

ANALYSIS OF GSC 5802-00929 AND GSC 5740-02196, 2 NEW VARIABLE STARS FOUND DURING ASTEROID LIGHTCURVE OBSERVATIONS

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Abstract

During Asteroid Lightcurve observations, 2 field stars that were used as Comparison stars were found to be variable over the duration of the observation run. GSC 0574-02196 was first observed 08 July 2006 and this was followed by GSC 5802-00929 first observed on 26 July 2006. Follow-up filtered observations over several nights were taken and analysis shows that both targets are likely Eclipsing Binary Stars with periods of 0.34730 ± 0.000021 d days and 0.34260 ± 0.000021 days respectively.

1. Introduction

Hunters Hill Observatory is located in Higgins' home in Canberra, Australia. Using an 0.35m Meade LX200GPS SCT at f/4 fitted with an SBIG ST-8e CCD camera and housed in a permanent setup. The observatory is automated and run remotely via LAN and ACP3 produced by DC3 Dreams. Over the past several years, Hunters Hill has been undertaking photometry of Minor Planets down to magnitude 16 (when conditions are good) with 0.03m precision and, more recently, in the search of Asynchronous Binary Asteroids as part of the Binary Asteroid Photometric Survey under Principal Investigator Dr Petr Pravec of the Astronomical Institute, Czech Republic.



Figure 1. Hunters Hill Observatory 0.35m SCT

All imaging is guided with the use of separate guide scope and CCD camera that allows exposures up to approximately 10 minutes.

2. Acquiring Data

The initial discovery runs taken on 08 July 2006 and 26 July 2006 were as the result of acquiring data for Survey targets. The first discovery was as a direct result of using the star as a comparison star when reducing the images for the photometric target. In the reduction process, MPO_Canopus provides the user with a plot of the nightly series for each comparison star. The earlier discovery was after revising earlier image runs using a piece of software called Muniwin. Muniwin provides the user with the ability to photometrically reduce the entire series of images and then just choose a field star at a time and get an instant plot of the entire nightly run for that chosen star. It also provides a statistical window showing likely targets which plots the stars lightcurve at the click of the mouse.

The original fields were all imaged in the clear filter at 240 second integrations. All subsequent images were conducted using BVR filters and were combined with runs on Landolt and Henden fields to allow me to reduce the target and comp star magnitudes to the standard system. All reductions were performed by MPO_Canopus and Photored.

It is not uncommon for Hunters Hill to automatically image multiple images in a night – typically no more than 3. The observing script informs the control software what to observe and how to observe it. The software points the scope, performs a plate solve and point correction then changes to the correct filter, commences autoguiding then

takes the final image before moving to the next image in the sequence. Although capable of autofocus, I have found it unnecessary. I manually control the focuser remotely on one or 2 occasions during the night. The focuser requires a fixed amount of movement every 5°C drop in temperature.

3. Measuring Images

All images are dark and flat frame corrected before they are measured. MPO_Canopus is used to extract 5 comp stars and the target and the nights run stored in a session file. Multiple sessions for a given target are then combined and merged. A Fourier routine written by Dr Alan Harris and incorporated into MPO_Canopus allows the software and the user to determine likely periods. Typically all images are reduced using differential photometry and each session 'lined up' using user chosen delta V.

This approach solves the period but a different approach is required to obtain the actual magnitude of the target and the comp stars. Henden and Landolt standard fields are imaged in BVR and reduced inside Photored to obtain transforms. Nightly first order extinctions are calculated using the nightly series of V filtered images for each target as outlined in Brian D Warner (2006).

At the start of each night a series of BVR images are taken of the target field. Combined with the colour transforms and the nightly first order extinctions, Photored is able to generate colour indices as well as Comp Star and target Standard Magnitudes. To determine the target Minimum magnitude I find the nightly image associated with the lightcurve minimum then measure the Vj magnitude using the photometry tools in MaxIm DL/CCD.

After the final period and amplitude solutions have been determined, MPO_Canopus calculates the time of minima. Combined with the period and the amplitude the user is able to determine the expected standard magnitude of the target at any given future date/time.

Based on the colour Indices calculated in this process, an estimate of the combined spectral type of each target can be determined. According to STScI (2006), both targets are between K1.0 to K2.0 indicating they have a temperature of approx 5000K.

4. Results for GSC 0574-02196

This target is located at J2000 RA 20h 10m 40.13s Dec - 07° 32' 41.36". The 2MASS catalogue gives J=12.776, H=12.354 and K=12.298. The star was not located in either the All Sky Automated Survey catalogue (ASAS 2006), General Catalogue of Variable Stars (GCVS 2006) or the Northern Sky Variability catalogue (NSV 2006).

The photometric findings for this variable and comparison stars are listed at Tables 1 and 2. A lightcurve plot and finder chart is shown at figures 2 and 3.

GSC 0574-02196 Summary	
Vj (minima)	$14.531 \pm 0.01\text{mag}$
Bj-Vj	$0.875 \pm 0.146\text{mag}$
Vj-Rc	$0.512 \pm 0.093\text{mag}$
Period	$8.3353 \pm 0.0005\text{hrs}$
	$0.34730 \pm 0.000021\text{d}$
Amplitude (BVR)	$0.60 \pm 0.01\text{mag}$
Time of Minima	2453952.059942

Table 1. Photometric Summary of GSC 0574-02196

Comp Star	Vj	Bj-Vj	Vj-Rc
C1	10.637 ± 0.016	0.556 ± 0.068	0.309 ± 0.043
C2	10.664 ± 0.012	0.811 ± 0.044	0.471 ± 0.028
C3	10.611 ± 0.012	1.128 ± 0.043	0.672 ± 0.027
C4	12.352 ± 0.023	1.107 ± 0.033	0.659 ± 0.021
C5	12.250 ± 0.031	0.621 ± 0.050	0.351 ± 0.032

Table 2. GSC 57402196 Comp Stars

Based on the colour Indices' calculated in the reduction process, an estimate of the combined spectral type of this target can be determined. According to STScI (2006) reference, the target is in the spectral range K1.0 to K2.0 indicating it has a temperature of approx 5000K.

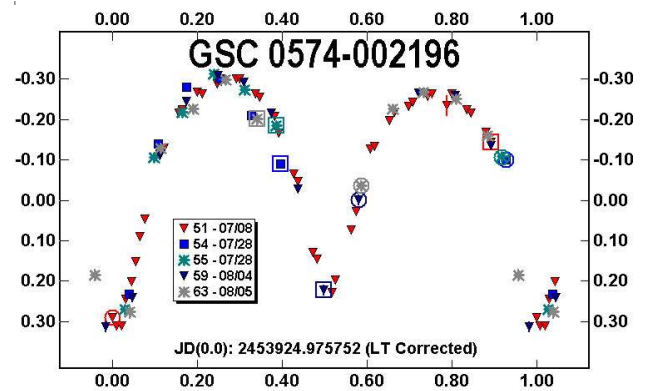


Figure 2: Period plot for GSC 0574-002196 generated by MPO_Canopus

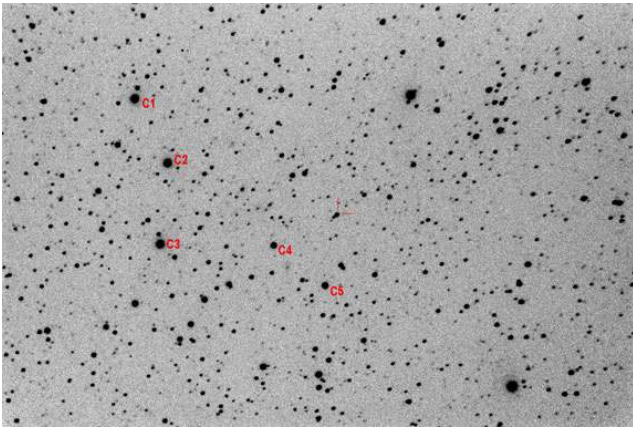


Figure 3: GSC 0574-02196 Finder Chart

5. Results for GSC 5802-00929

This target is located at J2000 RA 22h 02m 16.76s Dec - 08° 11' 24.6". The 2MASS catalogue gives J=13.334, H=12.950 and K=12.867. The star was not located in either the All Sky Automated Survey catalogue (ASAS 2006), General Catalogue of Variable Stars (GCVS 2006) or the Northern Sky Variability catalogue (NSV 2006).

The photometric findings for this variable and comparison stars are listed at Tables 3 and 4. A lightcurve plot and finder chart is shown at figures 4 and 5.

GSC 5802-00929 Summary	
V _j (minima)	14.922 ± 0.02mag
B _j -V _j	0.877 ± 0.151mag
V _j -R _c	0.513 ± 0.096mag
Period	8.2224 ± 0.0005hrs
	0.34260 ± 0.000021d
Amplitude (BVR)	0.45 ± 0.01 mag
Time of Minima	2453943.007801

Table 3. Photometric Summary of GSC 5802-00929

Comp Star	V _j	B-V	V-R
C1	13.269 ±0.024	0.737 ±0.141	0.424 ±0.089
C2	13.993 ±0.022	0.778 ±0.152	0.450 ±0.097
C3	13.910 ±0.024	0.833 ±0.166	0.485 ±0.105
C4	13.489 ±0.019	1.015 ±0.149	0.601 ±0.095
C5	12.538 ±0.018	0.717 ±0.141	0.412 ±0.089

Table 4. GSC 5802 00929 Comp Stars

Based on the colour Indices calculated in the reduction process, an estimate of the combined spectral type of this target can be determined. According to STScI (2006) reference, the target is in the spectral range K1.0 to K2.0 indicating it has a temperature of approx 5000K.

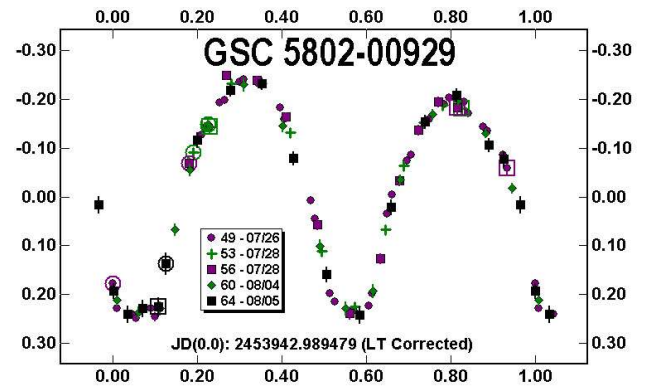


Figure 4: Period plot for GSC 5802-00929 generated by MPO_Canopus

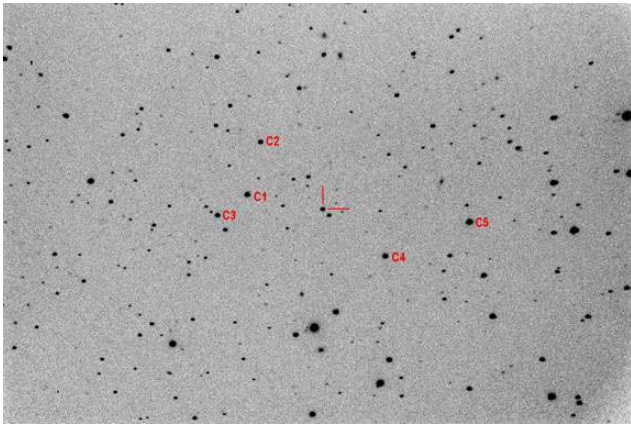


Figure 5: GSC 5802-00929 Finder Chart

6. Modelling

Binary Maker 3 (Bradstreet, 2006) was used to produce a theoretical model of each system. The software requires normalised phase-flux pair data to perform the modelling. Fortunately MPO Canopus will export this data for the user by normalising standard lightcurve data to unity at phase 0.25.

To model any Eclipsing Binary system accurately requires both lightcurve and radial velocity information. As there is no radial velocity information the best I can hope for is an approximate system. The modelling is performed by loading pre-existing known models that have the same basic shape as the lightcurve being modelled. The various parameters are then ‘tweaked’ until the theoretical lightcurve perfectly matches the actual lightcurve. The parameters for the known objects are obtained from the library supplied with the Binary Maker 3 CD or from the Catalogue and Atlas of Eclipsing Binaries (CALEB) website at <http://caleb.eastern.edu>.

6.1 GSC 5802-00929

This system displayed an eclipsing event and as such provides the ability to put a limit on the inclination and therefore the solution for semi-major axis. Since modelling was based on finding a known model with a lightcurve similar in shape to this target, the parameters for UZ Leo (Bradstreet 2004V) were chosen.

The first parameters changed were that of the temperature of each star (obtained from the B-V and V-Rc colour indices) and the period. The eclipsing event confined the inclination to a limited range and variations in the Maxim meant that some light variation was evident from one side of system to the other. In this case I added a hot spot and put the system into synchronous orbit to show that the maxima variation did not vary over a period of several days.

GSC 5802-00929	Star 1	Star 2
Mass Ratio	1	0.23
Omega	2.232916	2.247488
Fillout	0.50	0.40
Mean Radius	0.534384	0.281645
Temperature (K)	4950	5000
Inclination	84.0°	
Luminosity	0.151501	0.043810

Spot: Star 2.
Colat: 90°, Long: 90°, Radius: 20%, Temp: 0.60

Table 5. Binary Maker 3 parameters for GSC 5802-00929

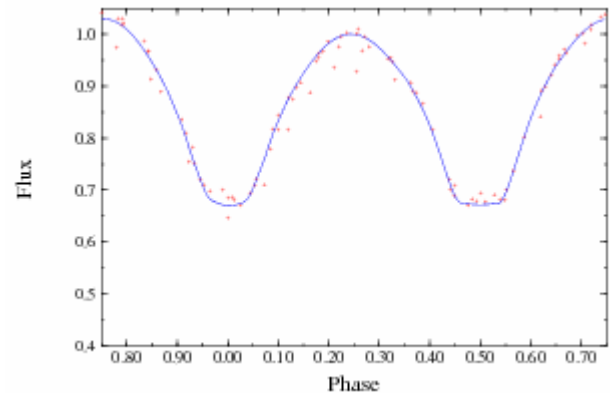
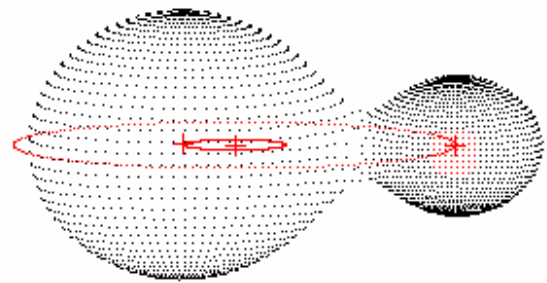


Figure 6. The normalised data for GSC 5802-00929 (dots) overlaid with the theoretical data generated by the model generated by Binary Maker 3 (continuous line)



0.2450

Figure 7. Binary Maker 3 model for GSC 5802-00929

6.2 GSC 0574-02196

This system did not display an eclipsing event and as such does not provide the ability to put a limit on the inclination and therefore the solution for semi-major axis. Since modelling was based on finding a known model with a lightcurve similar in shape to this target, the parameters for V417 Aql (Samec 1997V) were chosen.

The first parameters changed were that of the temperature of each star (obtained from the B-V and V-Rc colour indices) and the period. Without the eclipsing event the remaining tweaks were trial and error. One thing this target displayed was the different height maxima. I again added a single hotspot and put the orbits in synch to achieve the desired result.

GSC 0574-02196	Star 1	Star 2
Mass Ratio	3	1
Omega	6.498721	6.48721
Fillout	0.19	0.19
Mean Radius	0.481848	0.298781
Temperature (K)	4900	5100
Inclination	78.0°	
Luminosity	0.121353	0.053367
Spot: Star 2.		
Colat: 90°, Long: 90°, Radius: 17%, Temp: 0.60		

Table 6. Binary Maker 3 parameters for GSC 0574-02196

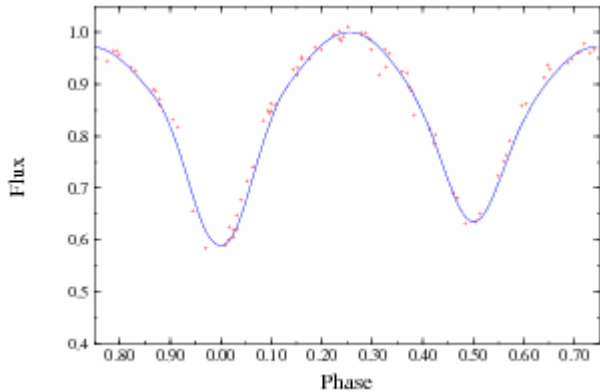
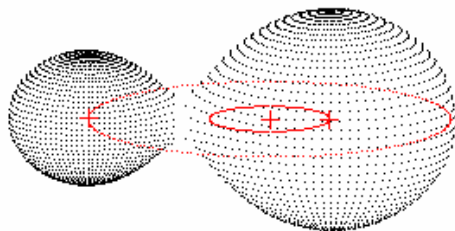


Figure 8. The normalised data for GSC 0574-02196 (dots) overlaid with the theoretical data generated by the model generated by Binary Maker 3 (continuous line)



0.2450

Figure 9. Binary Maker 3 model for GSC 0574-02196

7. Conclusion

These discoveries and the resulting analysis represent many firsts for the author, the first Variable Star discoveries and the first reductions of any object to standard magnitudes. The observations and analysis presented in this paper represent preliminary determinations of the photometric elements and the initial theoretical modelling indicates that both objects are likely contact binaries.

8. Acknowledgements

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Thanks go to Brian D Warner for his continued development and support for the data analysis software, MPO_Canopus v 9 and in particular for his support and guidance as I worked through my first standard magnitude reductions.

9. References

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