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GSC 1657.1754: A NEW DEEPLY ECLIPSING BINARY SYSTEM IN DELPHINUS

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The 10.5 magnitude star GSC 1657.1754 ($21^h06^m26^s.1$ +19°24'35") has recently been found to be variable on films taken over the last 7 years as part of the UK Nova/Supernova Patrol Programme. Details of the discovery and early observations are given by Collins et al. (1996). Initial reports of the variation were circulated electronically (Hurst 1996a) and the star has also been given the designation TAV J2106+194 (Hurst 1996b). On the survey films (Kodak Tech Pan 2415) the star was seen mostly at $m_{pv} \sim 10.5$ but occasionally it faded below the limiting magnitude of ~ 11.8 suggesting an eclipsing binary with a period of near 10.35 days. Extensive visual observations confirmed the initial estimate of the period and further showed that the star faded below $m_v \sim 12.4$. The eclipse history of the star has also been followed on plates of the Sonneberg and Hartha Observatories' sky patrols taken over the past 35 years. The plates are blue sensitive ORWO ZU2 (Kodak 103a-O like) and the exposures were typically 30 mins. The variable is visible throughout the primary eclipse and yielded 15 times of minimum. These are collected with the other photographic and visual times of minimum in Table 1. A more complete discussion of these observations will be published elsewhere.

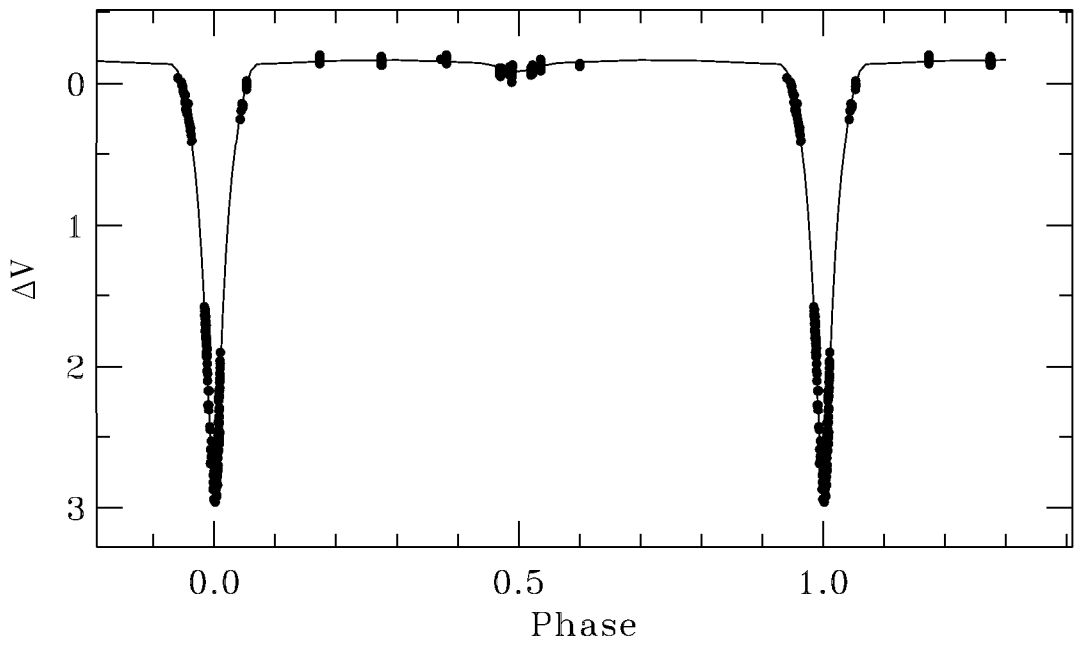

Figure 1. Light curve from the CCD observations with the model fit overlaid. The magnitude differences are relative to star D on the finding chart (Figure 4) GSC 1657.1766, which is given as $10^m.6$ in V

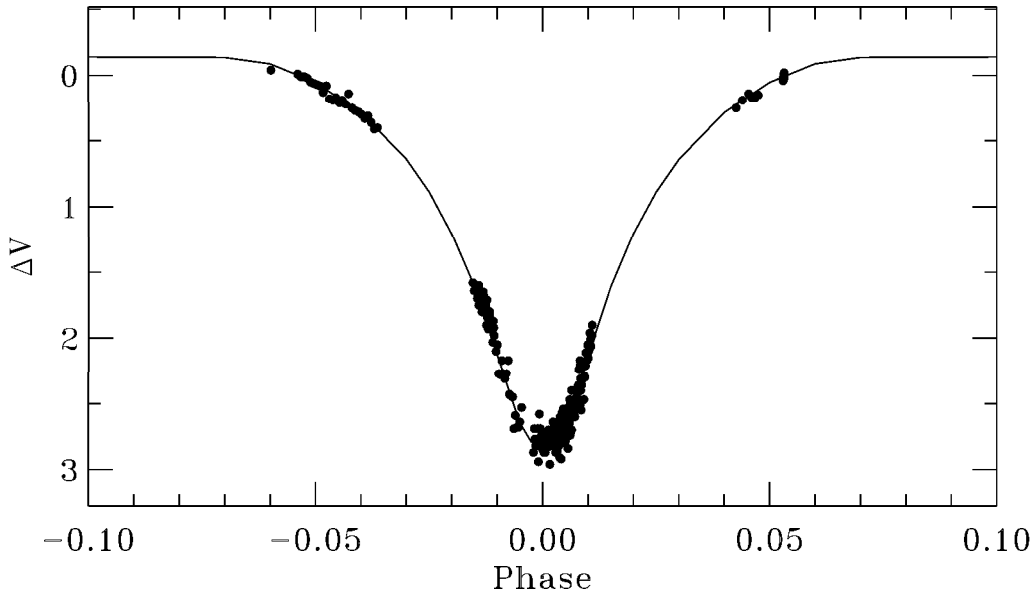

Figure 2. Detail of primary minimum with the model fit superimposed

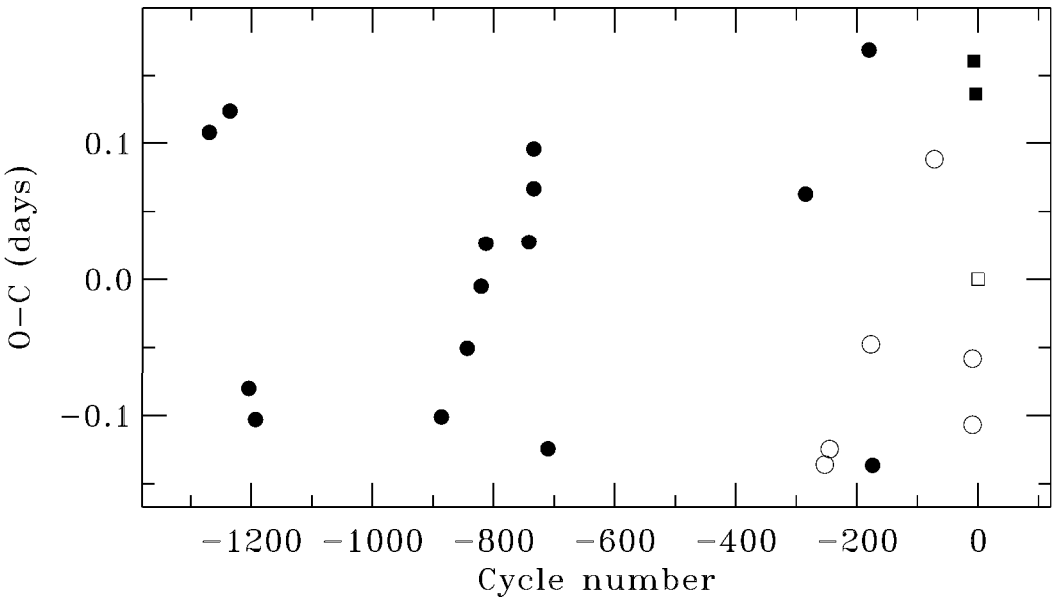

Figure 3. O−C diagram of the times of minima using the ephemeris given in the text. The photographic, photovisual, visual and CCD timings are plotted as filled circles, open circles, filled squares and an open square respectively

Since discovery GSC 1657.1754 has been observed extensively with a Starlight Xpress SX CCD and V filter on a 30-cm Newtonian telescope. Exposure times were 15 seconds and the limiting magnitude is typically 14 in V. The comparison star used was GSC 1657.1766 (V $\sim$ 10.6, star D on the finding chart, Figure 4) and the check star used was GSC 1657.1804 (V $\sim$ 12.7). The mean ΔV between the comparison and check star is 2.031 $\pm$0.065 mag which is consistent with the GSC magnitudes. The CCD observations show that the star reaches V $\sim$ 13.5, giving a primary eclipse of $\sim$ 3 mag, with a duration of just over one day. The secondary eclipse is not well defined but it probably has a depth of only $\sim$ 0.1 mag.

Table 1. Times of minima

JD	Cycle	O–C	Source	JD	Cycle	O–C	Source
2437191.404	−1270	0.1077	pg	2447719.486	−253	−0.1360	pv
2437543.399	−1236	0.1233	pg	2447802.316	−245	−0.1247	pv
2437874.470	−1204	−0.0805	pg	2448444.491	−183	0.2055	pv
2437988.323	−1193	−0.1032	pg	2448475.511	−180	0.1685	pg
2441166.492	−886	−0.1013	pg	2448506.352	−177	−0.0475	pv
2441601.341	−844	−0.0504	pg	2448537.320	−174	−0.1365	pg
2441839.490	−821	−0.0051	pg	2449593.483	−72	0.0882	pv
2441922.340	−813	0.0262	pg	2450245.485	−9	−0.1070	pv
2442657.357	−742	0.0273	pg	2450245.534	−9	−0.0580	pv
2442740.215	−734	0.0666	pg	2450266.457	−7	0.1603	vis.
2442740.244	−734	0.0956	pg	2450297.490	−4	0.1363	vis.
2442988.480	−710	−0.1244	pg	2450338.763	0	0.0000	CCD
2447388.410	−285	0.0628	pg				

Source: pg, Sonneberg/Hartha; pv, UK Nova/Supernova Patrol; vis., Visual

The times of minimum have been used to search for the period which can be determined unambiguously. The CCD observations around primary minimum have been used to derive E_0 and the period has been determined from the visual and photographic times of minimum. The ephemeris

$$\begin{array}{rl} \text{Min I} = \text{HJD}\,2450338.7630 & + 10.352336 \times E \\ \pm 18 & \pm 33 \end{array}$$

is used to plot the light curves in Figures 1 and 2, and O−C diagram in Figure 3.

Although the light curve is not complete the combination of very deep primary minimum and weak secondary minimum clearly suggest a high inclination Algol system. The light curve has been modelled using the LIGHT2 code (Hill 1979, see also Hill et al. 1989) and it was initially assumed that the system contains a hot main-sequence star and a larger cool companion. The solution is largely independent of the initial conditions although the temperatures of the stars are poorly constrained and this produces large uncertainties in the absolute parameters of the system. The ratio of the temperatures of the components is ~ 3, with the secondary at 4500 - 5500 K while the primary is probably in the range 9000 - 15000 K. The secondary may be filling its Roche lobe, for $q \sim 0.2$, and is only slightly smaller than the Roche radius for a wide range of mass ratios. The radius of the primary is only $\sim 25\%$ smaller than that of the secondary. The inclination is 85 – 87 degrees which is on the cusp of totality. It therefore seems most likely that the system contains a mid-B to mid-A type primary and a G - K subgiant secondary. If the primary is hot then the system may be similar to AU Mon or if it is somewhat cooler, VW Cyg. For all likely masses of the primary its radius is a factor of ~ 2 larger than would be expected for a main-sequence star, so this component would also seem to be evolved.

This new variable is a relatively rare example of a long-period Algol with very deep eclipses. As it is rather brighter than most of the stars in this group it should be a useful object for testing the evolutionary models of these systems and should repay further study.

It is a pleasure to acknowledge the management and staff of the Sonneberg Observatory for their help in accessing the Sky Patrol plates.

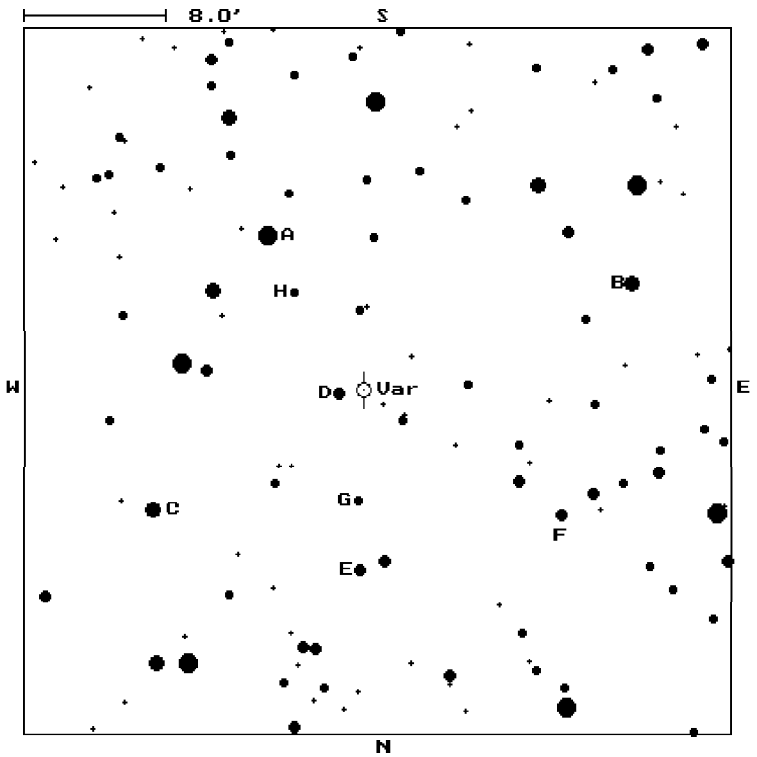

Figure 4. Finding chart for GSC 1657.1754 taken from Collins et al. (1996). The comparison is star D. South is up and the field is 40 arcmin square

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