Lander University 10” Spin-Cast Epoxy Mirror Tests

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March 12, 2011

*** Preliminary ***

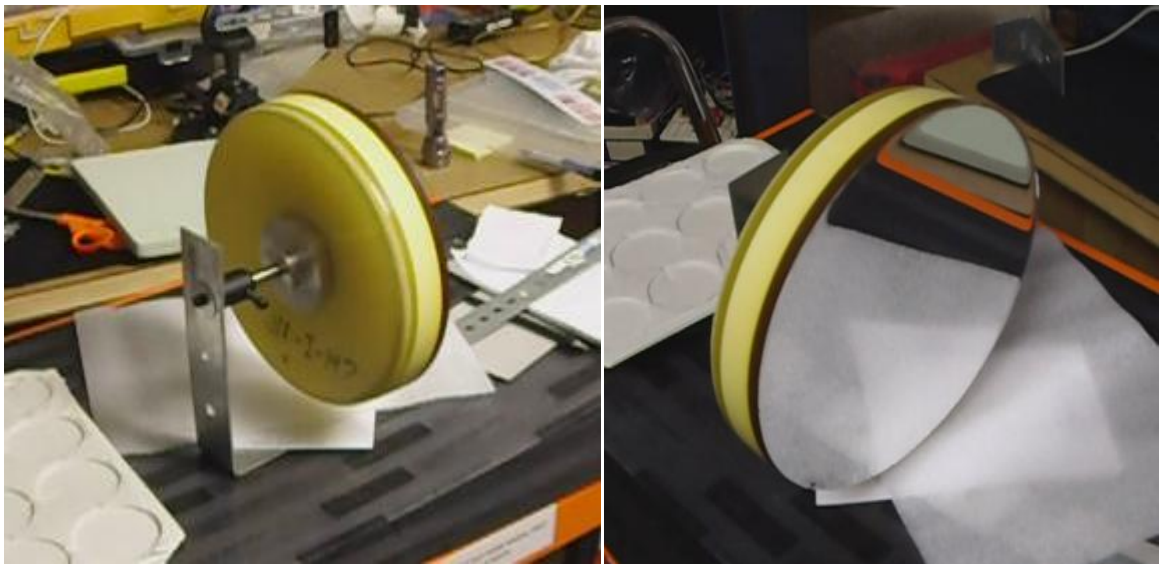
Introduction

At the request of Lisa Brodhacker from Lander University, we evaluated a 10 inch diameter spin-cast epoxy prototype mirror for optical performance.

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 mirror, No. J1R-I-147, is a three-layer epoxy composite. The mirror is 10 inches in diameter, weighs about 2 lbs (with the aluminum attachment point on the back of the mirror), and has an approximately 74” radius of curvature.

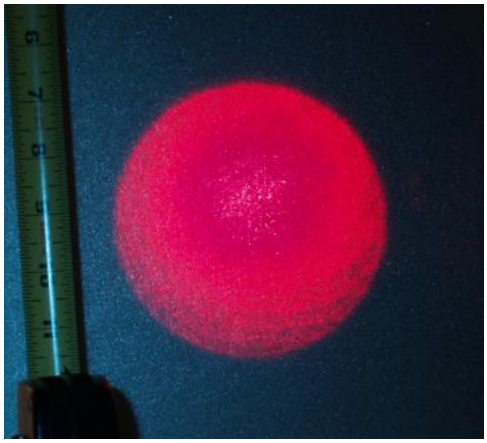
Up close, the mirror shows a thin raised edge of less than a millimeter width due to surface tension during the epoxy fabrication process. There were some scratches, fingerprints, and dust on the mirror which may have contributed to some scattering issues mentioned later. There is a convenient attachment disk on the rear of the mirror which was used for support.

Lab Tests

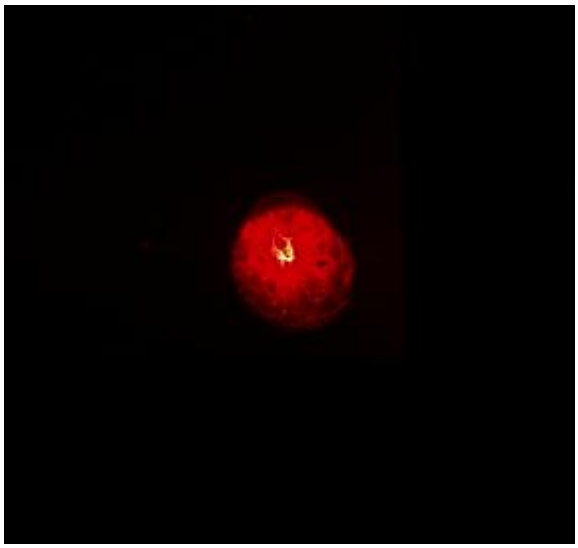
We masked off the mirror to avoid the turned-up outer edge. Our initial interferometer experiments using a 9.5 inch clear mirror aperture (masked off 0.25 inch edge) were devoid of fringes, so we decided to concentrate on characterizing the inner 50% diameter region.

Specular and Diffuse Reflection

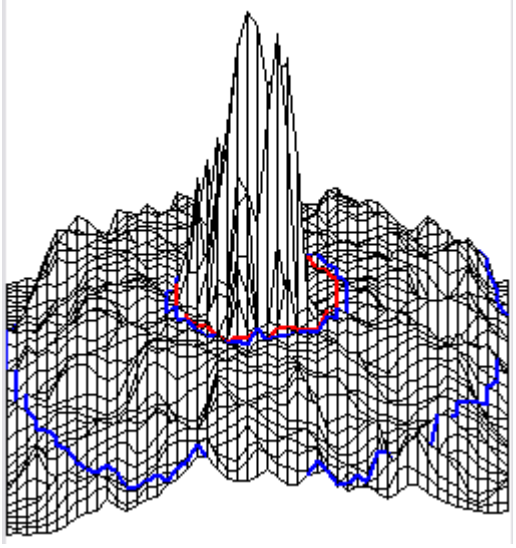
The central 5 inches of the mirror was illuminated with the interferometer serving solely as a monochromatic light source. The speed of the mirror in this mode was *f*/7.4.



The figure on the left shows an image of the 5 inch laser illuminated spot at the distance to the mirror. On the right is shown a picture of the returned flux at the radius of curvature with the lights out. Noticeable scatter of light around the central bright spot is apparent.



Best focus of the halo is about 5-mm in diameter.



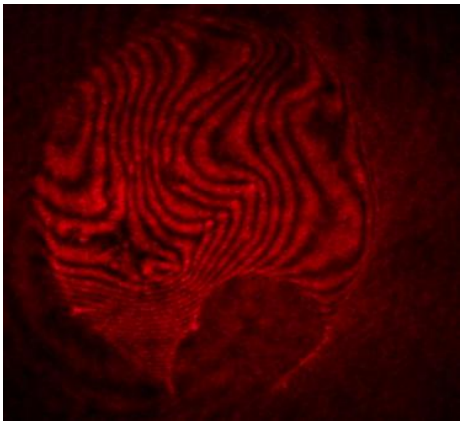
Point Spread Function (PSF)

The bright core of the PSF is shown with a red ring and the disk/halo is encircled in the outer blue ring.

	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)		

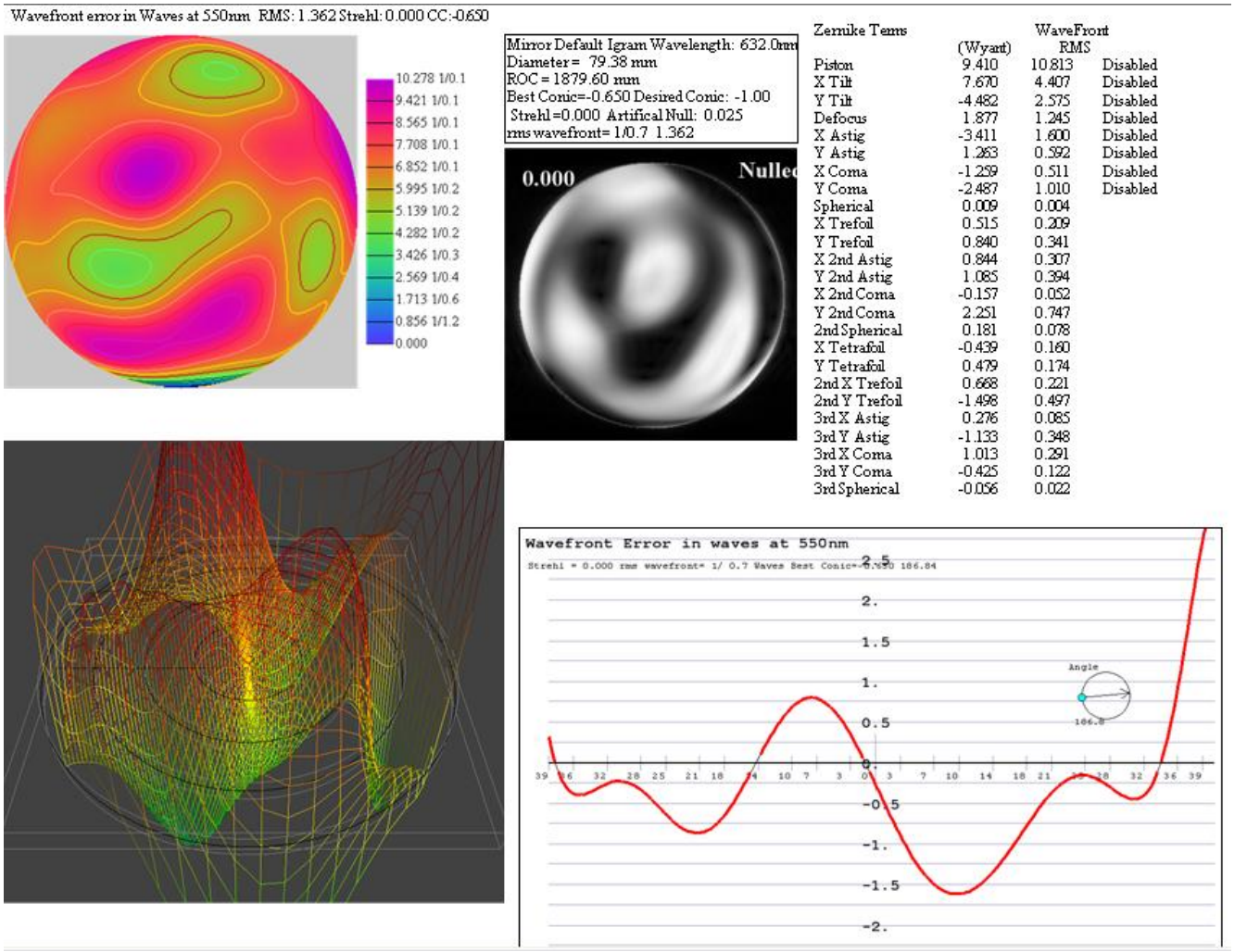
Interferograms

The 5 inch disk was too busy to analyze with the interferometer. So, a central 3.125 inch aperture was utilized. The mirror is operating at *f*/11.5 with this aperture.



Interferogram of central 3.125 inch aperture.

Immediately apparent in the interferograms are some dimples in the mirror surface. The dimples produced the two blotches at the 6 o'clock position in the interferogram. The rest of the interferogram is very busy but analyzable. Fringes that ended at the dimples were extended through the dimpled area when doing the analysis. This distorts the actual fringe analysis, but was hoped to give a view on what is happening at the level of the mirror surface.

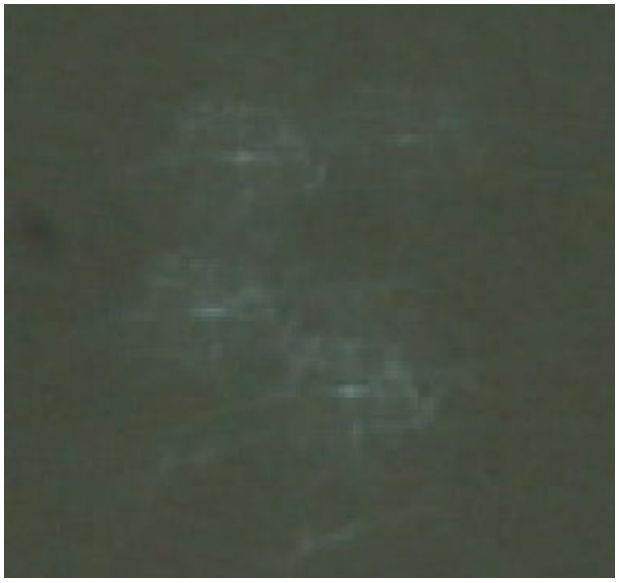


With astigmatism, coma and other lower order aberrations disabled, the calculated rms wavefront error is 1.32 waves and the best conic fit is -0.65. The interferometer results predict a ~30 arc second spot with those aberrations disabled. Adding back in the coma and astigmatism terms, the rms wavefront is 2.5 waves and the predicted spot is about an arc minute in diameter. It is unclear what part of the PSF results in the interferogram fringes – is it the central core or both the core and halo?

Star Tests

The 3.125 inch aperture was used on the mirror for artificial star tests in our lab setting. The mirror was washed before these tests. A Hubble Optics 5-star flashlight was used for illumination. The apertures are precision holes of 50/100/150/200/250 microns. The flashlight was placed about 36 feet away = 11.0 m. The largest hole in the Hubble flashlight appears to be 5 arc seconds in diameter at that distance. The hole-to-hole separation was

measured at 7.7 mm (144” or 2.4 arc min) and the diameter of the 5-stars is about 12.5 mm (234” or 4 arc minutes).



Subjective best focus of the Hubble test source at 11-m.

The halos of the “stars” are about 120” (about 2 arc min) in diameter. The smallest test star (50 microns) is not visible.

The figure above is of the 250 micron test star with the other stars covered. Some of the scattered flux is due to the dimples.