Photonfocus Camera Evaluation

Scott Sewell and Steven Tomczyk
Last Revised May 5, 2010

Summary: This note presents the results of the characterization of the Photonfocus CMOS camera which is a candidate camera for the COSMO K-coronagraph. The characterization consisted of three tests; a) light transfer curve measurement which determined the camera noise in e- and the camera gain in e-/ADU b) a linearity measurement and c) a test of the ability of the camera to reduce noise through image averaging.

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COSMO Tech Note #15 on the K-coronagraph error showed that the most important figure-of-merit for the K-coronagraph detector is the product of frame rate and full well depth. A review of available cameras identified the Photonfocus MV-D1024E as an excellent candidate with a 1024x1024 pixel format, readout rate of up to 150 fps, full well of 200 ke- and read noise of 100 e-. We obtained a loaner camera and performed a characterization of the camera using a Bitflow Camera Link board and LabView programming.

Light Transfer Curve Measurement

The optical setup for the light transfer curve (LTC) measurement is shown in Figure 1. The LED was driven by a stable current source, and stray light was controlled through the use of lens tubes. For the measurement, 30 pairs of images were taken at increasing values of illumination. Analysis of the data followed in the usual way, i.e. differences were taken at each illumination level and the variance was computed in 64x64 pixel subarrays across the image. The variance was divided by 2 to account for the increase in noise by differencing. The resulting curve is shown in Figure 2. It shows the camera to be significantly non-linear. A linear fit to the curve for ADU below 1200 yields a readout noise of 182 e- and an average gain factor of 44 e-/ADU. Taking the saturation level to be 3800 ADU gives a full well depth of ~170 ke-. The non-linearity is a serious concern.

A typical difference image at low light level is shown in Figure 3. It shows a banded appearance, which appears to be due to the presence of a quasi-sinusoidal modulation of the signal at a period close to the row readout time.
Figure 1. Setup for the light transfer curve measurement.

Figure 2. Light transfer curve for the Photonfocus camera. Each point represents the variance of one of the 64x64 pixel subarrays at one exposure level.

**Linearity Measurement**

The camera linearity was evaluated by illuminating the camera with a constant illumination from the LED and exposing the camera to successively longer integration times. The result is shown in Figure 4. The non-linear nature of the camera is confirmed here.
Figure 3. Difference image at low light level.

Noise Averaging Test

The ability to reduce the noise from this camera with averaging was tested by taking 20,000 images with the camera at a rate of 140 fps under dark conditions. This amounts to about 2.2 minutes of data. 10,000 image differences were computed and used to compute successively increasing averages of the difference images. The standard deviation, rms and average value were computed at each successive averaging step. Figure 5 shows the results with the standard deviation, rms and absolute value of the mean plotted in the three panels vs. the number of averages. The expected inverse root \( n \) dependence is shown as the dotted curves on the top two figures. The observed behavior follows very closely the expected dependence. Two orders of magnitude decrease is seen in all quantities.

References

Figure 5. Plots of the standard deviation, rms and absolute value of the mean from top to bottom vs. the number of images averaged.