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 optimized 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)