, oxygen, temperature, or nutrient availability) that strongly influence microbial physiology. The **SCUBA project** (*Exploring the single cell to understand the bioreactor*) aims to bridge the gap between microscale cell behavior and large-scale bioreactor performance. It develops a novel experimental platform combining **microfluidics**, **fluorescence imaging**, and **Holographic Optical Tweezers (HOT)** to study single microbial cells in real time under controlled and dynamic environmental conditions.

OBJECTIVES OF THE INTERNSHIP

The intern will participate in the development, optimization, and experimental validation of the SCUBA microfluidic platform, working jointly with the SCUBA team and an engineer dedicated to upgrading the existing optical tweezers setup toward a holographic input system.

Depending on the student's profile, the work will include:

- **Experimental development and testing:**
 - Participate in the upgrade of the optical tweezers setup to a holographic system using a spatial light modulator with support of a dedicated engineer
 - Align and calibrate the optical path for the simultaneous trapping of multiple microbial cells.
 - Integrate microfluidic chips allowing exposure of trapped cells to controlled environmental changes.
 - Use fluorescence microscopy to monitor cell physiological responses (e.g., pH, O₂, temperature).
- **Data analysis and modeling (optional):**
 - Analyze single-cell behavior under fluctuating environments.

- Contribute to the coupling of experimental data with population or metabolic models developed within the SCUBA framework.

The project offers hands-on experience in **optical system design**, **microfluidic manipulation**, and **single-cell biophysics**, in close collaboration with experts in optics, microbiology, and bioprocess modeling.

CANDIDATE PROFILE

- Master 2 student in **biophysics, bioengineering, biotechnology, physical chemistry, or related fields**.
- Strong motivation for **interdisciplinary experimental work** at the interface of **physics and microbiology**.
- Skills or genuine interest in **optics, laser manipulation, microscopy, or microfluidics** are highly desirable.
- Experience in **image analysis** (ImageJ, Python, MATLAB) or **instrument control** (LabVIEW, Python) is a plus.
- Team-oriented and motivated to work in a **collaborative research environment** with scientists and engineers.

SUPERVISION AND ENVIRONMENT

The internship will take place within the **Transfer-Interface-Mixing (TIM)** group at the **Toulouse Biotechnology Institute (TBI)**. The TIM group gathers complementary expertise in **bioprocess engineering, fluid dynamics, microbiology, and optical manipulation**, fostering a multidisciplinary approach to biotechnological research.

The student will work closely with the **SCUBA team** and an **optical engineer** responsible for implementing the holographic optical tweezers upgrade, under the supervision of **Mickaël Castelain**. This internship is embedded in the **ANR SCUBA project (2026–2029)** ANR-25-CE51-7100-01, and successful candidates will be encouraged to pursue a **PhD starting in October 2026**, continuing the research initiated during the internship.

APPLICATION

Please send the following documents in a **single PDF file** to mickael.castelain@insa-toulouse.fr

- Curriculum Vitae
- Motivation letter (max. 1 page)
- Academic transcripts (Bachelor and Master 1, if available)
- 2 letters of reference