**Acousto-optic signal generation with a nanosecond pulsed laser**

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### Motivation

Realize fast acousto-optics in dynamic media

- Benefits of pulsed laser:
  - Compatibility with photoacoustics
  - High pulse energy/ ns duration
  - Fluence compensation by sound light by combining photoacoustics (PA) and Acousto-optics (AO)
- Short integration time
  - τ<<in-vivo speckle decorrelation time

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### Setup

Ultrasound transducer (TR) 5MHz (Olympus Panametrics-NDT V310)

Camera (CCD)(Allied Vision Technologies Manta G-145B NIR)

Laser:Frequency doubled injection seeded Nd:YAG laser (Newport Quanta Ray lab series 170)

- FG: Function generators, Tektronix AFG 3102
- AMP: Power amplifier, Electronics & Innovation A075
- M: mirrors, BS: Beam splitter 50:50, PBS polarising beamsplitter
- L: 1000mm lens, BE: Beam expander (-50 mm and +75 mm lens)
- BD: beam dump

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### Theory/Method

- Inject two light pulses at different phases of ultrasound
- Two light pulses generate speckle patterns I1 and I2
- CCD camera integrates over both pulses
- Results in reduced speckle contrast
- AO signal ∆C = C0 − C

Where for the pulsed method $C = \frac{\langle I_1(n) + I_2(n) \rangle^2 - \langle I_1(n) + I_2(n) \rangle^2}{\langle I_1(n) + I_2(n) \rangle^2}$

And $C_0$ the contrast without ultrasound applied

For speckle patterns $I_1$ and $I_2$ and pixel $n$ where $\langle . \rangle$ denotes averaging over all pixels.

- 2 Samples
- Both homogeneous cylinders of ø20mm
  - Stable phantom
    - 3% agar 3% intralipid 20% in water
    - Speckle decorrelaration time seconds
    - Time between pulses 100 ns
  - Liquid Phantom
    - 3% intralipid 20% in water
    - Speckle decorrelaration time = 25μs
    - Time between pulses 25 ns
- Resulting double pulse by using 8m delay line:

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### Results

- Stable phantom (US burst length 5 cycles)
- Comparing the contrast reduction of pulsed (A) vs. CW light delivery, (B)
- Liquid Phantom with use of delay line (15 US cycles)
- Differences with above:
  - Different banana shape
  - 5 vs 15 cycle burst US
  - Signal strength
  - π vs π/4 phase shift
  - US burst length

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### Conclusion/Outlook

- Acousto-optic sensing possible in media with short speckle decorrelation time using ns tandem pulses
  - (2x5 ns with 25 ns separation)
- Fast decorrelating samples using delay line are feasible
- Combine with photoacoustics
- Enlarge delay of delay line
- Use biological samples (both ex vivo and in vivo)
- Spectroscopy
- Extend with heterodyne reference arm for:
  - Optic amplification of tagged light
  - Sense electric field of tagged light (wavefront shaping applications)

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