Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage

Date de la proposition : 03/11/2016

Responsable du stage / *internship supervisor*:

Nom / *name*:	Popoff	Prénom/ *first name* :	Sébastien
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Nom du Laboratoire / *laboratory name*: Institut Langevin

Code d'identification : UMR 7587 Organisme : CNRS/ESPCI

Site Internet / *web site*: https://www.institut-langevin.espci.fr/home?lang=en

Adresse / *address:* 1, rue Jussieu, 75005 Paris

Lieu du stage / *internship place*: 1, rue Jussieu, 75005 Paris

Titre du stage / *internship title*: Acousto-optical Transmission Matrix

This internship is co-supervised by François Ramaz (francois.ramaz@espci.fr) and Mathias Fink (mathias.fink@espci.fr).

Conventional imaging techniques do not allow retrieving images deep inside biological media because of diffusion. The trajectories of the photons are deviated as they encounter inhomogeneities. Acousto-optic imaging uses ultrasound, which are 1000 times less scattered by biological tissues, to "guide" light deep inside the medium. An ultrasound focus spot is generated, it shifts the frequency of the photons that went through this specific area. It is then possible to select the "tagged" photons and scan the focus spot to obtain an optical image deep inside the medium. The Langevin Institute plays a major role in the developpement of acousto-optic imaging techniques [1]. A limitation is the resolution that is fixed by the ultrasound focus spot, which is much bigger that typical optical resolutions.

In parallel, the development of spatial light modulators – devices that allow controlling the amplitude and/or the phase of the light over millions of pixels – created the emergence of new techniques called "wavefront shaping". They opened the possibility to control light propagation through or inside scattering media [2]. In particular, we conducted at the Langevin Institute the first experiments resulting in the measurement of the transmission matrix [3] of a disordered optical system thanks to wavefront shaping. The transmission matrix of a linear medium completely characterizes its transmission properties between an input and an output plane.

Recently, techniques were developed to use wavefront shaping with acousto-optic imaging to improve the resolution below the ultrasound resolution [4]. The goal of this internship is to combine the acousto-optic techniques with the measurement of the transmission matrix. The "acousto-optical" matrix characterizes the transmission properties of only the photons that were "tagged" by the ultrasounds. The knowledge of this matrix would allow controlling the optical field deep inside an inhomogeneous medium on a scale comparable to the optical wavelength and would give valuable information about the optical properties of the media in the region of the ultrasound focus spot.

Taking advantage of the expertise of the Langevin Institute in the manipulation of light in complex media, the intern will use wavefront shaping and acousto-optics techniques to measure and study the acousto-optical transmission matrix. He will in particular study imaging applications and the properties of this matrix.

[1] Ramaz, François, et al. "Photorefractive detection of tagged photons in ultrasound modulated optical tomography of thick biological tissues." Optics express 12.22 (2004): 5469-5474.
[2] Mosk, Allard P., et al. "Controlling waves in space and time for imaging and focusing in complex media." Nature photonics 6.5 (2012): 283-292.
[3] Popoff, S. M., et al. "Measuring the transmission matrix in optics: an approach to the study and control of light propagation in disordered media." Physical review letters 104.10 (2010): 100601.
[4] Judkewitz, Benjamin, et al. "Speckle-scale focusing in the diffusive regime with time reversal of variance-encoded light (TROVE)." Nature photonics 7.4 (2013): 300-305.

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

Si oui, financement de thèse envisagé/ *financial support for the PhD***:**

Lumière, Matière, Interactions	**X**	Lasers, Optique, Matière	**X**