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**PRECISION LIGHT ELEMENTS AND LIGHT CURVE
FOR THE ECLIPSING BINARY LD 355**

GUILBAULT, P.R.¹; HENDEN, A.A.²; BILLINGS, G.W.³; DAHLMARK, L.⁴; HAGER, T.⁵;
KAISER, D.H.⁶; LUBCKE, G.C.⁷; PULLEN, A.C.⁸

¹ P.O. Box 287, Chepachet, Rhode Island 02814, USA, e-mail: pete1199@aol.com

² Universities Space Research Association/U.S. Naval Observatory, P.O. Box 1149, Flagstaff,
Arizona 86002-1149, USA, e-mail: aah@nofs.navy.mil

³ 2320 Cherokee Drive NW, Calgary, Alberta, Canada T2L OX7, e-mail: obs681@telusplanet.net

⁴ Rés. Jeanne d' Arc, 176, Av. Majoral Arnaud, F-04100 Manosque, France

⁵ 34 Mount Tom Road, New Milford, Connecticut 06776, USA, e-mail: thager@pcnet.com

⁶ 2631 Washington Street, Columbus, Indiana 47201, USA, e-mail: dhkaiser@sprynet.com

⁷ 3817 Patrick Henry Way, Middleton, Wisconsin 53562, USA, e-mail: gil2@ix.netcom.com

⁸ 10215 Davis Road, P.O. Box 930, Wilton, California 95693, USA, e-mail: cpullen@pacsafe.com

LD 355 = GSC 3560.1804 is located at $19^{\text{h}}35^{\text{m}}23^{\text{s}}.12$, $+48^{\circ}03'00''.75$ (J2000) and was discovered to be variable by Dahlmark (2000). The discovery report notes that five dimmings were observed and the star was classified as an eclipsing binary, with an uncertain period of $25^{\text{d}}.81$ and a range of $m_v = 13.8$ – 14.6 , where m_v are photo-visual (yellow sensitive) magnitudes.

In a continuing collaborative effort to investigate newly discovered and poorly studied eclipsing binary stars, a team of AAVSO members have used CCD, visual and photographic observations to more precisely determine the nature and brightness history of LD 355. Here we present the results of our investigation which include accurate light elements and the light curve, as well as photometric calibration of the variable and comparison stars.

As part of our study of LD 355, Guilbault and Hager visited the Harvard College Observatory and examined 220 archival blue-sensitive plates from the RH and Damon Patrol Series. The star was found to be faint or invisible on 7 (seven) of the plates. At the same time Guilbault began visual monitoring of LD 355 using a 0.32-m reflector and a sequence of steps to estimate the changes in brightness. The star was observed in eclipse on JD2451779 and JD2451841 but in each instance only the ascending branch of the light curve was observed. On the consecutive nights of JD2451842 and JD2451843, however, the entire eclipse was observed. From these observations a preliminary period was determined so that CCD observation could commence.

Photometric *V*-filtered observation of LD 355 was carried out by six of the authors. Henden used the USNO Flagstaff Station 1.0-m telescope and a SItE/Tektronix 1024×1024 CCD to observe the system. Kaiser's observations were made with a 0.35-m Schmidt-Cassegrain telescope (SCT) equipped with a ST-9E CCD from his Crescent Moon Observatory, while Billings used a 0.35-m SCT with an AP-7 CCD. Pullen used a 0.28-m SCT

with a ST-6 CCD camera at the Clarke and Coyote Astrophysical Observatory. From their private observatories Hager used a 0.25-m SCT and a ST-9E CCD, and Lubcke used a 0.28-m SCT equipped with ST-9E CCD camera.

Using comparison stars selected on the basis of their magnitude and colors, LD 355 was observed by the above mentioned CCD observers on 14 nights from JD2451851 to JD2451905. A total of 647 CCD frames were measured, and from these data five (5) times of primary minimum and three (3) times of secondary minimum were determined. The times of primary minima derived from the visual data, the photographic minima from the Harvard plates, the minima of Dahlmark (2000), and the photometric times of minima are listed in Table 1.

Table 1: Times of minima, LD 355

HJD 2400000 +	Error \pm	Epoch	$O - C$	Observer	Type
25327.871	-	-24022	-0.005	Harvard	ptg
26914.720	-	-22586	-0.081	Harvard	ptg
42220.527	-	-8736	+0.074	Dahlmark	ptg
43347.671	-	-7716	+0.015	Harvard	ptg
45606.554	-	-5672	+0.071	Harvard	ptg
45819.803	-	-5479	+0.035	Harvard	ptg
46881.865	-	-4518	+0.095	Harvard	ptg
47270.810	-	-4166	+0.044	Harvard	ptg
49989.323	-	-1706	+0.008	Dahlmark	ptg
50274.465	-	-1448	+0.034	Dahlmark	ptg
51255.616	-	-560	-0.145	Dahlmark	ptg
51513.298	-	-327	+0.049	Dahlmark	ptg
51842.5695	0.0009	-29	+0.0001	Guilbault	visual
51843.6716	0.0009	-28	-0.0029	Guilbault	visual
51853.6206	0.0002	-19	-0.0001	Kaiser	ccd - V filter
51853.6206	0.0001	-19	+0.0001	Lubcke	ccd - V filter
51854.7257	0.0002	-18	+0.0001	Billings	ccd - V filter
51874.6174	0.0000	0	+0.0000	Henden	ccd - V filter
51905.5599	0.0001	+28	-0.0002	Henden	ccd - V filter

Minima from all sources were fitted into a least squares solution with the CCD minima weighted as one hundred (100). The visual and photographic minima were weighted as one (1). In most cases the photographic exposures were of 60 minutes duration and the time of mid-exposure is the date the variable was estimated to be at minimum light. Both the visual and the photometric times of minimum were determined using the computer program *AVE* (Barbera, 2000) based on the Kwee-Van Woerden (1956) method. From that analysis we extracted the best period and combined it with the most accurate time of minimum to derive the following light elements:

$$\text{Min. I} = \text{HJD } 2451874.6174 + 1^{\text{d}}1051023 \times E \\ \pm 0.0005 \pm 0.0000002$$

The CCD observations in the *V* passband were folded using the elements above and the phased *V* light curve in the instrumental system is shown in Figure 1. The curve shows that the star is an Algol-type (EA) eclipsing variable that fades from a maximum of $13^{\text{m}}61 \pm 0.01$ to $15^{\text{m}}24 \pm 0.01$ at primary minimum. The eclipse is total, with minimum light lasting 12 minutes and the duration of the eclipse is about $0.17 P_{\text{orb}}$. A shallow secondary eclipse of $0^{\text{m}}15 \pm 0.01$ occurs at phase 0.50.

Henden's 112 V -filtered observations centered on primary minimum on JD 2451874 and JD 2451905 were folded using the light elements given above and are represented in Figure 2. The symmetrical shape of the light curve and the flat bottom at minimum light are clearly evident.

Using all sky photometry, Henden observed the field of LD355 in standard Johnson-Cousins $BV(RI)_c$ bandpasses with magnitude and color errors less than 0^m01 . The comparison and check stars were standardized as given in Table 2.

Table 2: Comparison and check stars

Star	GSC	RA (J2000)	DEC	V	$B - V$	$V - R_c$	$R - I_c$
comp.	3560:1870	19:35:26.70	+48:02:03.4	13.415	0.467	0.275	0.284
check	3560:1950	19:35:40.59	+48:01:51.7	13.190	0.695	0.386	0.359

More complete photometric information about all stars within 5 arcmin of the variable can be found in Henden (2000). Using these stars, Henden measured the magnitude and colors of LD 355 at maximum light and at primary and secondary minimum. These data are shown below in Table 3, with errors again less than 0^m01 .

Table 3: Magnitude and color indices at maximum, primary and secondary minimum, LD 355

HJD 2400000 +	Phase	V	$B - V$	$V - R$	$R - I$
51857.6155	Maximum	13.608	0.310	0.176	0.191
51905.5588	Min I	15.235	0.524	0.353	0.366
51879.5903	Min II	13.754	0.252	0.141	0.154

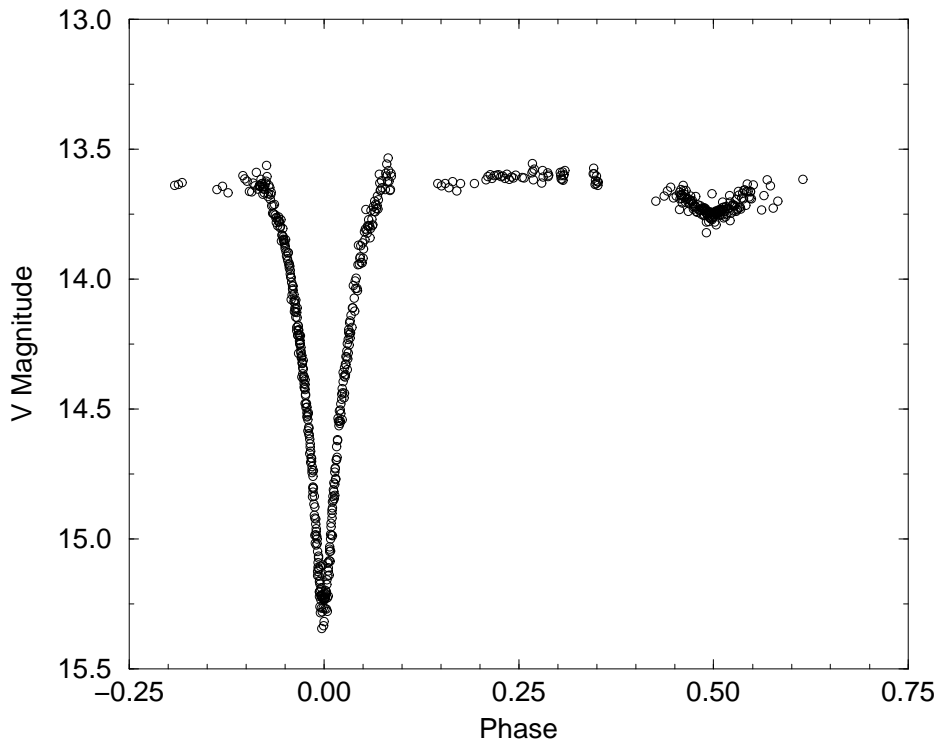


Figure 1. Phased light curve of LD 355 – V filter

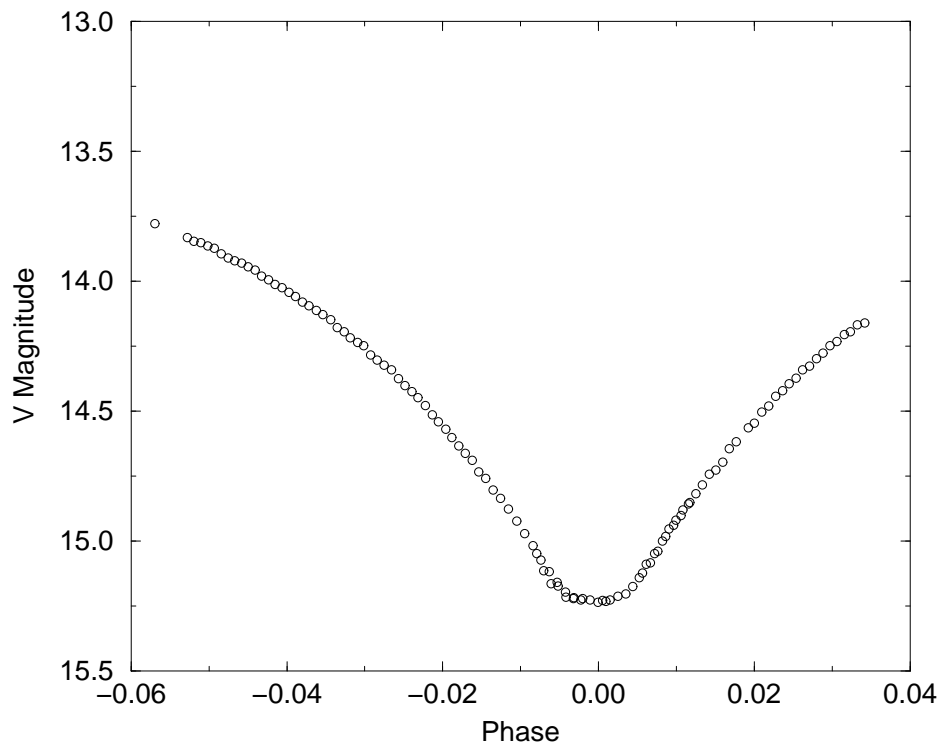


Figure 2. Differential phased light curve at primary minimum, LD 355 – V filter – Henden

Our CCD data are available electronically from the IBVS website as 5018-t4.txt, and may be used by anyone wishing to do so. We ask that our work be cited if it is used as the basis of further study of LD 355.

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