

# Passive optical interferometer without spatial overlap between the local oscillator and signal generation

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A passively stabilized third-order optical interferometer that spatially separates the local oscillator and signal generation is demonstrated with long-term phase stability. The lack of spatial overlap eliminates unwanted contamination of either field. Fully independent optical control over both fields is exerted after the sample. This independence is taken advantage of with what we believe to be a new approach to scanning the relative phase between the local oscillator and signal that has very high precision and reproducibility. The independence of the fields is also exploited in a flexible balanced heterodyne detection scheme.

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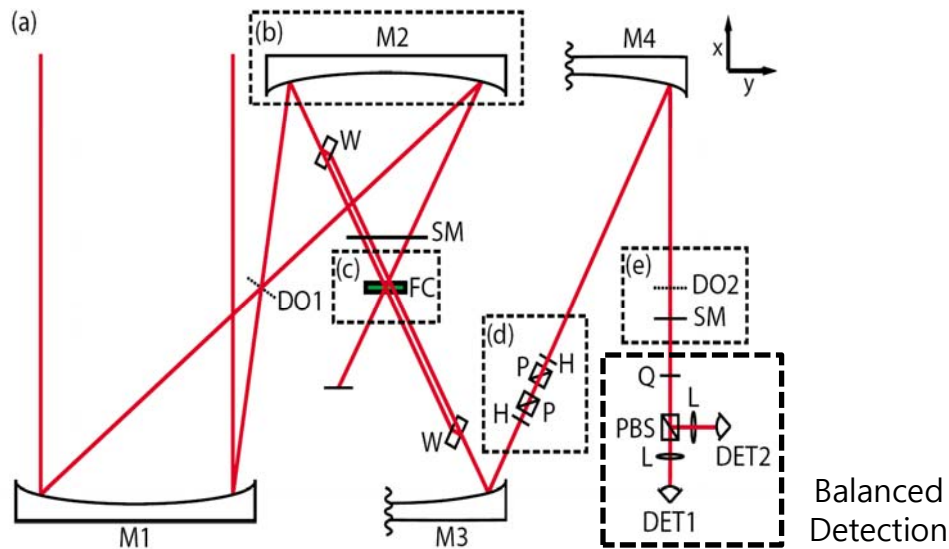
*OCIS codes:* 050.1970, 300.6290, 300.6310, 320.7150.

✓ Spatially separates (independence of the field)

$$I(t) = \frac{n\omega c}{4\pi} |E_{signal}(t) + E_{LO}(t)|^2$$

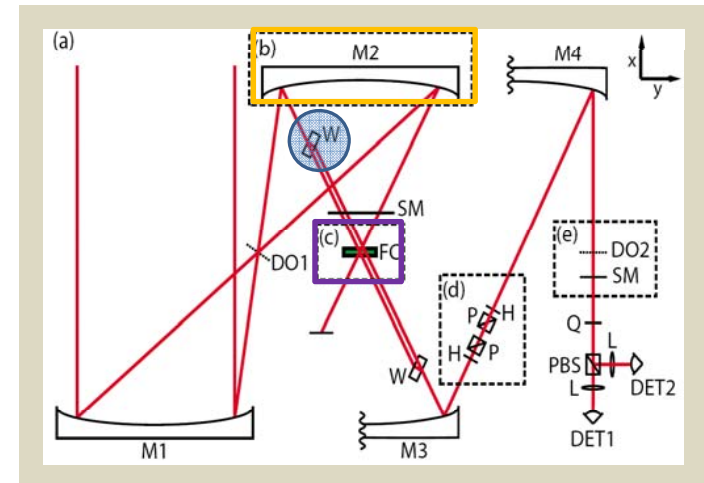
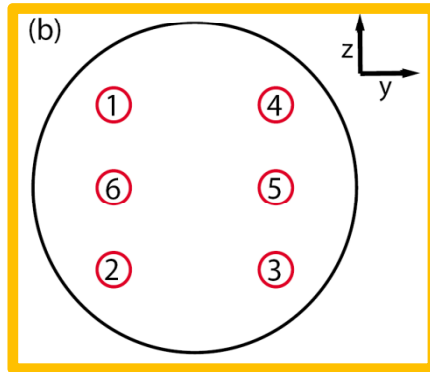
$$= I_{signal}(t) + I_{LO}(t) + \underbrace{\left(\frac{n\omega c}{4\pi}\right) 2 \operatorname{Re}[E_{signal}(t)E_{LO}(t)]}_{I(t)_{heterodyne}}$$

✓ Diagram of experiment



- **M1~M4** : spherical mirror  
(f=0.5, 1.0, 0.5, 0.5 m)
- **DO1, DO2** : diffractive optics
- **W** : window
- **SM** : spatial mask
- **FC** : 1mm flow cell
- **H** : half waveplate
- **P** : polarizer
- **Q** : quarter waveplate
- **L** : lens
- **PBS** : polarizing beam splitter

- ✓ **Beam diagram from the perspective behind M2 with beam numbering.**
- ✓ **diffraction from the two incoming beams forms two vertically displaced time coincident sets of three pulses each (+1,0,-1 diffraction orders) with nearly equal intensity.**



**Fields 1~3** : generate a third-order signal that propagates along the path defined by

$$\text{field 4 } \mathbf{k}_{\text{signal}} = \mathbf{k}_1 - \mathbf{k}_2 + \mathbf{k}_3$$

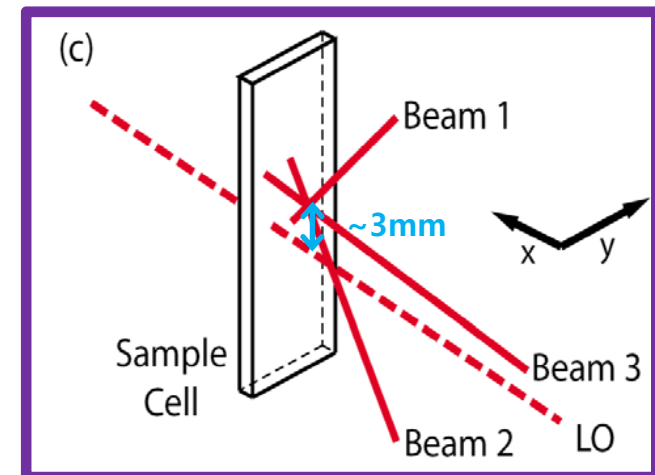
**Field 4** : signal tracer for spatial and temporal alignment of the signal

**Field 6** : block

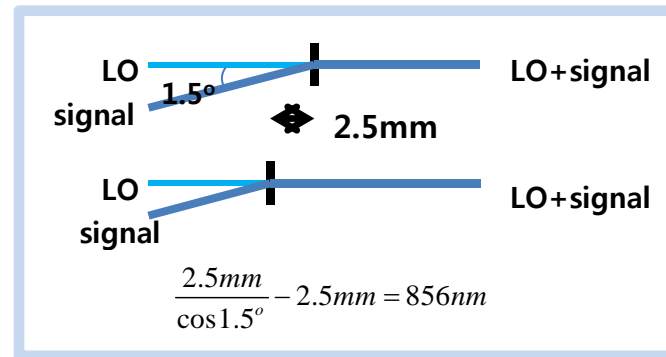
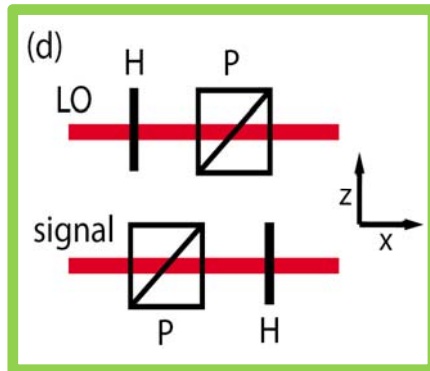
**Field 5** : LO

- ✓ **Close-up of the sample cell showing the separation between the LO and the three interacting beams.**

- ✓ LO passes through a 6.4mm thick fused silica window rotated 45°. The window diverts the path of the beam to separate the LO from the crossing of the other field at the focus by ~3mm.



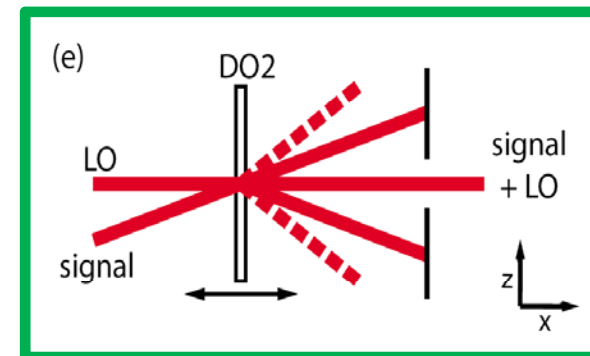
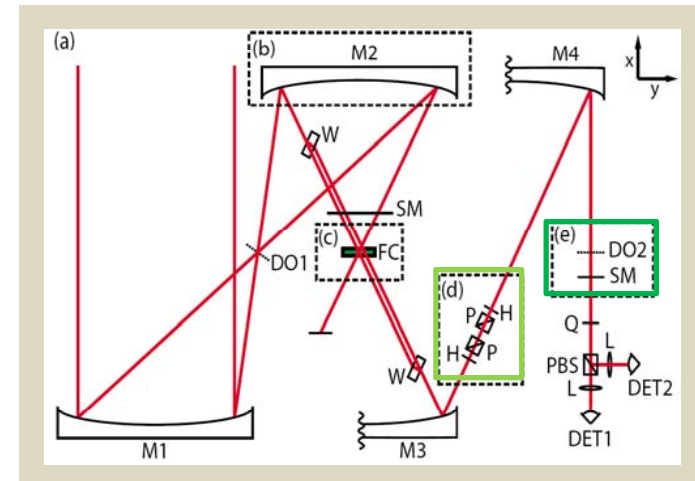
- ✓ Side view of collimation arm showing polarization optics in signal and LO
- ✓ The signal and the LO are collimated and propagate in parallel through matched sets of a half-wave plate and cube polarizer

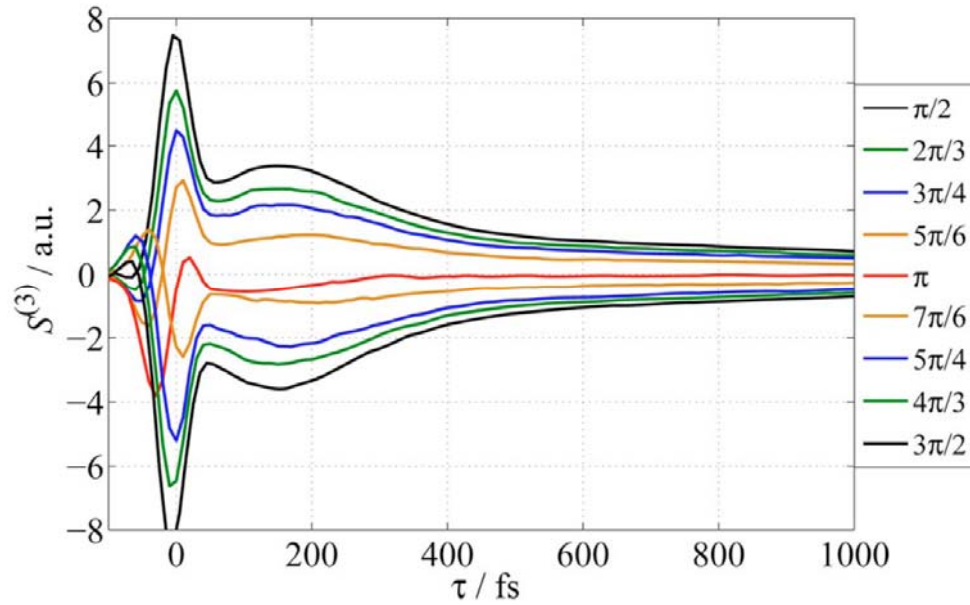


- ✓ Side view at DO2
- ✓ Controlling the relative phase between the signal and the LO with high stability, precision, reproducibility

The signal and the LO cross at DO2 with an angle of  $1.5^\circ$

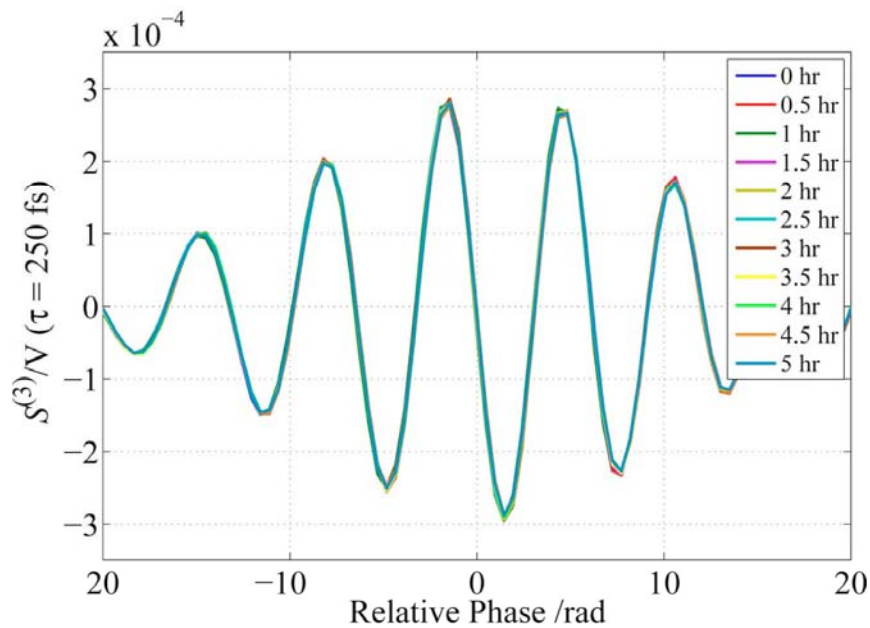
Rotating the relative phase of the signal and the LO by  $2\pi$  at 800nm requires translating DO 2.5mm.





✓ Transient birefringence CS2 taken at different relative signal phases.

✓ The phase is determined at  $\tau=250$ fs



✓ Relative signal phase measurements taken every half hour for 5h. Phase was measured by rotation of the relative signal phase by translating DO2 normal to the LO.

✓ Fix time delay  $\tau=250$ fs