# Acousto-optic with Fourier reconstruction by using spatio-temporaly modulated ultrasonic plane waves

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## 1) Background, Motivation, and Objective:

Acousto-optic (AO) imaging is a technique that allows to map the optical properties of biological tissues in depth by tagging light with ultrasound (US). Current AO sequences are based on focused US pulses and have shown interesting *ex vivo* results but remains too slow for *in vivo* imaging [1]. To increase acquisition speed and then AO imaging framerate, we have developed methods that use US plane wave [2] or US plane waves with subapertures [3] but at the cost of lateral resolution. Here a new type of US sequence is proposed that used a continuous emission of modulated US plane waves to tag light and retrieve directly lateral resolution by Fourier reconstruction without decreasing framerate.

## 2) Statement of Contribution/Methods:

We have developed an AO imaging system based on wavefront adaptive holography detection of photons coupled with an ultrafast US scanner driving a linear array @3 MHz (Aixplorer and SL10-2, Supersonic Imagine, France) allowing to measure AO signal on a photodiode with a good SNR @ 783 nm. An optical phantom of agar-agar intralipid of 25 mm thick, containing two light absorbing inclusions of 3 mm diameter and spaced by 3 mm was tested (scattering coef. 10 $cm^{-1}$ mimicking biological tissues). The US sequence is based on continuous emission of US plane waves which is modulated by a periodic signal with a delay that depends on the transducer position. The used periodic signal is a time slot windows with a time frequency f, which is equal to the spatial frequency $\nu_z$ in (z axis of US) times the speed of sound, and changing of sign for each half-period. The phase is then written as: $\varphi = \varphi 0 - \pi.\nu_z.x$. On figure 1a is presented a simulation of the US field.

## 3) Results/Discussion:

AO image was reconstructed from classical focused US (fig. 1b) and compared to the one obtained with phase modulated US plane wave (fig. 1c). In terms of acquisition time AO image with focused US was obtained in 9 s after averaging versus 2.2 s with the modulated plane waves while maintaining the same SNR for both. Thanks to a high SNR, this last technique is suitable for real-time AO imaging, which is required by various application such as live oxygenation of blood level.

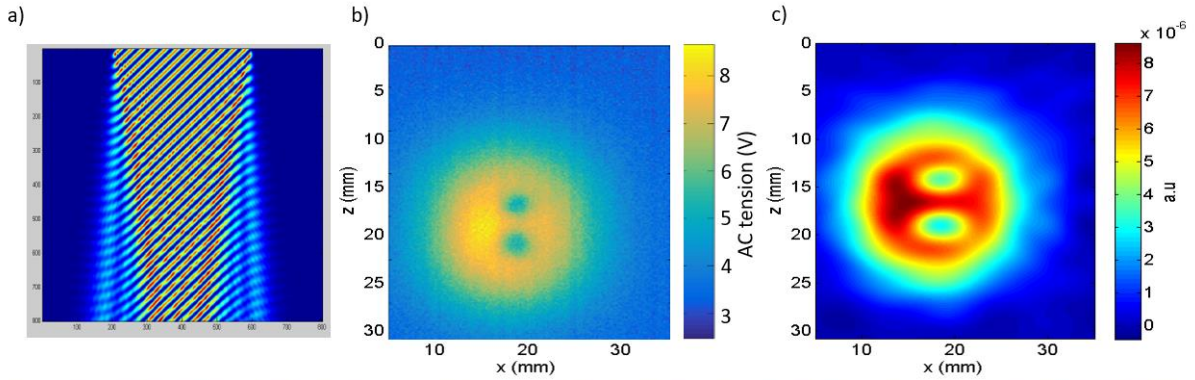


*Figure 1 : a) Simulation of the continuous modulated US field used to reconstruct AO image, b) Experimental AO image obtained with classical US focused AO sequences (192 lines) in an Agar-agar intralipid gel containing two dark inclusions, c) Experimental AO image obtained with the new US sequence in the same gel.*

**References:** [1] Laudereau, J. Biophoton., 2014 [2] Laudereau, Opt. Express 2016 [3] Bocoum, Appl. Opt. 2019