Astronomy Lab: Report 3

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Introduction

In this experiment, we capture and analyze flat field images. Flat frames help correct for pixel-to-pixel sensitivity variations (vignetting, dust shadows, or sensor inconsistencies) in astronomical images. By understanding these variations, we can normalize our images, ensuring that any brightness differences originate from the celestial objects and not from the equipment itself.

Experiment

We captured a series of flat frames by pointing the camera at a uniformly bright area of the sky during twilight, to make sure no significant objects like stars or clouds were present. We varied the exposure times as follows:

- 1/160s
- 1/100s
- 1/60s
- 1/40s
- 1/20s
- 1/13s
- 1/8s

In the previous dark frame experiment, we had an issue when converting files to the FITS format, resulting in automatic grayscale conversions by Siril. This time, I resolved the issue by adjusting Siril's settings to retain the original color data and without any unintended preprocessing.
The data analysis and plotting process were similar to the dark frame workflow. However, for this experiment, I chose to report mean values exclusively. The mean is more appropriate for flat frames because our goal was to capture the overall average sensitivity pattern across the sensor. The median, was helpful for rejecting outliers in dark frames but may underrepresent the true brightness levels in flat frames by suppressing valid pixel variations caused by vignetting.

Histograms

For each exposure time, I generated histograms representing the distribution of pixel intensities in the master flat frames.
The histograms are expected to exhibit a relatively narrow peak around a central intensity value becuase of the uniform illumination. Minor deviations may occur due to vignetting or dust shadows. The results here show clean, single-peaked distributions as expected. The shapes look like a slightly skewed normal distribution, which is also expected due to small variations in sensor noise.

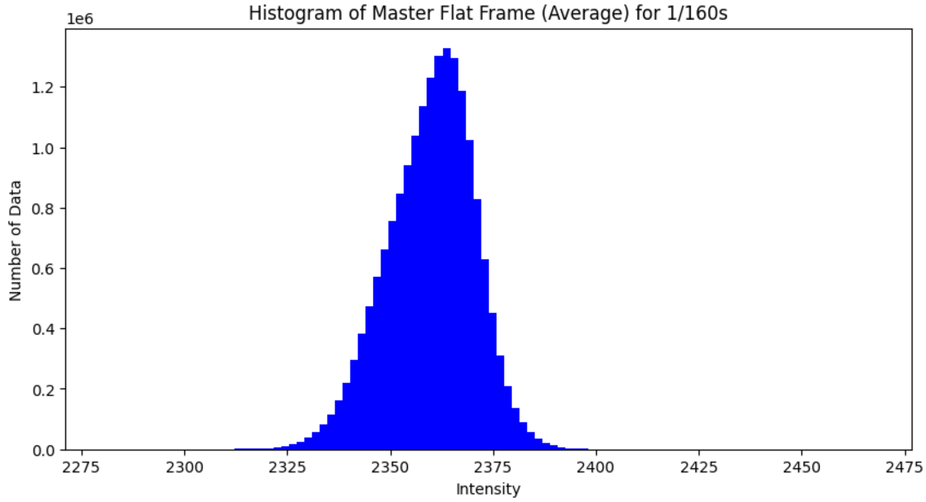

Figure 1: Number of data vs Intensity for average method with exposure time = 1/160 s

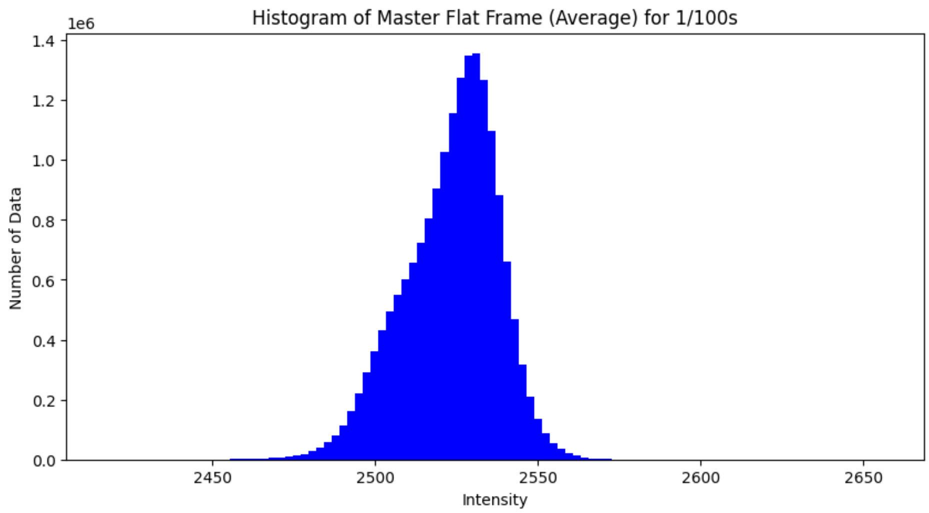

Figure 2: Number of data vs Intensity for average method with exposure time = 1/100 s

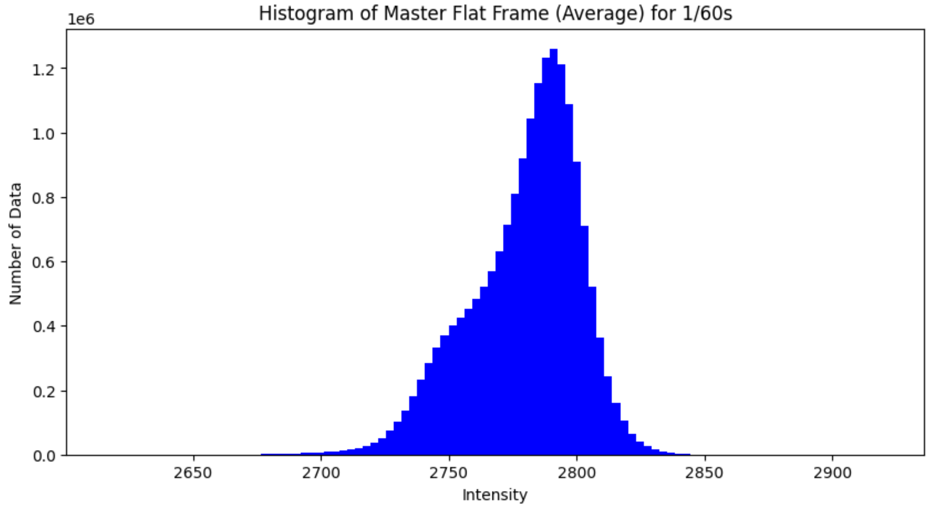

Figure 3: Number of data vs Intensity for average method with exposure time = 1/60 s

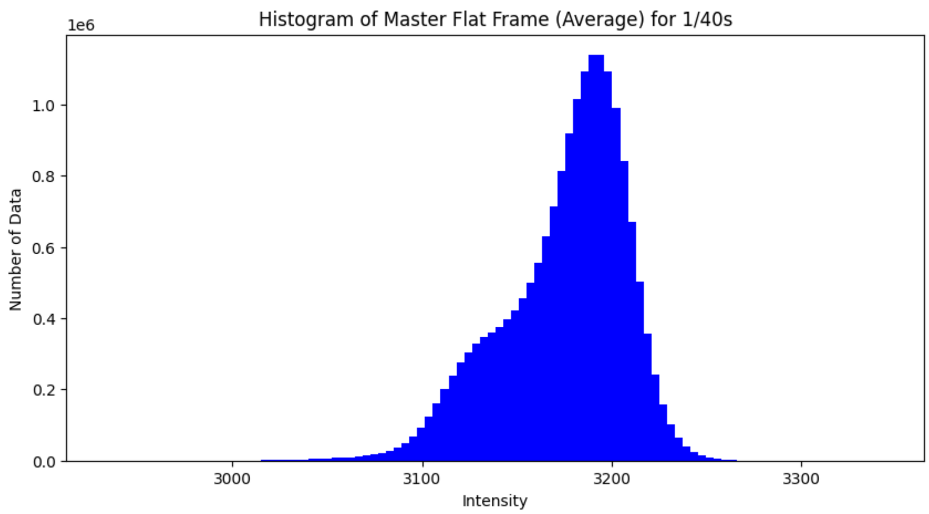

Figure 4: Number of data vs Intensity for average method with exposure time = 1/40 s

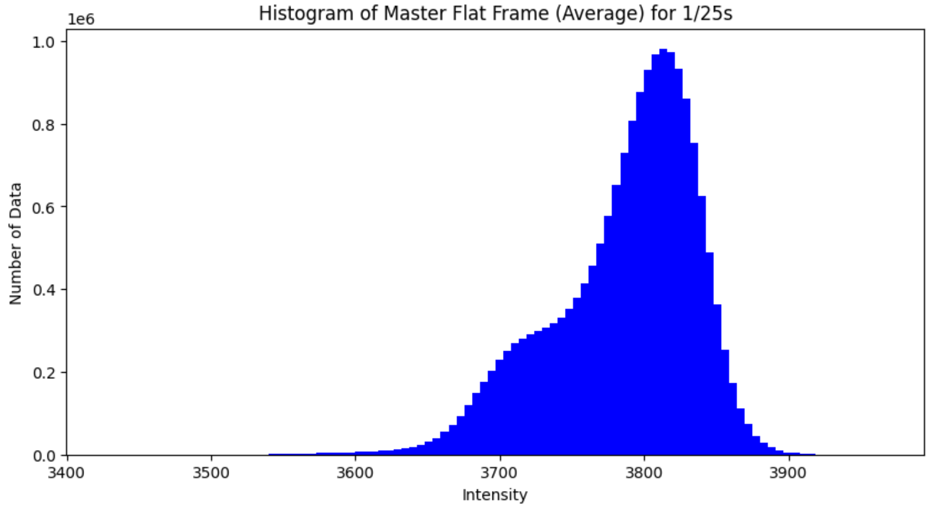

Figure 5: Number of data vs Intensity for average method with exposure time = 1/25 s

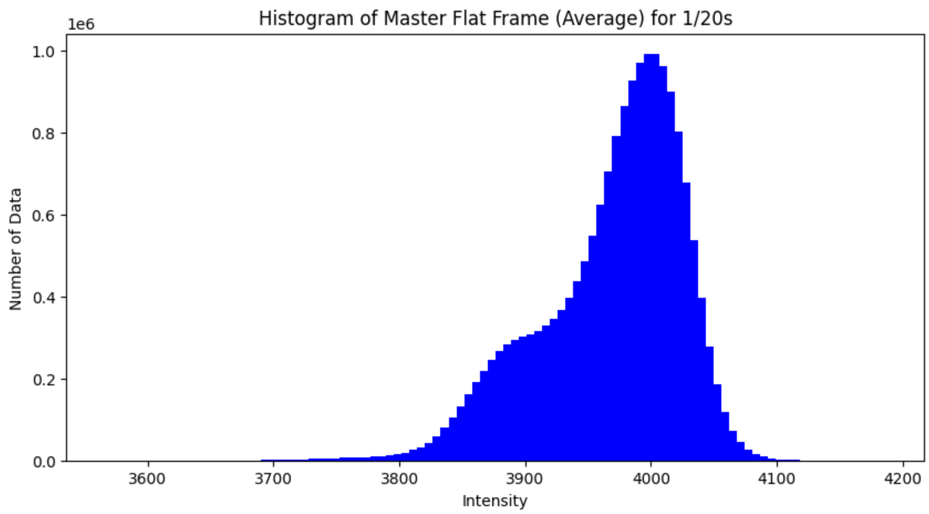

Figure 6: Number of data vs Intensity for average method with exposure time = 1/20 s

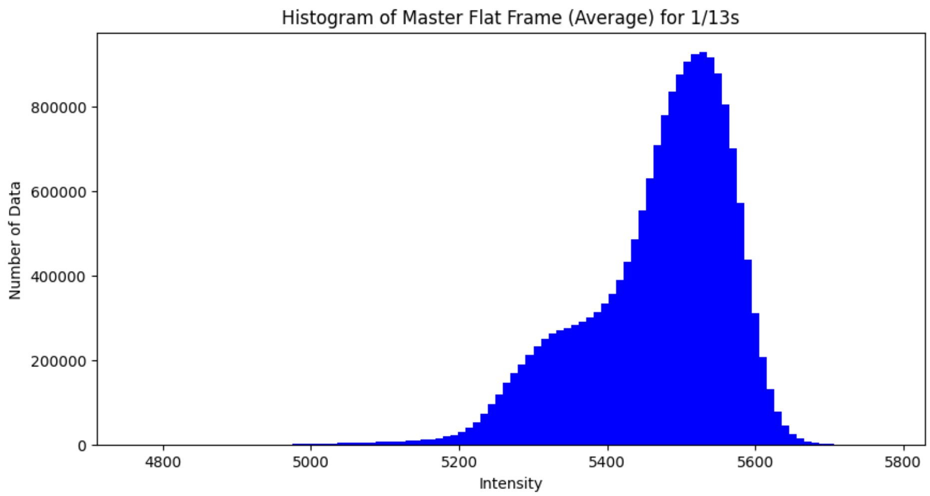

Figure 7: Number of data vs Intensity for average method with exposure time = 1/13 s

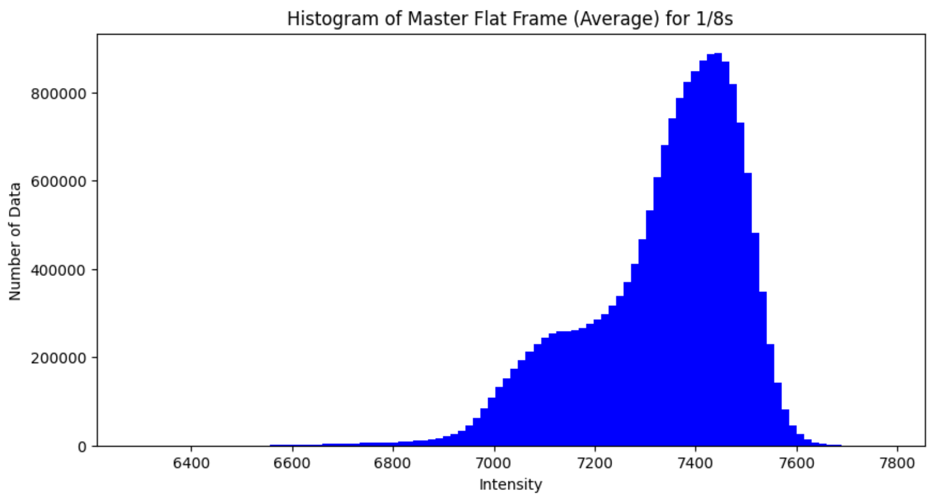

Figure 8: Number of data vs Intensity for average method with exposure time = 1/8 s

Error Analysis

Exposure Time (s)	**Mean Intensity ± Error**	**Variance**
1/160	2359.8353 ±0.0025	112.7813
1/100	2523.3302 ± 0.0034	209.6495
1/60	2779.8717 ± 0.0050	457.1656
1/40	3175.1429 ± 0.0076	1047.7445
1/25	3786.3896 ± 0.0117	2480.0904
1/20	3969.0007 ± 0.0132	3162.7928
1/13	5468.9781 ± 0.0231	9626.7434
1/8	7336.2021 ± 0.0360	23413.2208

Table 1: Mean Intensity Values with Uncertainty for Different Exposure Times

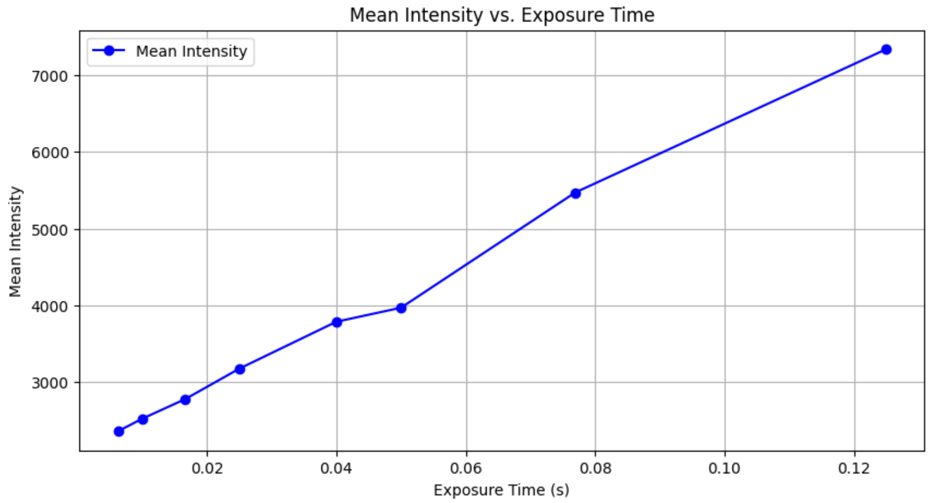

Figure 9: Mean Intensity vs. Exposure Time for average method

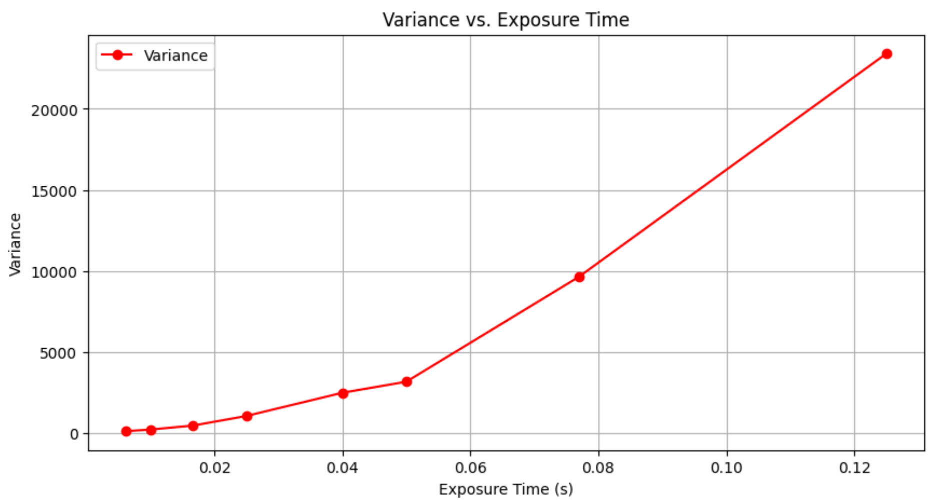

Figure 10: Variance vs. Exposure Time for average method

Question

If there is dust on the lens, will the image be sharp? What if it is on the filter or the detector itself?

If dust is on the lens, the dust will be out of focus and appear as a blurry shadow. This happens because the lens focuses light from the sky, but the dust is much closer to the sensor. If the dust is on the filter or the sensor itself, the dust shadow will appear sharp. This is because the dust is directly in the optical path at the plane of focus.