COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 4926

Konkoly Observatory
Budapest
21 July 2000

HU ISSN 0374 – 0676

A STUDY OF THE VARIABILITY OF LD 345

GUILBAULT, P.R.[1]; HAGER, T.[2]; HENDEN, A.[3]; KROLL, P.[4]; KUROCHKIN, N.E.[5]; MORO, D.[6]; SPLITTGERBER, E.[7]

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

[2] 34 Mount Tom Road, New Milford, Connecticut 06776, USA, e-mail: thager@pcnet.com

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

[4] Sonneberg Observatory, Sternwartestr. 32, D-96515 Sonneberg, Germany, e-mail: pk@stw.tu-ilmenau.de

[5] Sternberg Astronomical Institute, Universitetskij Prospect, 13, Moscow, 119899, Russia

[6] Asiago Astrophysical Observatory, Department of Astronomy, University of Padova, 36012 Asiago, (VI) Italy, e-mail: moro@pd.astro.astro.it

[7] Sonneberg Observatory, Sternwartestr. 32, D-96515 Sonneberg, Germany, e-mail: splitti@stw.tu-ilmenau.de

LD 345 (GSC 3530-2757) is located at $18^{\rm h}31^{\rm m}13\overset{\rm s}{.}83$, $+46^\circ 58' 34\overset{''}{.}7$ (J2000). Lennart Dahlmark discovered variability during a photographic variable star search (Dahlmark, 2000a). In the discovery report LD 345 is listed as an eclipsing binary type variable of no known period. Brian Skiff of the Lowell Observatory generated interest in this star when he notified several AAVSO members of its unusual behavior. Dahlmark reported the star had appeared to enter a deep decline lasting at least two years. The long duration of the decline caused speculation as to the possibility that LD 345 may be an eclipsing binary with a very long period or belong to a more exotic class of variables such as the R Coronae Borealis or symbiotic stars.

In this paper we present the results of our investigation of the classification of LD 345. As part of our study Henden performed high precision photometry in order to determine the color indices and magnitudes of the variable and suitable comparison and check stars. We also conducted a photographic plate survey of LD 345 using the plate collections located at the Asiago Astrophysical Observatory, the Harvard College Observatory, the Sonneberg Observatory, and the Sternberg State Astronomical Institute (SAI) of the Moscow State University. In addition to these archival plate collections, the photographic observations of Dahlmark were used.

Dahlmark indicated 18 exposures were taken between 1967 and 1982, and another 48 were taken between 1995 and May 2000. On all but three plates the star remains constant at $m_v = 11.4$, $m_{pg} = 13.1$, where m_v are photovisual (yellow) magnitudes and m_{pg} are photographic (blue) magnitudes. On the three plates, exposed in July 1972, July 1973 and June 1974, the star had faded more than three magnitudes to $m_v < 14.7$.

Guilbault and Hager visited the Harvard College Observatory and examined approximately 200 patrol plates from the RH and Damon series for evidence of variability. Those plates encompassed the years 1928 to 1952, a single plate from 1962, and 1975 to 1989.

At the Sternberg State Astronomical Institute Kurochkin measured LD 345 on 172 plates taken with the 40-cm astrograph of the SAI Crimean station. He examined four plates from 1905 to 1908, one each from 1940 and 1942, and the remainder from 1978 to 1995. No additional minima were found nor could we confirm Dahlmark's observations at minimum since no exposures of the field were taken at Harvard or Moscow during the years 1972 to 1974.

Dahlmark indicated to Guilbault that the Asiago Astrophysical Observatory had taken photographic plates during the years in question (Dahlmark, 2000b). As a result, Moro was contacted at Asiago and she measured the brightness of LD 345 on 6 Schmidt plates taken between 1967 and 1970, and 10 plates from 1974 to 1976. Comparison star magnitudes were determined using the GSC–ACT (Gray, 1999) and the USNO–A2.0 catalogue (Monet et al., 1998). Subsequently, additional observations were made using the Sonneberg plate collection. Splittgerber and Kroll examined 111 photovisual plates of the Sonneberg Sky Patrol taken from 1970 to 1977. The star appears faint at maximum but just above the plate limit of $m_v = 13.0$. Between December 1971 and September 1974, however, the star is not visible on the plates. Photographic observations near or at minimum appear along with those of Dahlmark in Table 1.

Table 1. Photographic Observations of Minimum of LD345

Julian date	Date	Magnitude	Type	Observer
2440750	1970-06-12	13.3	m_{pg}	Moro
2440773	1970-07-05	13.1	m_{pg}	Dahlmark
2441153	1971-07-21	13.1	m_{pg}	Dahlmark
2441248	1972-03-15	11.8	m_v	Kroll/Splittgerber
2441391	1972-03-15	< 12.7	m_v	Kroll/Splittgerber
2441394	1972-03-18	< 12.9	m_v	Kroll/Splittgerber
2441512	1972-07-14	< 14.7	m_v	Dahlmark
2441892	1973-07-29	< 14.7	m_v	Dahlmark
2442220	1974-06-22	< 14.7	m_v	Dahlmark
2442246	1974-07-16	16.8	m_{pg}	Moro
2442248	1974-07-19	16.8	m_{pg}	Moro
2442305	1974-09-14	15.6	m_{pg}	Moro
2442307	1974-09-16	15.6	m_{pg}	Moro
2442360	1974-11-08	14.7	m_{pg}	Moro
2442551	1975-05-18	13.3	m_{pg}	Moro
2442599	1975-07-06	13.1	m_{pg}	Dahlmark

These observations confirm both the occurrence and the depth of the decline as reported by Dahlmark and allow constraints to be applied so that the duration of the minimum and the descending and ascending branches of the light curve can be reasonably determined. The duration of the minimum is $\sim$ 1000–1200 days. The recovery from the observed minimum of 16.8 m_{pg} occurs within $\sim$ 150–200 days. Assuming a symmetrical light curve with a flat bottom and minimum at $\sim 16.8 m_{pg}$, constant light lasts $\sim$ 700–800 days.

Henden used the USNO Flagstaff Station 1.0-m telescope and a SITe/Tektronix 1024 $\times$ 1024 CCD to observe LD345 in standard Johnson-Cousins UBVRI bandpasses on three photometric nights. Comparison and check stars were standardized as follows:

Star	GSC	RA (J2000)	DEC	V	$B-V$	$U-B$	$V-R$	$R-I$
comp.	3530-02670	18:31:06.40	+46:55:52.7	11.919	1.126	1.007	0.588	0.518
check	3530-02617	18:31:02.86	+46:58:15.8	12.164	0.974	0.642	0.519	0.466

with magnitude and color errors less than $0\overset{m}{.}01$. More complete photometric information about all stars within 5 arcmin of the variable can be found in Henden (2000). Using these stars, the magnitude and colors of LD345 for the three nights were:

HJD − 2400000	V	$B-V$	$U-B$	$V-R$	$R-I$
51722.7493	11.748	1.611	...	0.924	1.162
51727.8363	11.790	1.595	1.858	0.962	1.130
51728.7805	11.783	1.610	1.866	0.957	1.137

with errors again less than 0.01mag.

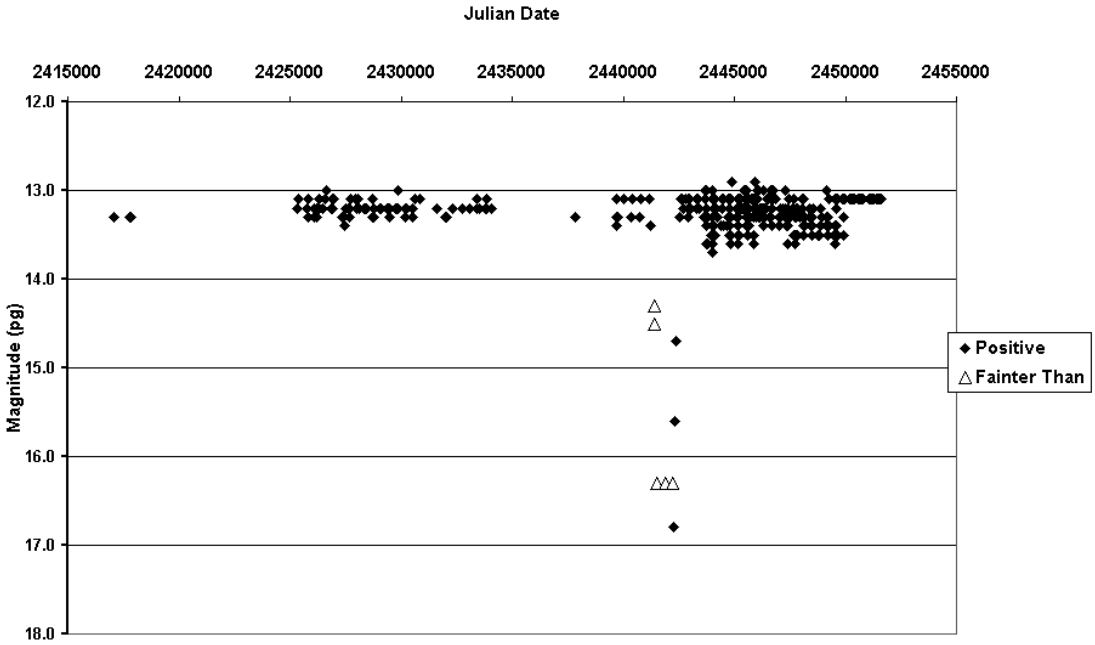

Figure 1. LD345 Photographic Light Curve

Figure 1 shows the photographic light curve from 1905 to 2000. For consistency and to improve the shape of the decline, the photovisual (yellow) magnitudes and limits were approximately converted to photographic (blue) values by adding the mean (B–V) color of the variable as given above. The data suggests the star may be variable at maximum on the order of perhaps a few tenths of a magnitude. Evident in the light curve is the absence of additional minima. If, in fact, the decline were the result of an eclipse by a companion, based upon the available photographic record the period would be very long indeed. Assuming that the minima occur at equal intervals the period cannot be shorter than 17200 days, nearly twice that of Epsilon Aurigae. Minima could have occurred during the gaps in photographic coverage, from 1908 to 1927, and 1953 to 1966, but in that case the declines would occur at irregular intervals. The photographic record does not seem to support the classification of LD 345 as an eclipsing binary, but is more characteristic of the symbiotic stars which can remain at maximum light for decades. On the other hand, the photometric colors are similar to a typical M0III star, but atypical for RCB or symbiotic stars.

In spite of the photographic and photometric observations presented in this report the classification of LD 345 remains uncertain. We hope that others will study this interesting star. AAVSO and VSnet observers have already begun visual monitoring programs. This is important if a future decline occurs. It would be valuable to search other archival plate collections for additional minima and to better define the light curve that we have presented here. Most importantly, spectroscopy is needed to reveal the properties of LD 345.

We would like to thank Lennart Dahlmark for allowing us to use his observations in this report. Guilbault and Hager would like to express their gratitude to Dr. Martha Hazen, Curator of the Harvard College Observatory Astronomical Photograph Collection, for allowing them access to this valuable resource. We also wish to thank Margareta Westlund who sent us her very recent visual observations of LD 345. We are grateful to Vitaly Goranskij of the SAI and Marvin Baldwin, Chairman of the Eclipsing Binary Committee of the AAVSO for their help in the preparation of this report.

References:

Dahlmark, L., 2000a, *IBVS*, No. 4898
Dahlmark, L., 2000b, Private Correspondence
Gray, W., 1999, `http://www.projectpluto.com/gsc_act.htm`
Monet et al., 1998, USNO–A2.0; U.S. Naval Observatory, Washington, DC
Henden, A., 2000, `ftp://ftp.nofs.navy.mil/pub/outgoing/aah/sequence/ld345.dat`