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Photometry of β Cygni

Zoe Weber ⋆

Department of Astronomy and Astrophysics, University of California, Santa Cruz, CA 95064

ABSTRACT

Here we present detailed photometry observations for the two components of β Cygni. This study was conducted using the five standard bandpasses (UV, B, V, R, IR) to view our stars. We find the magnitudes of star A to have values of: 4.881 ± 0.106 (UV), 2.928 ± 1.217 (B), 1.974 ± 1.225 (V), 1.971 ± 0.842 (R), 1.041 ± 1.051 (IR). Where as the magnitudes of star B were found to be: 4.847 ± 0.078 (UV), 3.916 ± 1.221 (B), 3.951 ± 1.188 (V), 4.598 ± 0.831 (R), 4.331 ± 0.999 (IR). Lastly, we determine the $(B-V)$ color indices that returned average surface temperatures of 4635.191 ± 268.776 K for star A, and 13403.378 ± 1179.822 for star B. These found values are in very good agreement with the accepted standard values (Wikipedia contributors 2018).

1 INTRODUCTION

Photometry is a Greek word that translates to light ("photo") measure ("metry"). For astronomy it is the process in which a measurement of both the flux and color of a star is made (Wikipedia contributors 2018). In the following paper we will be doing just that for five "standard" stars as well as β Cygni.

β Cygni is actual a binary system composed of two different stars, better known as β Cygni A and β Cygni B. β Cygni A is a red giant, where as the smaller and hotter star β Cygni B is a white dwarf.

In our study, we sought to find the magnitudes and temperature of both β Cygni A and B; to do so we made use of color index. In color index, an object's magnitude is observed in several bandpasses, or colors (Wikipedia contributors 2018). Each bandpass is a specific region of wavelength space; for example, the B (or Blue) bandpass region is typically from 360 nm to 560 nm. A bandpass magnitude can then be derived from the flux of the star (see Equation 1 in Procedure). Once these values are obtained as well as the air mass for all of our observed stars, a plot for bandpass magnitudes versus air mass of each standard star can be produced to find the atmospheric extinction for that one specific bandwidth. For example, Plot 1 shows the magnitude versus airmass of each standard star in the Ultraviolet bandpass. Through this method we were then able to determine the temperature and bandpass magnitudes for β Cygni as further detailed in the procedure.

2 PROCEDURE

For these observations we used a ten-inch Ritchey-Chretien reflecting telescope, manufactured by Astro-Tech, and the Santa Barbara Instruments Group SBIG ST-7E CCD detector that worked in parallel with our telescope. To start we aligned our telescope on a test star, adjusting the instrument until its cross hair aligned perfectly with our target. After aligning the telescope we were ready to begin our observations.

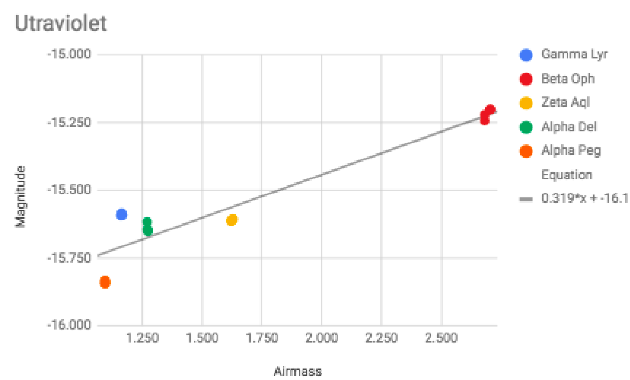

Figure 1.

The stars in which we observed we named γ Lyr, ζ Aql, α Del, α Peg and finally β Cygni. The first four stars are considered "standard" stars, their visual magnitudes are given in the United States Naval Observatory UVBRI standard stars, J2000.0 manual. For each star observed we took five snapshots per filter (UV, B, V, R, IR).

After the physical observations we used the CCDOps software to determine the number of counts (N) for each imagine. To determine N we used the X-hair tool in CCDOP's to determine the number of count directly over the star N_{on} as well as those of the background N_{off} . By taking the difference of these two values ,multiplied by the area in which the cross hairs encompassed, we were able to find the total value of counts N.

With this value we then calculated the instrumental magnitude of our observed standard stars by Equation 1

$$Mag_I = -2.5 \cdot \log \frac{N}{ExposureTime} \tag{1}$$

Once this was done we were able to determine airmass via the Equation 2:

$$M = \sec(90 - Altitude) \tag{2}$$

Where the altitude was determined via Stellarium. Once the airmass was determined we were then able to plot it against the determined instrumental magnitudes of our standard stars. These graphs then give us a linear equation in the form of $y = Mx + B$, where x represents the atmospheric extinction, M is the airmass and B is the instrumental constant. Armed with these values we were then able to determine the magnitude for each bandpass of our main stars, β Cygni A and B via Equation 3.

$$Mag_o = -2.5 \cdot \log \frac{N}{ExposureTime} - Mx + B \tag{3}$$

After having calculated the magnitude of both β Cygni A and B, we then calculated their temperatures (Equation 4) using the difference in magnitude between β Cygni's blue and visual filters

$$T_{eff} = \frac{7000}{B - V + 0.56} \tag{4}$$

3 RESULTS

The following results were taken approximately from 6:30pm until 10:00pm on October 5th, 2018. Our observations were made on top the Jack Baskin School of Engineering, where we found the skies to be completely free of cloud cover.

As presented prior, we used Equations 1 and 2 to determine the values found in Table 1.

Errors found in Table 1 were found via Equation 5

$$Error_{standard} = \sqrt{Counts^2 + Mag_I^2} \tag{5}$$

Finally we were able to take the results from Table 1 and plug them into Equations 3 and 4 to determine the actual magnitudes and temperature of both β Cygni A and B, as presented in Table 2 and 3.

It was found that the temperature of star A is, on average, equal to 4635.191 ± 288.775 K. Where as for star B it was determined to be $13,403.378 \pm 1179.822$ K. Errors were calculated via the standard deviation of the sample.

4 DISCUSSION

We found that our values for the temperature of β Cygni A and B were very close to the standard excepted values. The determined errors were found to be relatively small for all found magnitudes in Table 1 ; we reason that such low errors are the result of our observations being on an exceptionally clear night. Otherwise, we found that the errors for magnitude found in Table 2 were larger than expected. It would be most likely that these errors were from atmospheric disturbances. As two of our three observations of β Cygni were far later in the night than all others, we assume that it is possible for these disturbances to have increased as the night went on. Because β Cygni A and B would move closer to the horizon as the night went on, this conclusion of increased atmospheric intervention makes sense.

Table 1. Data for sample stars

	γ Lyr	β Oph	ζ Aql	*alpha* Del	*alpha* Peg
Ultraviolet					
Airmass	1.164	2.705	1.622	1.622	1.094
Average Magnitude	-15.590	-15.213	-15.610	-15.642	-15.840
Error	± 0.009	± 0.020	± 0.009	± 0.017	± 0.010
Blue					
Airmass	1.169	2.777	1.644	1.284	1.095
Average Magnitude	-18.587	-18.704	-18.768	-18.837	-18.880
Error	± 0.011	± 0.017	± 0.015	± 0.012	± 0.050
Visible					
Airmass	1.171	2.827	1.651	1.284	1.096
Average Magnitude	-18.782	-18.774	-19.024	-19.054	-19.095
Error	± 0.015	± 0.020	± 0.027	± 0.014	± 0.020
Red					
Airmass	1.173	2.991	1.659	1.280	1.096
Average Magnitude	-19.048	-18.836	-19.261	-19.303	-19.304
Error	± 0.018	± 0.074	± 0.023	± 0.009	± 0.019
Infrared					
Airmass	1.176	2.906	1.674	1.229	1.097
Average Magnitude	-18.183	-18.110	-18.462	-18.482	-18.485
Error	± 0.009	± 0.062	± 0.009	± 0.010	± 0.008

Table 2. Magnitude data ata for β Cygni A and B

		A			B	
Airmass	Mag_*oA*	Average Mag_*oA*	Error	Mag_*oB*	Average *Mag_oB*	Error
Ultraviolet						
1.404	4.848	4.881	± 0.106	4.807	4.847	± 0.078
1.614	4.864			4.816		
1.174	5.03			4.963		
1.206	4.78			4.802		
Blue						
1.408	3.956	2.928	± 1.217	4.945	3.916	± 1.221
1.621	4.003			4.999		
1.189	1.965			2.929		
1.211	1.787			2.792		
Visible						
1.413	3.035	1.974	± 1.225	4.979	3.951	± 1.188
1.628	3.034			4.981		
1.192	0.896			2.96		
1.217	0.93			2.884		
Red						
1.22	2.447	1.971	± 0.842	5.074	4.598	± 0.831
1.195	2.463			5.102		
1.628	2.258			4.854		
1.413	0.716			3.362		
Infrared						
1.418	1.805	1.041	± 1.051	5.054	4.332	± 0.999
1.394	1.811			5.043		
1.636	1.792			5.069		
1.197	0.089			3.435		
1.223	-0.291			3.06		

Table 3. Tempurature data for β Cygni A and B

Observation	T_*A*	Average	Error	T_*B*	Average	Error
1	4726.900	4635.190	± 268.775	13295.241	13403.378	± 1179.822
2	4577.943			12110.816		
3	4298.240			13234.084		
4	4937.677			14973.370		

5 CONCLUSION

Because of the excellent observing conditions we were able to take fairly accurate measurements for each observed star. In conclusion we find that although some of the errors for the calculated magnitudes were rather high, the overall result for the temperature values of β Cygni were accurate and within an acceptable range.

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