Postdoctoral position (2 years)
Institut Langevin ESPCI Paris
Starting september/october 2024

Novel laser sources and real-time detection for in-vivo acousto-optic imaging

The work will be shared between the Institut Langevin (Paris) and the Laboratoire Charles Fabry (Palaiseau)
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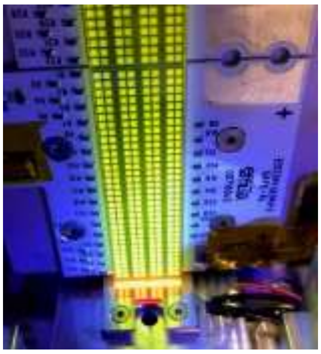
Imaging biological tissue with light is a great challenge for the detection of objects (e. g. tumors) at large depth (>cm), since multiple scattering processes prevent from a conventional imaging. The combination of ultrasound (US) and light within the medium allows to retrieve an optical information *guided* by the ultrasound beam, ballistic at medical application frequencies, e.g. 6MHz. Such a strategy is called Acousto-Optic Imaging (AOI), also called Ultrasound Optical Tomography (UOT), it is based on the acousto-optic effect (AO). Such an imaging is developed by many teams worldwide, in the scope to develop a bi-modal system for Medicine and Biology, in combining complementary contrast with ultrasound (e.g. conventional B-Mode imaging) and light. Many architectures have been studied up to now, but technological bottlenecks remain in order to go beyond a proof of principle. This is due to the weakness of the acousto-optic signal, itself superimposed on a strong speckle background. Among the various techniques developed at Institut Langevin, digital holography is a promising configuration for the detection, using a CMOS camera with a large number of pixels, while data treatment is optimzed with a GPU acquisition scheme. Original US-excitations are used in order to optimize the number of photons tagged by the US. Such a point will be developed by the candidate with a new fully-programmable US-system.



Light concentrator (LED's+Ce:YAG) pumping laser crystal (in red)

Among those difficulties, a key point stands with commercial laser sources, not powerful enough to compensate a temporal decorrelation (some 100µs) of the signal in the case of in vivo situations. We have a collaboration with the Laser Group at Laboratoire Charles Fabry (Institut d'Optique – Palaiseau), which develops original Quasi-Continuous laser sources (QCW), able to deliver a high power in a limited-time (40Watts). These sources are amplifiers (Alexandrite/Cr:LiSAF) pumped by an ensemble of LED's matrices + Ce :YAG light concentrator, seeded by a laser diode. The final purpose of this postdoc is to built a digital holographic setup with the QCW sources, and apply it to acousto-optic imaging with a programmable US-device on various thick scattering samples, in order to evaluate the potentialities of this new setup.

To run this project, many points will be considered :

- QCW laser source characterization
- Camera + GPU interfacing
- Optical setup & characteristics
- US-device coding for original ultrasound excitations

Candidate profile : PhD diploma required

This project has a strong experimental component, covering instrumental optics, ultrasound manipulation, apparatus interfacing, coding (C++, Matlab), optics in scattering media.

- *Suppression of the Talbot effect in Fourier transform acousto-optic imaging,*
M. Bocoum et al., Applied optics, 2023, 62 (18), pp.4740. (10.1364/AO.488757). (hal-04303757)
- *In vivo ultrasound modulated optical tomography with a persistent spectral hole burning filter,*
Q.M Thai et al, Vol. 13, Issue 12, pp. 6484-6496 (2022), https://doi.org/10.1364/BOE.475449 (open access)