Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: LKB
CNRS identification code: UMR8552
Internship director'surname: Sylvian GIGAN, Hilton BARBOSA DE AGUIAR
e-mail: sylvain.gigan@lkb.ens.fr Phone number:
Web page: http://www.lkb.upmc.fr/opticalimaging/
Internship location: ENS, 24 rue Lhomond, 75005 Paris

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

Exploiting wavefront shaping for ultrafast nonlinear spectroscopy of complex systems

Ultrafast nonlinear spectroscopy encompasses a set of optical techniques that aim at unraveling ultrafast phenomena (on sub-picosecond timescales), such as biological light-harvesting complexes and charge-carrier dynamics in quantum dots. Yet, many of the systems of interest, such as biological tissues, foams, photovoltaic structures etc, are highly complex, and extending these techniques to address questions on complex scattering materials is currently extremely challenging: ultrashort lasers pulses quickly deteriorates when impinging on scattering media, making a time-resolved measurement impossible.

Our group has been pioneer in exploiting wavefront shaping techniques to image and focus light at will in complex media. In particular, this concept has emerged as a potential solution to increase the penetration depth of nonlinear microscopy in complex biological systems1. Recent outcomes have shown that manipulating wavefronts of (I) coherent monochromatic light allows for increasing the energy deposition within the medium2, and (II) for controlling the spatio-temporal behavior of ultrafast pulses outside the medium3. While most efforts are focused on high-resolution biomedical applications, little has been devoted to ultrafast spectroscopy.

In this project, we aim at exploiting these two effects in order to increase the energy deposition within a nonlinear medium efficiently. We are looking for a candidate interested in an experimental approach, at the crossing of fundamental physics and ultrafast optical phenomena. The project will involve (i) sample fabrication combining non-linear optical materials with multiple scattering (ii) designing and operation state-of-the-art setup for wavefront shaping of ultrafast pulses and (iii) non-linear spectroscopy studies. The project will be co-supervised by SG and by Hilton B. de Aguiar.

Depending on the outcome of the project, it could potentially follow up as a PhD project, which will explore how this spectroscopic approach can be combined with microscopy, towards so called "micro-spectroscopy" in complex systems. Informal queries are welcome.

[1] Gigan Nat. Photonics 11, 14 (2017).
[2] Ojambati et al. New J. Physics 18, 43032 (2015).
[3] Mounaix et al. Phys. Rev. Lett. 116, 253901 (2016); Boniface et al. arXiv:2007.09050

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

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