# Polarization phase-shifting point-diffraction interferometer

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**Abstract:** A new point-diffraction interferometer has been developed utilizing a birefringent pinhole plate, which allows for phase-shifting by changing the polarization state of the laser source. The interferometer is compact, simple to align, vibration insensitive and can phase-shift without moving parts or separate reference optics.

**OCIS codes:** (120.3180) Interferometry; (120.3930) Metrological instrumentation: (120.3940) Metrology: (120.5050) Phase Measurement; (260.1440) Birefringence

## 1. Introduction

A new instrument, the polarization phase-shifting point-diffraction interferometer, uses a birefringent pinhole plate to interfere orthogonally polarized test and reference beams. This interferometer combines the robust nature of the Linnik/Smartt original point-diffraction interferometer with the ability to phase shift for interferogram analysis.

## 2. Polarization phase-shifting point-diffraction interferometer

The key to this interferometer lies in the birefringent pinhole plate. The pinhole plate is created by etching a pinhole in a half-wave birefringent thin film. The film is deposited using bi-directional oblique deposition giving a birefringence of .2816 at 633nm and a half-wave plate thickness of 1.1μm. The relatively small thickness of the film allowed for easy etching of the 5μm diameter pinhole using a focused ion beam milling process.

The laser source, polarized at 45$^{o}$, first passes through an electrooptic modulator, which adds a variable phase to the vertical orthogonal component of the beam. Then, after passing through the test optic, the aberrated beam is focused onto the birefringent pinhole plate. The portion of the light incident on the pinhole does not encounter the half-wave thin film and is diffracted into a spherical reference wavefront by the pinhole aperture retaining its original polarization state but losing the aberration information of the test optic. The remainder of the light passes through the thin film, with fast axis oriented at 45$^{o}$, and emerges with its polarization state rotated by 90$^{o}$. This portion of the light, although changed in polarization state, retains the aberration information of the test optic and serves as the test wavefront for the interferometer. By rotating the polarization state by 90$^{o}$, the pinhole plate has, in effect, swapped the orthogonal components of the test beam, moving the variable phase shift from the vertical to the horizontal component of the test beam. A final analyzer isolates either the horizontal or vertical components of the test and reference beams. By varying the voltage applied to the electrooptic modulator the variable phase shift between the test and reference beams can be changed allowing for phase shifting.

## 3. Experimental Results

The results from our instrument compare favorably with measurements made on a commercial Fizeau interferometer. For the f/12 test lens pictured in figure 1, the peak-to-valley error is found to be 2.553 waves and the rms error is .409 waves versus 2.61 and .535 waves for the commercial system. Due to an improper thin film retardance of 160$^{o}$ and a diattenuation of 20%, simulations predict a best-case rms measurement repeatability of .035 waves. Subtracting successive measurements of the test lens gave an actual rms measurement repeatability of .036 waves. The measurement accuracy and repeatability would improve drastically with thin film retardances closer to 180$^{o}$.

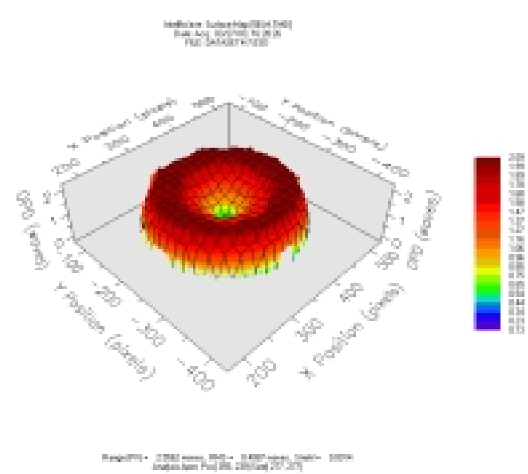

Fig1. Wavefront map for f/12 test lens