Optical Testing of Light Bucket Mirrors

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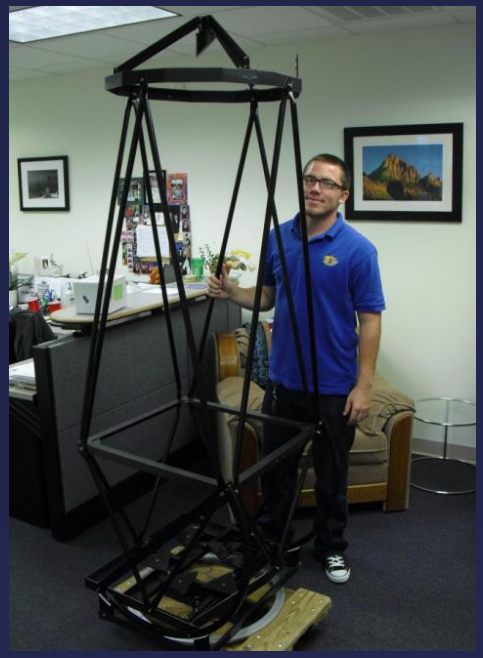
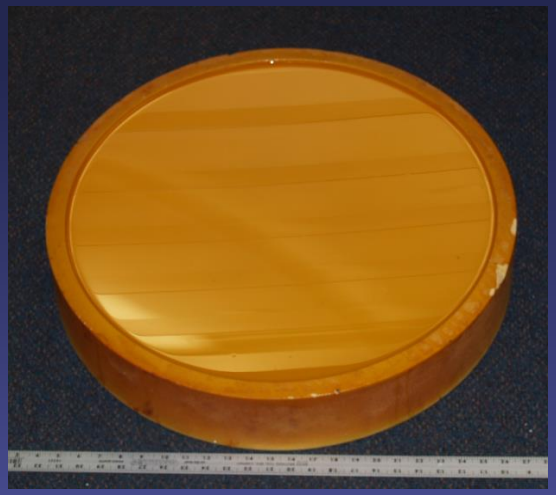
Some Mirrors Tested

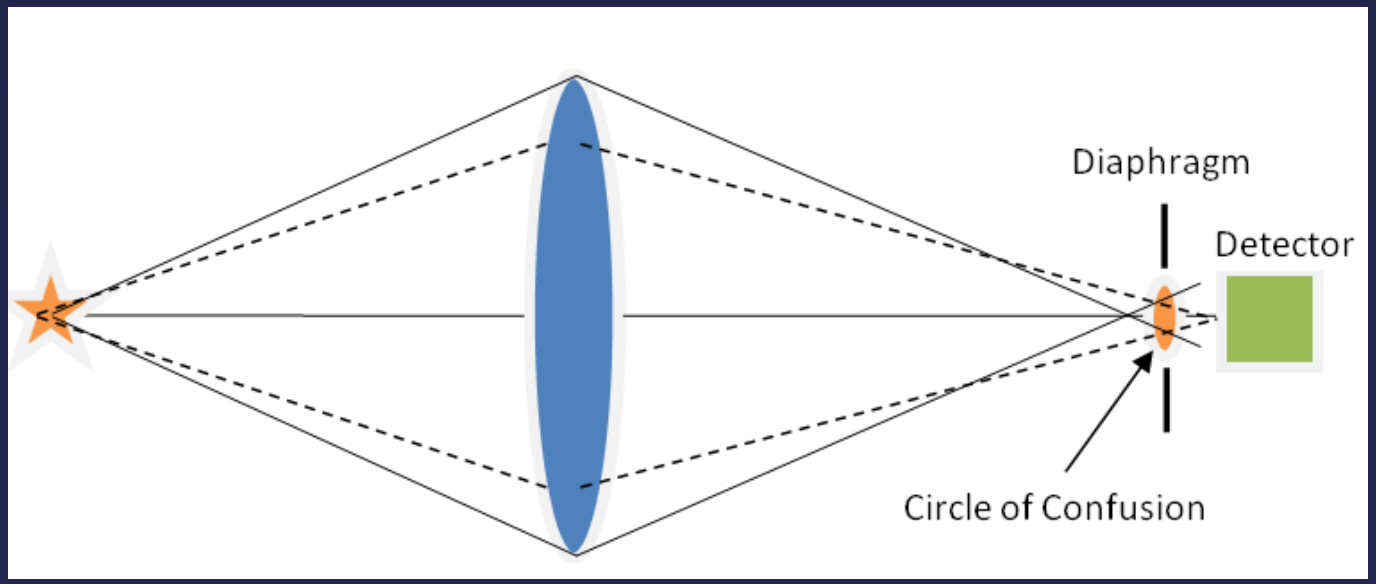




Tests & Measures

- Foucault, Ronchi, Interferometry, Artificial star PSF
- Physical parameters
  - Materials, Weight, Usable D, CTE, Focal Length and F/#
- Figure (conic)
- Aberrations present & magnitude: P-V, Strehl
- Smoothness
- Reflectivity

Circle of Confusion

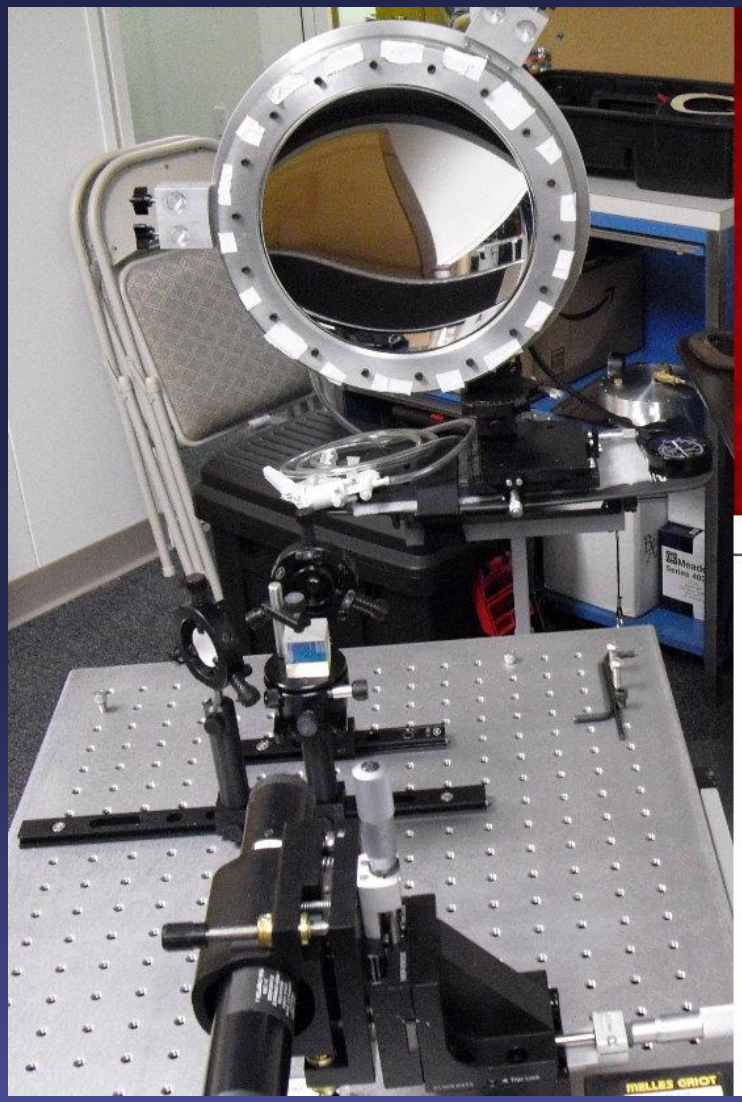


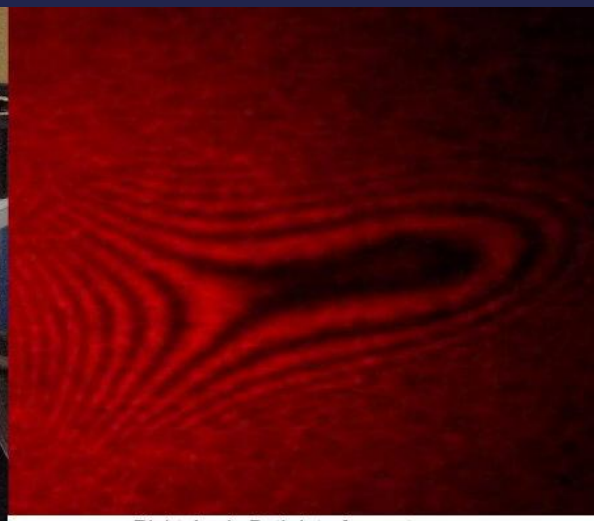
- Circle of Confusion = blur spot at focal plane
- Diaphragm = circular isolator before the detector

Vega – 12” pneumatic mirror, 1’ dia.

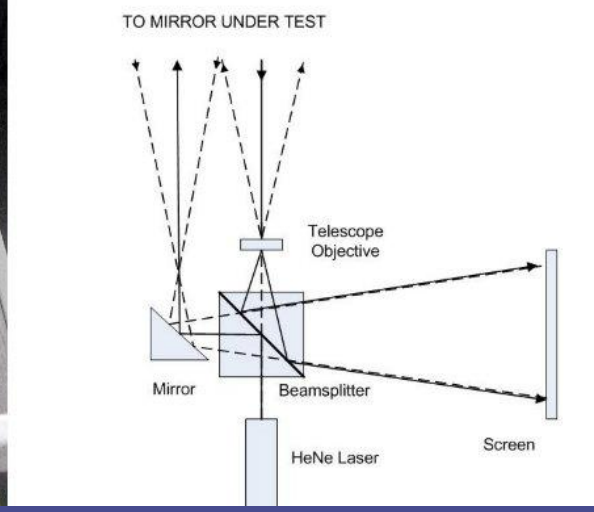
Aberration Characterization

- Zone-sampling with a Right-angle Bath Interferometer
- Analysis produces Zernike representation of wavefront , $W(\rho,\theta)$
- Stitching and statistical combination of sample zone results

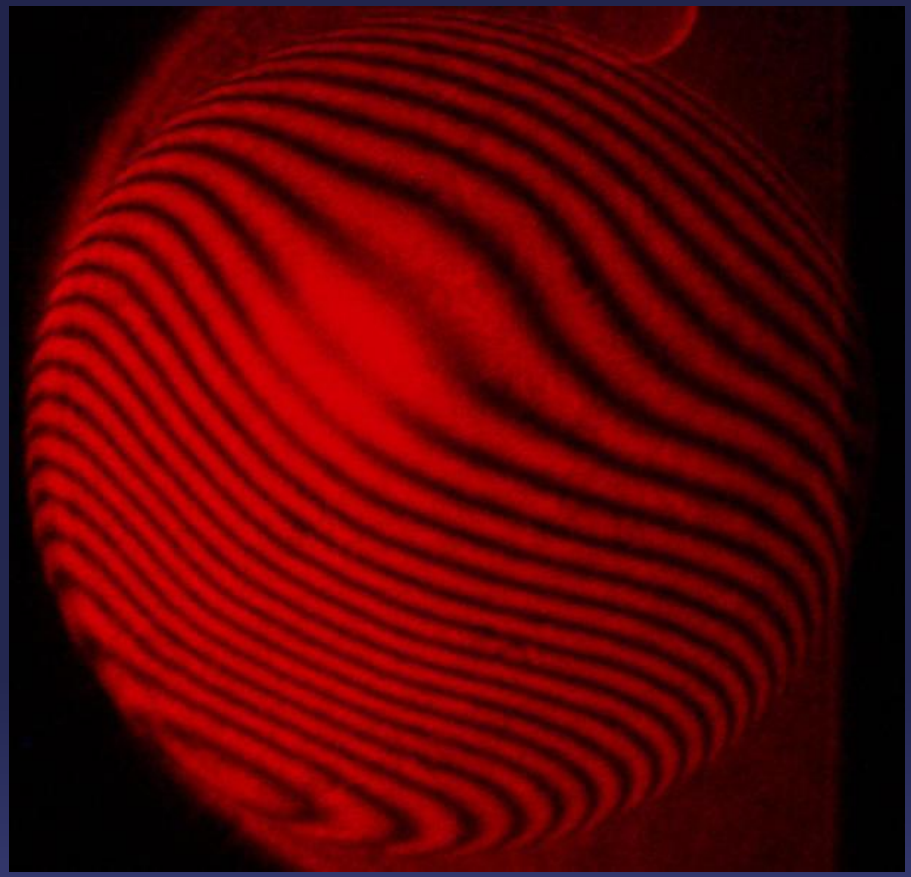




Right-Angle Bath Interferometer

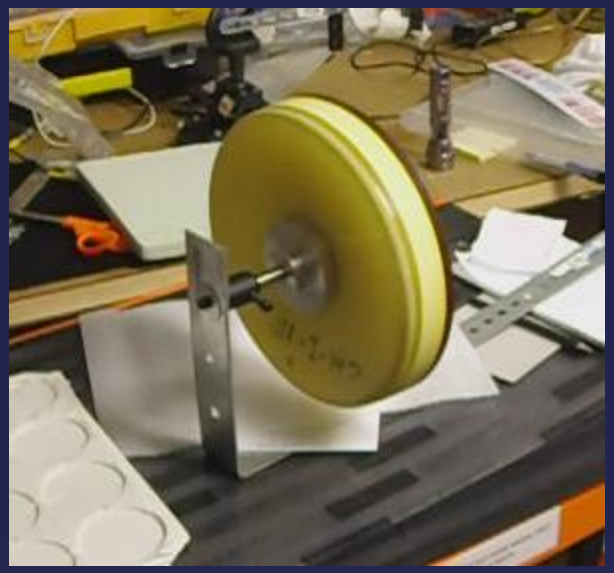


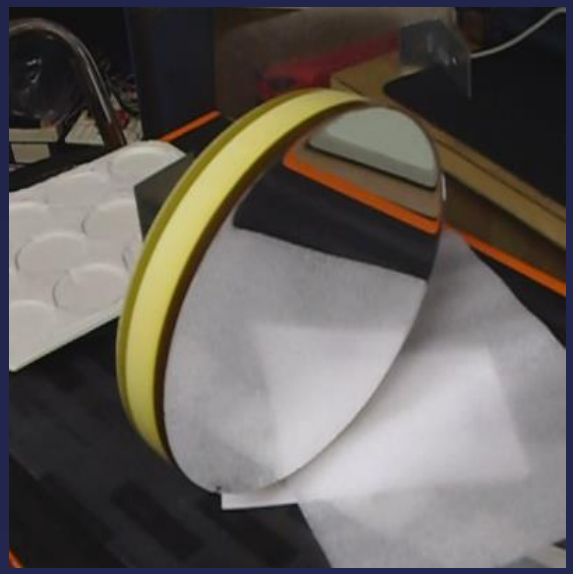
OTF Designs – Starstone 8” *f*/2.25



- Mirror 0001A 8” f/2.25

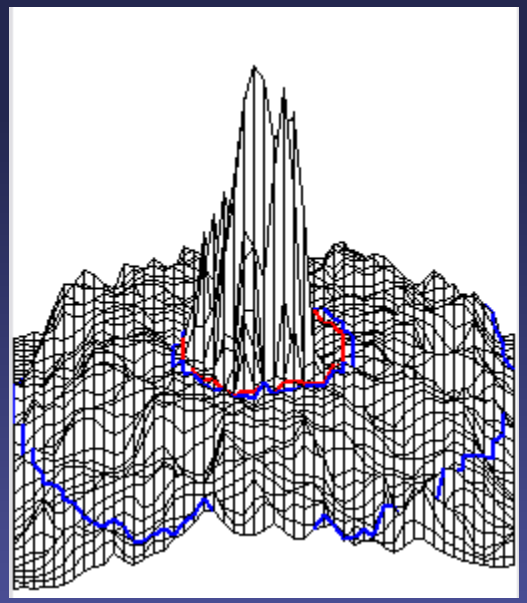
Lander 10” epoxy *f*/3.7 No. J1R-I-147





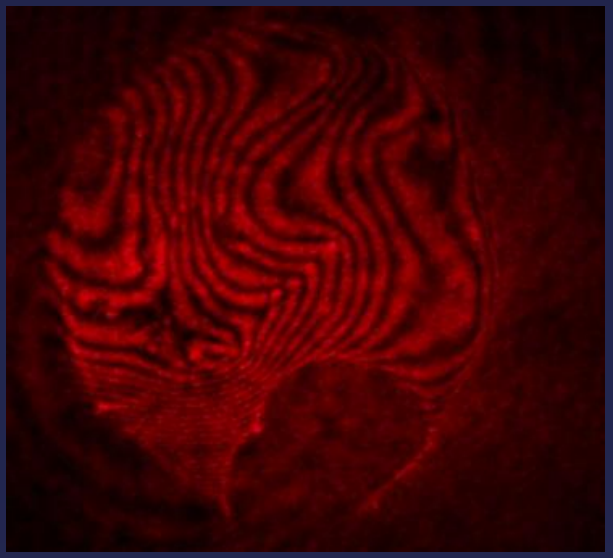
3-layer, weight – 2lbs.

5-in. mask best focus at RoC

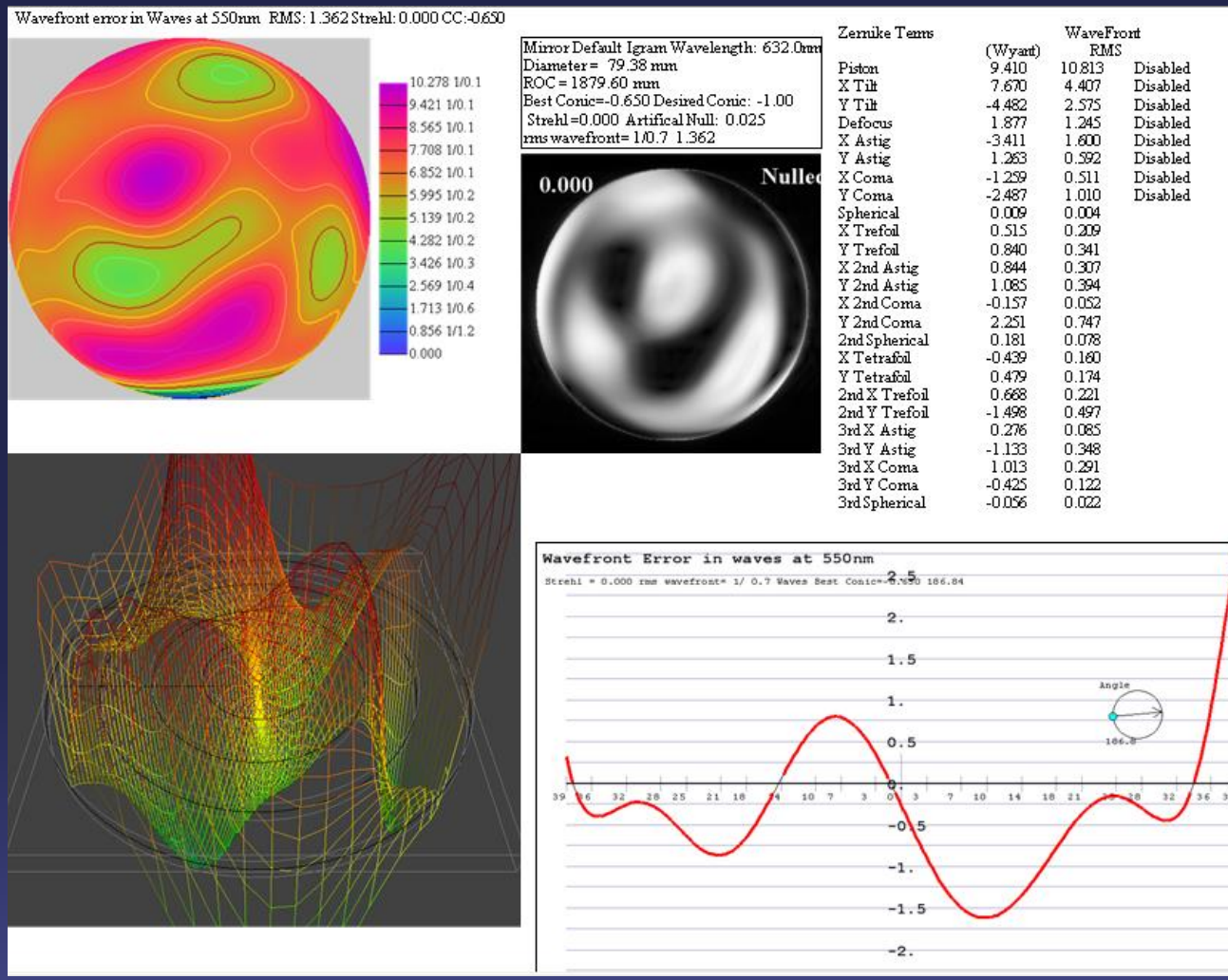


	16 pixel dia. “core”	50 pixel dia. “disk”	Total
Pixel counts	22564	101318	123882
Encircled energy	18.2%	91.8%	100%
PSF diameter	0.085 milliradians 3 arc min.	0.27 milliradians 9 arc min.	
RMS surface slope (S_{rms})	0.018 milliradians (1.3 waves/radius)		

Lander 10” *f*/3.7 No. J1R-I-147

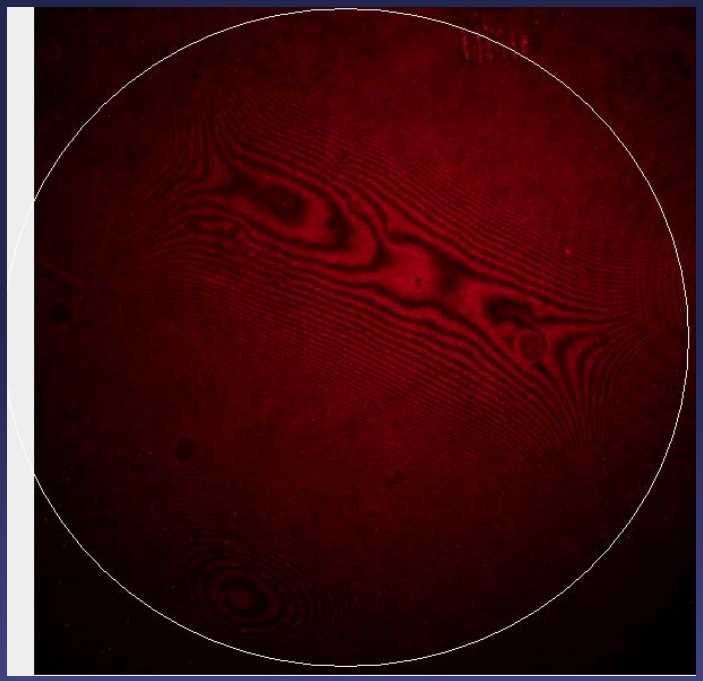


iGram of central 3.125”



OpenFringe analysis

Lander 11” *f*/1.75 No. KLB-157 (rotated)



Central 7.75” rotated CCW 90 deg.

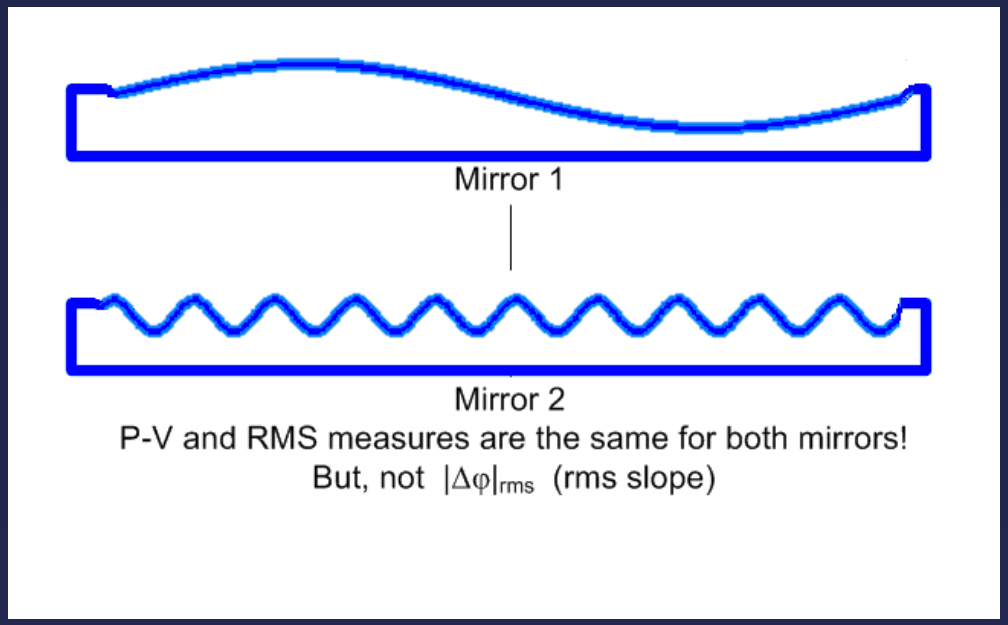
Artificial Star PSF

- Hubble Optics 5-star flashlight used for illumination. The apertures are precision holes of 50/100/150/200/250 microns.
- Mirror 8” Starstone *f*/2 @ 11-m

180” – no correction

25” – with correction

RMS Slope Characterization



- Traditional quantification such as P-V and Strehl Ratio may not be helpful for light buckets

Holenstein et. al. 2010

PSF size from slope error & aberrations

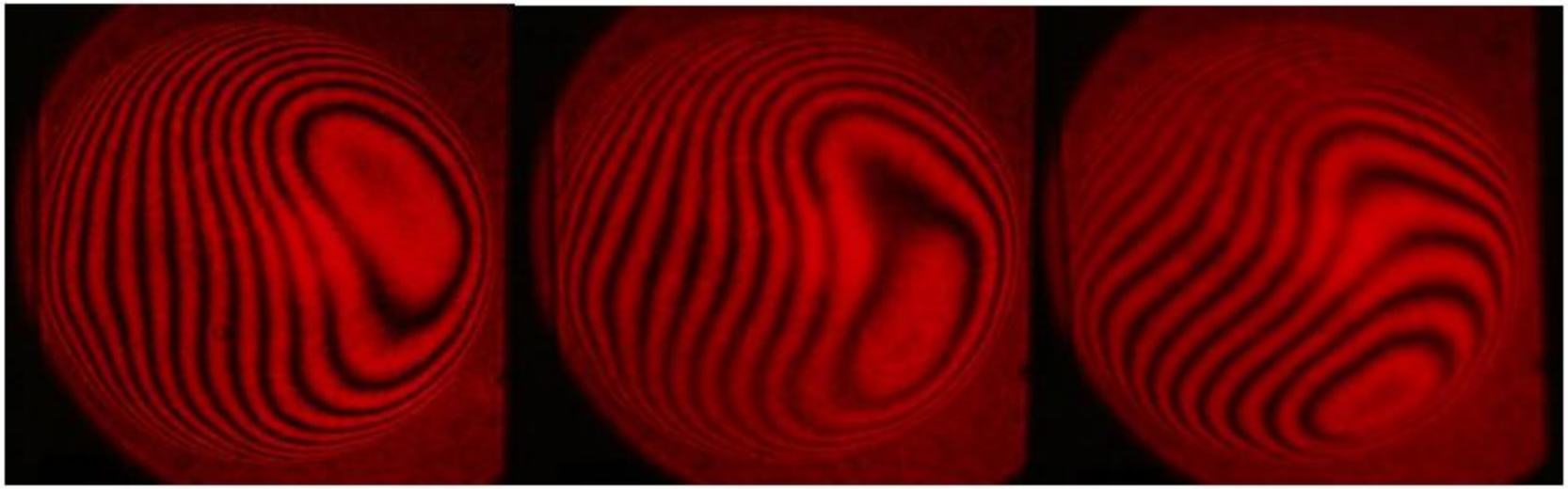
- ***FWHM spot size = 4.70 x S_{rms}***
  - ***Where S_{rms} is the rms slope error***

- ***FWHM spot size* (arc sec) ≈ 10^6 *E /D***
  - ***Where D is the aperature, E ~ peak aberration present***

- ***Example:***
  - One wave of astigmatism in the visible on a 1-m mirror corresponds to about an arc second *FWHM* spot (and vice versa)
  - But note higher order aberrations are much worse!

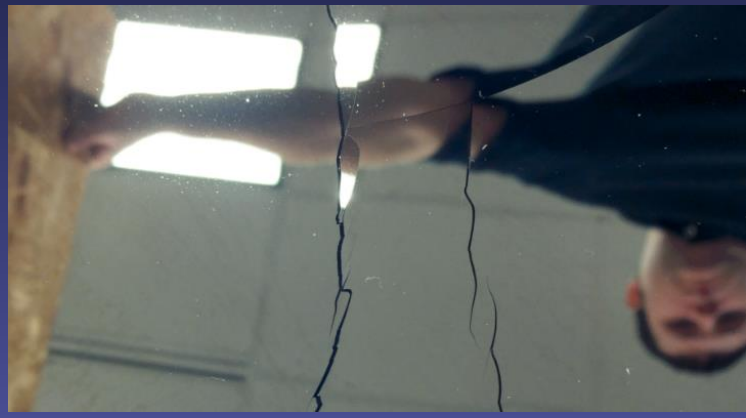
Holenstein et. al. 2011

CTE - Starstone (8”)



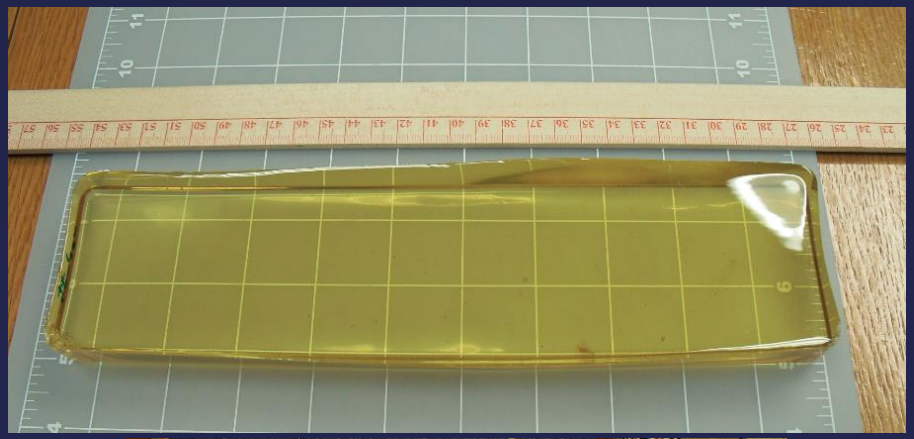
- Cooling after 30 sec. warming with heat gun

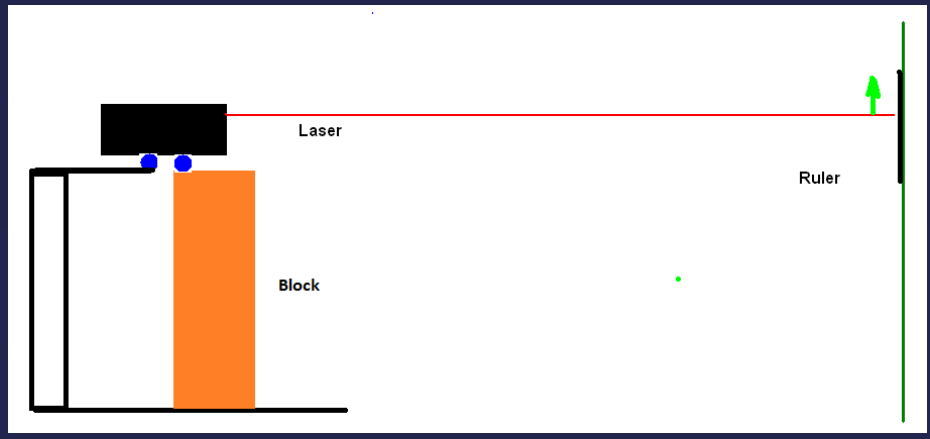
CTE Part II

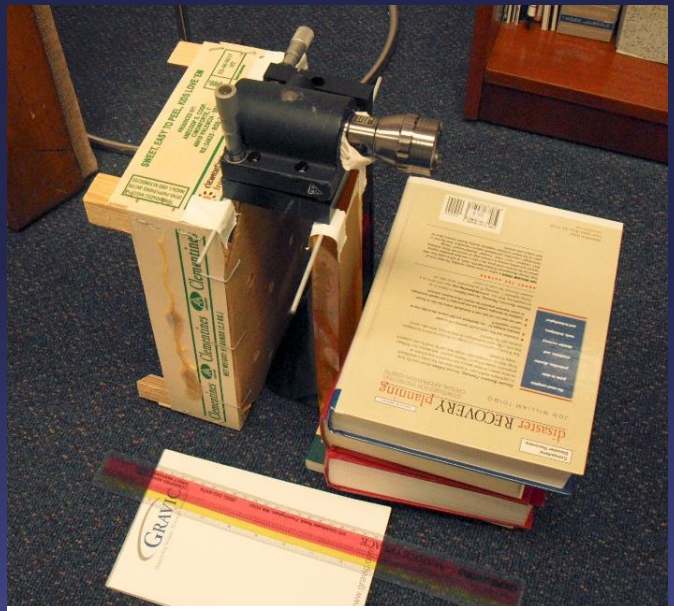


- Lander 1-m after night in cold weather

Measuring CTE







$$CTE = \frac{\Delta h}{H\,\Delta T}$$ where H is the block height and

$$\Delta h = \frac{Max\ deflection\ x\ Rod\ separation}{Distance\ to\ wall}$$

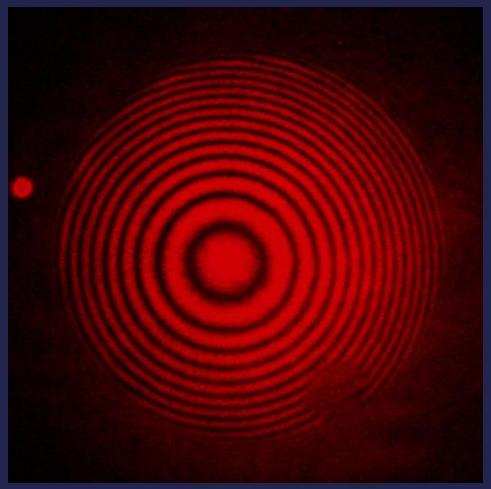
	Max Def.(cm)	*Δh (mm)*	*H (mm)*	*ΔT (°C)*	*CTE (ppm/°C)*
Sample 1	17.1	0.60	265	37.2	60.8

Coatings and Reflectivity Tests

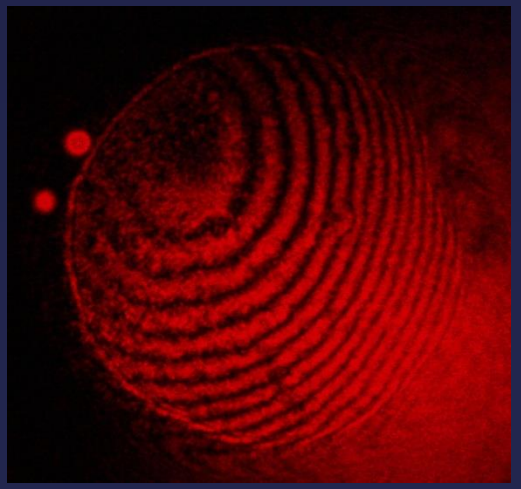
- Cold silvered (4) – verify Strehl
- Extra Thin Peacock Labs Permalac coated (3)
- Flats (2 each) – test reflectivity

Coating Tests II

- Just silvered – very fine (confirmed)
- Extra Thin still not thin enough



Silvered



Extra Thin Permalac

Mirror #	BEFORE COATING			AFTER SILVERING	
	RMS Wavefront Error (waves @ 550nm)	Strehl Ratio		RMS Wavefront Error (waves @ 550nm)	Strehl Ratio
No overcoat					
20	0.031	0.963		0.001	0.962
22	0.120	0.567		0.071	0.821
24	0.073	0.812		0.065	0.847
26	0.080	0.778		0.099	0.680
Extra-thin overcoat					
5	0.042	0.933		0.088	0.735
21	0.085	0.753		0.199	0.211
36	0.083	0.760		0.285	0.040

Contact and further information

- Email: bholenstein@gravic.com
- Gravic Labs Papers (source for many pictures): http://www.gravic.com/graviclabs/rd/astronomy/papers.html
- Alt-Az Telescope Initiative Website: www.AltAzInitiative.org
- Bath interferometer: http://starryridge.com/mediawiki-1.9.1/index.php?title=Bath_Interferometer
- Yahoo Discussion Groups: http://groups.yahoo.com/group/AltAzInitiative http://groups.yahoo.com/group/Interferometry