Lander University 11” Spin-Cast Epoxy Mirror Tests

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Rev 2: October 24, 2011

*** Preliminary ***

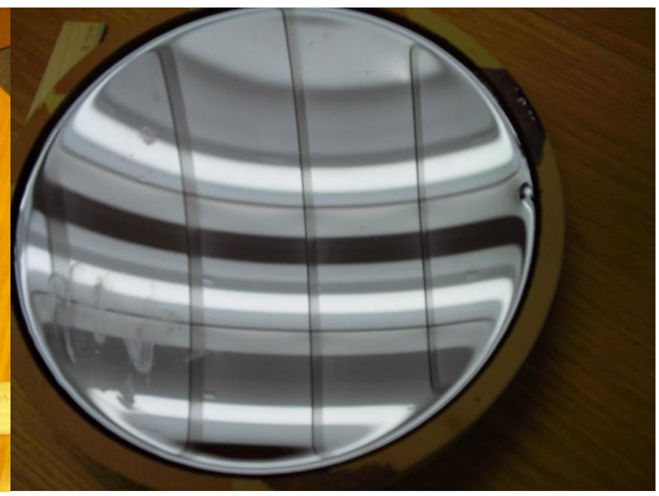
Introduction

At the request of Lisa Brodhacker from Lander University, we evaluated an 11 inch diameter spin-cast epoxy prototype mirror for optical performance. The testing protocol matches the March 12, 2011 report on the Lander 10” mirror.

Equipment

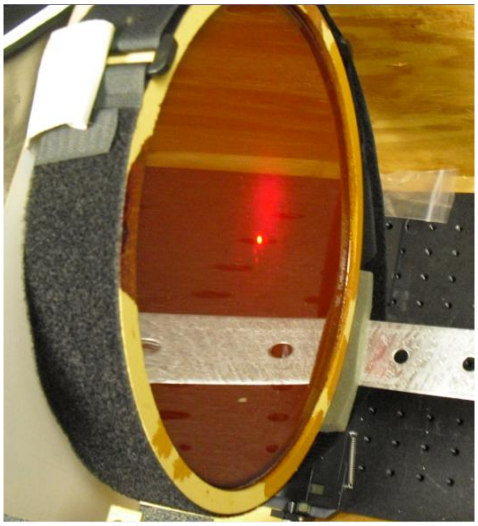
Thorlabs HeNe Laser
Bath interferometer
LiMovie video photometry analysis software
OpenFringe v10
Olympus EM500 DSRL
Casio Exlim EX-S5
Hubble Optics 5-Star Flashlight

Mirror Description

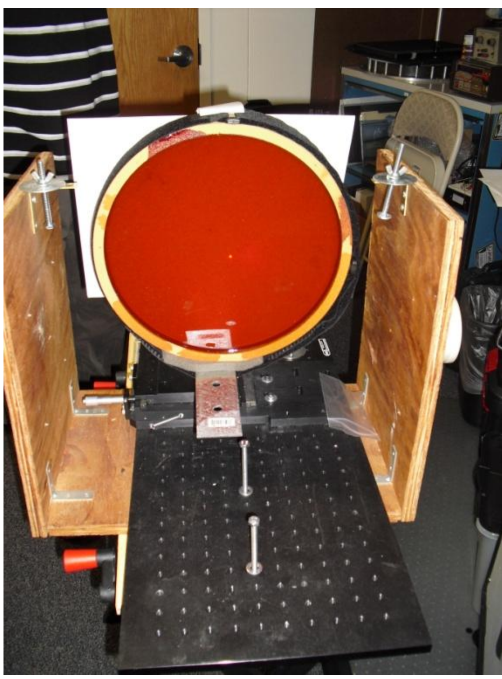
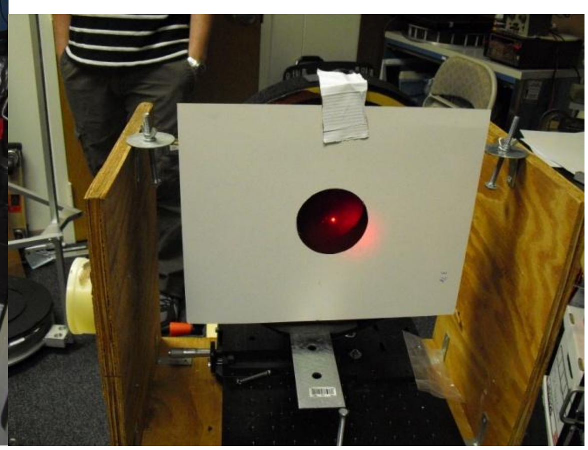
The Lander 11” mirror, No. KLB-157, is a three-layer epoxy composite. The mirror is 11 inches in diameter, weighs about 3.75 lbs, and has an approximately 38.5” radius of curvature. The mirror is uncoated. The epoxy has a reddish color.

The mirror was fabricated in a CNC’ed foam shell. Up close, the mirror shows a thin raised edge of less than a millimeter width due to surface tension during the epoxy fabrication process. There are fingerprints seen in the above right image reflection of the office fluorescent lights. The appearance of the surface of the mirror is very smooth with just a few fine ripples.

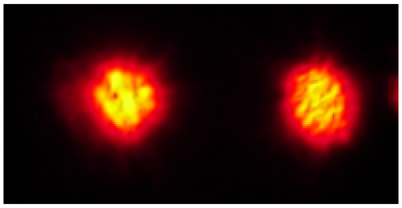


Lab Tests

We masked off the mirror to avoid the turned-up outer edge and the fingerprints. Our initial interferometer experiments used a 3.125 inch clear mirror aperture. The speed of the mirror in this mode was *f*/6.1. The central 3.125 inches of the mirror was illuminated with the interferometer serving solely as a monochromatic light source.



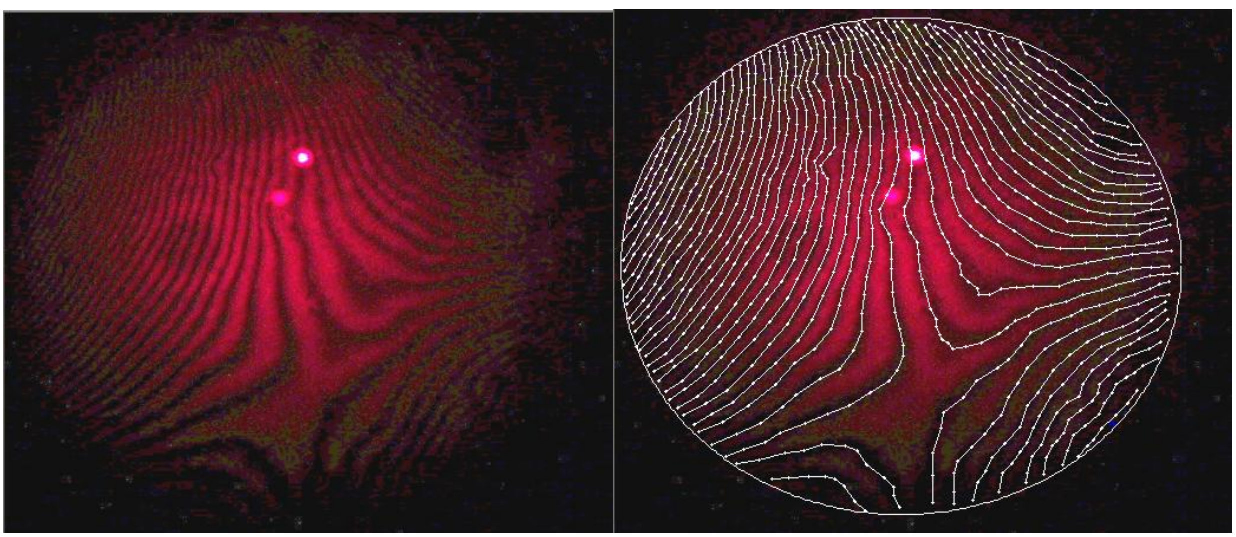
Specular and Diffuse Reflection



The above images (enlarged) show the result of specular reflection at the radius of curvature. The spot on the left is the unexpanded reflection of the the HeNe laser off the mirror. The spot of the right is the expanded and then re-converged laser beam reflected off the central 3.125 inches of the mirror. The best focus is approximately the same diameter as the reflection of the unexpanded beam. Some astigmatism is apparent. Also, little to no diffuse reflection is apparent.

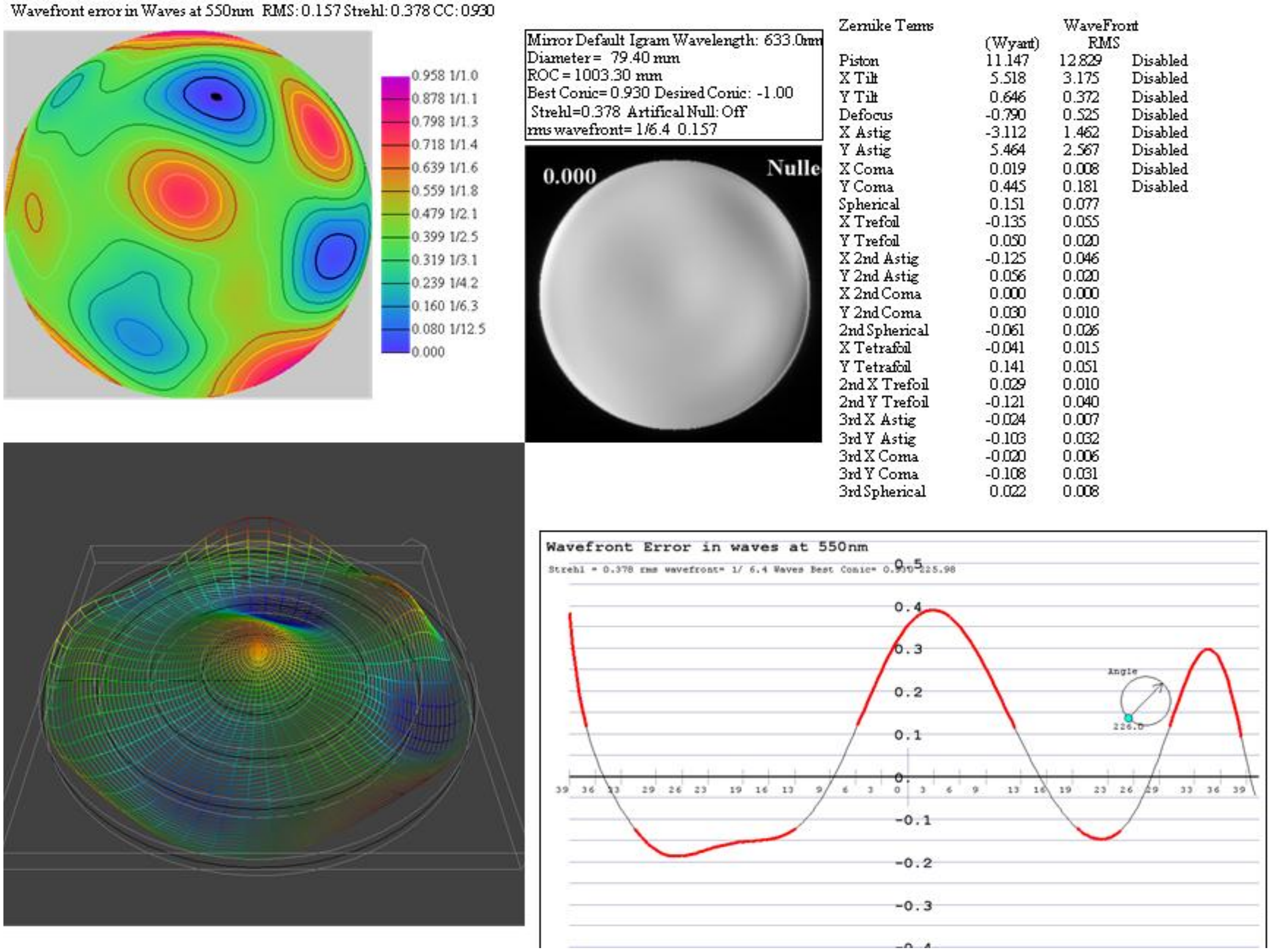
Interferometer Results

The following results are from the central 3.125 inches of the mirror.



The un-aluminized epoxy reflected a very small amount of light and so the fringes were very faint. We used fringe tracing to map the surface.

The mirror report follows. The mirror appears to be under-corrected to a parabola. Was there enough spin time for the parabola to form? The Strehl ratio is an encouraging 0.378. However, the Astigmatism terms are large and turned off in the following report. The Bath interferometer in this configuration should inject only a tiny fraction of a wave of astigmatism (9 nm).

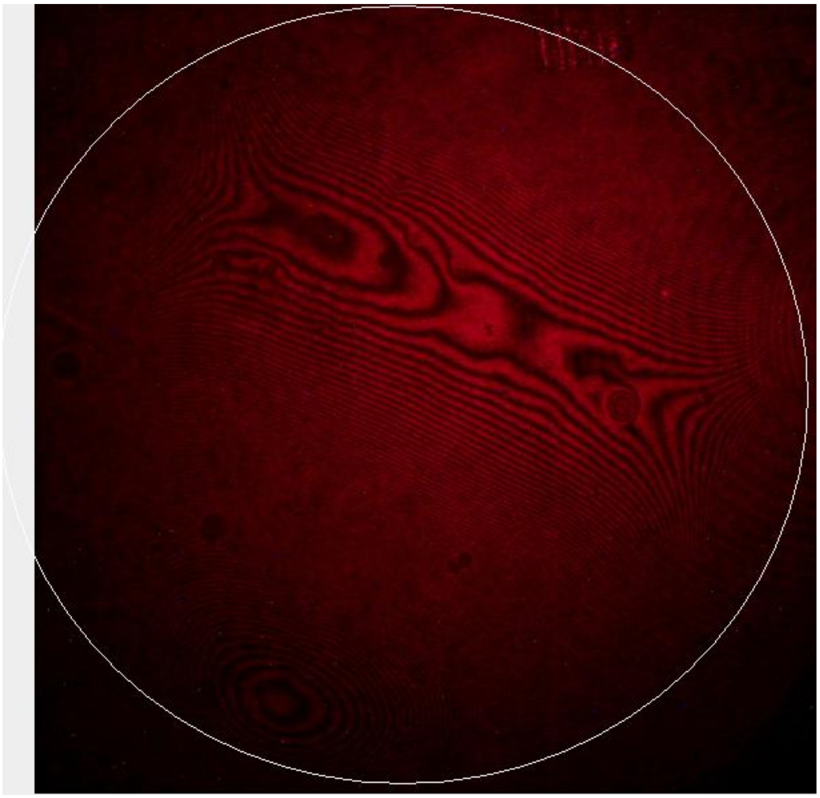


Zernike Terms	(Wyant)	WaveFront RMS	
Piston	11.147	12.829	Disabled
X Tilt	5.518	3.175	Disabled
Y Tilt	0.646	0.372	Disabled
Defocus	-0.790	0.525	Disabled
X Astig	-3.112	1.462	Disabled
Y Astig	5.464	2.567	Disabled
X Coma	0.019	0.008	Disabled
Y Coma	0.445	0.181	Disabled
Spherical	0.151	0.077	
X Trefoil	-0.135	0.055	
Y Trefoil	0.050	0.020	
X 2nd Astig	-0.125	0.046	
Y 2nd Astig	0.056	0.020	
X 2nd Coma	0.000	0.000	
Y 2nd Coma	0.030	0.010	
2nd Spherical	-0.061	0.026	
X Tetrafoil	-0.041	0.015	
Y Tetrafoil	0.141	0.051	
2nd X Trefoil	0.029	0.010	
2nd Y Trefoil	-0.121	0.040	
3rd X Astig	-0.024	0.007	
3rd Y Astig	-0.103	0.032	
3rd X Coma	-0.020	0.006	
3rd Y Coma	-0.108	0.031	
3rd Spherical	0.022	0.008	

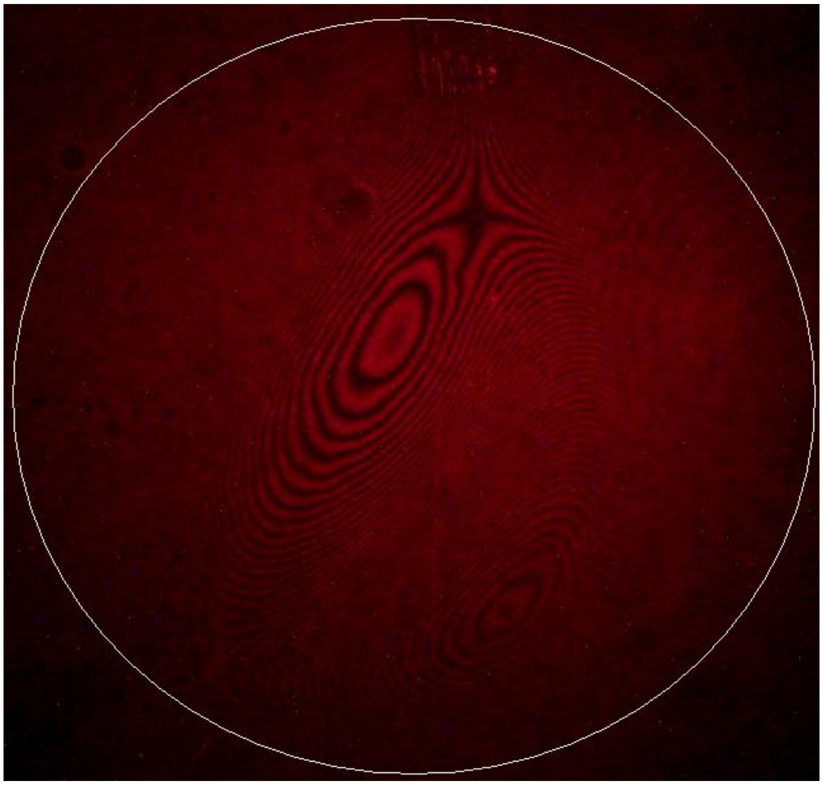
Larger interferograms

We restructured the Bath interferometer to use a 2.3 mm focal length lens to illuminate more of the mirror surface. The system was acting at about *f*/2.5. This is about the fastest limit that we think that our current interferometer can operate. We found that the edge of the mirror was diffuse and hard to locate, in part because of the fingerprints.

Still, the following results are from the central 7.75 inches of the mirror are instructive.



Astigmatism is large and dominant. The circle is only an approximation for the igram edge.



Rotated, 90 degrees CCW from the front, and the astigmatism rotated too.
Notice the high spot in the lower right corner.

Because the astigmatism rotates with the mirror, most of the astigmatism seen must be introduced by the mirror, and not the mirror holder, nor interferometer. So, the results (and Strehl ratio) reported above for the central 3.125 inch portion of the mirror must include the astigmatism terms.

What is the source of the large and real astigmatism? Perhaps the epoxy shrinking as it dries is leading to some buckling of the foam cell. In this case, perhaps gluing the foam cell to a rigid disk of some material like aluminum might reduce the warping.

Star Tests

We will test the mirror with the Hubble 5-Star flashlight and some real stars.