THE ECLIPSING BINARY LD 282

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Presented at the 88th Annual Meeting of the AAVSO, October 30, 1999

Abstract

The authors have used two seasons of visual observations, one season of CCD photometric observations, and an examination of the photographic plate collection at the Harvard College Observatory to reveal that LD 282 is a 12th-magnitude Algol-type eclipsing binary with ΔV Min. I = 2.77 V magnitudes, Min. II = 0.11 magnitude. The light elements are:

$$\text{Min. I} = \text{JD (hel.) } \underset{\pm 0.0015}{2451453.6315} + \underset{\pm 0.0000003}{1.1928335}\,E.$$

1. Introduction

LD 282 (GSC 3932:0152) is located in Draco near the Cygnus border at R.A. $19^h07^m56^s$, Decl. $+59°23\overset{'}{.}5$ (2000). Variability was discovered by Lennart Dahlmark during a variable star search in the Northern Milky Way and announced in the *Information Bulletin on Variable Stars* (IBVS) (Dahlmark 1998). Dahlmark classified the new variable as an eclipsing binary with a visual range of 11.7–14.8. Although four dimmings were observed, two of which were within one hour of normal brightness, no period was listed in the report.

Interest in LD 282 began when Brian Skiff of the Lowell Observatory contacted Marvin Baldwin, chairman of the Eclipsing Binary Committee of the AAVSO, asking

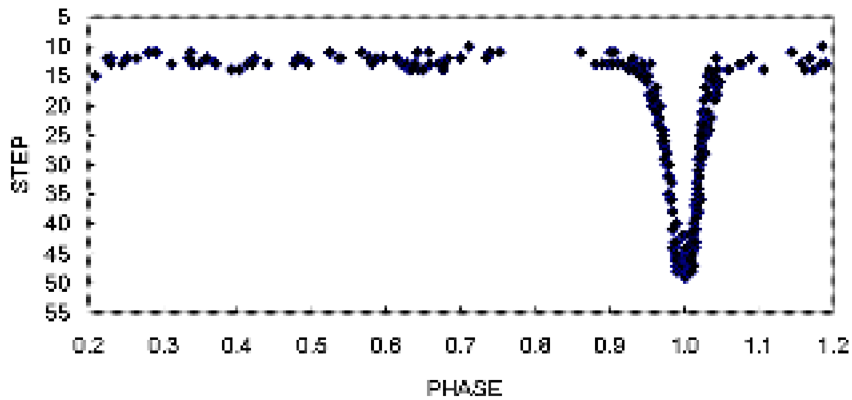

Figure 1. The phased visual light curve of LD 282, based on 341 observations by Guilbault.

if he knew of anyone who would monitor the new variable in order to determine the period of the system. That request was forwarded to Peter Guilbault.

In mid-November 1998, two eclipse events were recorded visually by Guilbault. In both instances the eclipse was well under way when the first observation was made and only the ascending branch of the eclipse was observed. The interval between the two was 5.96 days, but the lack of sufficient data made the determination of the period impossible, although a provisional period of 5.96days and fractions of that were considered possible.

Aware of the progress, Skiff posted requests to the on-line AAVSO Discussion Group and Vsnet for additional observers to join the project, especially those with CCDs. He instructed all interested parties to contact Guilbault via e-mail for information on the star. CCD observers Timothy Hager, Daniel Kaiser, and Gilbert Lubcke expressed their interest in joining the project. Later, Arne Henden of the U.S. Naval Observatory at Flagstaff was contacted to standardize the comparison stars and gather high-time-resolution data at primary minimum.

2. The visual light curve

Observations recorded by Guilbault were made with a 12.5-inch f/4.8 reflector at random intervals using a sequence of steps to estimate the changes in brightness. In the spring and early summer of 1999 Guilbault gathered more visual data of LD 282 in eclipse. But as before, only the ascending leg was observed. A usable period was determined when Kaiser conducted a computerized period search using the phased dispersion method. All observations up to that date fit a period of 1.19286days. Visual data by Baldwin and Guilbault, and photometric data gathered by Kaiser and Hager in the next few days confirmed that the new period was correct. Now that a working period was known, efforts were concentrated on finding times of minimum.

The phased visual light curve consisting of Guilbault's 341 observations spanning two observing seasons appears in Figure 1.

In addition to those of Guilbault and Baldwin, the visual observations of AAVSO member Margareta Westlund of Sweden, Timo Kinnunen of Finland, and Kurt Locher of Switzerland (Locher 1999) have been used in the preparation of this report. The resulting times of minimum derived from all visual observations appear in Table 1.

Table 1. Times of primary minimum for LD 282 in HJD along with the error, O-C residuals, method of observation, and observer. The O-C residuals were calculated from equation (1).

Observer	*HJD*	*Error +/-*	*O–C*	*Method of Observation*
Hager	2427681.6790		0.028	photographic
Hager	2428678.8192		-0.041	photographic
Hager	2429049.7923		-0.039	photographic
Hager	2429499.5600		0.030	photographic
Hager	2429797.7376		-0.001	photographic
Hager	2430490.8109		0.036	photographic
Hager	2441957.5207		0.037	photographic
Hager	2444902.5414		-0.048	photographic
Hager	2445472.7160		-0.048	photographic
Hager	2446975.7627		0.028	photographic
Hager	2447153.4674		0.001	photographic
Hager	2447797.5568		-0.040	photographic
Locher	2451199.5600		0.002	visual
Locher	2451254.4300		0.002	visual
Locher	2451255.6250		0.004	visual
Locher	2451273.5140		0.000	visual
Locher	2451280.6700		-0.001	visual
Locher	2451303.3300		-0.004	visual
Locher	2451316.4500		0.002	visual
Locher	2451341.5050		0.000	visual
Locher	2451347.4700		0.001	visual
Guilbault	2451410.6900	0.0044	0.000	visual
Kinnunen	2451421.4255	0.0009	0.001	visual
Guilbault	2451422.6180	0.0008	0.000	visual
Hager	2451422.6187	0.0006	0.001	CCD
Kaiser	2451447.6677	0.0002	0.000	CCD
Henden	2451453.6321	0.00002	0.001	CCD
Hager	2451453.6323	0.0003	0.001	CCD
Guilbault	2451453.6335	0.0003	0.002	visual
Lubcke	2451459.5968	0.0002	0.001	CCD
Guilbault	2451459.5973	0.0004	0.002	visual
Westlund	2451464.3676	0.005	0.001	visual
Lubcke	2451465.5606	0.0001	0.001	CCD

3. CCD observations of LD 282

LD 282 has been observed photometrically by four AAVSO members with CCD cameras. Hager used a 0.51-m telescope and ISI model CCD800 CCD with Vand I filters at the Western Connecticut State University Observatory. Henden used the 1.0-m telescope with an SITe 1024x1024 thinned, backside-illuminated CCD and standard Johnson-Cousins BVRI filters at the U.S. Naval Observatory Flagstaff station. Lubcke observed from his private observatory using a 0.28-m telescope with an SBIG ST6 CCD and R filter. Finally, Kaiser used his Crescent Moon Observatory's 0.35-m telescope with an SBIG ST6 CCD and Johnson Vand R filters. Standard photometric reduction procedures were followed by all.

CCD observations were initiated in June 1999 after an e-mail message from Guilbault to Hager indicating that an eclipse of LD 282 was in progress. Hager, who was

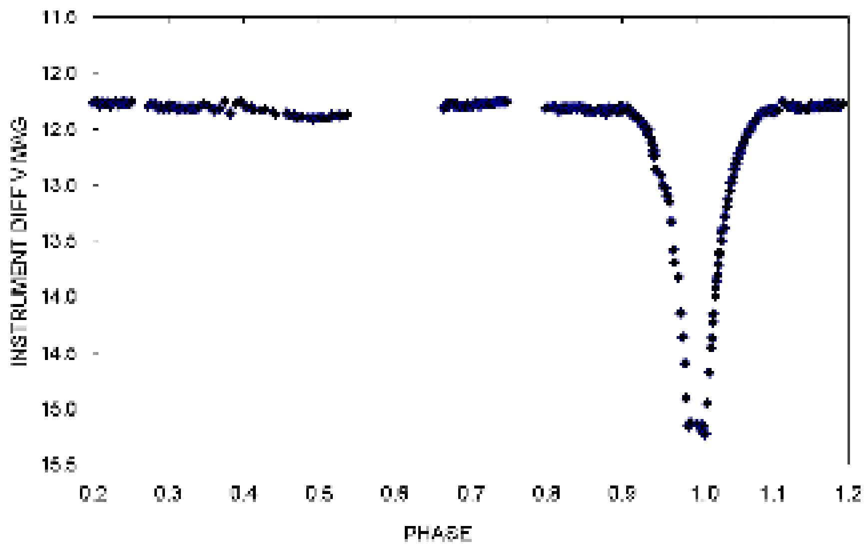

Figure 2. The differential V phased light curve of LD 282, based on 354 CCD observations by Kaiser.

at the telescope for another project, obtained 18 differential V filter observations of the ascending branch that confirmed the rapid rise from minimum previously observed by Guilbault.

Kaiser's earliest CCD observations were done using the comparison stars suggested by Skiff, GSC 3932-1233, 0528 and 0588, and showed that GSC 3932-0588 might itself be variable on short time scales with an amplitude in the order of 0.1 magnitude in V. It was subsequently dropped as a comparison star. If final analysis confirms variability in GSC 3932-0588, the results will be published elsewhere. Kaiser's 354 V filter observations comprise the phased light curve in Figure 2.

Henden used all-sky photometry to determine standard BVRI magnitudes for the remaining comparison stars, with all errors under 0.01magnitude.

GSC	*V*	*(B-V)*	*(V-R)*	*(R-I)*
3932-0528	11.230	0.394	0.247	0.252
3932-1233	11.905	0.494	0.302	0.272

Henden collected 96 observations in and outside eclipse. His eclipse observations clearly show a flat bottom to the eclipse as suggested by Guilbault's visual data, with constant light lasting 40 minutes (see Figure 3). The duration of the primary eclipse is 0.18 of the V light curve, or about 6 hours.

Times of minimum derived from CCD observations are included in Table 1.

4. Photographic observations of LD 282

As part of our study of LD 282, Hager visited the Harvard Observatory photographic plate collection. He examined approximately 200 patrol plates from the RH/RB series, 1928–1952, and Damon series, 1965–1990. In most cases exposures were 60 minutes, and the time of midexposure is the date the variable was estimated to be at minimum.

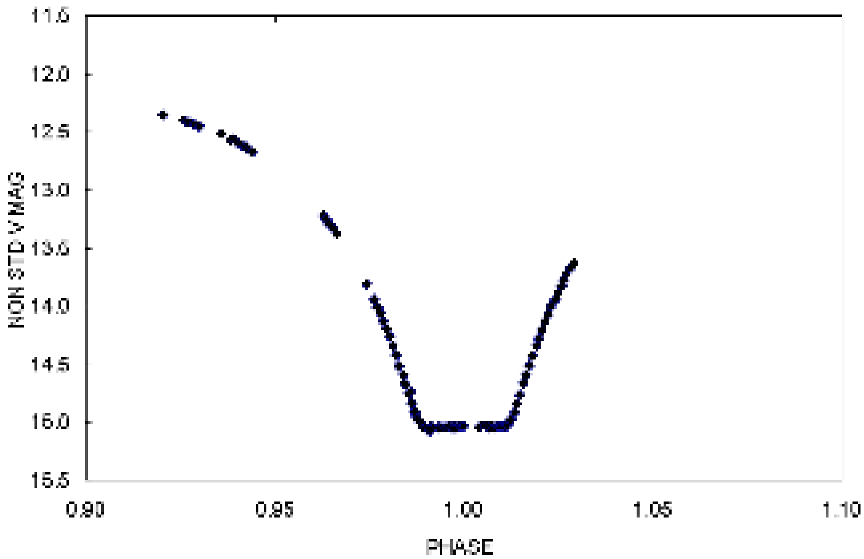

Figure 3. The primary eclipse of LD 282, based on differential V CCD observations by Henden.

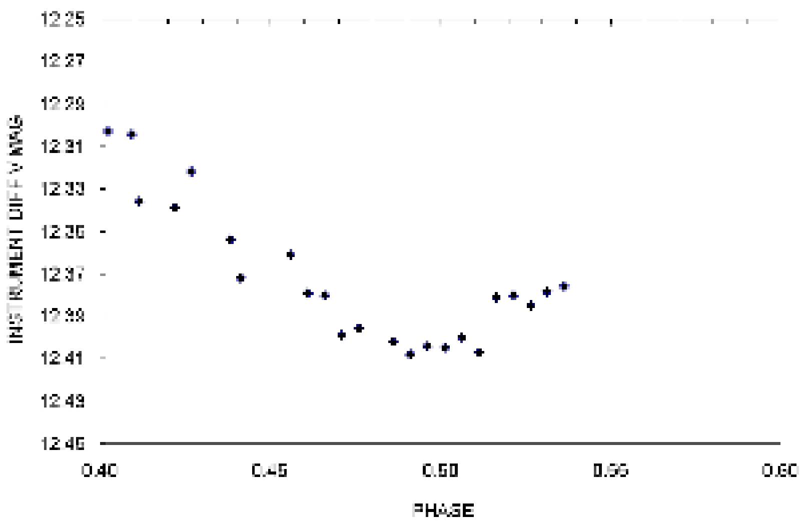

Figure 4. The secondary eclipse of LD 282, based on differential V CCD observations made by Kaiser.

Estimates were made on each plate using a sequence of steps, ranging from 30 at maximum light to 50 at primary minimum. A total of 184 observations were made by Hager and resulted in 12 times of minimum being recorded, expanding the baseline of observations of LD 282 to over 65 years (more than 19,000 orbital cycles) (see Table 1).

5. Results and conclusion

All visual and CCD times of minimum were determined by the method developed by Kwee and Van Woerden (1956). For the purpose of analysis the CCD observations were assigned a weight of ten (10), visual and photographic observations a weight of one (1). A least squares solution was then applied and resulted in the elements given below:

$$\begin{array}{rl} \text{Min I} = \text{JD(hel.) } & 2451453.6315 + 1.1928335\,E. \\ & \pm 0.0015 \quad \pm 0.0000003 \end{array} \tag{1}$$

Henden's photometry gave the following maximum and primary/secondary minimum magnitudes:

	V	*(B-V)*	*(V-R)*	*(R-I)*
Maximum	12.26	0.56	0.35	0.34
Primary minimum	15.03	1.23	0.76	0.71
Secondary minimum	12.37	0.52	0.31	0.29

These data give V amplitudes of 2.77 magnitudes for primary eclipse and 0.11 magnitude for secondary eclipse. The shallow secondary eclipse has not been observed with enough precision to provide an exact time of minimum. However, observations to date do indicate that it may occur before phase 0.5 of the V light curve, somewhere in the phase 0.48–0.49 range, indicating the possibility of a slightly eccentric orbit (see Figure 4).

The flat-bottom primary eclipse lasting 40 minutes, the shallow secondary, and the primary and secondary B-V values suggest that the primary star is an early F spectral type, and the secondary star a late K giant.

6. Acknowledgements

The authors would like to thank Timo Kinnunen amd Margareta Westlund, whose visual observations we have used in this report. We wish to thank Karl Gustav Andersson of Sweden and although we could not use all of his observations we appreciate his contribution. We gratefully acknowledge Dr. Martha Hazen, curator of the Harvard astronomical photograph collection at the Harvard College Observatory, for allowing the authors to access this valuable resource. We also would like to thank David B. Williams, who shared his expertise in working with the Harvard patrol plates and offered many suggestions during the preparation of this report, and Brian Skiff of the Lowell Observatory, whose request for observations of LD 282 initiated this project.

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