Lander University 22 Inch Spin-Cast Epoxy Mirror Tests

Bruce Holenstein and Dylan Holenstein/Gravic

December 21, 2011

*** Preliminary ***

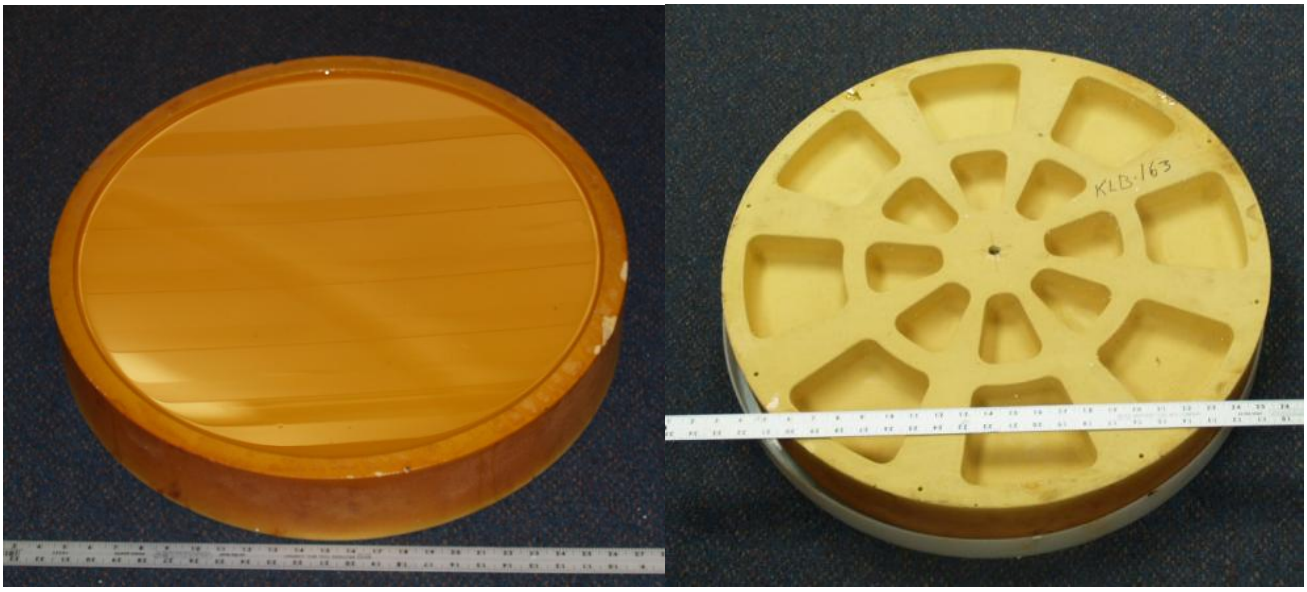
Introduction

At the request of Lisa Brodhacker from Lander University, we evaluated a 22 inch diameter prototype spin-cast epoxy mirror, No. KLB-163, for optical performance.

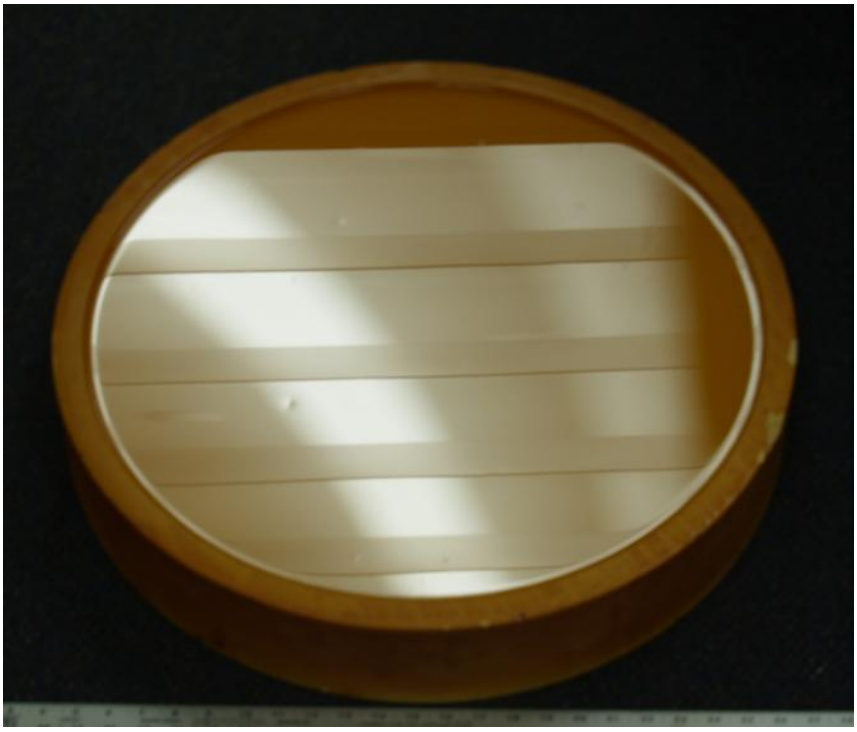
Equipment

Thorlabs HeNe Laser
Bath interferometer
OpenFringe v10
Olympus E-500 DSRL
Casio Exlim EX-S5
LED flashlight with 1mm diameter aperture
Various masks (4" to 15" diameter)
Watec WAT-902H CCD camera
VirtualDubMod
4CH DVR

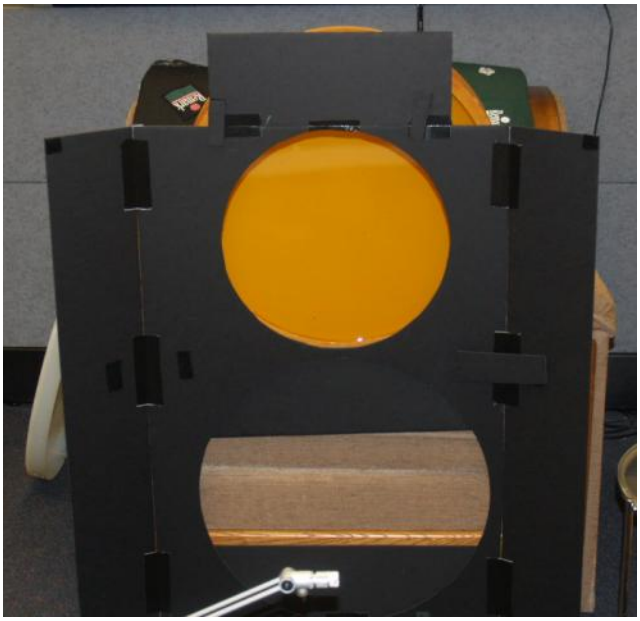
Mirror Description



The Lander 22 inch mirror, No. KLB-163, is a multi-layer epoxy composite. The mirror measures 22 inches in diameter, weighs about 16 lbs (with cell), and has an approximately 74 inch radius of curvature. The mirror is uncoated and the epoxy has an orange color. The back side of the foam cell has been CNC machined to remove material to make the cell lighter. The overall diameter of the cell is 24 inch, with a 4 inch thickness.



Specular reflection of the office lights shows some minor dimples. The surface is smooth to the eye and free of visible ripples or other high-frequency defects.



The arms of a plush armchair bolstered with wrist and arm beanbags cradled the mirror for the tests. A 15” diameter mask is in place.

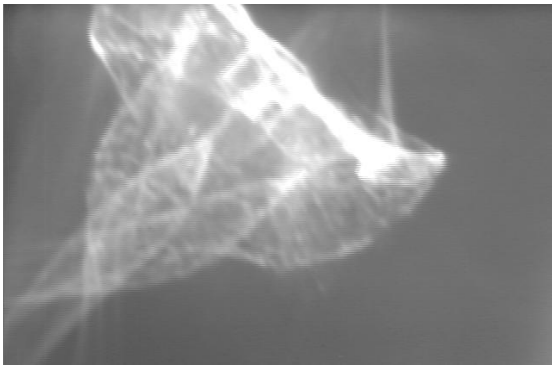
Lab Tests

The lab work consisted of i) artificial star, ii) Bath interferometer, and iii) straight edge mask.

Artificial star

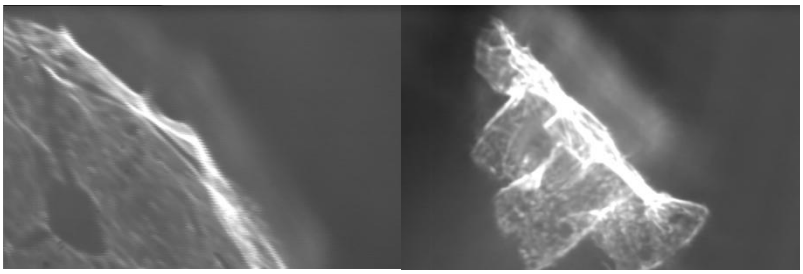
We placed an artificial star (planet) consisting of a 1 mm aperture over an LED flashlight at a distance of 21.9 m (72 feet) from the mirror. At this distance the artificial star subtends 9 arc seconds. We conducted the spot tests unmasked, full 22 inch aperture and then used a 15 inch mask. We imaged the flux captured on the monochrome Watec camera. This CCD in this camera has ½ inch diagonal array of 8.4 μm(H)×9.8 μm(V) pixels. The focal distance of the mirror is about 37 inches, so the full CCD has a field of view of about 45 arc minutes and each pixel is about 1.7 arc seconds.

Full 22 Inch Aperture Spot

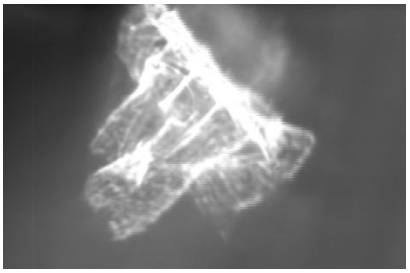


Since the spot was so large (30 arc minutes), we moved over to the masked mirror.

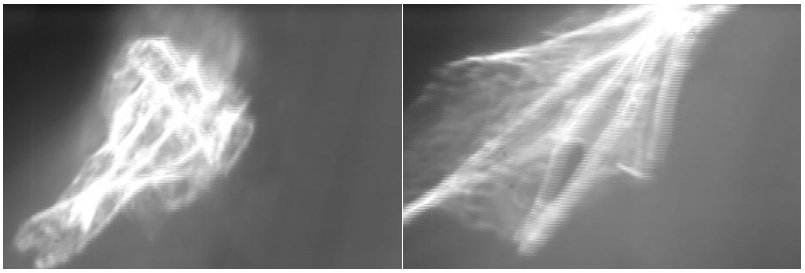
Spot from 15 Inch Masked Mirror



Intra-focus side



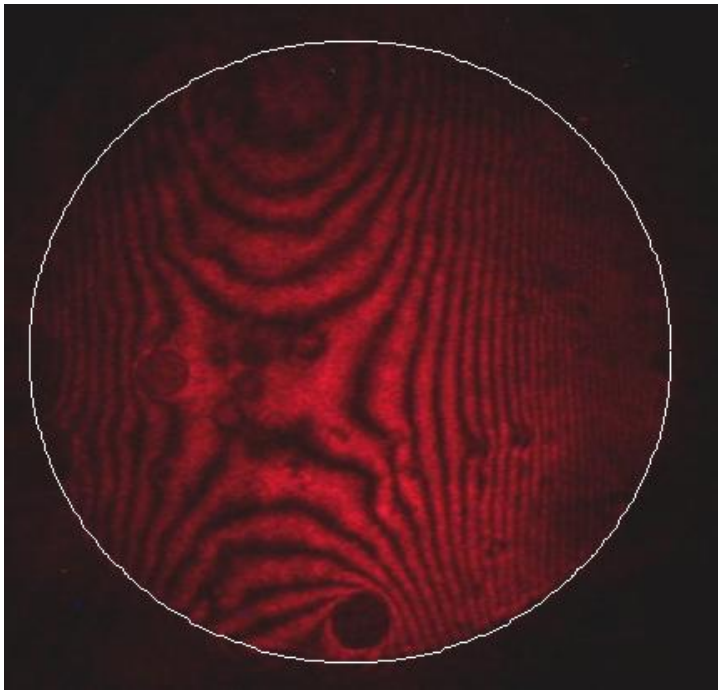
Near best focus the spot size was somewhat improved compared with the unmasked mirror.



Extra-focus side

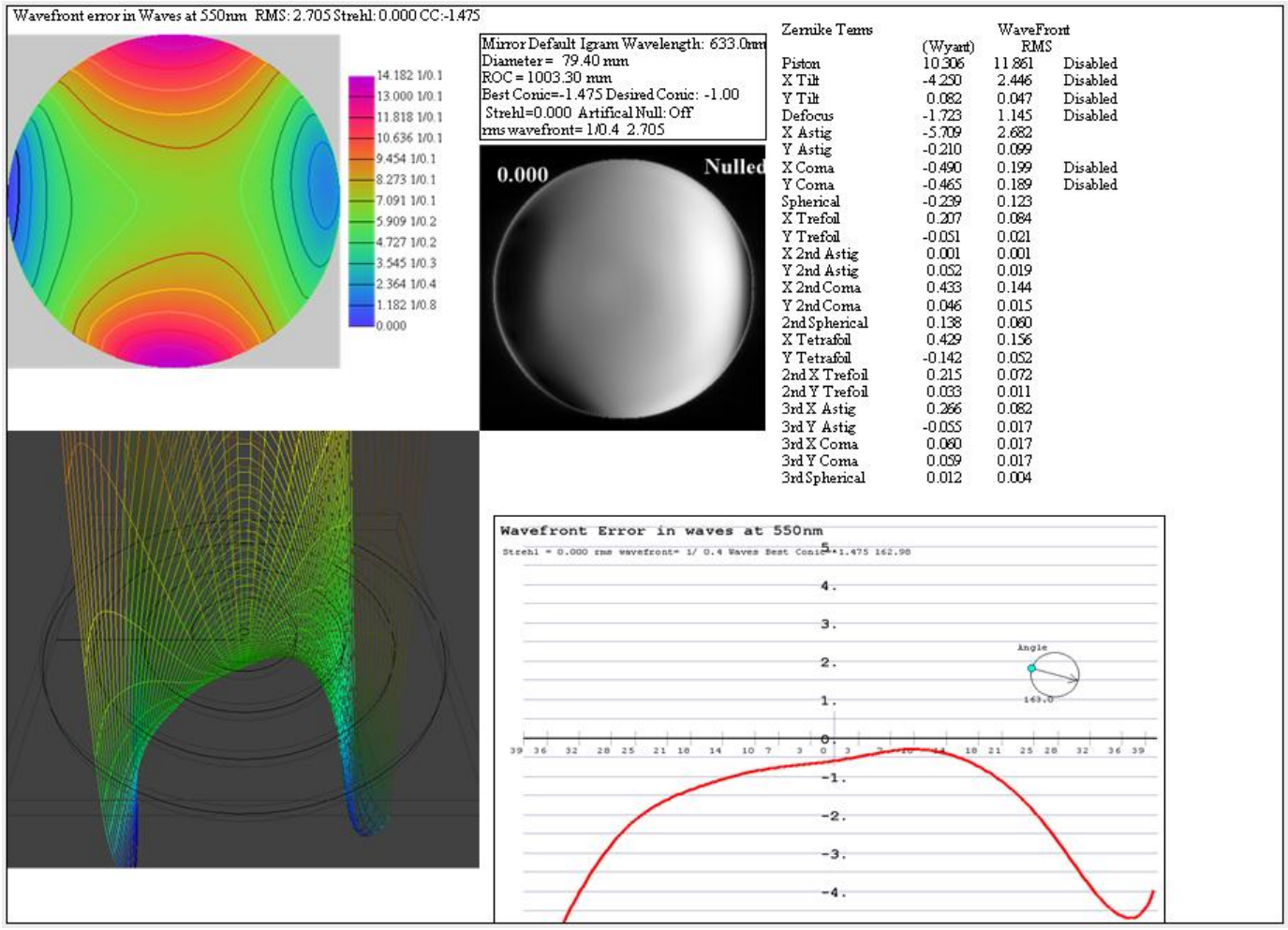
Interferometer Results

The following Bath interferometer results are from the central 10.5 cm (4.125 inch) of the mirror. High frequency structure (surface roughness) is present as are a couple of visible dimples.

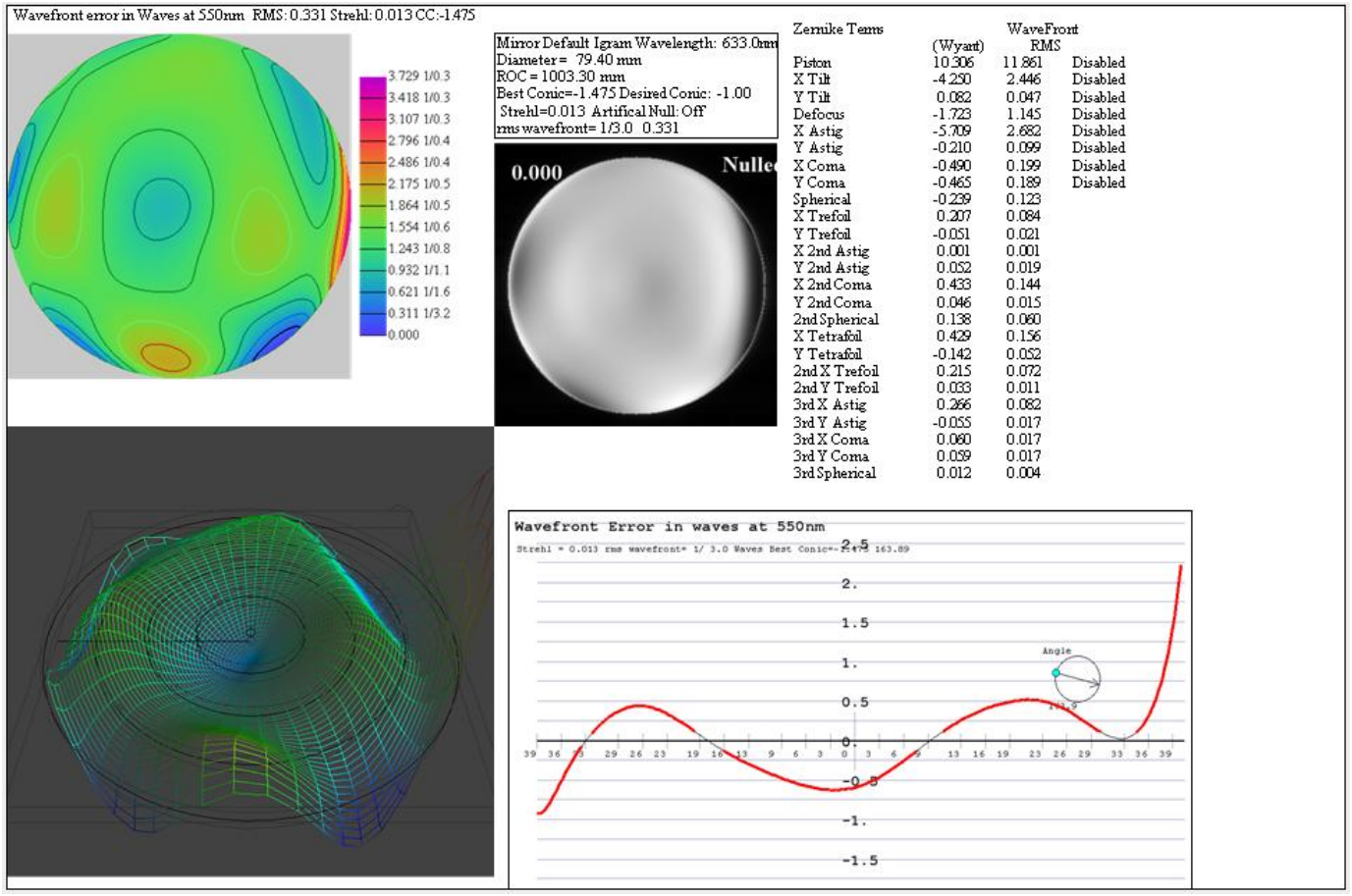


The un-aluminized epoxy reflected a small amount of light and so the fringes were faint. We used fringe tracing to map the surface.

The mirror report follows and shows that the mirror is over-corrected from a parabola, but this could just be an artifact of the large astigmatism. The Strehl ratio is zero because the Astigmatism terms are large and turned on in the report. The Bath interferometer in this configuration should inject only a tiny fraction of a wave of astigmatism (9 nm). The astigmatism largely rotated when the mirror was rotated.

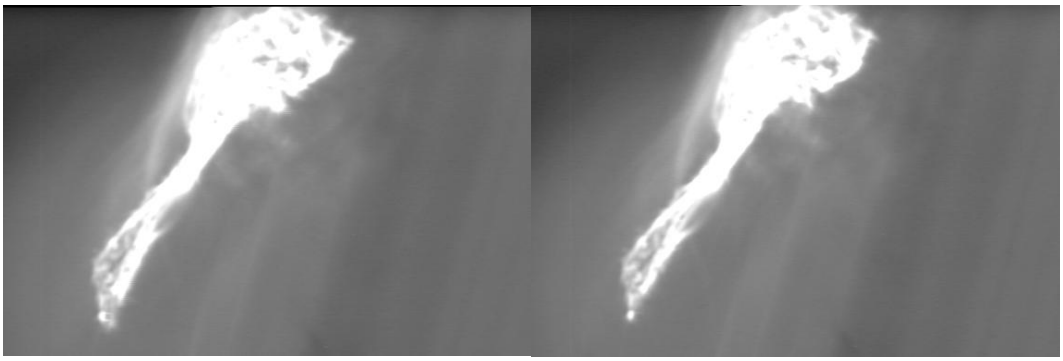


The large astigmatism in the mirror may be a result of the epoxy shrinking as it dries. If so, a stiffer backing or other solution is needed. Adding another thin layer of epoxy on the mirror may not help because it will add in new stresses. The following report has the astigmatism terms turned OFF:

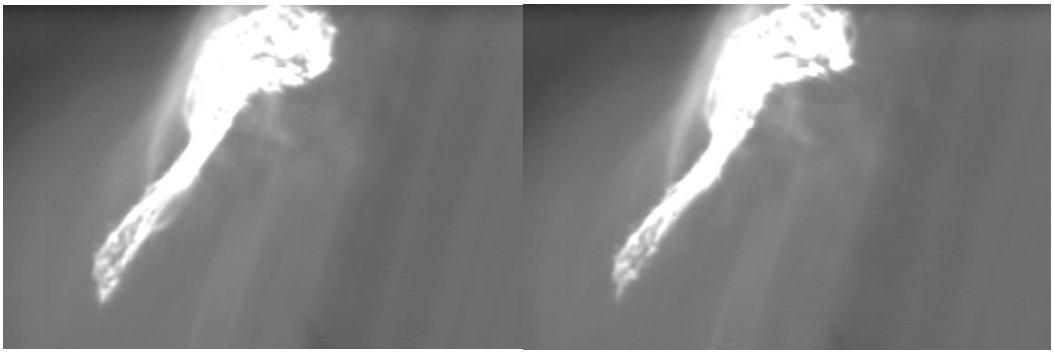


Straight edge mask

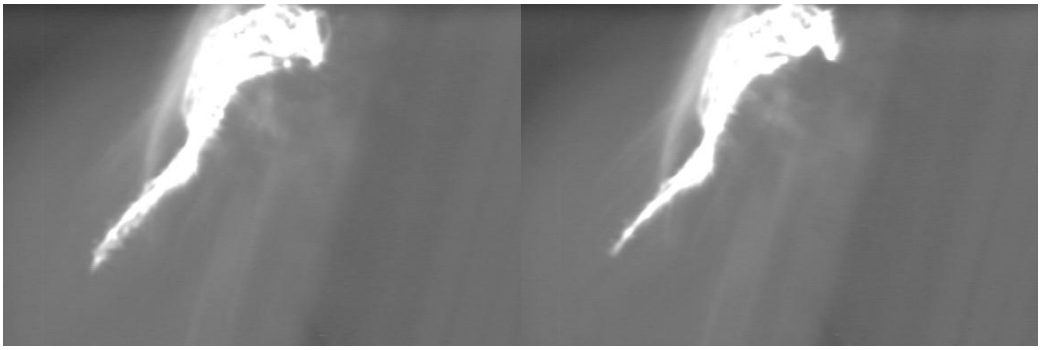
We used an opaque sheet to occult the unmasked mirror to see zones contributing flux to the spot. The mask was held horizontal and dropped over a period of three seconds at a uniform rate to completely occult the beam. The following ten images represent the spot every ten frames as it disappears. .



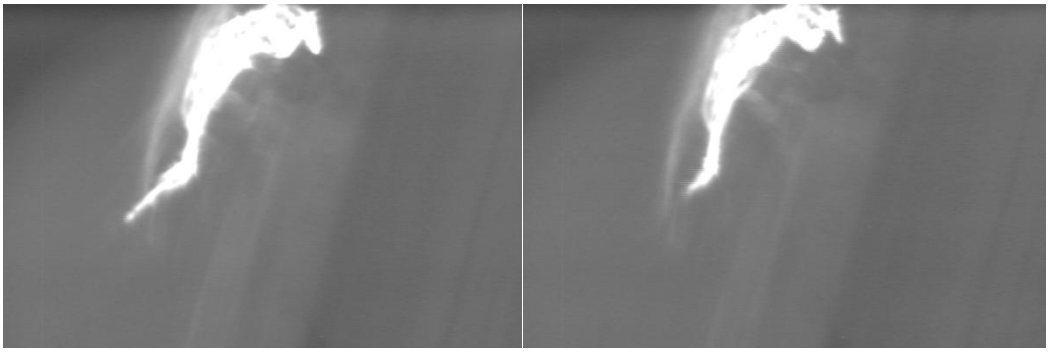
Frame 0 10



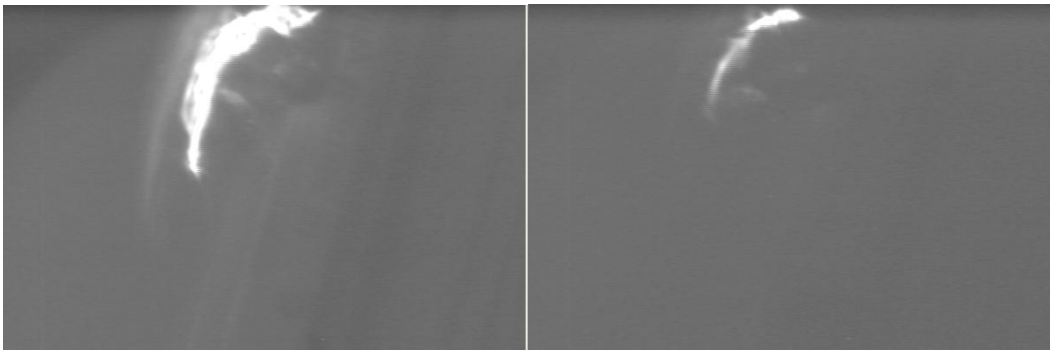
20 30



40 50



60 70



80 90

Frame 0 shows the full spot just outside of best focus. It has a lot of astigmatism.
One sees some scatter from high-frequency surface defects diminish in the halo around the spot.