Master Thesis: Low-Cost Raman Spectrometer & Microscope

Development, Optical Optimization, and Field Applications for Microplastic Sensing

Institution & Lab:	LNET – Laboratory of Nanoscience for Energy Technologies (EPFL)
Academic Supervision:	Prof. Giulia Tagliabue (Head of Lab) | Diana Dall'Aglio (Supervisor)
Sailowtech Lead:	Sara Maisonhaute (President of Sailowtech MAKE Project)
Target Application:	Field-deployable, low-cost detection and characterization of microplastics

1. Context & Objective

Microplastic pollution poses a critical threat to marine ecosystems. Identifying these sub-millimeter particles requires label-free chemical fingerprinting, a capability unique to Raman spectroscopy. However, commercial instruments are expensive, bulky, and unsuitable for field oceanography. In collaboration with **EPFL LNET** and the **Sailowtech MAKE project**, this master project aims to build and optimize an open-source, affordable, and field-deployable Raman microscope for shipboard sampling.

2. Current System Status & Prior Generations

This master project builds upon two successful preceding student projects (Alexandre Blaga & Iacopo Rebecchi, Spring 2026), which laid the optical and structural foundations:

- **Generation 1 – Optical Bench & Proof-of-Concept:** Established the core optical architecture, evaluated key tradeoffs (excitation wavelength, filter optical density, blazed grating efficiency), and developed the initial alignment protocols and custom camera acquisition software.
- **Generation 2 – Casing & Setup Upgrades:** Encapsulated the setup into a ruggedized, portable case for field transportation, improved photon efficiency by upgrading the beam-splitting optics, added secondary longpass filtering to block stray laser light, and integrated power management for field readiness.

While significant structural and optical progress has been made, a clear Raman spectrum cannot yet be identified due to residual Rayleigh scattering and photoluminescence, setting the exact baseline for this next project phase.

3. Immediate Next Steps & Strategic Roadmap

- **Laser & Rayleigh Rejection Upgrade:** Minimize residual laser background reaching the camera and optimize excitation source power and spectral stability to resolve clear Raman spectra.
- **SERS Signal Amplification:** Design and fabricate plasmonic nanostructures (gold/silver substrates at EPFL CMi cleanroom) to boost Raman signal by 10^6–10^{10} for sub-micron microplastic detection.
- **Ruggedized Field Encapsulation:** Finalize IP-rated casing, modular 3D-printed mounts, and battery integration for shipboard deployment.

4. Key Student Opportunities

- **Academic Publication:** Strong experimental results (especially SERS integration and resolving the Raman signal bottleneck) offer concrete potential for a co-authored peer-reviewed scientific paper.
- **Summer 2027 Oceanographic Expedition:** High involvement and solid results will give the student the unique opportunity to join the Sailowtech sailing expedition at sea in Summer 2027 to test and deploy the instrument in real marine conditions.

5. Ideal Student Profile

- **Autonomous & Proactive:** Takes ownership of the setup, independently explores literature, and proposes creative optical/mechanical fixes.
- **Iterative & Resilient mindset:** Comfortable with hands-on trial and error. Aligning low-cost optics and isolating weak signals requires patience and many experimental iterations.
- **Technical Background:** Microtechnology, Optics, or Physics with strong interest in practical optics and nanofabrication (CMi cleanroom).