Astronomy 61

Lab 3: Differential Photometry

Chua Zheng Fu Edrei
Department of Physics & Astronomy, Dartmouth College, Wilder Laboratory, Hanover, NH, USA

Lab partners: Natalia Drozdoff & Krystyna Miles

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1 Purpose

The purpose of this lab is to obtain a time series, differential photometry of the variable star Eq Eri. This lab serves as an introduction to photometry in Astronomy and a demonstration of how Astronomers made use of light curves and photometry to obtain useful information. Eq Eri is a variable star of Delta Scuti type and spectral type F2III. Its equatorial co-ordinates are given as RA = $+04^h29^m57^s.616$ and DEC = $-28°52'46".69$.[1]

A variable star is a star that fluctuates in brightness. A Delta Scuti variable star exhibits periodic variation in luminosity due to both radial and non-radial pulsations of the star's surface. Delta Scuti variables are important standard candles and they have been used to establish distances to the Large Magellanic Cloud, globular cluster, open cluster and the galactic center. They exhibit a period-luminosity relationship similar to Cepheids variables[2].

The basic properties of Eq Eri are found in Table 1[3] below:

Name of object:	Eq Eri
Type of object:	Variable star of Delta Scuti type
Spectral Type:	F2 III
Constellation:	Eridanus
Right ascension:	$+04^h29^m57^s.616$
Declination:	$-28°52'46".69$
Apparent magnitude:	8.01 (B) and 7.72 (V)

Table 1: Variable star Eq Eri

2 Procedure

2.1 Pre-observing

We recorded the right ascension, declination, altitude, air mass, phase of the moon, the moon-object angle and illumination due to the moon of Eq Eri prior to observation. The observation date for our group is 5 February 2015, the observing time is from 22:15 to 23:30 local time and the observation site is at the roof of the University of Cape Town, RW James Physics and Astronomy building. The expected observing conditions on 5 February 2015 at 22:30 local time are recorded in Table 2 below. The information was obtained using JSkyCalc and the Simbad data base.

It is noted that the field of interest has an air mass of 1.170 during the observing time, which is ideal. In addition, the field is around 59° above the horizon and is thus, less affected by light pollution from the city light and will not be obstructed by the surrounding buildings. However, the observing date coincides with 2 days after full moon which result in an illumination of 19.6 V mag/ sq arcsec. This is not ideal but it is a necessary

[1] Retrieved from `http://simbad.u-strasbg.fr/simbad/sim-id?Ident=V*+EQ+Eri`. Accessed on 05 February 2015
[2] Retrieved from `http://en.wikipedia.org/wiki/Delta_Scuti_variable`. Accessed on 05 February 2015
[3] Retrieved from `http://simbad.u-strasbg.fr/simbad/sim-id?Ident=V*+EQ+Eri`. Accessed on 05 February 2015

compromise due to time constraint. Fortunately, the moon-object angle is 94.0°, which is large enough such that observing conditions are still acceptable.

Name of object:	Eq Eri
Right ascension:	$+04^h29^m57^s.616$
Declination:	$-28°52'46".69$
Apparent magnitude:	8.01 (B) and 7.72 (V)
Altitude:	$+58°40'33"$
Air mass:	1.170
Phase of moon:	2 days after full moon
Moon-object angle:	94.0°
Illumination due to moon:	19.6 V mag/ sq arcsec

Table 2: Observation conditions for Eq Eri on 5 February 2015, 22:30 local time

2.2 Observing

The group started observing at around 22:30 local time. The sky is clear during observing and while the moon is bright, it is far enough from the star such that observing conditions are still acceptable.

The telescope used for the lab has an aperture of 14" and software used is TheSkyX Version 10.3.0.The CCD used is STL-6303E and the average CCD temperature is around $-9°C$ to $-10°C$. For the lab, images are taken using 2 x 2 binning. Two different filters - Blue and V - are used in the lab.

We took some time to find Eq Eri. It was noted that we should print a copy of the star field of interest from the Digitized Sky Survey (DSS) and bring it with us for future observing session so that we will be able to properly identify the star.

Before taking the series of images, it is necessary to determine the exposure time used for capturing the images through the Blue and V filter. To do this, we use an iterative approach. We started with an exposure time of 10.00 s for the Blue filter and noted that the counts are above 55000 counts, which is close to the threshold of linearity. The ideal count should be between 10000 and 20000 and since count rate increases linearly with exposure time, we decrese the exposure time. With an iterative approach, we found out that 3.00 s is a suitable exposure time for imaging Eq Eri through the blue filter. We went through the same procedure for the V filter and determine the ideal exposure time to be 6.00 s.

We proceed to take a sequence of images that comprises of 3 images taken through the Blue filter with 3.00 s exposure, followed by 3 images taken through the V filter with 6.00 s exposure and 3 bias images. We repeat the same sequence throughout the observing time. We also check between frequent intervals that the target star is still within the frame and has not shifted by too much, that the count is below the linearity threshold and that everything is working as expected.

The observing log is included in the Appendix. We took 172 images over the course of the observing session, from #5234 (taken at 22:47 local time) to #5406 (taken at 23:33 local time). We also obtain images from the previous group so that we can get a longer time baseline for our analysis. The previous group took images from #5022 (taken at 20:57 local time) to #5213 (taken at 22:01 local time).

3 Analysis

3.1 Adjusting the images to account for flat and bias

It is crucial to account for flat and bias before analysing the science frame (or the image of the object). The image can be adjusted for bias by performing image subtraction and division as shown below:

$$outputimage = \frac{Scienceframe - Biasframe}{Flatfield - Biasframe} \tag{1}$$

It was determined from the first lab that the dark current of the CCD used (STL-6303E) is 0.0090 ± 0.0005 electron/pixel/s, which translates to about 1.8 electron/pixel over the longest exposure time of 180 s. Since the gain as determined from the first lab to be 1.4 electron/adu, the noise introduced by dark current is roughly 1 count per pixel. Given that the bright pixels in the CCD has a count of around 10000 count per pixel, the error introduced by dark current is about 0.0001%, which is low enough to be ignored.

To create the master bias frame for the blue filter, we first combine all the bias images taken with the CCD using the *imcombine* command on PyRAF. We then subtract the master bias from all the images taken with exposure time below 120 s (including the flat field) using the *imarith* command. Next, we create the master flat field for the blue filter by doing the following:

1. Combine the flat fields (with the bias subtracted) using *imcombine*, with the *combine* parameter set to "median" and the *scale* parameter set to "mean". The IRAF tutorial provides the detailed instruction. The count of each pixel is combined by taking the median count so as to eliminate outliers introduced by cosmic ray. Each of the flat fields are also scaled such that they have the same mean.
2. Use *imstat* to find the mean of the master flat.

3. Use *imarith* to divide the master flat by its mean so that the mean is 1.0 i.e. the master flat is normalized. This is necessary because the flat image has a large number of counts per pixel, whereas the object images have relatively few counts per pixel (astronomical objects are faint). Therefore a scaling factor needs to be introduced.

All of the science frames taken through the blue filter should be divided by the master flat.

A slightly different approach is adopted for creating the flat field for the V filter. A master dark frame is created by combining frame #5216, #5218, #5220, #5222, #5224 and #5226 (image type dark and exposure time 120 sec) instead of a master bias field. The flat field is creating by using the light frame taken with 120 sec exposure (#5215, #5217, #5219, #5223, #5225 and #5226). We used the same procedure outlined above regarding normalization to create the master dark flat for the V filter.

Fig 1 and 2 are CCD images taken through the V filter and Blue filter respectively after adjusting for flat and bias.

Fig. 1: CCD image of Eq Eri adjusted for flat and bias (6.00 s exposure and V filter)

Fig. 2: CCD image of Eq Eri adjusted for flat and bias (3.00 s exposure and Blue filter)

3.2 Differential photometry

We used AstroimageJ to perform differential photometry in this lab. It is necessary to perform astrometry (matching the stars in the CCD image to its corresponding WDC co-ordinates) before doing photometry. The same automated astrometry server, Astrometry Nova, is used to assign WCS co-ordinates to the CCD images.

Astrometry Nova is unable to assign WCS co-ordinates to 3 of the images taken through the blue filter, namely frame #5293, #5312 and #5366. Inspection of the 3 images reveals that the image quality is normal. Professor Chaboyer suggest that the error might be due to the default size of aperture used in astrometry nova and recommend that we ignore the 3 images in our photometry analysis.

The next step would to perform differential photometry for the images taken through the blue filter and V filter separately. To do this, we have to select 2 reference star to compare the apparent magnitude of Eq Eri with. The 2 reference stars should be relatively stable in brightness (i.e. they shouldn't be variable stars). The reference stars are used to adjust the magnitude of Eq Eri to account for external factors that might diminish the brightness of a star, such as atmospheric turbulence, difference in exposure time etc. The flux of Eq Eri will be given as relative to the reference star.

Figure 3 and 4 show the reference stars C2 and C3 that are chosen for differential photometry of Eq Eri. The equatorial co-ordinates of C2 are RA=$04^h29^m43^s.218$ and DEC=$-29°01'53''.65$ while the equatorial co-ordinates of C3 are RA=$04^h30^m07^s.330$ and DEC=$-28°54'39''.77$. C2 and C3 are chosen because they are relatively bright (the count is higher) compare to the other stars in the field and are close to T1. In addition, a simbad search reveals that C2 is the star HD 28639 and C3 is the star CD-29 1749. Both stars are not variable stars and their brightness shouldn't fluctuate with time.

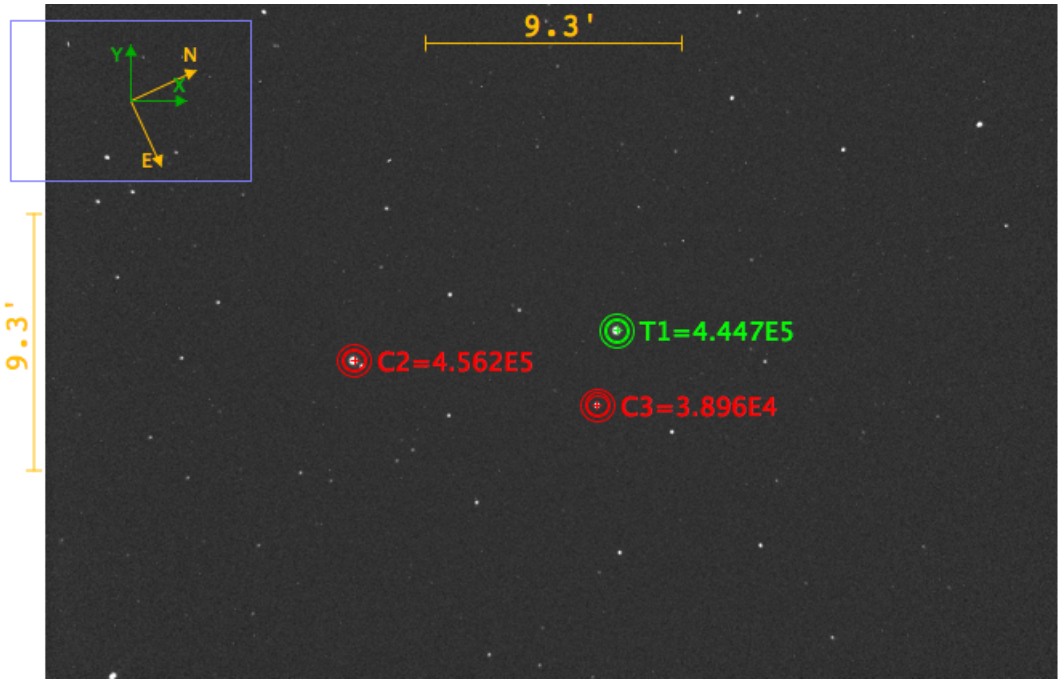

Fig. 3: CCD image of Eq Eri adjusted for flat and bias with reference star C2 and C3 (6.00 s exposure and V filter)

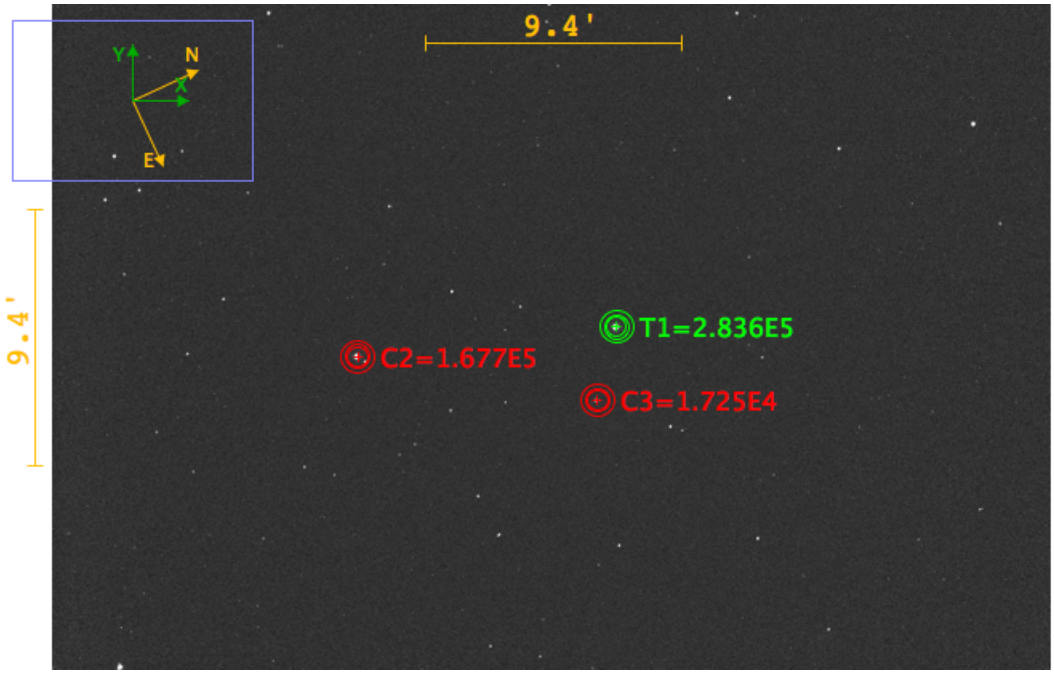

Fig. 4: CCD image of Eq Eri adjusted for flat and bias with reference star C2 and C3 (3.00 s exposure and Blue filter)

To ensure that the magnitude of C2 and C3 doesn't change with time, we plot a graph of V magnitude against time (Fig 5) and Blue magnitude against time (Fig 6) for the reference star C2 and C3. It was shown that the magnitude of C2 and C3 did not vary much over the observing time (the graph are almost horizontal) and thus they are suitable to be used as reference stars for differential photometry.

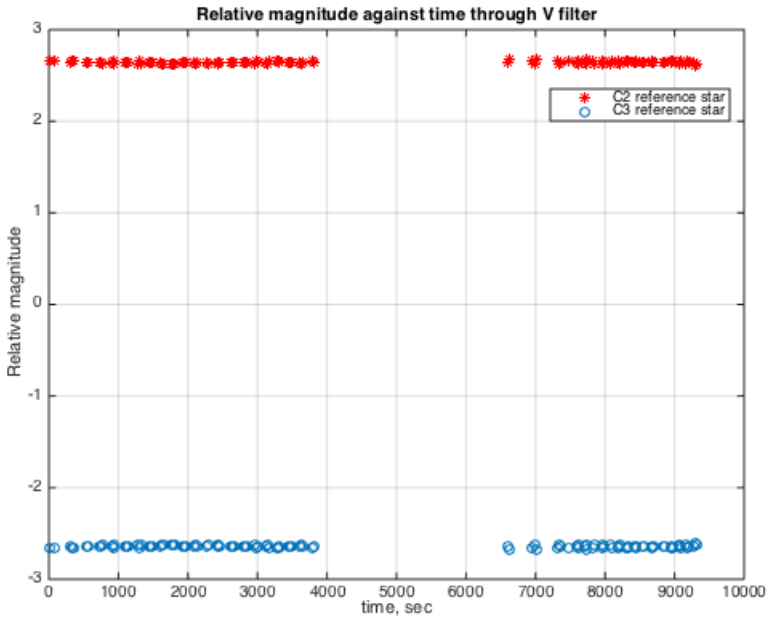

Fig. 5: V mag of reference stars against time

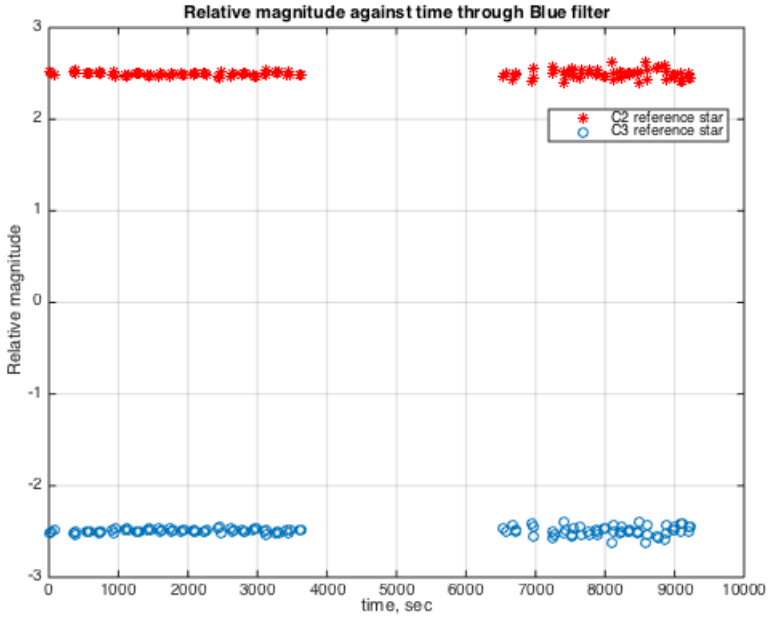

Fig. 6: Blue magnitude of reference stars against time

In addition, when we plot the counts of the reference stars per exposure time against air mass, we observe that C2 and C3 have the same trend in both the V filter (Fig. 7) and the Blue filter (Fig. 8). This suggests that they have roughly the same colour and thus change with airmass at the same rate. This means that they can be used as reference stars.

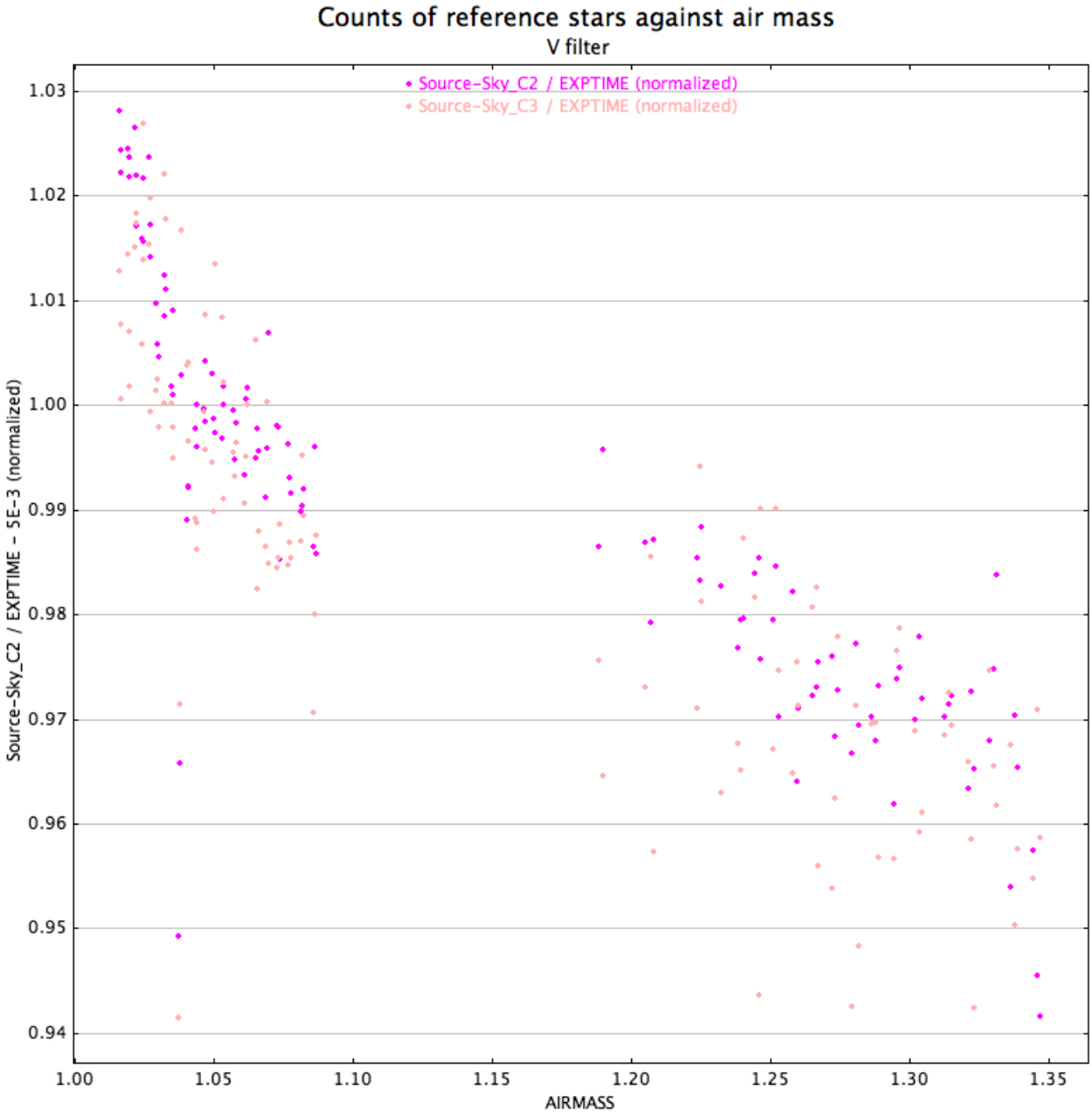

Fig. 7: Dependence of counts of reference stars against air mass (V filter)

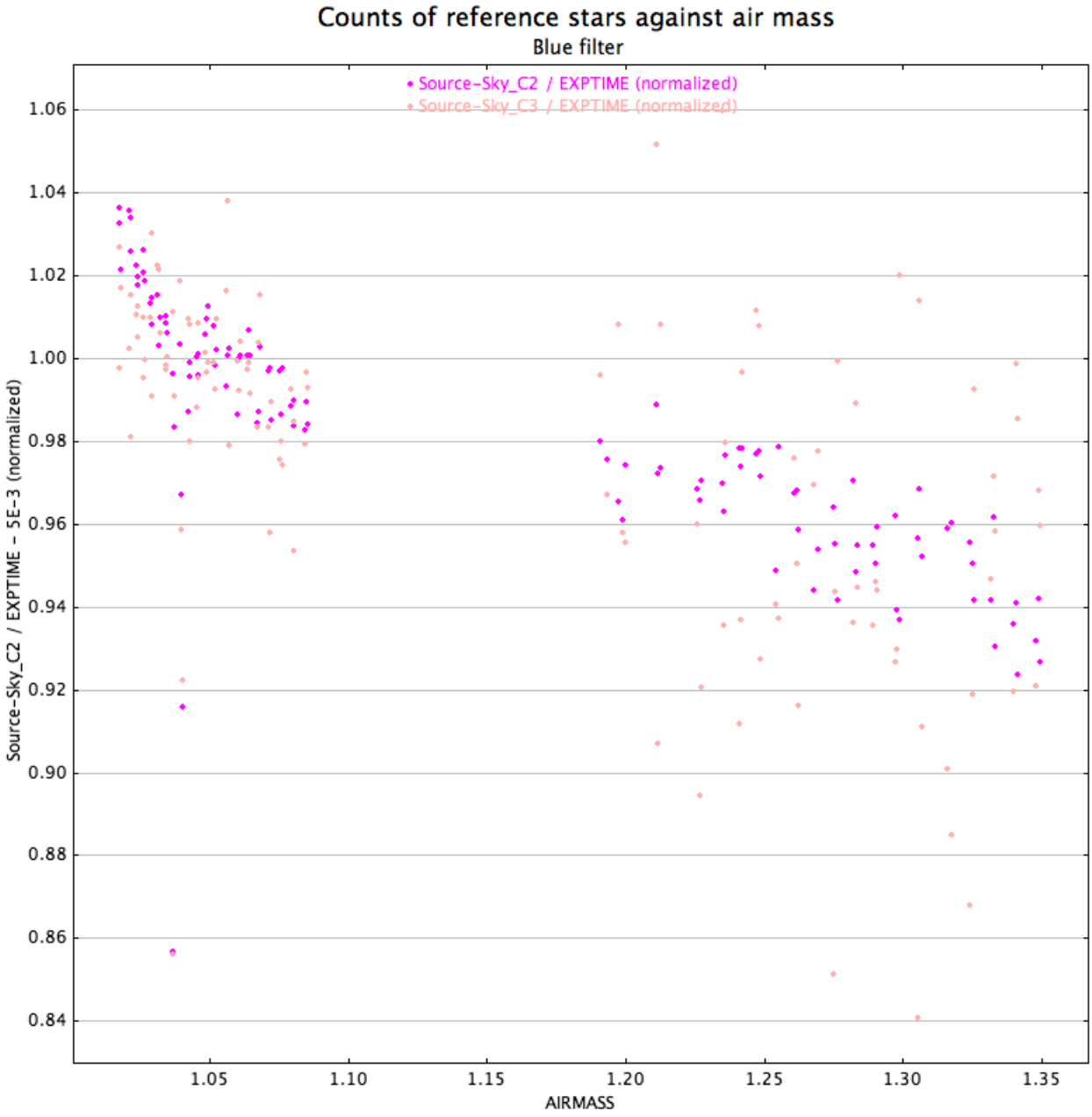

Fig. 8: Dependence of counts of reference stars against air mass (Blue filter)

Once the reference stars have been established, we import image sequence into AstroimageJ. The images used for the photometric analysis are #5022 (taken at 20:57 local time) to #5213 (taken at 22:01 local time) taken by the previous group and #5234 (taken at 22:47 local time) to #5406 (taken at 23:33 local time) taken by our group. The observation log is included in the Appendix. Photometry is performed separately for images taken through the blue filter and V filter. Values for the CCD gain (1.416 electron/adu), readout noise (13.56 electron/pixel) and dark current (0.009 electron/pixel/s) are extracted from the first lab and input into the setting for AstroimageJ. Finally, we place the aperture over the target star (Eq Eri) and the reference stars (C2 and C3) and run the differential photometry program.

The results are then exported to an excel file for further analysis. The photometric graphs of Eq Eri as plotted by AstroimageJ are presented in Fig. 9 (V mag) and Fig. 10 (Blue mag).

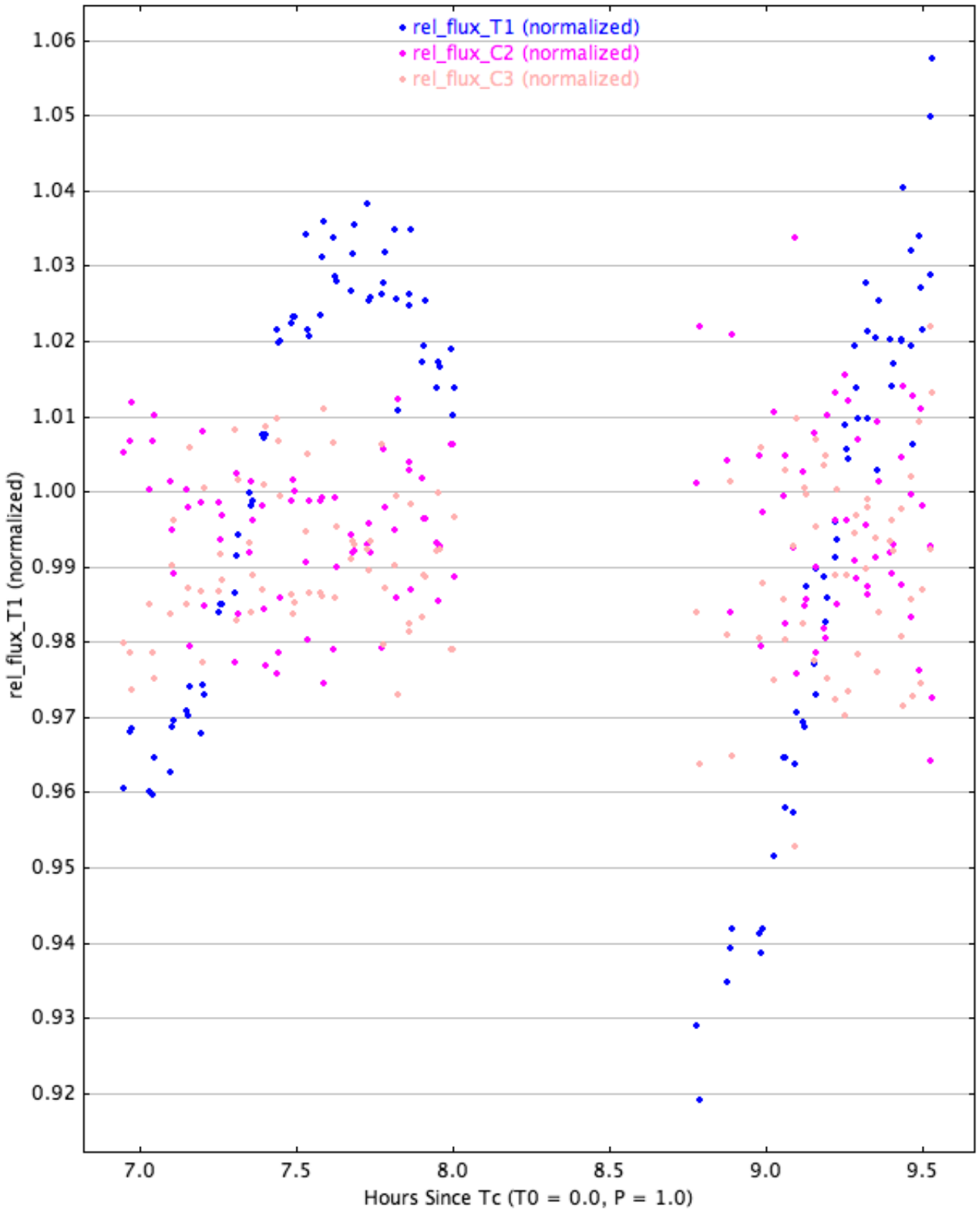

Fig. 9: Photmetric graph (V mag) of Eq Eri with relative flux against time

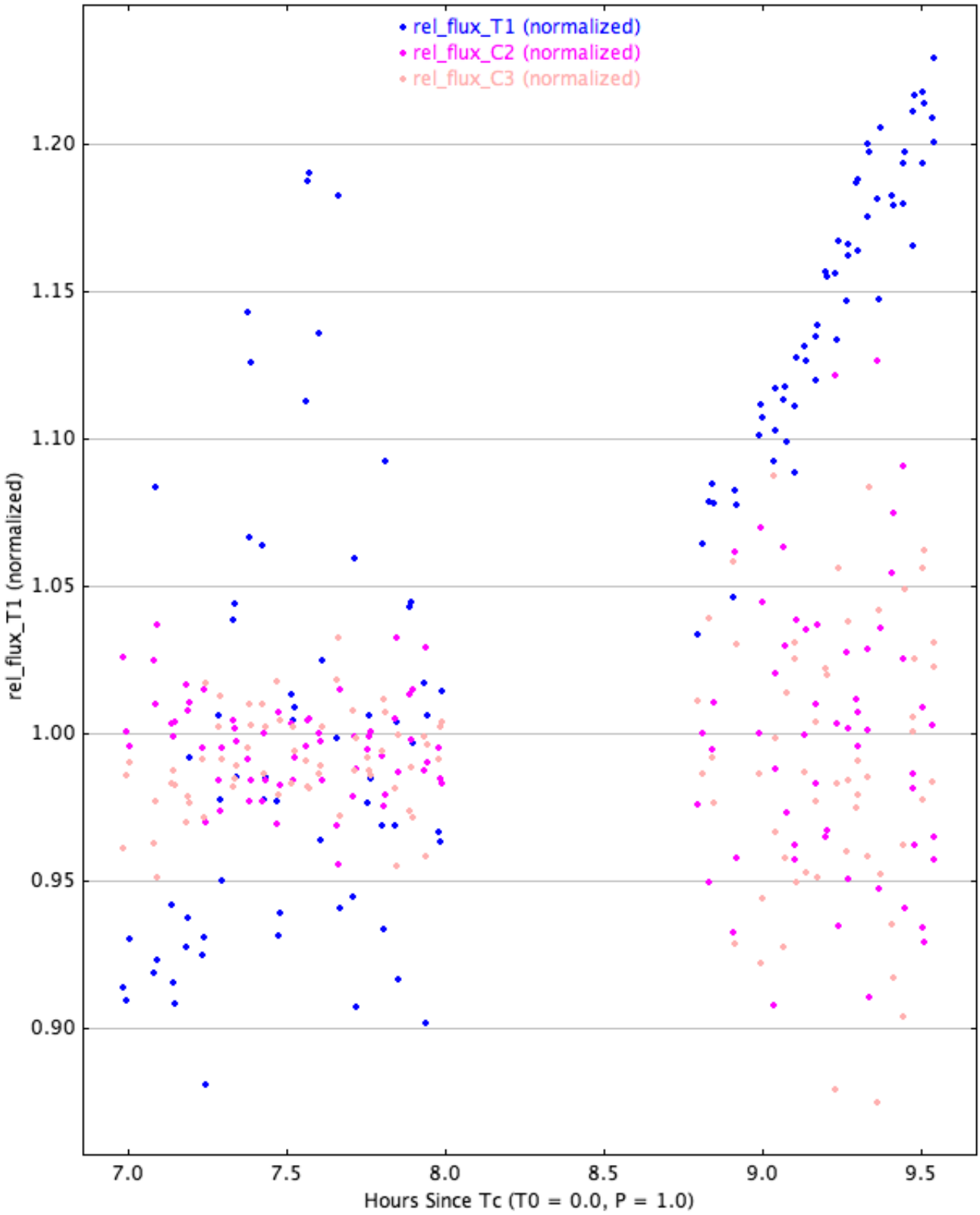

Fig. 10: Photmetric graph (Blue mag) of Eq Eri with relative flux against time

3.3 Error analysis

Error analysis is performed by calculating the difference in relative magnitude for Eq Eri for adjacent CCD images. Since the images are taken less than half a minute apart, the relative magnitude of Eq Eri shouldn't change by much.

Relative flux is converted to relative magnitude using the magnitude-flux relationship expressed in the equation below:

$$m_1 - m_2 = 2.5log(f_2/f_1) \tag{2}$$

Using Matlab, we calculated that the average change in relative magnitude between adjacent images (the error) for the V filter is 0.0079 mag. The average change in relative magnitude between adjacent images for the Blue filter is 0.0425 mag. The data used to calculate the error is available in an excel file for the interested reader. The amplitudes for the change in magnitude for the V filter and Blue filter are estimated to be 0.045 mag and 0.14 mag respectively (discussed in Results section), which yield percentage errors of roughly 17.5% and 30% respectively. The errors are significant given that the photometry curve for Eq Eri has a small amplitude.

4 Results

The photometric graphs for Eq Eri, with relative magnitude against time, are presented in Fig. 11 (V mag) and Fig. 12 (Blue mag). A rough curve is fitted for the photometric data taken through V filter as shown in Fig 9. The photometric curves obtained with the V filter seems to show a clear periodic relationship compared to the curve obtained with the Blue filter.

Fig. 13 shows both photometric curve (V and Blue filter) for Eq Eri on the same graph. It can be seen that both set of data reveals an approximate periodic relationship, and both curve has roughly the same period.

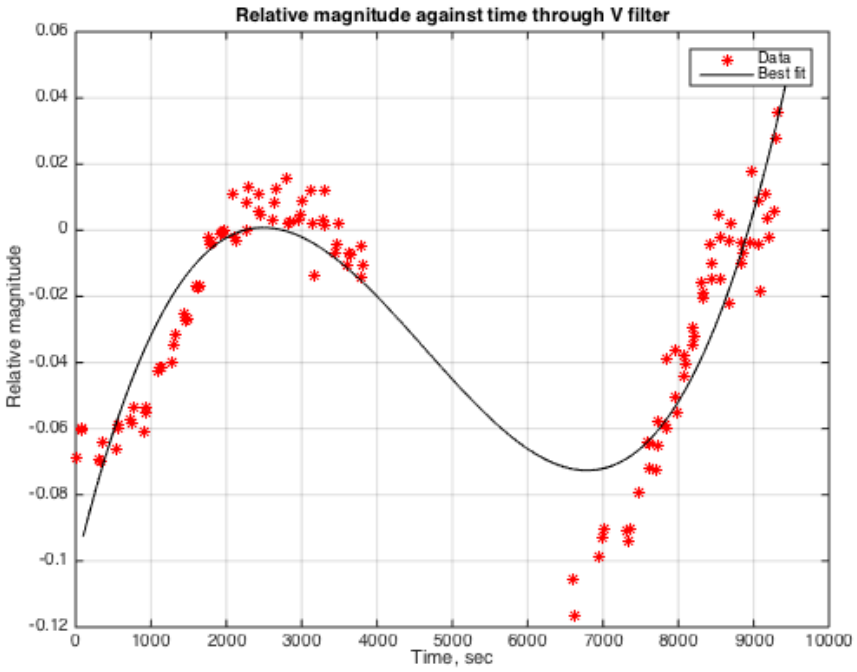

Fig. 11: Photmetric graph (V mag) of Eq Eri with relative flux against time

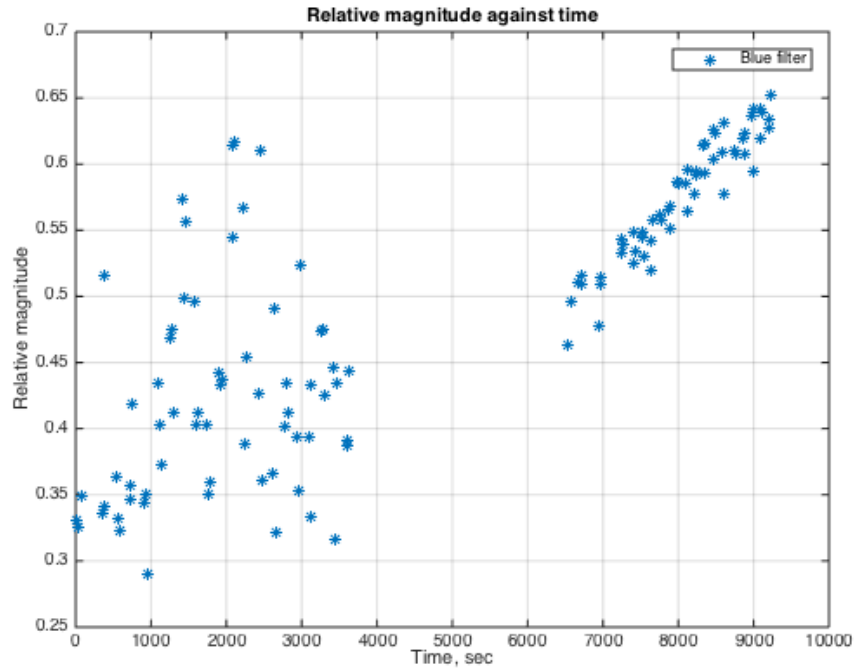

Fig. 12: Photmetric graph (Blue mag) of Eq Eri with relative flux against time

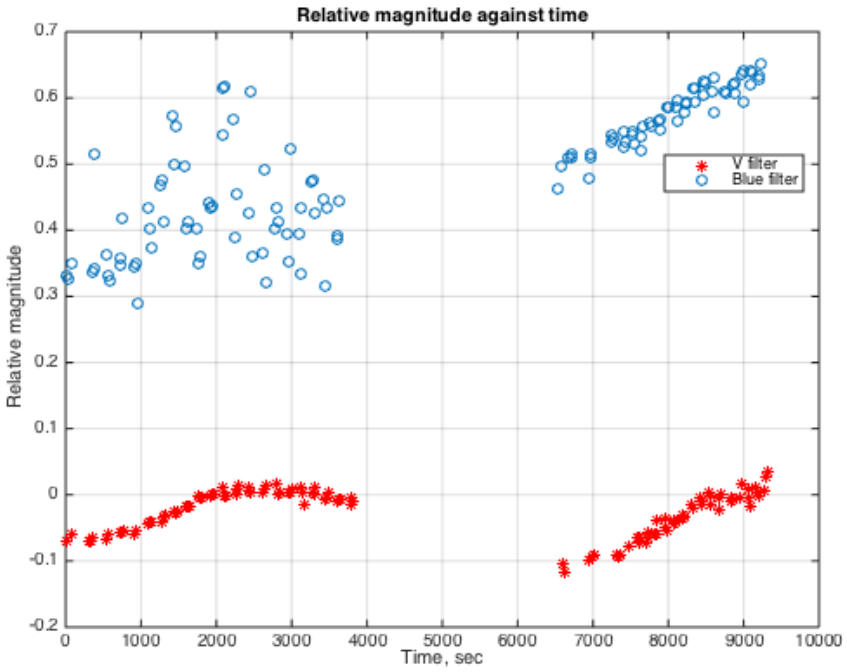

Fig. 13: Photmetric graph (Blue and V mag) of Eq Eri with relative flux against time

By visual inspection, the period for the fluctuation in magnitude for Eq Eri is roughly 7000 s, which translate to 1.94 hours.

$$T \approx 7000 seconds = 1.94 hours \tag{3}$$

Visual inspection also reveals that the amplitude for the change in magnitude for Eq Eri is 0.045 mag in the V filter and 0.14 mag in the blue filter. By using the error estimates presented in the section above, this would yield the following amplitude for the photometric curve:

$$\Delta M_V \approx (0.0450 \pm 0.008) mag \tag{4}$$

$$\Delta M_B \approx (0.14 \pm 0.04) mag \tag{5}$$

5 Summary

In this lab, we learnt to perform differential photometry, which is the process of tracking the brightness of an astronomical object relative to a reference star of approximately constant magnitude. We also learnt to use a photometry software, AstroimageJ, to analyse the periodic fluctuation of the brightness of a variable star.

We performed differential photometry for Eq Eri, a Delta Scuti type variable star. We determined the period to be roughly 7000 s, which corresponds to 1.94 hours. In addition, we found the amplitude of the photometric light curve to be 0.0450 ± 0.008 V mag and 0.14 ± 0.04 B mag. Given more time, it would be helpful to run a period search algorithm through the photometric data to find the period more accurately.

6 Acknowledgements

I would like to acknowledge professor Brian Chaboyer for outling the steps for performing differential photometry using AstroimageJ. I am grateful to the TAs Erek Alper and Mackenzie Jones for helping with the analysis section of the lab. I have also collaborated with Natalia Drozdoff and Krystyna Miles in obtaining data for this lab. To get a longer time baseline, we also shared data with the previous group (Jack, Nick and Marie).

7 References

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8 Appendix

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5001	Flat	18:07:13.609	20:07:13.609	1.32	5.00	Blue	
5002	Flat	18:08:04.059	20:08:04.059	1.31	5.00	Blue	
5003	Flat	18:08:33.570	20:08:33.570	1.31	5.00	Blue	
5004	Flat	18:09:01.030	20:09:01.030	1.31	5.00	Blue	
5005	Flat	18:09:32.600	20:09:32.600	1.31	5.00	Blue	
5006	Flat	18:10:02.810	20:10:02.810	1.31	5.00	Blue	
5007	Flat	18:10:37.469	20:10:37.469	1.30	5.00	Blue	
5015	Flat	18:33:21.570	20:33:21.570	1.39	10.00	V	
5016	Light	18:49:06.429	20:49:06.429	1.01	10.00	V	Delete; adjusting camera
5017	Light	18:51:11.019	20:51:11.019	1.01	10.00	V	Delete; adjusting camera
5018	Light	18:51:49.799	20:51:49.799	1.01	10.00	V	Delete; adjusting camera
5019	Light	18:52:23.079	20:52:23.079	1.01	10.00	V	Delete; adjusting camera
5020	Light	18:53:02.549	20:53:02.549	1.01	10.00	V	Delete; adjusting camera
5021	Light	18:53:53.350	20:53:53.350	1.01	10.00	V	Delete; adjusting camera
5022	Light	18:56:52.850	20:56:52.850	1.02	10.00	V	
5023	Light	18:58:02.169	20:58:02.169	1.02	10.00	V	
5024	Light	18:58:22.079	20:58:22.079	1.02	10.00	V	
5025	Light	18:58:57.770	20:58:57.770	1.02	10.00	Blue	
5026	Light	18:59:29.000	20:59:29.000	1.02	10.00	Blue	
5027	Light	19:00:09.500	21:00:09.500	1.02	10.00	Blue	
5028	Bias	19:00:46.219	21:00:46.2 21	1.02	0.00	Blue	
5029	Bias	19:00:57.210	21:00:57.210	1.02	0.00	Blue	
5030	Bias	19:01:09.220	21:01:09.220	1.02	0.00	Blue	
5031	Light	19:01:57.950	21:01:57.950	1.02	10.00	V	
5032	Light	19:02:29.530	21:02:29.530	1.02	10.00	V	
5033	Light	19:02:53.890	21:02:53.890	1.02	10.00	V	
5034	Light	19:04:48.509	21:04:48.509	1.02	10.00	Blue	
5035	Light	19:05:06.700	21:05:06.700	1.02	10.00	Blue	
5036	Light	19:05:24.890	21:05:24.890	1.02	10.00	Blue	
5037	Light	19:05:49.280	21:05:49.280	1.02	10.00	V	
5038	Light	19:06:07.450	21:06:07.450	1.02	10.00	V	
5039	Light	19:06:26.329	21:06:26.329	1.02	10.00	V	
5040	Bias	19:06:44.170	21:06:44.170	1.02	0.00	V	
5041	Bias	19:06:52.070	21:06:52.070	1.02	0.00	V	
5042	Bias	19:07:00.300	21:07:00.300	1.02	0.00	V	
5043	Light	19:08:05.169	21:08:05.169	1.02	10.00	Blue	
5044	Light	19:08:24.050	21:08:24.050	1.02	10.00	Blue	
5045	Light	19:08:42.240	21:08:42.240	1.02	10.00	Blue	Delete; Out of focus
5046	Light	19:09:05.950	21:09:05.950	1.02	10.00	V	
5047	Light	19:09:24.109	21:09:24.109	1.03	10.00	V	
5048	Light	19:09:42.640	21:09:42.640	1.03	10.00	V	
5049	Bias	19:10:00.830	21:10:00.830	1.03	0.00	V	
5050	Bias	19:10:08.720	21:10:08.720	1.03	0.00	V	
5051	Bias	19:10:17.300	21:10:17.300	1.03	0.00	V	
5052	Light	19:10:55.399	21:10:55.399	1.03	10.00	Blue	
5053	Light	19:11:13.589	21:11:13.589	1.03	10.00	Blue	
5054	Light	19:11:32.119	21:11:32.1 21	1.03	10.00	Blue	
5055	Light	19:11:56.490	21:11:56.490	1.03	10.00	V	

Table 3: Observation Log

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5056	Light	19:12:14.679	21:12:14.679	1.03	10.00	V	
5057	Light	19:12:32.869	21:12:32.869	1.03	10.00	V	
5058	Bias	19:12:51.060	21:12:51.060	1.03	0.00	V	
5059	Bias	19:12:59.289	21:12:59.289	1.03	0.00	V	
5060	Bias	19:13:06.160	21:13:06.160	1.03	0.00	V	
5061	Light	19:14:06.219	21:14:06.2 21	1.03	10.00	Blue	
5062	Light	19:14:24.410	21:14:24.410	1.03	10.00	Blue	
5063	Light	19:14:42.600	21:14:42.600	1.03	10.00	Blue	
5064	Light	19:15:06.980	21:15:06.980	1.03	10.00	V	Delete; Out of focus
5065	Light	19:15:25.149	21:15:25.149	1.03	10.00	V	Delete; Out of focus
5066	Light	19:15:43.340	21:15:43.340	1.03	10.00	V	
5067	Bias	19:16:02.560	21:16:02.560	1.03	0.00	V	
5068	Bias	19:16:10.460	21:16:10.460	1.03	0.00	V	
5069	Bias	19:16:18.010	21:16:18.010	1.03	0.00	V	
5070	Light	19:17:09.849	21:17:09.849	1.03	10.00	Blue	
5071	Light	19:17:28.039	21:17:28.039	1.03	10.00	Blue	
5072	Light	19:17:46.219	21:17:46.219	1.03	10.00	Blue	
5073	Light	19:18:10.589	21:18:10.589	1.03	10.00	V	
5074	Light	19:18:28.780	21:18:28.780	1.03	10.00	V	
5075	Light	19:18:47.310	21:18:47.310	1.03	10.00	V	
5076	Bias	19:19:05.160	21:19:05.160	1.03	0.00	V	
5077	Bias	19:19:13.400	21:19:13.400	1.03	0.00	V	
5078	Bias	19:19:20.600	21:19:20.600	1.03	0.00	V	
5079	Light	19:20:00.070	21:20:00.070	1.03	10.00	Blue	
5080	Light	19:20:18.260	21:20:18.260	1.03	10.00	Blue	
5081	Light	19:20:36.450	21:20:36.450	1.03	10.00	Blue	
5082	Light	19:21:00.820	21:21:00.820	1.04	10.00	V	
5083	Light	19:21:19.010	21:21: 21.010	1.04	10.00	V	
5084	Light	19:21:37.539	21:21:37.539	1.04	10.00	V	
5085	Bias	19:21:55.729	21:21:55.729	1.04	0.00	V	
5086	Bias	19:22:03.620	21:22:03.620	1.04	0.00	V	
5087	Bias	19:22:11.519	21:22:11.5 21	1.04	0.00	V	
5088	Light	19:22:40.350	21:22:40.350	1.04	10.00	Blue	
5089	Light	19:22:58.539	21:22:58.539	1.04	10.00	Blue	
5090	Light	19:23:17.070	21:23:17.070	1.04	10.00	Blue	
5091	Light	19:23:41.090	21:23:41.090	1.04	10.00	V	
5092	Light	19:23:59.280	21:23:59.280	1.04	10.00	V	
5093	Light	19:24:17.820	21:24:17.820	1.04	10.00	V	
5094	Bias	19:24:36.009	21:24:36.009	1.04	0.00	V	
5095	Bias	19:24:43.899	21:24:43.899	1.04	0.00	V	
5096	Bias	19:24:51.789	21:24:51.789	1.04	0.00	V	
5097	Light	19:25:21.309	21:25:21.309	1.04	10.00	Blue	
5098	Light	19:25:39.840	21:25:39.840	1.04	10.00	Blue	
5099	Light	19:25:58.030	21:25:58.030	1.04	10.00	Blue	
5100	Light	19:26:22.410	21:26:22.410	1.04	10.00	V	
5101	Light	19:26:40.590	21:26:40.590	1.04	10.00	V	
5102	Light	19:26:58.780	21:26:58.780	1.04	10.00	V	
5103	Bias	19:27:16.969	21:27:16.969	1.04	0.00	V	
5104	Bias	19:27:24.170	21:27:24.170	1.04	0.00	V	
5105	Bias	19:27:32.409	21:27:32.409	1.04	0.00	V	

Table 4: Observation Log (to be continued)

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5106	Light	19:28:06.730	21:28:06.730	1.04	10.00	Blue	
5107	Light	19:28:25.260	21:28:25.260	1.04	10.00	Blue	
5108	Light	19:28:43.799	21:28:43.799	1.04	10.00	Blue	
5109	Light	19:29:07.480	21:29:07.480	1.04	10.00	V	
5110	Light	19:29:26.350	21:29:26.350	1.04	10.00	V	
5111	Light	19:29:44.200	21:29:44.200	1.04	10.00	V	
5112	Bias	19:30:02.390	21:30:02.390	1.04	0.00	V	
5113	Bias	19:30:10.970	21:30:10.970	1.04	0.00	V	
5114	Bias	19:30:18.519	21:30:18.5 21	1.05	0.00	V	
5115	Light	19:30:47.009	21:30:47.009	1.05	10.00	Blue	
5116	Light	19:31:05.200	21:31:05.200	1.05	10.00	Blue	
5117	Light	19:31:23.379	21:31:23.379	1.05	10.00	Blue	
5118	Light	19:31:47.750	21:31:47.750	1.05	10.00	V	
5119	Light	19:32:06.290	21:32:06.290	1.05	10.00	V	
5120	Light	19:32:24.480	21:32:24.480	1.05	10.00	V	
5121	Bias	19:32:42.659	21:32:42.659	1.05	0.00	V	
5122	Bias	19:32:50.560	21:32:50.560	1.05	0.00	V	
5123	Bias	19:32:57.780	21:32:57.780	1.05	0.00	V	
5124	Light	19:33:33.109	21:33:33.109	1.05	10.00	Blue	
5125	Light	19:33:51.320	21:33:51.320	1.05	10.00	Blue	
5126	Light	19:34:09.839	21:34:09.839	1.05	10.00	Blue	
5127	Light	19:34:33.859	21:34:33.859	1.05	10.00	V	
5128	Light	19:34:52.390	21:34:52.390	1.05	10.00	V	
5129	Light	19:35:10.580	21:35:10.580	1.05	10.00	V	
5130	Bias	19:35:28.769	21:35:28.769	1.05	0.00	V	
5131	Bias	19:35:35.979	21:35:35.979	1.05	0.00	V	
5132	Bias	19:35:44.560	21:35:44.560	1.05	0.00	V	
5133	Light	19:36:11.330	21:36:11.330	1.05	10.00	Blue	
5134	Light	19:36:29.859	21:36:29.859	1.05	10.00	Blue	
5135	Light	19:36:48.049	21:36:48.049	1.05	10.00	Blue	
5136	Light	19:37:12.419	21:37:12.4 21	1.05	10.00	V	
5137	Light	19:37:30.609	21:37:30.609	1.05	10.00	V	
5138	Light	19:37:48.799	21:37:48.799	1.05	10.00	V	
5139	Bias	19:38:07.330	21:38:07.330	1.05	0.00	V	
5140	Bias	19:38:15.230	21:38:15.230	1.05	0.00	V	
5141	Bias	19:38:23.120	21:38:23.120	1.05	0.00	V	
5142	Light	19:39:38.280	21:39:38.280	1.06	10.00	Blue	
5143	Light	19:39:56.810	21:39:56.810	1.06	10.00	Blue	
5144	Light	19:40:14.660	21:40:14.660	1.06	10.00	Blue	
5145	Light	19:40:39.030	21:40:39.030	1.06	10.00	V	
5146	Light	19:40:57.560	21:40:57.560	1.06	10.00	V	
5147	Light	19:41:15.750	21:41:15.750	1.06	10.00	V	
5148	Bias	19:41:33.939	21:41:33.939	1.06	0.00	V	
5149	Bias	19:41:42.179	21:41:42.179	1.06	0.00	V	
5150	Bias	19:41:50.070	21:41:50.070	1.06	0.00	V	
5151	Light	19:42:38.799	21:42:38.799	1.06	10.00	Blue	
5152	Light	19:42:56.990	21:42:56.990	1.06	10.00	Blue	
5153	Light	19:43:15.179	21:43:15.179	1.06	10.00	Blue	
5154	Light	19:43:39.549	21:43:39.549	1.06	10.00	V	
5155	Light	19:43:58.100	21:43:58.100	1.06	10.00	V	

Table 5: Observation Log (to be continued)

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5156	Light	19:44:16.379	21:44:16.379	1.06	10.00	V	
5157	Bias	19:44:34.460	21:44:34.460	1.06	0.00	V	
5158	Bias	19:44:42.359	21:44:42.359	1.06	0.00	V	
5159	Bias	19:44:49.560	21:44:49.560	1.06	0.00	V	
5160	Light	19:45:19.079	21:45: 21.079	1.06	10.00	Blue	
5161	Light	19:45:37.270	21:45:37.270	1.06	10.00	Blue	
5162	Light	19:45:55.460	21:45:55.460	1.06	10.00	Blue	
5163	Light	19:46:19.820	21:46: 21.820	1.07	10.00	V	
5164	Light	19:46:39.039	21:46:39.039	1.07	10.00	V	
5165	Light	19:46:57.229	21:46:57.229	1.07	10.00	V	
5166	Bias	19:47:15.419	21:47:15.4 21	1.07	0.00	V	
5167	Bias	19:47:22.629	21:47:22.629	1.07	0.00	V	
5168	Bias	19:47:30.870	21:47:30.870	1.07	0.00	V	
5169	Light	19:47:58.320	21:47:58.320	1.07	10.00	Blue	
5170	Light	19:48:16.870	21:48:16.870	1.07	10.00	Blue	
5171	Light	19:48:35.049	21:48:35.049	1.07	10.00	Blue	
5172	Light	19:48:59.070	21:48:59.070	1.07	10.00	V	
5173	Light	19:49:17.260	21:49:17.260	1.07	10.00	V	
5174	Light	19:49:35.450	21:49:35.450	1.07	10.00	V	
5175	Bias	19:49:53.640	21:49:53.640	1.07	0.00	V	
5176	Bias	19:50:02.220	21:50:02.220	1.07	0.00	V	
5177	Bias	19:50:10.109	21:50:10.109	1.07	0.00	V	
5178	Light	19:50:33.450	21:50:33.450	1.07	10.00	Blue	
5179	Light	19:50:52.329	21:50:52.329	1.07	10.00	Blue	
5180	Light	19:51:09.830	21:51:09.830	1.07	10.00	Blue	
5181	Light	19:51:34.200	21:51:34.200	1.07	10.00	V	
5182	Light	19:51:52.390	21:51:52.390	1.07	10.00	V	
5183	Light	19:52:10.580	21:52:10.580	1.07	10.00	V	
5184	Bias	19:52:29.800	21:52:29.800	1.07	0.00	V	
5185	Bias	19:52:37.689	21:52:37.689	1.07	0.00	V	
5186	Bias	19:52:45.240	21:52:45.240	1.07	0.00	V	
5187	Light	19:53:19.559	21:53: 21.559	1.08	10.00	Blue	
5188	Light	19:53:37.750	21:53:37.750	1.08	10.00	Blue	
5189	Light	19:53:56.280	21:53:56.280	1.08	10.00	Blue	
5190	Light	19:54:20.649	21:54:20.649	1.08	10.00	V	
5191	Light	19:54:38.840	21:54:38.840	1.08	10.00	V	
5192	Light	19:54:57.030	21:54:57.030	1.08	10.00	V	
5193	Bias	19:55:15.560	21:55:15.560	1.08	0.00	V	
5194	Bias	19:55:23.449	21:55:23.449	1.08	0.00	V	
5195	Bias	19:55:30.320	21:55:30.320	1.08	0.00	V	
5196	Light	19:56:01.889	21:56:01.889	1.08	10.00	Blue	
5197	Light	19:56:20.079	21:56:20.079	1.08	10.00	Blue	
5198	Light	19:56:38.270	21:56:38.270	1.08	10.00	Blue	
5199	Light	19:57:02.640	21:57:02.640	1.08	10.00	V	
5200	Light	19:57:20.829	21:57:20.829	1.08	10.00	V	
5201	Light	19:57:39.359	21:57:39.359	1.08	10.00	V	
5202	Bias	19:57:57.890	21:57:57.890	1.08	0.00	V	
5203	Bias	19:58:05.799	21:58:05.799	1.08	0.00	V	
5204	Bias	19:58:13.679	21:58:13.679	1.08	0.00	V	
5205	Light	19:58:53.149	21:58:53.149	1.08	10.00	Blue	
5206	Light	19:59:11.359	21:59:11.359	1.09	10.00	Blue	
5207	Light	19:59:29.550	21:59:29.550	1.09	10.00	Blue	

Table 6: Observation Log (to be continued)

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5208	Light	19:59:53.909	21:59:53.909	1.09	10.00	V	
5209	Light	20:00:12.099	22:00:12.099	1.09	10.00	V	
5210	Light	20:00:30.640	22:00:30.640	1.09	10.00	V	
5211	Bias	20:00:48.829	22:00:48.829	1.09	0.00	V	
5212	Bias	20:00:56.719	22:00:56.719	1.09	0.00	V	
5213	Bias	20:01:04.610	22:01:04.610	1.09	0.00	V	
5214	Light	20:04:59.369	22:04:59.369	1.10	10.00	V	Delete; Out of focus
5215	Light	20:05:39.880	22:05:39.880	1.10	120.00	V	
5216	Dark	20:07:53.719	22:07:53.719	1.11	120.00	V	
5217	Light	20:10:09.619	22:10:09.619	1.11	120.00	V	
5218	Dark	20:12:27.250	22:12:27.250	1.12	120.00	V	
5219	Light	20:14:50.359	22:14:50.359	1.12	120.00	V	
5220	Dark	20:17:07.299	22:17:07.299	1.13	120.00	V	
5221	Bias	20:19:34.539	22:19:34.539	1.13	120.00	V	
5222	Dark	20:21:53.189	22:21:53.189	1.14	120.00	V	
5223	Light	20:24:15.279	22:24:15.279	1.14	120.00	V	
5224	Dark	20:26:30.149	22:26:30.149	1.15	120.00	V	
5225	Light	20:28:54.979	22:28:54.979	1.15	120.00	V	
5226	Dark	20:31:21.179	22:31:21.179	1.16	120.00	V	
5227	Light	20:33:41.219	22:33:41.219	1.17	120.00	V	
5228	Light	20:37:18.120	22:37:18.1 22	1.16	10.00	V	Delete; Star not found in image
5229	Light	20:38:34.299	22:38:34.299	1.17	10.00	V	Delete; Star not found in image
5230	Light	20:41:37.570	22:41:37.570	1.18	10.00	V	Delete; Star not found in image
5231	Light	20:42:42.439	22:42:42.439	1.18	10.00	V	Delete; Star not found in image
5232	Light	20:43:24.989	22:43:24.989	1.18	10.00	V	Delete; Star not found in image
5233	Light	20:44:01.720	22:44:01.7 22	1.18	10.00	V	Delete; Star not found in image
5234	Light	20:44:33.979	22:44:33.979	1.18	10.00	V	Delete; Star not found in image
5235	Light	20:46:57.090	22:46:57.090	1.19	10.00	V	
5236	Light	20:47:23.519	22:47:23.519	1.19	10.00	V	
5237	Light	20:47:48.929	22:47:48.929	1.19	10.00	Blue	
5238	Light	20:48:40.409	22:48:40.409	1.19	5.00	Blue	
5239	Light	20:50:12.730	22:50:12.730	1.20	3.00	Blue	
5240	Light	20:50:46.359	22:50:46.359	1.20	3.00	Blue	
5241	Light	20:51:00.430	22:51:00.430	1.20	3.00	Blue	
5242	Bias	20:51:29.949	22:51:29.949	1.20	0.00	Blue	
5243	Bias	20:51:38.869	22:51:38.869	1.20	0.00	Blue	
5244	Bias	20:51:50.200	22:51:50. 220	1.20	0.00	Blue	
5245	Light	20:52:51.969	22:52:51.969	1.21	6.00	V	
5246	Light	20:53:29.379	22:53:29.379	1.21	6.00	V	
5247	Light	20:53:47.920	22:53:47.9 22	1.21	6.00	V	
5248	Light	20:54:48.659	22:54:48.659	1.21	3.00	Blue	
5249	Light	20:55:03.759	22:55:03.759	1.21	3.00	Blue	
5250	Light	20:55:17.829	22:55:17.829	1.21	3.00	Blue	
5251	Bias	20:55:55.590	22:55:55.590	1.21	0.00	Blue	
5252	Bias	20:56:06.570	22:56:06.570	1.22	0.00	Blue	
5253	Bias	20:56:15.839	22:56:15.839	1.22	0.00	Blue	
5254	Light	20:58:56.109	22:58:56.109	1.22	6.00	V	
5255	Light	20:59:10.179	22:59:10.179	1.22	6.00	V	

Table 7: Observation Log (to be continued)

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5256	Light	20:59:25.280	22:59:25.280	1.23	6.00	V	
5257	Light	20:59:40.729	22:59:40.729	1.23	3.00	Blue	
5258	Light	20:59:51.710	22:59:51.710	1.23	3.00	Blue	
5259	Light	21:00:04.059	23:00:04.059	1.23	3.00	Blue	
5260	Bias	21:00:15.050	23:00:15.050	1.23	0.00	Blue	
5261	Bias	21:00:23.280	23:00:23.280	1.23	0.00	Blue	
5262	Bias	21:00:30.489	23:00:30.489	1.23	0.00	Blue	
5263	Light	21:01:40.159	23:01:40.159	1.23	6.00	V	
5264	Light	21:01:54.570	23:01:54.570	1.24	6.00	V	
5265	Light	21:02:08.990	23:02:08.990	1.24	6.00	V	
5266	Light	21:02:24.780	23:02:24.780	1.24	3.00	Blue	
5267	Light	21:02:36.450	23:02:36.450	1.24	3.00	Blue	
5268	Light	21:02:47.079	23:02:47.079	1.24	3.00	Blue	
5269	Bias	21:02:58.409	23:02:58.409	1.24	0.00	Blue	
5270	Bias	21:03:06.650	23:03:06.650	1.24	0.00	Blue	
5271	Bias	21:03:14.539	23:03:14.539	1.24	0.00	Blue	
5272	Light	21:03:32.729	23:03:32.729	1.24	6.00	V	
5273	Light	21:03:47.149	23:03:47.149	1.24	6.00	V	
5274	Light	21:04:01.219	23:04:01. 239	1.24	6.00	V	
5275	Light	21:04:17.350	23:04:17.350	1.24	3.00	Blue	
5276	Light	21:04:29.359	23:04:29.359	1.24	3.00	Blue	
5277	Light	21:04:40.340	23:04:40.340	1.24	3.00	Blue	
5278	Bias	21:04:50.979	23:04:50.979	1.24	0.00	Blue	
5279	Bias	21:04:59.560	23:04:59.560	1.24	0.00	Blue	
5280	Bias	21:05:07.110	23:05:07.110	1.25	0.00	Blue	
5281	Light	21:05:27.359	23:05:27.359	1.25	6.00	V	
5282	Light	21:05:42.119	23:05:42.119	1.25	6.00	V	
5283	Light	21:05:56.189	23:05:56.189	1.25	6.00	V	
5284	Light	21:06:11.980	23:06:11.980	1.25	3.00	Blue	
5285	Light	21:06:23.300	23:06:23.300	1.25	3.00	Blue	
5286	Light	21:06:34.280	23:06:34.280	1.25	3.00	Blue	
5287	Bias	21:06:45.609	23:06:45.609	1.25	0.00	Blue	
5288	Bias	21:06:54.189	23:06:54.189	1.25	0.00	Blue	
5289	Bias	21:07:01.740	23:07:01.740	1.25	0.00	Blue	
5290	Light	21:07:20.960	23:07:20.960	1.25	6.00	V	
5291	Light	21:07:35.030	23:07:35.030	1.25	6.00	V	
5292	Light	21:07:50.130	23:07:50.130	1.25	6.00	V	
5293	Light	21:08:05.570	23:08:05.570	1.26	3.00	Blue	Unable to find WCS header
5294	Light	21:08:16.899	23:08:16.899	1.26	3.00	Blue	
5295	Light	21:08:28.910	23:08:28.910	1.26	3.00	Blue	
5296	Bias	21:08:40.240	23:08:40.240	1.26	0.00	Blue	
5297	Bias	21:08:48.130	23:08:48.130	1.26	0.00	Blue	
5298	Bias	21:08:55.340	23:08:55.340	1.26	0.00	Blue	
5299	Light	21:09:25.879	23:09:25.879	1.26	6.00	V	
5300	Light	21:09:39.960	23:09:39.960	1.26	6.00	V	
5301	Light	21:09:54.030	23:09:54.030	1.26	6.00	V	
5302	Light	21:10:10.500	23:10:10.500	1.26	3.00	Blue	
5303	Light	21:10:21.480	23:10: 23.480	1.26	3.00	Blue	
5304	Light	21:10:33.149	23:10:33.149	1.26	3.00	Blue	
5305	Bias	21:10:43.789	23:10:43.789	1.26	0.00	Blue	

Table 8: Observation Log (to be continued)

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5306	Bias	21:10:52.030	23:10:52.030	1.27	0.00	Blue	
5307	Bias	21:10:59.920	23:10:59.920	1.27	0.00	Blue	
5308	Light	21:11:26.350	23:11:26.350	1.27	6.00	V	
5309	Light	21:11:40.420	23:11:40.420	1.27	6.00	V	
5310	Light	21:11:54.829	23:11:54.829	1.27	6.00	V	
5311	Light	21:12:10.960	23:12:10.960	1.27	3.00	Blue	
5312	Light	21:12:22.289	23:12:22.289	1.27	3.00	Blue	Unable to find WCS header
5313	Light	21:12:33.270	23:12:33.270	1.27	3.00	Blue	
5314	Bias	21:12:44.600	23:12:44.600	1.27	0.00	Blue	
5315	Bias	21:12:53.179	23:12:53.179	1.27	0.00	Blue	
5316	Bias	21:13:01.070	23:13:01.070	1.27	0.00	Blue	
5317	Light	21:13:22.019	23:13:22.019	1.27	6.00	V	
5318	Light	21:13:36.079	23:13:36.079	1.28	6.00	V	
5319	Light	21:13:50.490	23:13:50.490	1.28	6.00	V	
5320	Light	21:14:06.639	23:14:06.639	1.28	3.00	Blue	
5321	Light	21:14:18.629	23:14:18.629	1.28	3.00	Blue	
5322	Light	21:14:29.960	23:14:29.960	1.28	3.00	Blue	
5323	Bias	21:14:40.939	23:14:40.939	1.28	0.00	Blue	
5324	Bias	21:14:48.149	23:14:48.149	1.28	0.00	Blue	
5325	Bias	21:14:56.390	23:14:56.390	1.28	0.00	Blue	
5326	Light	21:15:21.780	23:15: 23.780	1.28	6.00	V	
5327	Light	21:15:35.869	23:15:35.869	1.28	6.00	V	
5328	Light	21:15:50.270	23:15:50.270	1.28	6.00	V	
5329	Light	21:16:06.400	23:16:06.400	1.28	3.00	Blue	
5330	Light	21:16:17.730	23:16:17.730	1.28	3.00	Blue	
5331	Light	21:16:28.710	23:16:28.710	1.29	3.00	Blue	
5332	Bias	21:16:39.689	23:16:39.689	1.29	0.00	Blue	
5333	Bias	21:16:48.270	23:16:48.270	1.29	0.00	Blue	
5334	Bias	21:16:56.159	23:16:56.159	1.29	0.00	Blue	
5335	Light	21:17:16.070	23:17:16.070	1.29	6.00	V	
5336	Light	21:17:30.480	23:17:30.480	1.29	6.00	V	
5337	Light	21:17:44.549	23:17:44.549	1.29	6.00	V	
5338	Light	21:18:01.030	23:18:01.030	1.29	3.00	Blue	
5339	Light	21:18:12.009	23:18:12.009	1.29	3.00	Blue	
5340	Light	21:18:22.989	23:18:22.989	1.29	3.00	Blue	
5341	Bias	21:18:34.320	23:18:34.320	1.29	0.00	Blue	
5342	Bias	21:18:42.560	23:18:42.560	1.29	0.00	Blue	
5343	Bias	21:18:50.789	23:18:50.789	1.30	0.00	Blue	
5344	Light	21:19:16.870	23:19:16.870	1.30	6.00	V	
5345	Light	21:19:30.949	23:19:30.949	1.30	6.00	V	
5346	Light	21:19:45.359	23:19:45.359	1.30	6.00	V	
5347	Light	21:20:01.490	23:20:01.490	1.30	3.00	Blue	
5348	Light	21:20:12.820	23:20:12.820	1.30	3.00	Blue	
5349	Light	21:20:24.140	23:20:24.140	1.30	3.00	Blue	
5350	Bias	21:20:35.119	23:20:35.119	1.30	0.00	Blue	
5351	Bias	21:20:43.020	23:20:43.020	1.30	0.00	Blue	
5352	Bias	21:20:51.259	23:20:51.259	1.30	0.00	Blue	
5353	Light	21:21:20.440	23:21:20.440	1.30	6.00	V	
5354	Light	21:21:34.840	23:21:34.840	1.31	6.00	V	
5355	Light	21:21:48.909	23:21:48.909	1.31	6.00	V	

Table 9: Observation Log (to be continued)

Frame #	Type	Universal Time	Local Time	Airmass	ExpTime(s)	Filter	Comments
5356	Light	21:22:05.059	21:22:05.059	1.31	3.00	Blue	
5357	Light	21:22:16.370	21:22:16.370	1.31	3.00	Blue	
5358	Light	21:22:27.350	21:22:27.350	1.31	3.00	Blue	
5359	Bias	21:22:39.359	21:22:39.359	1.31	0.00	Blue	
5360	Bias	21:22:47.259	21:22:47.259	1.31	0.00	Blue	
5361	Bias	21:22:54.810	21:22:54.810	1.31	0.00	Blue	
5362	Light	21:24:00.700	21:24:00.700	1.32	6.00	V	
5363	Light	21:24:15.119	21:24:15.119	1.32	6.00	V	
5364	Light	21:24:29.530	21:24:29.530	1.32	6.00	V	
5365	Light	21:24:45.320	21:24:45.320	1.32	3.00	Blue	
5366	Light	21:24:56.990	21:24:56.990	1.32	3.00	Blue	Unable to find WCS header
5367	Light	21:25:07.629	21:25:07.629	1.32	3.00	Blue	
5368	Bias	21:25:18.949	21:25:18.949	1.32	0.00	Blue	
5369	Bias	21:25:26.839	21:25:26.839	1.32	0.00	Blue	
5370	Bias	21:25:35.420	21:25:35.420	1.32	0.00	Blue	
5371	Light	21:26:01.169	21:26:01.169	1.32	6.00	V	
5372	Light	21:26:15.580	21:26:15.580	1.32	6.00	V	
5373	Light	21:26:29.989	21:26:29.989	1.33	6.00	V	
5374	Light	21:26:46.140	21:26:46.140	1.33	3.00	Blue	
5375	Light	21:26:57.109	21:26:57.109	1.33	3.00	Blue	
5376	Light	21:27:08.779	21:27:08.779	1.33	3.00	Blue	
5377	Bias	21:27:19.420	21:27:19.420	1.33	0.00	Blue	
5378	Bias	21:27:28.000	21:27:28.000	1.33	0.00	Blue	
5379	Bias	21:27:35.890	21:27:35.890	1.33	0.00	Blue	
5380	Light	21:27:52.020	21:27:52.020	1.33	6.00	V	
5381	Light	21:28:06.089	21:28:06.089	1.33	6.00	V	
5382	Light	21:28:20.500	21:28:20.500	1.33	6.00	V	
5383	Light	21:28:36.630	21:28:36.630	1.33	3.00	Blue	
5384	Light	21:28:47.619	21:28:47.619	1.33	3.00	Blue	
5385	Light	21:28:59.630	21:28:59.630	1.34	3.00	Blue	
5386	Bias	21:29:09.929	21:29:09.929	1.34	0.00	Blue	
5387	Bias	21:29:18.850	21:29:18.850	1.34	0.00	Blue	
5388	Bias	21:29:26.760	21:29:26.760	1.34	0.00	Blue	
5389	Light	21:29:42.530	21:29:42.530	1.34	6.00	V	
5390	Light	21:29:57.630	21:29:57.630	1.34	6.00	V	
5391	Light	21:30:12.050	21:30:12.050	1.34	6.00	V	
5392	Light	21:30:28.179	21:30:28.179	1.34	3.00	Blue	
5393	Light	21:30:39.500	21:30:39.500	1.34	3.00	Blue	
5394	Light	21:30:50.479	21:30:50.479	1.34	3.00	Blue	
5395	Bias	21:31:01.470	21:31:01.470	1.34	0.00	Blue	
5396	Bias	21:31:09.699	21:31:09.699	1.34	0.00	Blue	
5397	Bias	21:31:17.940	21:31:17.940	1.35	0.00	Blue	
5398	Light	21:31:36.149	21:31:36.149	1.35	6.00	V	
5399	Light	21:31:50.200	21:31:50.200	1.35	6.00	V	
5400	Light	21:32:05.299	21:32:05.299	1.35	6.00	V	
5401	Light	21:32:20.760	21:32:20.760	1.35	3.00	Blue	
5402	Light	21:32:31.730	21:32:31.730	1.35	3.00	Blue	
5403	Light	21:32:44.079	21:32:44.079	1.35	3.00	Blue	
5404	Bias	21:32:55.409	21:32:55.409	1.35	0.00	Blue	
5405	Bias	21:33:03.299	21:33:03.299	1.37	0.00	Blue	
5406	Bias	21:33:10.509	23:33:10.509	1.37	0.00	Blue	

Table 10: Observation Log (to be continued)