Master in Photonics – “PHOTONICS BCN”
ERASMUS+ “EUROPHOTONICS”

MASTER THESIS PROPOSAL

Dates: April - September 2020

Laboratory : Optical Trapping Lab - Grup de Biofotònica (BiOPT)
Institution: Department of Applied Physics, Universitat de Barcelona
City, Country : Barcelona, Spain

Title of the master thesis: Programmable Laser Microscope based on Acousto-optic Modulation

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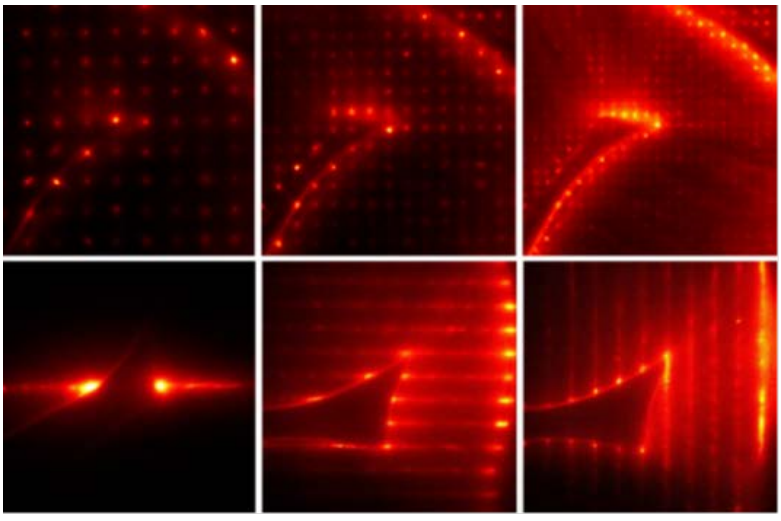
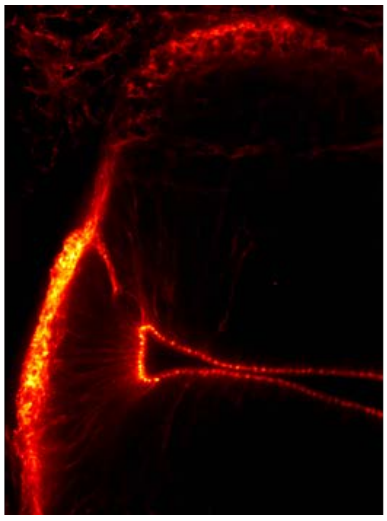
Keywords : Confocal microscopy, fluorescence microscopy, programmable array microscope

Summary of the subject (maximum 1 page):





The confocal microscope is the workhorse for sample visualization in all fields of cell biology and biomedical research due to its contrast, resolution and optical sectioning capacity. However, imaging technologies in general, and confocal microscopy in particular, are subjected to the so-called "triangle of frustration", a principle that states that the main quality criteria when acquiring an image, such as spatial and temporal resolution, optical sectioning

capacity, signal-to-noise ratio or photo-toxicity, are mutually incompatible magnitudes. In other words, these quantities are linked in a way that prevents their simultaneous maximization since improvement in one magnitude is always accomplished to the detriment of the other ones. The consequence is the existence of a multiplicity of confocal instruments, each of them embodying a particular trade-off between the different quality parameters, with a narrow, specialized field of application. For example, single point confocals provide exceptional contrast and optical sectioning ability but are very slow so that they can only be used with fixed (i.e. dead) samples. "Spinning disk" confocals are very fast (up to thousands of images per second) and very gentle with the samples so that they are optimal for live cell microscopy but the image quality, especially for thick samples such as embryos, is poor.
In general, a single instrument cannot satisfy the needs of the average user in cell biology, who needs to resort to several devices at a cost of hundreds of thousands euros per instrument.
At the BiOPT we have devised a technology concept that transcends conventional confocal microscopy as it can implement multiple imaging modes and scanning modalities using a single optical device. As the illumination patterns and matching confocal apertures can be synthetized by digital means, the main characteristics of the microscope (speed, resolution, optical sectioning ability, photo-toxicity and photo-bleaching, etc.) can be tuned according to user's demands. This concept has been pursued both by academia and industry for a long time (under the name of "programmable array microscope" or PAM) but prior attempts have been only partially successful in such a way that there are no systems commercially available yet. Ours will be the first commercial incarnation of a working PAM.
This MSc thesis aims at systematically comparing the performance of our microscope to the individual instruments we aim to replace in terms of speed, resolution, SNR, phototoxicity, etc. through a combination of approaches including computer simulation and lab work.
As the final objective of the group with this technology is starting up a company in the upcoming months, confidentiality of the results may be required from the applicant.
Also, a monthly economic compensation will be negotiated depending on the commitment and CV of the applicant student. Further collaboration once the MSc has been completed is possible within the context of the startup.

Additional information :
* Required skills : Python or Matlab programming fluency and interest in biophotonics. A complementary background to that of most current group components (in Physics), such as Electronic or Biomedical Engineering is a plus.
* Miscellaneous : A monthly stipend will be agreed upon based on the student's background and achievements.