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GSC 3576-0170: A NEW NEAR-CONTACT SOLAR-TYPE BINARY, PERIOD ANALYSIS AND CLASSIFICATION

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GSC 3576-0170 (at $20^h23^m38^s$, $+46°55'52''$, J2000.0) was discovered to be variable by one of us (RHN) while doing CCD observations of ZZ Cyg at his private observatory (see Nelson, 2003) in early June 2003. Several stars were included in the aperture photometry to serve as check stars and one of them displayed the features of an eclipsing binary. During that period, RMR obtained a full light curve in R_C (525 points) (see Robb & Greimel, 1999) and four times of minima. The light curves shown in Figure 1 show that the system is a close binary. Since the maxima are of different height, we expect spots on one or both stars.

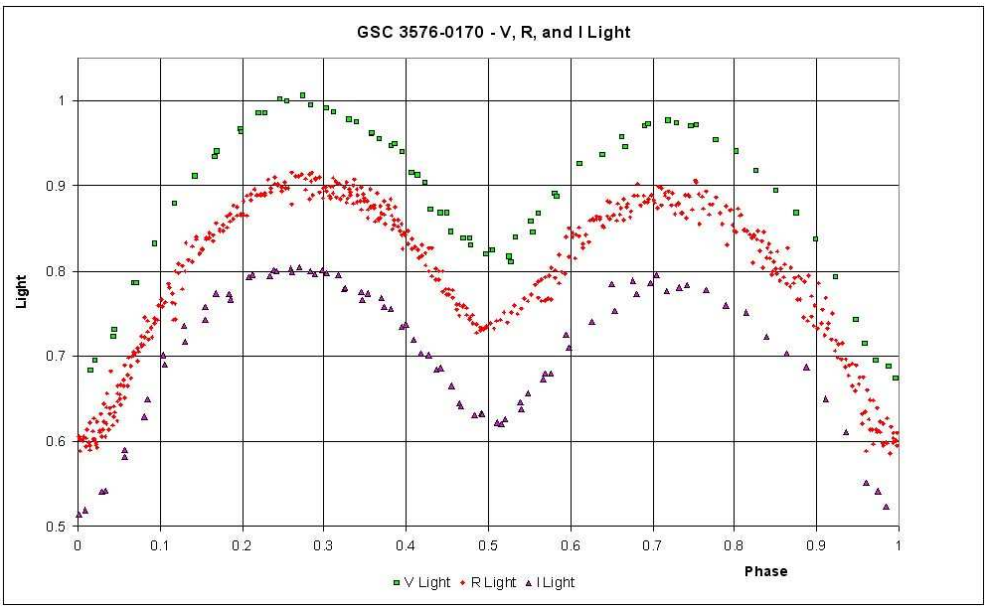

Figure 1.

Table 1: Positions and magnitudes

Star	GSC	Phase	V	$B-V$	$V-R_C$	R_C-I_C
Var	3576-0170	0.39	12.496(5)	0.737(3)	0.438(3)	0.398(5)
Var	3576-0170	0.68	12.484(5)	0.735(3)	0.432(3)	0.411(5)
C	3576-0964	na	11.014(3)	0.138(6)	0.090(1)	0.100(2)
K	3576-0702	na	11.561(6)	0.432(8)	0.265(4)	0.256(5)

Table 2: Observed minima of GSC 3576-0170

Observer	HJD − 2400000	Error (days)	Type	Cycle	$O-C$ (days)
Nelson	52794.863	0.0040	II	−2.5	0.0009
Nelson	52795.8716	0.0005	I	0	−0.0030
Robb	52799.9230	0.0005	I	10	−0.0016
Quester	52802.554	0.0020	II	16.5	−0.0032
Robb	52806.8076	0.0003	I	27	−0.0021
Robb	52807.821	0.0010	II	29.5	−0.0012
Quester	52812.478	0.0020	I	41	−0.0018
Nelson	52826.860	0.0010	II	76.5	0.0025
Krajci	53263.8659	0.0005	II	1155.5	0.0081
Krajci	53264.6735	0.0002	II	1157.5	0.0057
Robb	53305.7787	0.0004	I	1259	0.0029
Krajci	53837.9506	0.0002	I	2573	−0.0018
Krajci	53852.937	0.0002	I	2610	−0.0006
Krajci	53900.7278	0.0002	I	2728	−0.0004
Robb	53939.8099	0.0005	II	2824.5	−0.0012
Robb	53941.8337	0.0004	II	2829.5	−0.0025
Robb	53943.8605	0.0008	II	2834.5	−0.0007

At the USNO Flagstaff Station 1.00-m telescope (see Nelson, 2002), AAH observed the GSC 3576-0170 and ZZ Cyg field in the standard Johnson–Cousins BVR_CI_C passbands on 2003-08-10 (UT). This photometry is summarized in Table 1 with magnitude errors, in millimagnitudes, appearing in brackets.

All known times of minima were collected (Table 2) and an $O-C$ plot constructed (Fig. 2).

Assigning equal weights, the following ephemeris (in days) was obtained, and the above tabular $O-C$ values were calculated from the linear least squares best fit relation:

$$\text{Min. I} = \text{HJD } 2452795.8746(22) + 0.40500(1) \times E.$$

It is clear from Figure 2 that deviations from the line of best fit far exceed the internal error estimates and we suspect there is some systematic effect(s). A quadratic fit can be invoked; however that still leaves the rms error at 0.0020 days. Clearly more times of minima are required to sort out the true period and any period variation and we will reserve a full discussion of the subject to a future paper. Therefore although the period is quoted to five figures, the last figure is uncertain. The error in the period has been

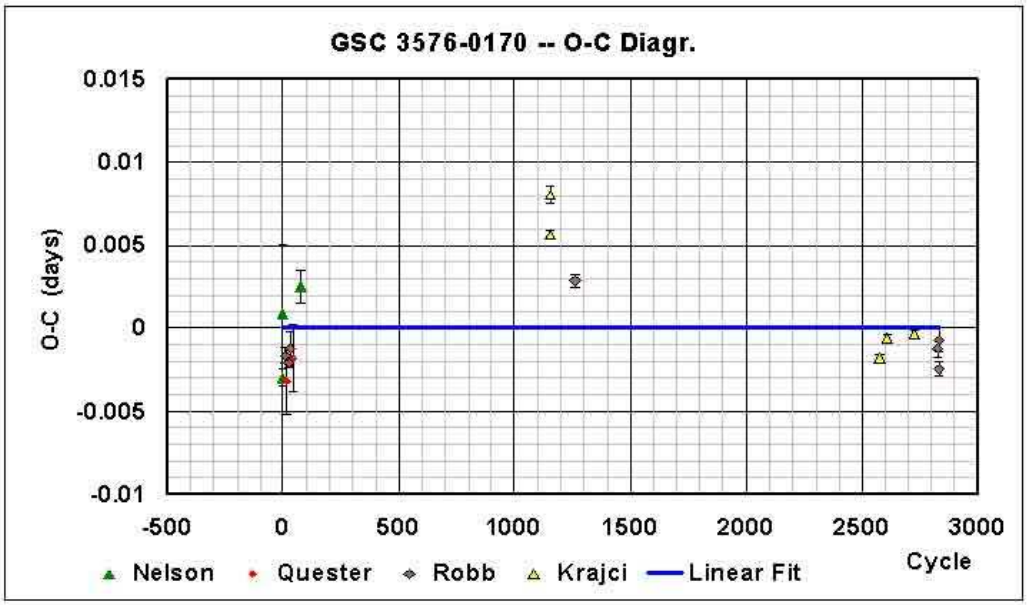

Figure 2.

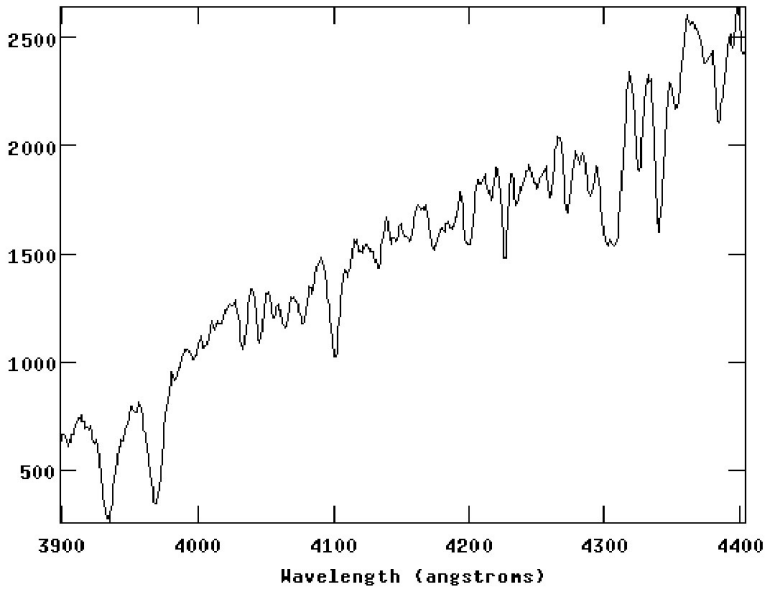

Figure 3.

estimated by the difference in period between the period obtained from the first (2003) and second (2004) groups of data only, and the period from all the data.

A spectrum of GSC 3576-0170 observed with 1.8-m telescope of the Herzberg Institute of Astrophysics (by RMR) is shown in Figure 3. The dispersion was 0.96 Å per pixel. By comparing the Hγ to the FeI 4384 and the Hδ to the CaI 4227 lines we classify this star as G1V with an uncertainty of one sub class. Therefore we estimate its temperature to be 5865 K (Cox, 2000).

Wilson–Devinney modelling (Wilson & Devinney, 1971) was attempted, but since (based on the low depths of the minima) the eclipses were obviously partial, it was not possible to determine the mass ratio based on photometric data alone (Terrell & Wilson, 2005).

Nevertheless, modelling runs were made for a range of mass ratios using detached, overcontact, semi-detached with a bright spot on star 2, and double contact. However, detached consistently gave smaller residuals by $100.15 < q < 0.35$ (because of steeply rising residuals outside this range) giving an inclination in the range of 65–70. The temperature of the secondary is 4800-4900 K, giving it a spectral type of K2 $\pm$ one subclass. One G1V and one K2V star would have an absolute magnitude of $V = 4.37$ with a $(B-V)_0$ of 0.67. Therefore the reddening or colour excess, $E(B-V) = (B-V)-(B-V)_0$ would be 0.07 and, assuming an R of 3.0, the absorption would be $A_V = 0.21$ and the distance becomes approximately 400 parsecs.

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ERRATA FOR IBVS 5557, 5586

Sebastian Otero reported the following errors:

IBVS No.	item	printed	correct
5557	identifier (NSV 233)	GSC 0013-0919	GSC 0013-0976
5586	filter (NSV 15024)	13.20(12.80)	13.20(12.80)*