ASTR 3520: Homework 1 Answers

- **Question 1: What is the rotation from the reference image (and world coordinates)?**

Full credit was given for this question if you made an attempt. A demonstration may be given in class or lab.

- **Question 2: What is the pixel scale of the image?**

The image scale is simply the size of the vector (the distance between two points) in arcseconds, i.e. on the sky, divided by the size of the vector on the image. I use both vectors as a check. The answer is .63±.01

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In[16]:= ObservedVector1 = {1002.00, 817.37} - {1011.71, 399.37}

Out[16]= {-9.71, 418.}

In[17]:= ObservedVector2 = {935.17, 658.89} - {1011.71, 399.37}

Out[17]= {-76.54, 259.52}

In[21]:= WCSVector1cos = {19.5 * Cos[33 °], 22.4} - {37.2 * Cos[33 °], 4 * 60 + 47.2}

Out[21]= {-14.8445, -264.8}

In[23]:= WCSVector2cos = {46.1 * Cos[33 °], 3.2} - {(60 + 37.2) * Cos[33 °], 2 * 60 + 47.2}

Out[23]= {-42.8561, -164.}

ImScale1 = Norm[WCSVector1cos] / Norm[ObservedVector1]

0.634316

ImScale2 = Norm[WCSVector2cos] / Norm[ObservedVector2]

0.626478
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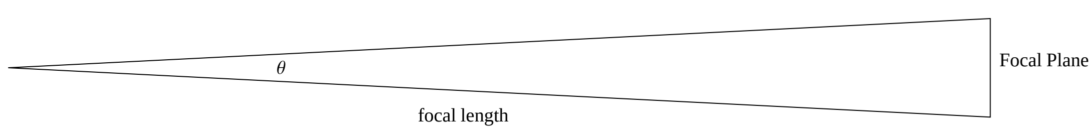
- **Question 3: What is the focal length?**



In this graphic, we have the focal plane on the right and the telescope aperture on the left. The angular size of an object on the sky is given by θ .Using the small angle approximation ($\sin(\theta) \simeq \theta$), we see that $\theta = \frac{\text{Size on the Focal Plane}}{\text{Focal Length}}$. The focal length is therefore the pixel size divided by the angle in radians, or Focal Length = $\frac{\text{number of pixels} \times 6.8\ \mu\text{m}}{\theta/206\,265}$. In this case, we're using 1 pixel, and there are .63" per pixel, so:

$$\text{FocalLength} = \frac{6.8}{.63/206\,265}$$

2.22635×10^6

So our answer is 2.226m (though our precision is really limited to 2.2m)

Question 4: What is the limiting magnitude?

Approximate faintest stars were measured by finding a very faint (nearly sky − obscured) star and looking it up in the USNO catalog via Vizier.The B and R magnitudes are given for each; they may not be the most accurate but they' re not bad.
75 Clear : USNO − A2 .0 1200 − 09999461 18 : 53 : 16.25 + 33 : 02 : 05.8.B : 19.6 R : 18.8
77 Red : USNO − A2 .0 1200 − 10000565 18 : 53 : 18.271 + 33 : 02 : 23.02 B : 18.5 R : 18.2
78 Green : USNO − A2 .0 1200 − 10000565 18 : 53 : 18.271 + 33 : 02 : 23.02 B : 18.5 R : 18.2
79 Blue : USNO − A2 .0 1200 − 09999137 18 : 53 : 15.656 + 33 : 02 : 15.33 B : 17.3 R : 16.7

Question 5: What is the magnitude of a single count on the image?

You need to use the magnitude formula $\left(M - m = -2.512 \log\left(\frac{F_1}{F_2}\right)\right)$ to answer this question. F_1 and F_2 are fluxes, and in this case you can use counts in place of calibrated fluxes (ideally, they should be directly proportional, i.e. $F \propto$ counts). You know you're comparing something to a count of 1, so you have one of your fluxes. To get the other magnitude and flux, pick a star that is not saturated and take an imexam aperture reading of it. That will give you the measured counts (sky subtracted) for the star, then you can use the Vizier database to look up its magnitude.
Imexam aperture output :
COL LINE COORDINATES
R MAG FLUX SKY PEAK E PA BETA ENCLOSED MOFFAT DIRECT
1120.65 308.22 1120.65 308.22
15.16 11.05 381495. 483.7 11032. 0.15 22 12.5 4.94 5.11 5.05
For the star : 1200 − 10003774, with B − mag = 14.1, at 18 53 24.080 + 33 03 42.92
http : // vizier.u − strasbg.fr/viz − bin/VizieR − 5?−out.add =. & − source = I/252/out & USNO − A2 .0 === 1200 − 10003774
With a flux of 381495 (sky subtracted) for a magnitude of 14.1, we have the equation :
M1 = -2.512 Log[10, 1 / 381495] + 14.1 = 28.1207 magnitudes for 1 count. Note that I selected B magnitudes. Comparing this to the faintest star detectable, 1 count is about 8 magnitudes fainter than the faintest we can see. It is also interesting to note (but was not asked as a question) that the sky background is at a level of

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Msky = -2.512 Log[10, 483.7 / 381495] + 14.1
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21.377
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which shows why our faintest detectable star is so much brighter than a single count on the chip.