INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: LPICM
CNRS identification code: UMR 7647
Internship director'surname: NOVIKOVA Tatiana
e-mail: tatiana.novikova@polytechnique.edu Phone number: 06 72 14 46 58
Web page: https://lpicm.cnrs.fr/
Internship location: LPICM, Ecole polytechnique, Palaiseau, 91120, France

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Towards Real-Time Brain Surgery: Polarimetric Assessment of the Partial Mueller Matrix Macroscope

Background. During neuro-oncological surgery, accurately distinguishing between healthy and diseased tissue is critical for successful tumor removal and preserving neurological functions. However, this remains difficult with current surgical microscopes. The HORAO project (https://horao.eu/) addresses this challenge by focusing on visualizing the brain's microarchitecture during surgery, where the absence of brain fibers often indicates tumor tissue. Studies using wide-field imaging Mueller polarimetry (IMP) have demonstrated it to be a promising technique for differentiating tissue and tracking brain fibers, based on depolarization, linear retardance, and azimuth orientation maps. Our current imaging system utilizes the full Mueller matrix (MM) to characterize the interaction between polarized light and biological samples, requiring 16 separate intensity measurements followed by complex data processing. Recent studies, however, suggest that a simplified form of the Mueller matrix can achieve similar results, opening the door to a more efficient and real-time system.

Aim. This project aims to integrate and evaluate a new partial polarimetric imaging system designed for simplified, real-time data acquisition. You will focus on calibrating, optimizing, and testing the system with calibration samples and brain phantoms that mimic real tissue. In collaboration with the University Hospital of Bern, the system will ultimately be tested and validated with real brain tissue, ensuring it delivers high-quality, real-time imaging suitable for surgical applications.

Materials and Methods. A major challenge in this project will be defining robust performance assessment metrics, using reference samples that can also be applied to biological tissue. You will learn how to calibrate and optimize polarimetric instruments efficiently using various methods, with a strong focus on ensuring real-time operation and precision in a surgical setting.

This project offers hands-on experience in optical physics, image processing, and understanding light behavior in brain tissue for real-world medical applications. As part of a large multidisciplinary effort, you'll collaborate with experts in various fields, enhancing your scientific experience and practical skills.

Proposed duration: 6 months

Applicant profile: Master's student with focus in physics/photonics/biomedical engineering.

Required skills and interests: Basic hands-on knowledge in optics, image processing and programming. Interest in biomedical applications.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: NO Soft Matter and Biological Physics: YES
Quantum Physics: NO Theoretical Physics: NO