Stage de master de physique / Physics Master Internship

Proposition de stage/ Internship proposal (1 page max)

Date de la proposition : 19/11/21

Responsable du stage / *internship supervisor*:

Nom / *name*:	**Ronzitti**	Prénom/ *first name* :	**Emiliano**
Tél :	+33 1 53 46 2702	Fax :	
Courriel / *mail*:	emiliano.ronzitti@inserm.fr		

Nom du Laboratoire / *laboratory name*: **Institut de la Vision**

Code d'identification : UMRS 968 Organisme : Inserm

Site Internet / *web site*: www.institut-vision.org/en/wavefront-engineering-microscopy.html

Adresse / *address:* 17 rue Moreau

Lieu du stage / *internship place*: Institut de la Vision, 17 rue Moreau, 75011 , Paris

Titre du stage / *internship title*: Development of three-photon excitation strategies for all-optical in-depth neuronal circuits investigation

Résumé / *summary*

Motivation: A full understanding of brain functioning remains an unsolved challenge for science. In the last decade, neuroscientists conceived a revolutionary approach to reach this goal by proposing *optogenetics* (*2*), a genetic strategy to make neurons sensitive to light, such that the neuronal activity can be *all-optically* recorded and triggered by detecting and delivering light into the brain. This new research framework dramatically called into question physics as, once established that light can control neurons, new methodologies must be put in place to control the light across millions of neurons entwined in a scattering medium like the brain.

Two-photon excitation (2PE) (*3*) is at the moment the gold standard for *in vivo functional imaging* (*4*) and *light-targeting photostimulation* (*5*). Recently, novel strategies for functional volume imaging and holographic-based light shaping (*6*) enabled the extension of neuronal 2PE optical investigation to large population of neurons across a 3D volume(*7–11*). Nevertheless, light scattering limits 2PE investigations to superficial cortical areas extending only few hundred microns in the brain.

Aim: Aim of this project will be to study and implement strategies for in-depth *all-optical* circuits optogenetic able to overcome these limitations by integrating current approaches with three-photons excitation (3PE) (*12*, *13*). 3PE has few major advantages over 2PE, namely: *(i)* reduction of scattering due to longer wavelengths; *(ii)* higher excitation localization, which axially falls off as $\sim 1/z^4$ (with z distance from the focal plane), compared to $1/z^2$ in 2PE; *(iii)* optimum excitation wavelengths window (ranging around 1700nm) due to brain tissue absorption. The candidate will work on the design, the realization and the validation of 3PE light delivery systems based on *ad hoc* laser sources for 3P excitation featuring low-duty-cycle and high-energy pulses. The system will be developed in the framework of a project aiming to extend for the first-time circuits optogenetic to subcortical areas of brain in living animal. Not only limited to neurobiology, the research outcomes are expected to step beyond giving more general physical insights to light-matter interaction and control of light in turbid media.

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : Oui**

Si oui, financement de thèse envisagé/ *financial support for the PhD***: Fonds propres du laboratoire ou bourse ministérielle**

References

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