MASTER M2 PROJECT 2019

At : Institut Fresnel, Domaine Universitaire St Jérôme Marseille

Optical imaging deep in scattering media (optics : experimental, modelling and data analysis)

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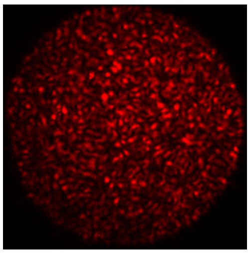
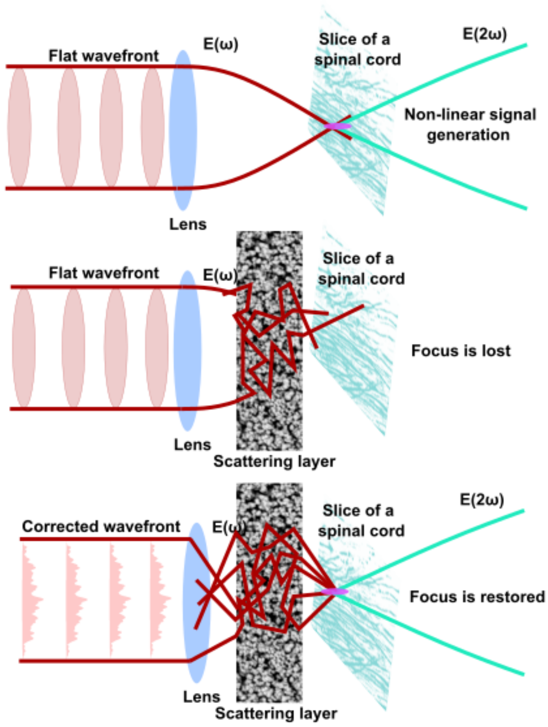
Keywords: optical imaging; complex media; scattering; microscopy; nonlinear optics

The MOSAIC team at Institut Fresnel (http://www.fresnel.fr/mosaic) aims at developing novel optical microscopy techniques that push the limits of biological imaging beyond the state of the art. Optical microscopy in biological tissues is currently mainly limited by their disordered nature, which cause multiple light scattering. This effect does not allow to focus light deep inside the biological medium and therefore prohibits or nonlinear imaging. At a first glance what is seen on the detector seems to be a random light intensity distribution (speckle) caused by multiple scattering (the same effect be seen pointing laser pointer at a white wall)[figure 1], however this speckle is deterministic and defined by positions of scattering particles.



Shaping the wavefront of incident light it is possible to compensate multiple scattering and restore a focus deep inside a medium (figure 2) (see reference). This can be achieved by use of a spatial light modulator - a device that pixel by pixel controls a phase of a wave front. Wave front shaping however requires having access to the optical field map at the other side of the scattering medium, which is not suitable for clinical/biological applications. Other approach, called adaptive optics, optimizes a wavefront using nonlinear generated signal as a feed back (non-linear signal is proportional to how tightly the light is focused).



In this project, we want to understand the link between the two approaches, with the far goal to develop a wave front shaping strategy in reflection for biological samples. The student will contribute to the development (in collaboration with a postdoc fellow) of an adaptive optics set-up. Adaptive optics will be applied to the imaging of fluorescent or nonlinear optical nanoparticles buried inside a scattering medium, for instance, a mouse spinal cord. The project is mainly instrumental but it involves also image analysis and model development for the propagation of light in scattering media. The project brings together fundametal questions of light propagation in biological media and applications, namely developing real techniques and devices that can be used in hospitals.

Required skills and interests: basic knowledge in optics, interest in experimental work, in physics of complex systems, image processing and programming.

Financial support: 570 € / month

Reference: H. B. De Aguiar, S. Gigan, S. Brasselet, Enhanced nonlinear imaging through scattering media using transmission matrix based wavefront shaping, Phys. Rev. A, 94, 043830 (2016)