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

MASTER THESIS PROPOSAL

Dates: April 2023 – July or September 2023

Laboratory: Optical Trapping Lab-Grup de Biofotònica, Departament de Física Aplicada
Institution: Universitat de Barcelona (UB)
City, Country: Barcelona, Spain

Title of the master thesis: Super-resolution structured illumination microscopy at extra large fields of view

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Keywords: Structured illumination microscopy, super-resolution microscopy, fluorescence microscopy, spatial light modulation, acousto-optic deflectors

Summary of the subject:

At the turn of the 21st century, Moerner, Betzig and Hell invented optical nanoscopy, for the first time breaking the diffraction barrier, an apparently insurmountable obstacle that had severely limited the resolution of optical microscopes since their inception. These new super-resolution microscopies opened up a world of possibilities for observing molecular-scale features in biological samples, unreachable until then. Unfortunately, these initial super-resolution techniques are very extreme: they excel in discriminating tiny details in microscopic samples but perform poorly in other crucial metrics. For example, STED microscopy uses high power lasers that focused on the sample cause deleterious effects on living specimens. PALM-STORM and other single-molecule localization microscopies are based on an excruciatingly slow process of imaging molecule by molecule, which may need tens of minutes to compose a single meaningful image. Fortunately, different alternatives have emerged in the last years to challenge these largely one-sided super-resolution microscopies, through a more balanced set of properties. Among these, structured illumination microscopy (SIM) is quickly gaining a reputation as an ideal fluorescence imaging technique for many biological studies due to its affordability, use of conventional fluorescent dyes and low light dosages, speed and resolution. Our group in the University of Barcelona has invented and patented a SIM technology, based on acousto-optic devices, that is extremely flexible, fast and efficient and that will be converted into a commercial product

in the upcoming months. However, a major limitation of our technology is a limited field of view (≈90 μm for a 100x objective), which is roughly half of what modern sCMOS fluorescence microscopy cameras allow.
The student that chooses this master thesis will help us overcome this issue by upgrading our current microscopy prototype with a new generation of acousto-optic deflectors and improved algorithms. A skilled student should be able to drive the development to the point of eventually obtaining super-resolution images of cellular samples (Fig.1) on a greatly expanded (≈200 μm), commercially competitive field-of-view.

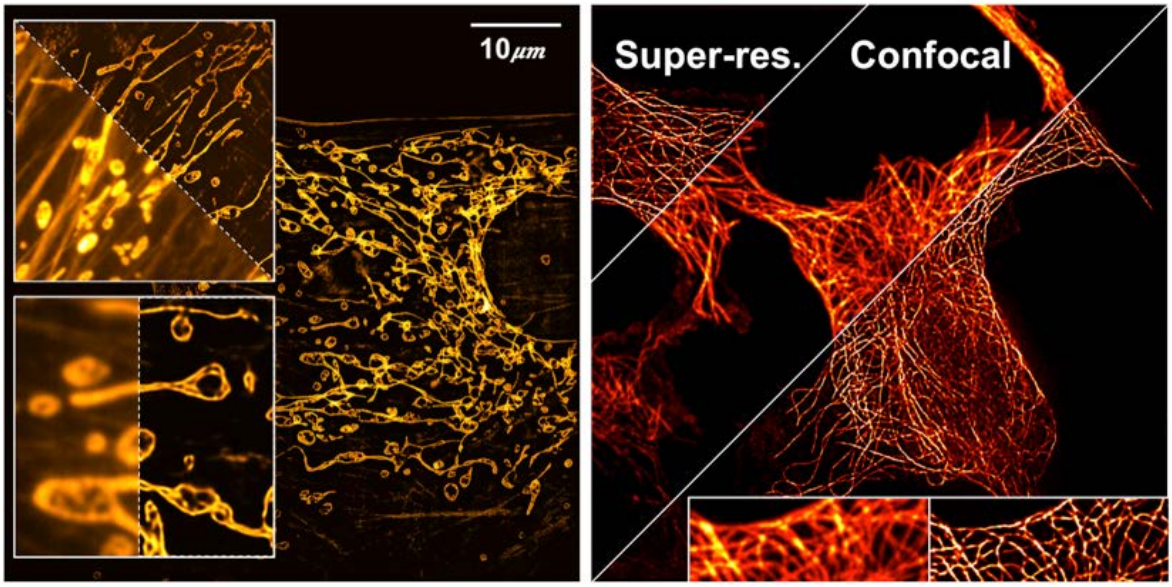

Fig. 1. *Super-resolution SIM images of mitochondria in BPAE cells (left) and microtubules in COS7 cells (right) obtained with current prototype.*

Objectives:
The final goal is the upgrade of a structured illumination microscope prototype in order to roughly double the field of view, through the use of more advanced devices and modifications to our control algorithms.
The master thesis therefore will have an experimental side in the optics lab and another involving programming for the development of algorithms and simulations.
More details will be individually discussed with the candidates.

Additional information:
* Required skills: Disposition for experimental work in a microscopy lab, interested in biophotonics, proficient in a computer language with preference for Matlab, Python and LabVIEW.
* Miscellaneous: Early incorporation is possible.