A PHOTOELECTRIC LIGHT CURVE AND PERIOD STUDY FOR V448 CYGNI

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Abstract

V448 Cygni is a long neglected eclipsing binary star; no minima have been published since 1948. One hundred and five photoelectric observations of this star were made during the latter part of 1978. Results indicate that Ashbrook's 1942 ephemeris is nearly correct. A slightly revised ephemeris is derived and the obtained light curve is presented. The nature of the eclipses remains unresolved, although the existing evidence seems to favor partial eclipses somewhat.

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Introduction

V448 Cygni was first discovered to be an eclipsing variable star by Wachmann (1939). In the following two years, Ashbrook (1942) established a Beta Lyrae type variation, and determined an ephemeris for this star using Harvard patrol plates dating back to 1899. Ashbrook concluded that the eclipses were total, although the duration of constant brightness at the minima was short. A photographic light curve was also published a few years later by Smirnov (1946). Wachmann (1948) published four additional times of minima. Eight years later, Petrie (1956) completed an extensive spectrographic study of the star. He found the ratio of the light from the two stars to be nearly unity, whereas Ashbrook had obtained 0.44. Petrie concluded that if the eclipses were indeed total, Ashbrook's light ratio was probably accurate; but this would imply a serious discrepancy in the spectrographic value, to the point of violating the mass-luminosity relationship. If the eclipses were partial, the spectrographic data were consistent. Cohen (1958) later conducted a UBV study of the star.

Since Cohen's study, it seems that essentially no work has been published concerning the system's ephemeris. It is thus highly desirable to determine if the old ephemeris can still predict times of eclipse accurately, and to resolve the question of total or partial eclipses.

Equipment and Procedure

The light curve was measured using an uncooled RCA 1P21 photomultiplier with a V filter (Schott GG495) attached to a 12.5-inch f/15 Cassegrain telescope. All measurements were taken directly from a microammeter.

The comparison star used was BD +34°3876. A nearby UBV standard star, 44 Cygni, was initially observed twice each night in order to check the constancy of the comparison star. This precaution was later dropped when it became apparent that any light variation greater than about $0\overset{m}{.}03$ in the comparison star was undetected with the instrument. Ashbrook also used BD +34°3876 as a comparison star and noted no variability. Magnitude estimates of V448 Cygni were made differentially with respect to the comparison star. Atmospheric extinction was ignored in these estimates due to the proximity of the comparison star to V448 Cygni (6'). The V magnitude of BD +34°3876 was found to be 9.01 ± 0.02 on the standard UBV system through measurements of standard stars. This magnitude estimate has been corrected for atmospheric extinction and color corrected to the UBV system using a value of $\varepsilon = -0.055$ for the photometer system. Comparison star readings taken before and after each variable reading formed the basis for each differential magnitude measurement. Sky was measured after each reading.

Data and Analysis

One hundred and five magnitude measurements of V448 Cygni were obtained on 50 different nights from June 13 to November 18, 1978. R. Binzel procured 13 measurements, and the rest were made by the author.

Ashbrook's 1942 ephemeris is given as:

$$\text{J.D. MIN (Hel.)} = 2416361.095 + 6.5197283*E \qquad (1)$$

Data for each observation are given in Table 1. Formula 1 was used to calculate phases and number of elapsed periods. All Julian dates listed are heliocentric. Magnitude determinations of V448 Cygni were obtained assuming V = 9.01 for BD +34°3876. The resulting light curve is plotted in Figure 1, which may be compared to Ashbrook's 1942 curve plotted in Figure 2. Ashbrook found the photographic magnitude of BD +34°3876 to be 8.57 ± 0.03; he lists its spectral type as A2.

No time of minimum was determined from a single night of data due to the relatively long interval between ascending and descending branches of primary minimum. Nevertheless, if we construct a regression line through the points comprising both branches of the primary eclipse in Figure 1, and average the phase corresponding to a given magnitude, we can estimate an O-C value. Averaging the results for ten equidistant values of M between 8.10 and 8.55 inclusive, one finds an O-C = -0.064 ± 0.003 day. (Starred points in Table 1 were used in the appropriate regression equation). Plotting this, Wachmann's four timings, and Ashbrook's ten timings, we obtain Figure 3. The abscissa of the most recent point was chosen to be 2443750, near the midpoint of the observations. Corresponding to an O-C of -0.064 is a time of minimum equivalent to 2443750.409.

The regression line in Figure 3 intersects the Y axis at 0.012, implying that Ashbrook's original epoch should be adjusted to 2416361.107. The slope of this line indicates a period of 6.5197162 days. An improved set of elements would be represented by:

$$\text{J.D. MIN (Hel.)} = \underset{\pm 0.014}{2416361.107} + \underset{\pm 0.0000060}{6.5197162}*E \qquad (2)$$

The error estimate given for the initial epoch is that quoted by Ashbrook; the error estimate in the period is based on the assumed accuracy of the most recent O-C timing.

It would be unwise to conclude that the eclipses are definitely partial, due to the lack of sufficient data near primary minimum. The data do not contradict such an interpretation, however.

TABLE 1

Individual V Magnitudes for V448 Cygni

J.D. (Hel.) 2,443,000+	Phase	V	J.D. (Hel.)	Phase	V
672.824	.0901	8.075*	740.632	.4904	8.397
672.840	.0925	8.044*	740.740	.5070	8.368
672.850	.0940	8.024*	741.630	.6435	8.064
680.737	.3037	7.965	749.729	.8858	8.081*
680.753	.3062	7.977	750.726	.0387	8.481*
680.763	.3077	8.005	750.741	.0410	8.484*
686.732	.2233	7.948	752.709	.3429	8.002
686.745	.2253	7.948	754.608	.6341	8.138
687.786	.3850	8.041	755.632	.7912	7.888
687.796	.3865	8.093	755.646	.7933	7.903
687.808	.3884	8.050	756.591	.9383	8.376*
697.723	.9091	8.232*	756.648	.9470	8.393*
697.735	.9109	8.233*	756.655	.9481	8.379*
697.746	.9126	8.233*	773.657	.5558	8.236
699.687	.2103	8.026	774.706	.7167	7.965
700.787	.3790	8.007	774.713	.7178	7.968
701.651	.5115	8.372	775.756	.8778	8.161*
701.662	.5132	8.310	775.763	.8789	8.205*
703.643	.8171	7.981	776.592	.0060	8.678
703.651	.8183	7.923	776.657	.0160	8.715
713.653	.3524	8.026	776.721	.0258	8.633
713.660	.3535	8.026	776.774	.0339	8.547*
716.687	.8177	8.090	777.675	.1721	7.973
716.694	.8188	8.068	779.692	.4815	8.358
716.703	.8202	8.068	782.583	.9250	8.257*
717.840	.9946	8.617	782.644	.9343	8.327*
717.851	.9963	8.582	782.767	.9532	8.518*
721.707	.5877	8.184	789.705	.0174	8.647
721.714	.5888	8.146	789.726	.0206	8.625
721.725	.5905	8.146	793.656	.6234	8.139
721.817	.6046	8.119	793.661	.6242	8.080
723.700	.8934	8.209*	794.619	.7711	7.901
723.713	.8954	8.209*	794.695	.7828	7.996
723.864	.9185	8.265*	800.589	.6867	7.995
724.735	.0521	8.333*	801.579	.8386	8.049
724.744	.0535	8.307*	801.685	.8548	8.036
724.800	.0621	8.231*	804.672	.3130	7.996
724.812	.0639	8.196*	804.689	.3156	8.005
725.735	.2055	7.976	809.563	.0632	8.229*
726.741	.3598	8.059	809.588	.0670	8.196*
728.711	.6620	8.055	809.617	.0715	8.161*
728.720	.6634	8.032	809.652	.0769	8.199*
729.696	.8131	8.030	809.686	.0821	8.142*
729.707	.8147	8.026	811.624	.3793	8.120
730.663	.9614	8.570*	811.666	.3858	8.077
730.672	.9628	8.542*	813.602	.6828	8.035
730.822	.9858	8.579	814.546	.8274	8.049
731.735	.1258	8.020	814.566	.8305	7.932
733.622	.4152	8.202	816.651	.1503	8.123
733.632	.4168	8.200	816.687	.1558	8.065
733.710	.4287	8.214	831.588	.4413	8.305
734.626	.5692	8.315	831.643	.4497	8.282
734.715	.5829	8.257			

Visual eclipsing binary observers may be interested to learn that the primary minimum was deep enough to be detected visually by the author. However, the unchanging nature of V448 Cygni's period suggests that visual observers' efforts might be more useful elsewhere.

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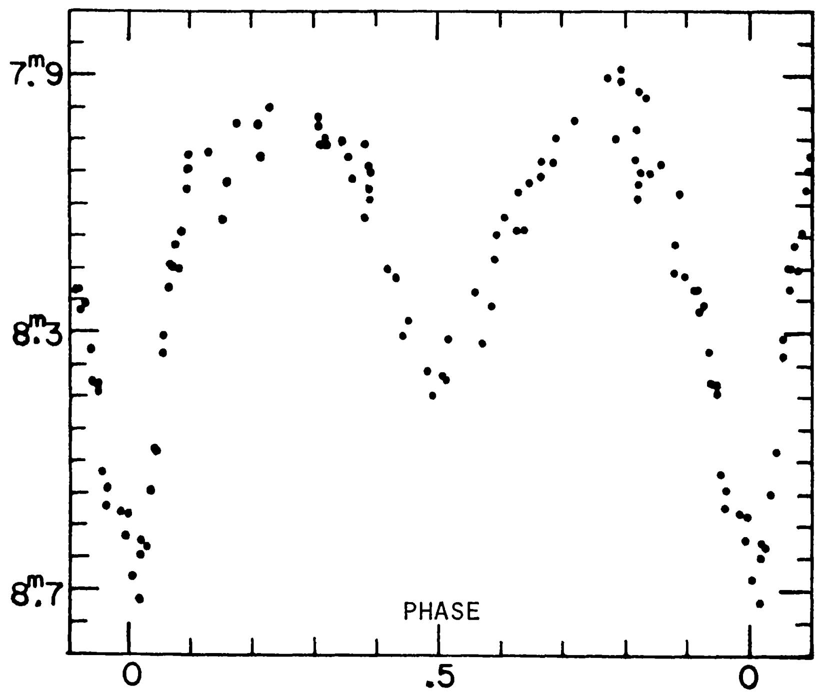

Figure 1. Photoelectric light curve of V448 Cygni from the data in Table I.

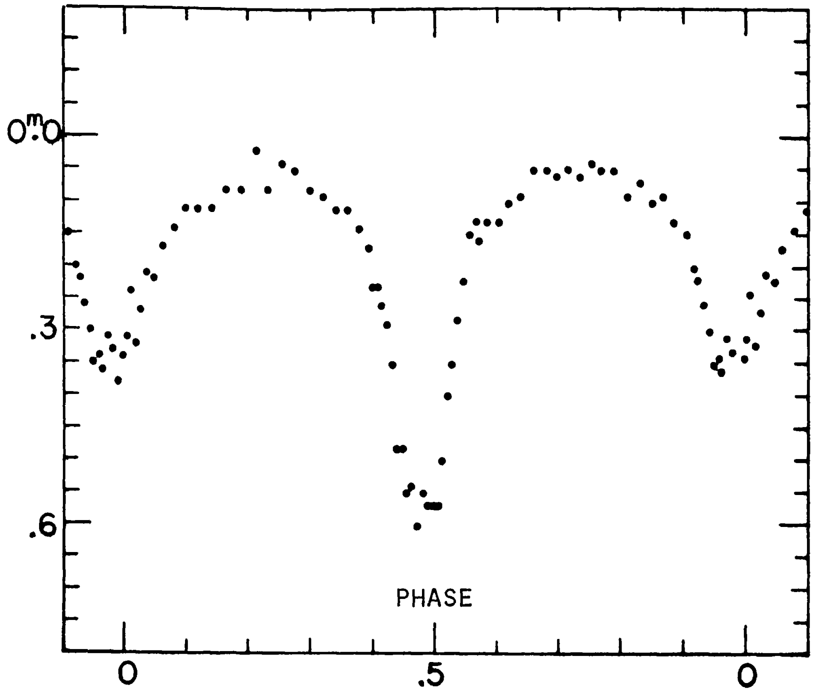

Figure 2. Photographic light curve of V448 Cygni determined by Ashbrook (1942).

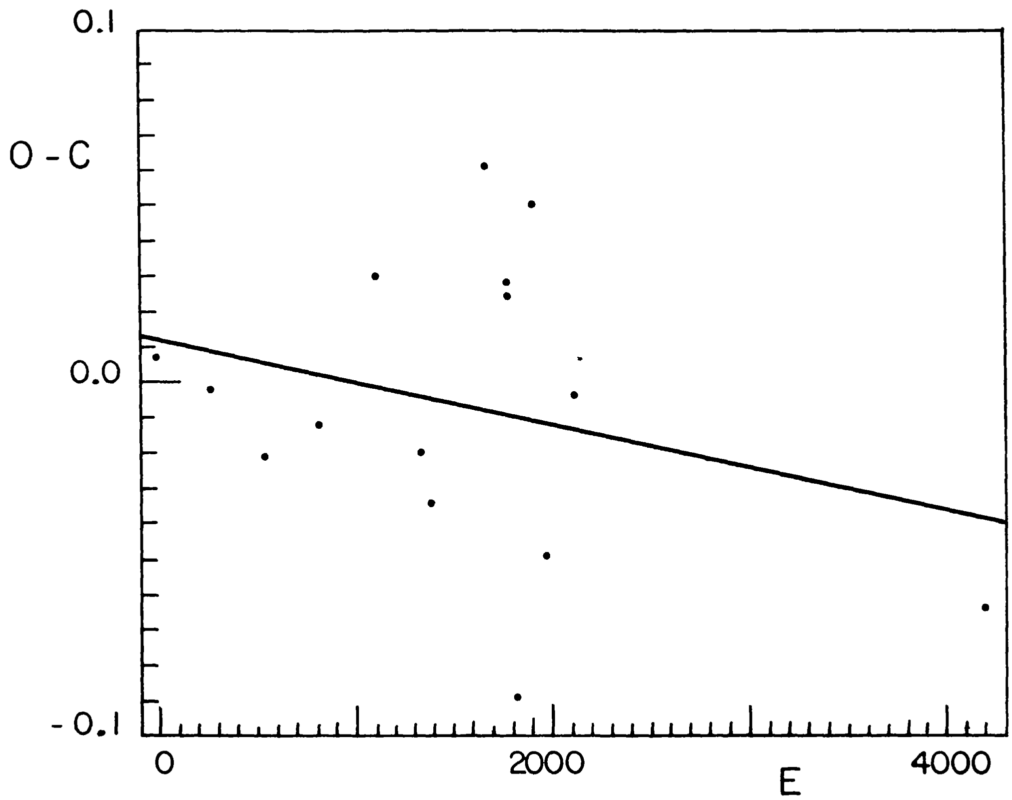

Figure 3. O-C diagram for V448 Cygni computed from equation 1.