# Interferometric complex-field retrieval in photorefractive transient detection imaging

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## Introduction

A transient detection imaging system (TDI), also known as optical novelty filter, is an adaptive interferometric device that detects temporal changes in a scene while suppressing its static parts. Removal of background improves contrast and helps visualizing and measuring intensity and phase changes. Following the first proposal [1], most TDI systems are based on photorefractive two-wave mixing [2]. Previous works rely on conventional intensity measurements, where partial information about input signal phase changes is obtained by previous calibration using an input phase-output intensity transfer function of the particular system.

In this work, we report our results on the TDI output complex field, and its relation with the input signal phase changes, via photorefractive two-wave mixing in a strontium-barium niobate (SBN) crystal. The single-frequency laser beam @532nm is split into a signal beam, a pump beam, and a reference beam for interferometry. Signal and pump beams intersect at the SBN crystal, whose $c^{+}$-axis is oriented to get virtually complete signal depletion under steady-state operation: the signal output port is a dark port. Any modification from that state produces a signal output so changes are revealed with high contrast.

To illustrate the phase performance of the device, the input signal beam is reflected onto a piezo-mirror for fine control of phase changes. Output signal phase is retrieved from off-axis Fourier holography which, compared to conventional intensity-based TDI, provides important additional features such as directionality of the phase change, higher resolution, and differential-phase measurement for enhanced sensitivity, all this without calibration.

We have evidenced the linear relation between input ($\Delta\varphi_1$) and output ($\Delta\varphi_{\text{out}}$) phase changes for the entire range from $-\pi$ to $\pi$ (see Fig. 1) in excellent agreement with our theory [3],

$$\Delta\varphi_{\text{out}} = \frac{1}{2}\left(\Delta\varphi_1 + \pi\,\text{sign}\,\Delta\varphi_1\right), \tag{1}$$

which predicts a $\pi$ jump "amplification" around $\Delta\varphi_1 = 0$.

Here we report new results on TDI for dynamic microscopic phase objects. We have modified the original setup [3] with a microscope objective and tube lens, achieving imaging resolutions around 1 μm, and phase target objects mounted on motorized translation stages. With this setup, we investigate interferometric transient phase retrieval of moving objects (see Fig. 2).

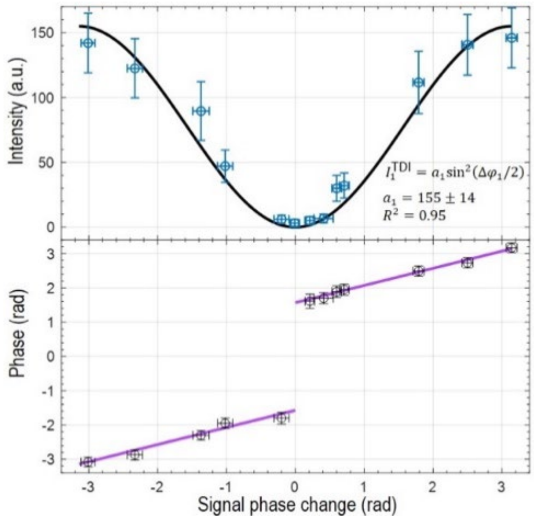


Fig. 1. Transient output intensity (top) and phase (bottom) depending on the applied signal-phase change. Intensity is fitted whereas phase follows the linear theoretical Eq. (1).

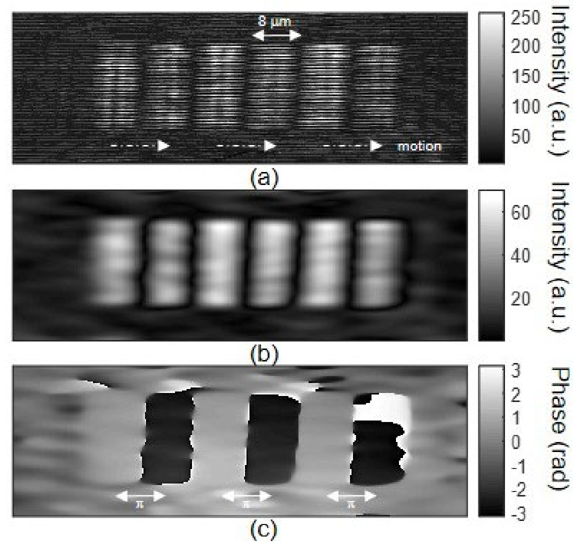


Fig. 2. Example of transient 2D interferogram (a), and retrieved intensity (b) and phase (c) of 3 rectangular phase objects moving from left to right. Differential phase shows π "amplification".

# Conclusions

We have demonstrated photorefractive TDI with interferometric complex-field retrieval.

We have evidenced the linear relation existing between input and output phase changes for the entire range from −π to π in agreement with our theory.

Phase-change inference from transient phase (complex field) measurements improves inference from transient intensity measurements, reaching /30 resolution without pre-calibration.

We have demonstrated differential-phase detection in TDI, showing the direct measurement of phase changes, and π jump "amplification" around zero.

Finally, we believe that this work takes advantage of adaptive background suppression with high phase-sign sensitivity, especially important for low-power small-phase change signals sensors, and opens up new possibilities for imaging and temporal single-spot signal detection [4].

# References


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We acknowledge financial support from the Spanish Government through projects PID2020-120056GB-C21 and PID2020-120056GB-C22 funded by MCIN/AEI/ 10.13039/501100011033.