Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Full time from April 2026 (it can start part time from February 2026)
Presentation date to be chosen: end of July or beginning of September 2026

Note: The main Master Thesis supervisor has to be a professor of the Master in Photonics program. One co-supervisor (internal or external) can be defined. Main Supervisor is responsible for the subject of the proposal and has to give continuous support to the student (research development, Report writing and presentation preparation). For external proposals a co-supervisor from the Master program and a collaboration agreement with UPC are needed.
You can find all information about the Master Thesis process in our webpage.

Laboratory: Medical Optics
Institution: ICFO – Institut de Ciències Fotòniques
City, Country: Castelldefels (Barcelona), Spain

Title of the master thesis:
Validation of a multi-modal diffuse optical device for bone fragility assessment in osteoporosis patients.

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Keywords: medical optics, photon diffusion, time-domain near-infrared spectroscopy, laser speckle technologies, diffuse correlation spectroscopy, osteoporosis

1. **Summary of the subject (maximum 1 page):**

Preliminary studies suggest that diffuse optical technologies can non-invasively estimate bone strength at various skeletal sites with promising results. By quantifying tissue collagen and lipid content, oxygenation, and blood-flow index, such technologies offer potential to assess bone-quality parameters overlooked by current osteoporosis diagnostic technologies (e.g., DXA) — such as collagen integrity, marrow fat, porosity and vascularity — thus improving identification of osteoporosis patients at highest fracture risk and guiding treatment decisions.

This project aims to deploy and test a multi-modal diffuse optical device to retrieve additional complementary biomarkers of bone fragility at multiple bone locations, overcoming the limitation of current diagnostic protocols. By measuring tissue scattering and absorption properties that reflect

collagen content, lipid accumulation, porosity, and microvascular perfusion and oxygenation, the device will afford additional insights into bone matrix integrity and vascularization—parameters not captured by current diagnostic techniques. We hypothesize that incorporating non-invasive optical assessment of bone fragility into clinical practice will improve diagnostic accuracy and fracture-risk stratification in osteoporosis patients.

The device combines clinical ultrasound with two different diffuse optical spectroscopy techniques, time-domain diffuse optical spectroscopy (TD-DOS, also known as time-resolved spectroscopy - TRS) and diffuse correlation spectroscopy (DCS), which are non-invasive techniques using near-infrared light to monitor deep-tissue (1–3 cm) hemodynamics and composition.
DCS, by measuring laser speckle fluctuations induced by red blood cell movement, is able to quantify regional microvascular blood flow; TD-DOS, by measuring wavelength selective tissue scattering and absorption, is able to quantify tissue structure (i.e., porosity) and composition, retrieving concentration of components such as oxygenated and deoxygenated hemoglobin, lipid, collagen and water. These techniques are often used simultaneously since they offer complementary physiological information about the tissue probed, combination that allows to retrieve the effective oxygen transport to the tissue and its extraction (i.e., tissue metabolism), and nowadays have been clinically validated in a wide range of situations and pathologies.

The project will be carried out at ICFO, in collaboration with Rheumatology department of Hospital Clínic de Barcelona / IDIBAPS (Dra P. Peris).

References:
-Durduran T. et al., Rep Prog Phys.73(7):076701. doi: 10.1088/0034-4885/73/7/076701 (2010)
-Cortese L. et al., Biomed Opt Expr:12, 6 3392 (2021)
-Konugolu Venkata Sekar S, PLOS ONE, 11(12): e0168426 (2016)

2. Objectives (maximum 1 page):

The student will adapt an existing multi-modal diffuse optical device for performing measurements on multiple bone locations, such as calcaneus, trochanter, sternum and radius. The student will evaluate the performances of device and different probes for different bones in laboratory settings by the use of standard tissue simulating phantoms, reproducing tissue optical and hemodynamic properties. The student will perform an *in vivo* study in healthy subjects (and, in case it is possible, on a small set of osteoporosis patients) evaluating possible sources of artifacts on the optical signal (i.e., subject movements, external light contamination, probe pressure on tissue, etc.) and seek for solutions to limit their contribution. Ultimately, the student will correlate the measured optical data to subject demographic data, sex, bone locations, age, body mass index, etc. and, in case of patients, standard indicators of bone fragility.

Specific tasks:

- Learn principles of diffuse optics and near-infrared spectroscopy applied to medicine
- Familiarize with the technology and data analysis algorithms
- Adapt and test different device probes for different bone locations in laboratory settings and pre-clinical environment (with tissue simulating standard phantoms)
- Validate the use of the device and probes *in vivo* in healthy subjects and, if possible, in a small set of osteoporosis patients in multiple bone locations