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Astro 480

Characterizing a CCD

Introduction:

We walked over to the SDSS lab and Oliver helped us connect the program and pull up the manual. It took awhile for the CCD program to connect and we then realized that the usb was not plugged in all the way. Set the bin to 1x1. We took the biases first and there was no real setup and it went very smoothly. We took 5 biases. We then moved on to the flats where we took 5 second test exposures without saving. These were taken with the small hole in the box open, and we got about 22,000 ADUs. The tests went well so then we turned on autosave and ran 3 exposures of 6 seconds each. We then moved on to saturation. We were not sure how much light to let in so we started by keeping the box open with a big roll of tape for around 100 seconds and it was extremely saturated. Next, we used a skinnier roll of tape for the same amount of time and still too much saturation. Finally, we used a pencil to keep the box open with an exposure time of time of 105, and we got right at saturation. It was at a mean count of about 34,000. We went down in exposure time by 10 seconds at a time because that was about .1 of 105. We went all the way down 0.16 seconds. We then shut down the systems and let the CCD warm up.

<u>Gain:</u>

Flat 1 mean = 17697.96, Flat 2 mean = 17669.28

Bias 1 mean = 107.69, Bias 2 mean = 111.65

Flat sigma = 285.41, Bias sigma = 52.18

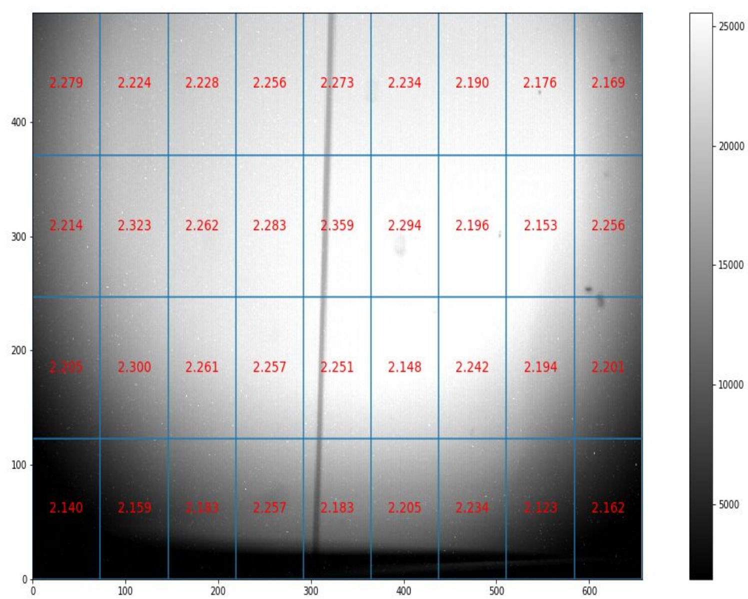
Gain = 2.24, Read Noise = 16.47

Sub flat 1 mean = 21156.94, Sub flat 2 mean = 21118.59

Sub bias 1 mean = 112.29, Sub bias 2 mean = 116.49

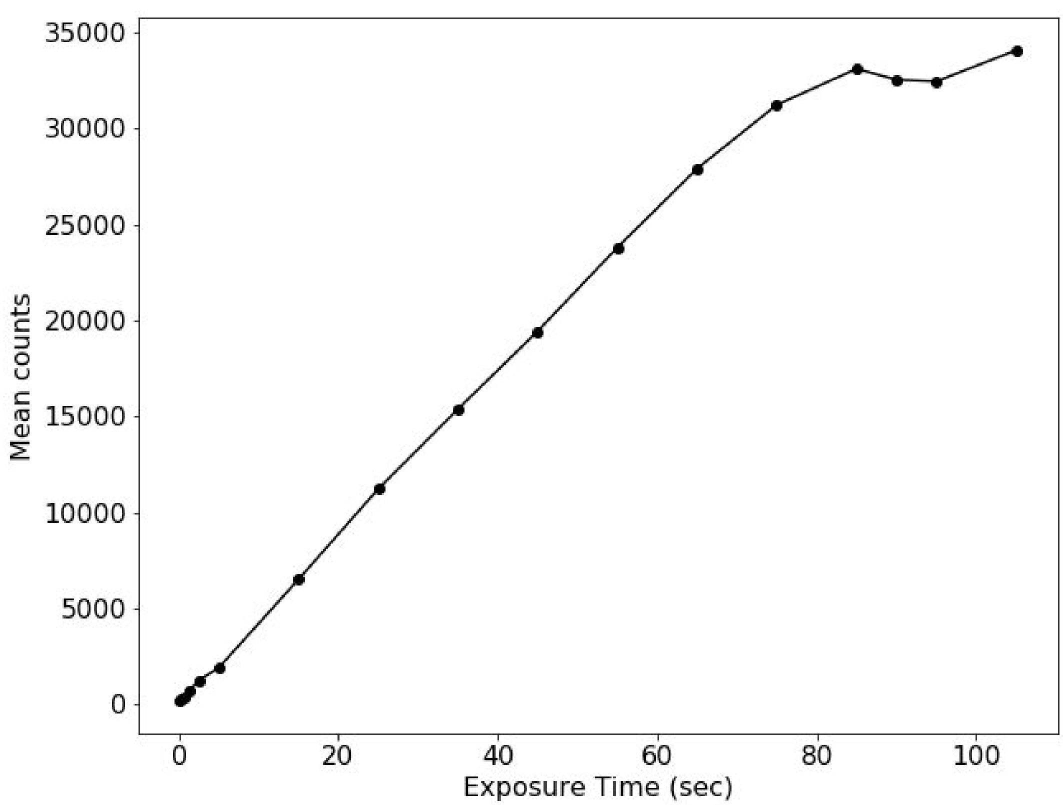
Sub flat sigma = 312.09, Sub bias sigma = 52.20

Sub Gain = 2.24, Sub Read Noise = 16.39



I found all of our means and standard deviations from the equations given in the pamphlet. I plugged in two seemingly identical flats and biases. Our gain came out 2.24 which is a valid value for our CCD. The python function spit out gain in the units of ADU/e- so we received a value of about 0.44. To get our gain in the correct units of e-/ADU, I took the inverse of the gain to get about 2.24. Compared to the given gain of 1.3e-, our gain is almost double that value which could be due to the use of a different type of detector.

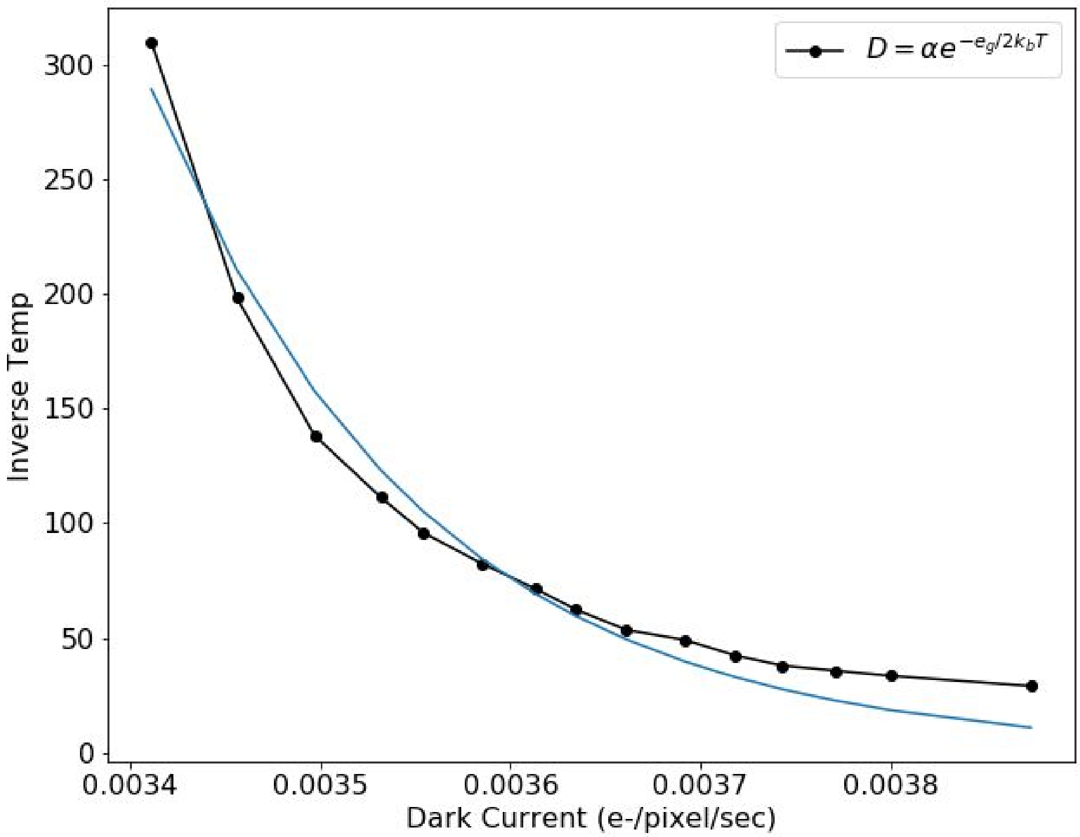
Linearity:



File name	Exposure time (sec)	Mean Counts
Pencil0.16	0.16	185.59
Pencil0.31	0.31	260.67
Pencil0.63	0.63	402.87
Pencil1.25	1.25	698.58
Pencil2.5	2.5	1255.83
Pencil5	5	1912.06
Pencil15	15	6514.27
Pencil25	25	11222.69
Pencil35	35	15383.94
Pencil45	45	19442.49
Pencil55	55	23804.44
Pencil65	65	27911.69
Pencil75	75	31235.74
Pencil85	85	33109.37
Pencil95	95	32454.10
Pencil105	105	34076.27

Above you can see the linearity plot of our CCD, it has a linearity range of 5000 mean counts and 30000 mean counts which is a good range because it gives a lot options with your exposure times. It has a bin of 1x1 so when we attempted to saturate the CCD it reached full well saturation before it reached ADU saturation because each pixel acts on its own so each pixel will fill up before the converter saturates. Also if use the gain of our CCD, we see that full well saturation occurs at 33000 mean counts where as ADU saturation occurs at 65000. It is important to stay in the linearity range because because once you reach nonlinearity you will receive inaccurate readouts from your nonlinear or saturated pixels. If a star is extremely bright and the CCD hits nonlinearity before it captures the full brightness of the star, you will see inaccurately low counts for that star. An observer who does not plot its detector's mean counts vs. exposure times or view their resulting image might not notice that it is nonlinear might not notice that their data is inaccurate. If we were using a Kodak camera, that had a full well of 150,000 electrons, a gain of 1.6 e-/ADU, and a 16 bit A/D converter we should worry about hitting ADU saturation before full well saturation. Full well capacity happens at 150,000/1.6 = 93,750 ADU while ADU saturation will occur at about 65,000 ADU. Clearly ADU saturation will occur first. If it 2x2 binning instead of 1x1 it would still reach ADU saturation first because the number of bits would stay the same so ADU saturation would stay the same, about 65,000 count, but full well saturation count would increase . If we were to retake the flats with UV filter the linearity graph could be much different because it would only let in short wavelengths instead of all wavelengths, but it would not affect which saturation it reaches first. The IR filter would do the same except for long wavelengths. You should take flats in the filter you are observing in because it pertains to your observation. For both filters it would lower your signal to noise ratio because you would only be getting signal from one regime.

Dark Current:



Our derived value of E_g, from our curve fit, came out to be 1.22 which compared to the known value of 1.1 is extremely close. The upper limit for the dark current is the grouped constant, K, in front of the exponential, because as temperature increases the exponential becomes e^0 so it becomes completely based on the constant. The upper temperature limit will be determined by how much heat the detector can take, so that would most likely be the melting point of silicon. While at low temperatures it would converge to 0, cold minimizes dark current. Since the first curve is technically just ADU, the difference in the slope comes from the difference between ADU and e-/pixel/second. So the difference would the original slope multiplied by the gain and then divided by the exposure time. It would change the accuracy of constant because it only has an affect on the exponential term in the equation. I derived a value 0.4e-/pixel/sec which compared to the value of 1e-/pixel/sec it is not too far off. The differences might lie in the fact that we used a different detector. To solve this problem we could run identical experiments on the two detectors side-by-side, and see if we get the same difference.

Summary:

Compared to the ST-10XME, our results for ST-7XME our results are very similar. It has the same amount of bits, but the gain was a little less than 2 times the gain for the 10. The read noise was also about 2 times that of 10, so the fact that the both are close to 2 times greater I believe those differences are from the different types of detectors. It might also be due to the difference in full well saturation between the two detectors, they differ by about 25,000 e-. The dark current at 0 degrees Celsius is only off by 0.1 so that is very close. In general, this exercise was extremely useful in seeing how to test a CCD before you can use it in an astronomical setting.