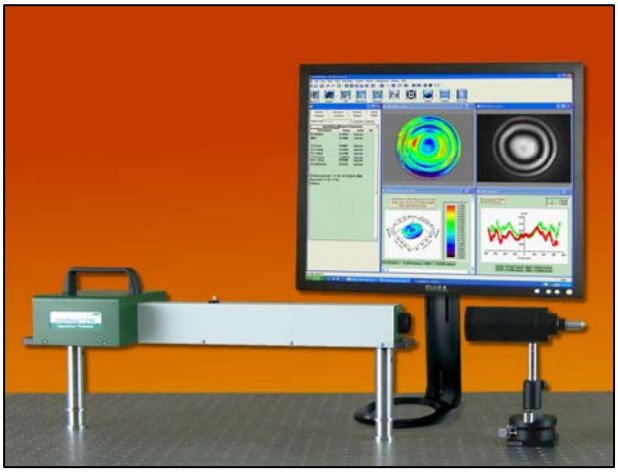
Intellium™ PDI (with *HyperPhase™*) Overview

Introduction



Intellium™ PDI is a state-of-the-art point diffraction interferometer (PDI) that generates its own reference spherical wavefront using a pinhole in a waveplate. A simple representation of the PDI is shown in Figure 2 below. A wavefront of interest (coherent source) is partially focused through a pinhole producing a spherical wavefront. The remainder of the wavefront passes through the waveplate unaffected with the exception that its polarization is rotated 90º with respect to the reference wavefront. The result is a highly stable interferometer, which can phase-shift one wavefront with respect to the other using polarization methods. A perfectly flat wavefront will produce a spherical wavefront due to the pinhole generated spherical reference wavefront. A collimated light source can be used to subtract out the reference wavefront.

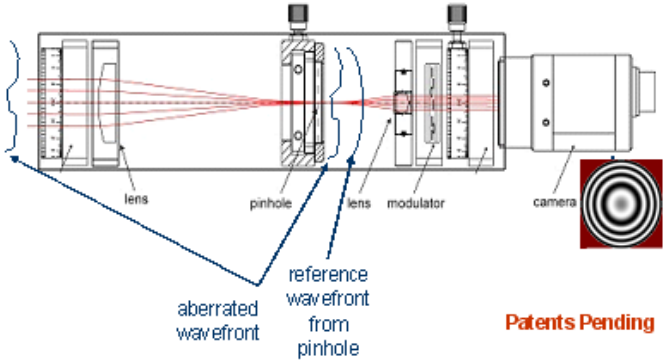


Figure 2: Point Diffraction Interferometer

Real-Time Phase Shifting

For comprehensive wavefront analysis, phase-shifting is required such that multiple interferograms can be used to generate the actual wavefront. A minimum of three interferograms are needed. In order to generate three independent interferograms, the test and reference beams are split at the same rate into three channels inside ESDI's HyperPhase™ phase-shifting module, which is incorporated in the PDI. In each channel, phase delays are introduced independently in a controlled fashion so that the phase shifts between the interfering beams are set to 90^0 between consecutive interferograms. The three interferograms are captured simultaneously and transferred to the computer. The

exposure time to capture the interferograms is typically 0.25 ms, but can be as low as 10us, and is limited only by the amount of available light and the capabilities of the cameras. Note that splitting the incoming beam into three channels does not violate the principle of the common optical path as the two interfering beams are split the same way and they traverse the same optical path all the way to the detectors. Figure 3 illustrates the beam arrangement inside the interferometer.

Note: Although the ***Intellium™ HyperPhase™ PDI*** uses three cameras, they are sub pixel aligned and monolithically bonded together along with the beam splitting and polarization optics into a package smaller then two decks of cards stacked on top each other. The result is a rigid camera system similar to high-end 3-Chip color cameras with lifetime alignment. The advantage of using three cameras is that each of the interferograms retains the true resolution of the camera.

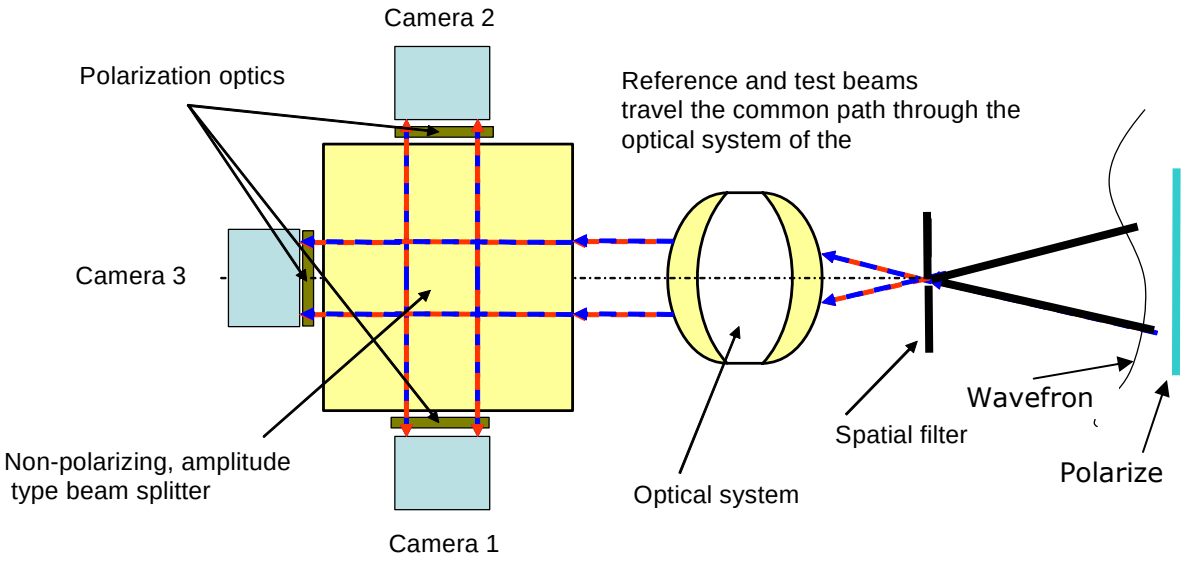


Figure 3: Diagram showing the optical path and layout of optical elements inside the simultaneous phase shifting PDI ***HyperPhase™*** interferometer. The "spatial filter" shown above is a pinhole in a thin polymer waveplate. A portion of the wavefront goes through the pinhole; the remainder goes through the waveplate with its polarization being rotated 90º. After the spatial filter, the two wavefronts are orthogonally polarized and travel into the ***HyperPhase™*** mode, where three 90º phase-shifted interferogram are generated and acquired by three sub-pixel aligned cameras.

PDI Wavefront Data

Figures 4A and 4B show wavefront data acquired from the ***Intellium™ HyperPhase™ PDI***. A laser source was spatially filtered, expanded to 5 mm diameter, and then directed into the PDI. As can be seen the interferograms exhibit high contrast and are phase-shifted 90 degrees with respect to each other. Figure 4B shows the resulting wavefront. With this data, full wavefront diagnostics are possible including Peak-Valley and RMS statistics, aberration analysis, diffraction analysis, and geometric analysis.

Also, since ***IntelliWave™*** can acquire data rapidly (30 Hz), motion analysis can be performed as wavefront data changes over time.

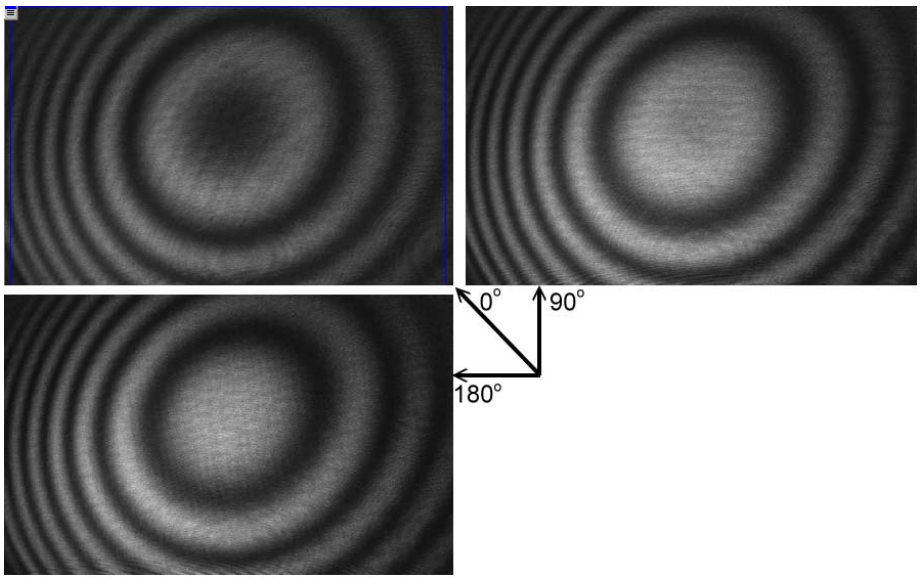


Figure 4A: Three phase-shifted interferograms acquired simultaneously from a laser source using the ***Intellium ™ HyperPhase™ PDI***.

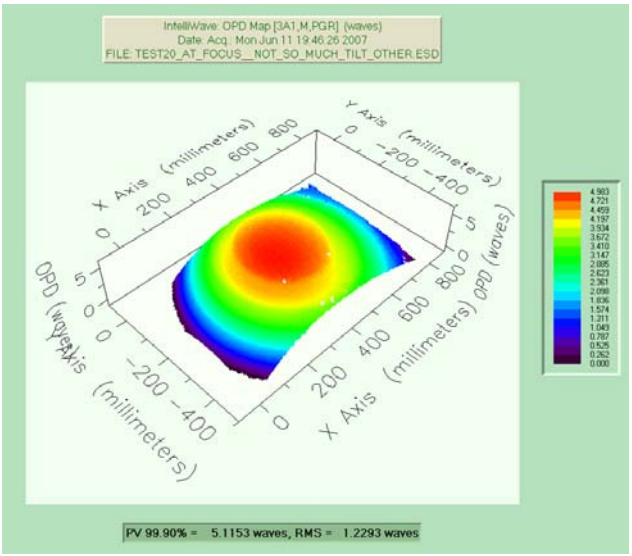


Figure 4B: Laser beam wavefront from the ***Intellium™ PDI***.

Summary

The ***Intellium™ HyperPhase™ PDI*** can acquire real-time wavefronts from coherent sources. Vibration insensitivity is achieved through self referencing, a common path design, and simultaneous phase-shifting. The result is a rugged wavefront sensor with higher resolution than Shack-Hartman Sensors while maintaining acquisition speed.

Applications

- Wavefront and collimation testing of telescopes and periscopes
- Test lasers at wavelengths from 480 to 1800 nm
- Test beams from 3-25 mm diameter
- Alignment and collimation of fiber optic systems
- Optical alignment of holographic storage & disk mastering systems
- OEM integration for real-time monitoring of laser collimation
- Atmospheric Turbulence testing
- Adaptive Optic Measurements/Applications

Main Features & Benefits

- Self referencing interferometer
- Measure collimation to better than 100-200 micro radians (wavelength dependent)
- Wavelengths from 480-1800 nm
- Sensitivity
- Dynamic Range: 4 waves
- Simple operation reduces alignment time to minutes
- ***IntelliWave™*** Software for complete wavefront diagnostics.

PDI Performance		
RMS Repeatability[1]	λ/1000	
Uncalibrated Accuracy	λ/20	
Height Sensitivity	λ/8000	
Spatial Resolution	1024 x 768 Visible	768x576 NIR
Fringe Resolution	5 fringes	
Digitization	8 bits	
Acquisition Time	30 ms	
Exposure Time	Minimum 10 µs (optical power dependant)	
Averaging Modes	Intensity and Phase	