Light-Tightness Quality Check for Curtis Schmidt 8-inch Shutters

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Abstract: We seek to measure how much incident light is "leaked" through a closed CCD shutter. We find that by orienting the actuator towards the CCD the shutter leaks 1 in 100,000 at most and that by orienting the actuator away from the CCD the shutter leaks 1 in 250,000 at most.

I. INTRODUCTION

Light-tightness is an important quality in shutters. Poor tightness can introduce error into approximations of star brightness. To better understand how this shortcoming can affect the science goals of the Curtis Schmidt Telescope, we seek to quantify the "leaked" light.

II. EXPERIMENT

Shutter 1 and shutter 2 were each tested with the actuator towards and away from the CCD. Three images (Dark, Intensity, and Signal) were acquired for each of the four configurations. For all images, one sheet of white printer paper was taped to the shutter to sample the transmitted light at the plane of the shutter. The papers properties (diffusion, homogeneity, etc.) will be divided out in the data processing. For all images, the experiment set-up contained a light source, the shutter and the CCD. The simulated point light source was constructed by placing a cardboard box with a 2-inch diameter aperture over a reading lamp. The light source was placed 3 feet from the shutter, and the CCD was placed at a distance of 6 feet on the other side of the shutter. For all images, the exposure time was 10 seconds with F1.8.

For dark image data, a circular piece of black cardboard was taped to the light-facing side of the shutter. This ensured that no light was transmitted, and that the noise light (which we want to measure in the dark) was not disturbed. The shutter was left closed.

For intensity image data, the unobstructed (except for the paper) shutter was opened. To keep the CCD from saturating, a natural density filter was placed into the light source aperture to cut the brightness by a factor of 1000. The intensity image data was used to measure the distribution of light across the surface of the shutter. The division of the intensity from the signal data will normalize the data in the event that one portion is better lit than another, and it will remove the properties intrinsic to the paper.

For the signal data, the unobstructed shutter was left closed. The intensity image data was used to measure how much light leaked through the cracks of the closed shutter.

We choose to characterize the leaks by the percentage of light leaked. By subtracting the dark from the signal, we get the transmitted light image. By subtracting the dark from the intensity, we get the incident light image. By dividing the transmitted by the incident, we get the percentage of light leaked. The results for the four configurations are listed in the following pages.

$$Percent\ Leaked = \frac{Signal - Dark}{Intensity - Dark} \tag{1}$$

III. RESULTS

In shutter 1, the actuator towards CCD position leaked about 2.5 times more light than the actuator away from CCD position. At its brightest, the leaked light from the actuator towards CCD position was 25 times brighter than its noise. At its brightest, the leaked light from the actuator away from the CCD position was 4 times brighter than its noise. From this, I would conclude that the actuator away CCD position did better in spite of that its test did have more noise.

In shutter 2, the actuator away from CCD position leaked about 1.8 times more light than the actuator towards CCD position. At its brightest, the leaked light from the actuator towards CCD position was 5.4 times brighter than its noise. At its brightest, the leaked light from the actuator away from the CCD position was 18 times brighter than its noise. From this, I would conclude that the actuator away CCD position is better even though its test did have more noise. This suggest the opposite position from shutter 1 is better for shutter 2. I would question the accuracy of my results from shutter 2.

IV. CONCLUSIONS

Shutter 1 and shutter 2 had similar results for the actuator away from CCD position, but different data for the actuator towards CCD position. Shutter 1 data produced similar results to previous experiments. I doubt the data for shutter 2 actuator towards CCD position.

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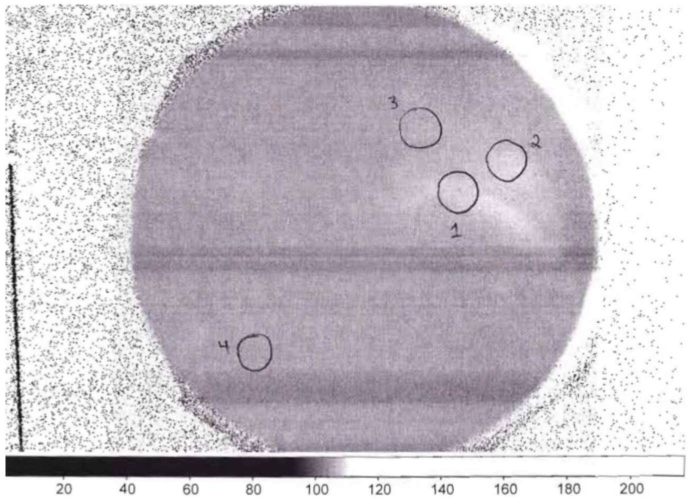

FIG. 1. Shutter 1 with actuator facing towards CCD.

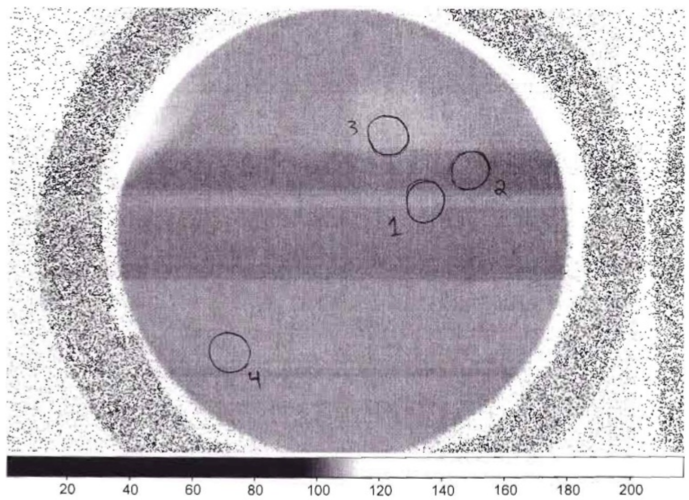

FIG. 2. Shutter 1 with actuator facing away from CCD.

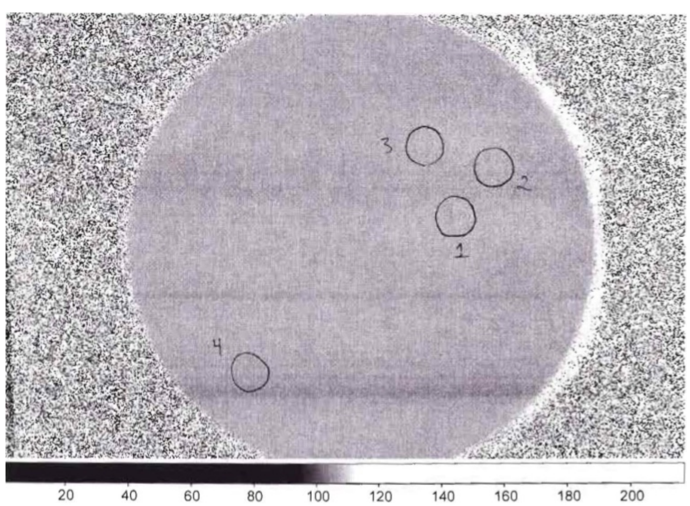

FIG. 3. Shutter 2 with actuator facing towards CCD.

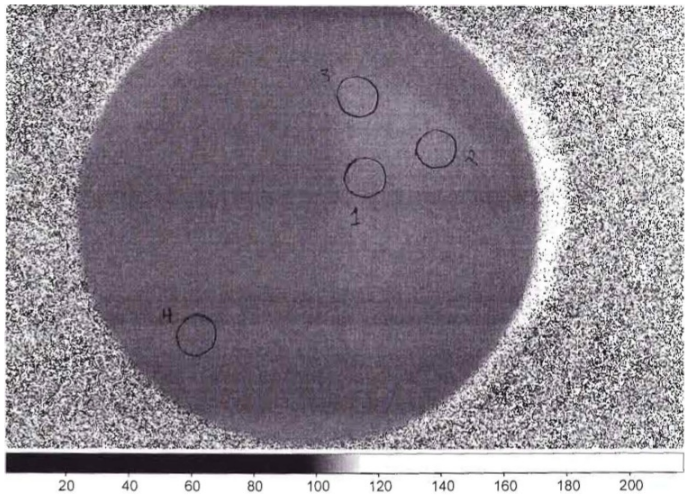

FIG. 4. Shutter 2 with actuator facing away from CCD.

TABLE I. Mean of 25 Pixels Taken at Points of Interest.

Shutter/Orientation	Point	Percent Leaked (1=100%)	Standard Deviation
1 Towards	1	8.732E-6	6.896E-7
	2	9.622E-6	7.843E-7
	3	3.136E-6	7.774E-7
	4	2.196E-7	5.542E-7
1 Away	1	2.358E-6	5.954E-7
	2	3.208E-6	6.901E-7
	3	4.127E-6	5.809E-7
	4	1.067E-6	5.634E-7
2 Towards	1	1.462E-6	7.998E-7
	2	1.940E-6	7.394E-7
	3	1.474E-6	6.270E-7
	4	3.551E-7	6.498E-7
2 Away	1	2.328E-6	5.727E-7
	2	3.544E-6	6.990E-7
	3	2.634E-6	6.842E-7
	4	1.993E-7	5.498E-7