Weekly Report

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July 13, 2012

1 Collecting star data

I devoted most of this week's time to collecting data, and refining my methods for doing so. I wrote a procedure to automate collecting several days' worth of data for a single star at a single site, and turning the data into a file to save for later. I've been able to measure useable parameters for 17 of 20 imager sites, and by the end of this week I should have data for five different stars, for seventeen different sites, all arranged into files containing both pixel values and zenith angles.

The problem is that I figured it would be more efficient to collect data first and figure out how useful it is later; I used to have to do the opposite since the tracking methods would not work very well unless they had a star to point at most of the time. So there still remains the task of picking out useful data from the whole set. This task is made somewhat easier by the fact that I can look at the star data itself and pick out a familiar pattern that I've determined to be 'useful star data': repeating curves in the pixel value data having some correlation to the curves followed by the zenith angle.

2 Relating zenith angle to pixel value

I believe that I have been able to find a mathematical relationship between pixel value and zenith angle that should be consistent for all data, and should allow for the calculation of apparent magnitude values that are consistent between sites and correspond to conventional magnitude values, though with different scaling.

We know that the apparent magnitude of a star should be proportional to its flux (the type of flux that has to do with the number of photons that enter the device). The flux should in turn be proportional to the pixel values that I'm colllecting from the data.

Meanwhile, the apparent magnitude, when measured from the surface of the Earth, is reduced by a value dependent on the zenith angle of the star, and approximately proportional to the secant of the zenith angle, for angles below 70°, or around 1.2 radians. So for pixel count y and zenith angle θ a relationship of the form

$$\log(y) = a + b\sec\theta \tag{1}$$

where a and b are both constants. b is related to the amount of extinction the atmosphere causes at the zenith; a is reduced by b exactly when θ is 0. a is the magnitude one would expect to measure without the atmosphere, and for the same star at different sites, values of a should be the same throughout, even as b changes, since b is related to factors such as the device's altitude. Furthermore, we should be able to find that for different stars, different values of a should be linear in some way to apparent magnitude values in the conventional system, where Vega has a magnitude of 0, and stars are brighter as their magnitudes become more negative.

For angles too large for the approximation to be used, there are a number of formulas for the extinction coefficient, all evidently designed to provide more accurate values as the star approaches the horizon. Data taken very close to the horizon doesn't seem to work very well anyway, as the number of counts approaches zero and the relative uncertainty of the logarithm becomes too large, so I opted for a relatively simple formula that seems to work well for angles less than 1.4 radians, or 80 degrees:

$$\log(y) = a + \frac{b}{\cos\theta + 0.025e^{-11\cos\theta}} \tag{2}$$

So far the formula seems to work well and return a linear plot provided that the data I am using is very clear. It should soon be possible for me to determine whether values of a for different stars are consistent within a single site; I may need to look at different stars since evidently the five I've selected are very close in apparent magnitude to one another, so the differences in magnitude might be on the order of the uncertainties. This should provide more evidence that the relation that I hypothesized works; so far the only evidence I have comes from the linearity of individual plots. Once that is done I'll look at different sites, expecting to obtain consistent values of a. I think this will answer the question of whether different sites are able to provide consistent data, as convincingly as one can with the star data I'm collecting.

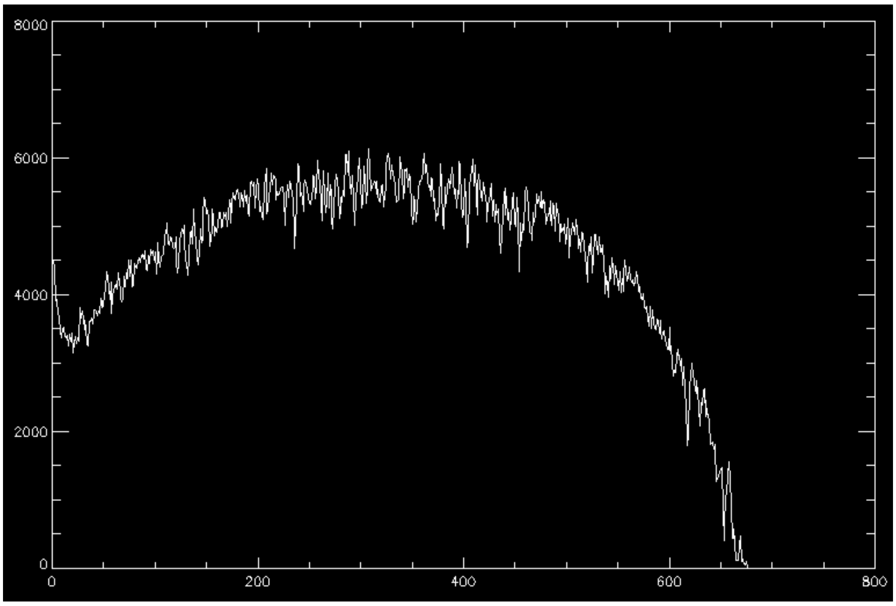

Figure 1: The brightness of Procyon at The Pas on January 31, 2011. I'm using Procyon specifically as an example of a star that reaches large zenith angles and that I've found clear data for.

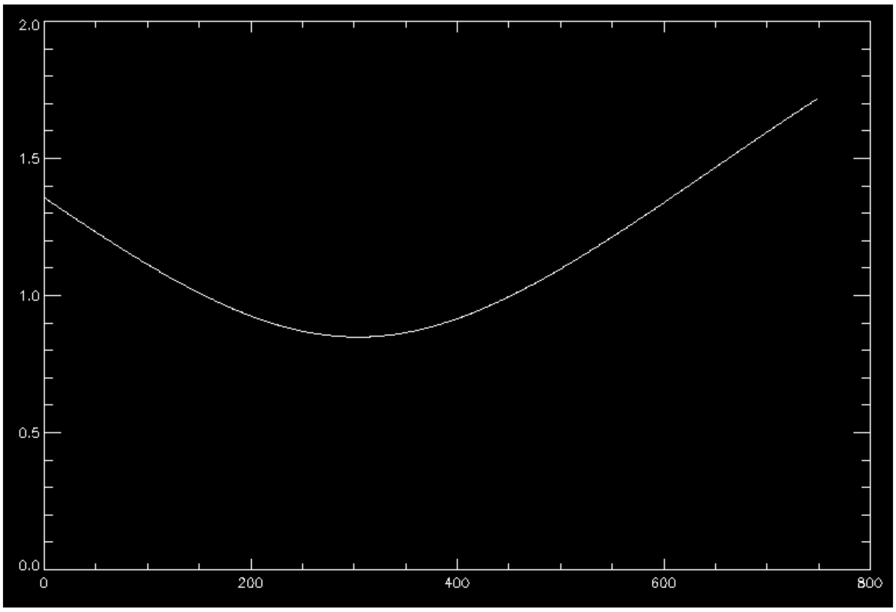

Figure 2: The zenith angle of Procyon at the same site, on the same night.

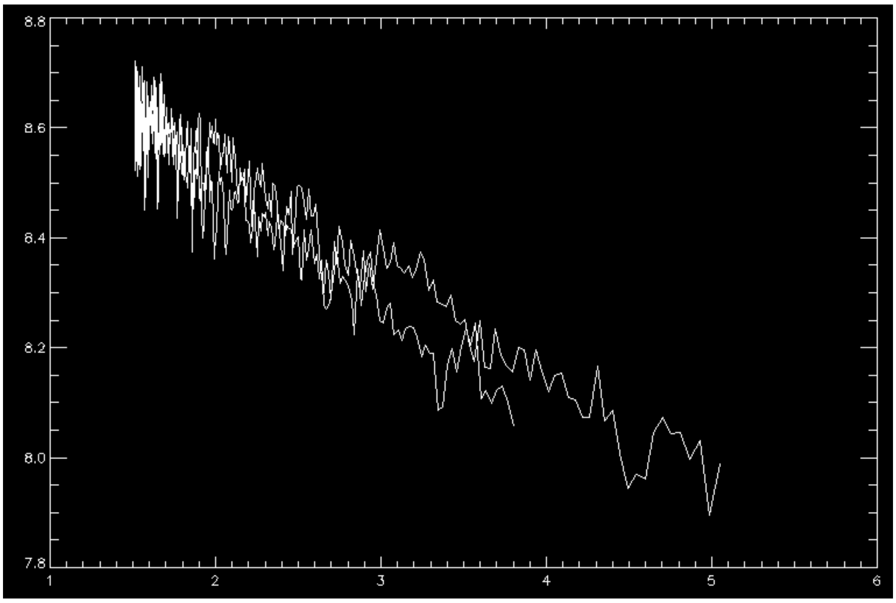

Figure 3: A plot of $\log y$ versus $1/(\cos\theta + 0.025e^{-11\cos\theta})$, using the same data from the previous plots. Points where the zenith angle is above 1.4 radians are omitted.