REVISED ELEMENTS FOR V1510 CYGNI

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Abstract

V1510 Cygni is an RR Lyrae star whose published period, epoch, and amplitude have been modified in the light of more observational evidence.

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V1510 Cygni is an RR Lyrae star discovered in 1973 at the Maria Mitchell Observatory by Bonnie Buratti. Its period and epoch were found in 1974 by Lucia Dexter, who examined about 900 Nantucket plates from JD 2424695 to 2442314. The values she obtained were $0^d.581147$ for the period and JD 2441915.652 for the epoch (Dexter 1974). I have examined the plates which have been taken since that work was completed to determine whether the elements now need revision.

The technique involved is as follows. The first step required examining plates which show V1510 Cyg and its field, and comparing the variable with selected comparison stars which were given arbitrary brightness numbers, later converted to photographic magnitudes. These brightnesses were then plotted against phase to form light curves for each year from 1974 to 1982. The phase, ϕ, is defined by the equation:

$$JD = JD_0 + P\,(N + \phi), \qquad (1)$$

in which JD refers to the Julian Date of each observation, JD_0 is the epoch, P is the period, and $(N + \phi)$ is a number representing the number of cycles since the epoch. N is an integer, and the fractional portion remaining (ϕ) is what is known as the phase. If no revisions of the variable's period and epoch are necessary, then the phase should always be zero at each JD where the star is at maximum brightness. The period and epoch used were those found by Dexter.

To study the phase, the light curves were each compared with a standard, which was a smooth curve drawn through the clearest of all of these light curves. To conform to the asymmetric shape of the standard light curve of this star and to obtain reproducible estimates of the time of maximum light, I adopted a method that differs slightly from the simple bisection of the ascending and descending branches. The maximum was defined as that point on the standard which was 0.058 cycle later than the point on the ascending branch where the width of the curve was 0.3 cycle. This defined maximum was used to measure the shift in phase for each light curve, and these observed minus calculated (O-C) values were plotted against time (JD) to create what is known as an O-C diagram. This graph can be used to determine whether a star's period is changing, needs revision, or is accurate the way it is. The O-C diagram also includes points based on Dexter's brightness estimates for the years from 1926 to 1973. Figure 1 is an O-C diagram for V1510 Cyg, and Table I summarizes the data in Figure 1. The "Estimated Error" in Table I was found by estimating the extreme amounts of phase shifts that still fit the data reasonably well for each light curve.

Since the O-C values very seldom exceeded 0.05 cycle, and never even reached 0.1 cycle, a first conclusion that can be drawn is that for this span of fifty-seven years, the period of V1510 Cyg appears to be remarkably constant. However, there are slight trends that perhaps

should not be ignored. Using a computer program that fits lines and parabolas to data by using the least squares method, these data were analyzed with several assumed variations, and from the results predictions were extrapolated for the phase shift for 1983, summarized in Table II. At the end of the 1983 season of observations, these predictions were tested. As Table II shows, the observed value for 1983 is consistent with all three of the linear hypotheses, but not with a parabola. Further observations will be needed to determine whether the apparent upward trend in the recent years is real.

Meanwhile, the most likely linear elements have been calculated by running the data through the least squares program again, this time including the last point; the resulting line is the one shown on the O-C diagram. See Figure 1. The new elements implied by this final line are $0^d.58114616 \pm 0.00000012$ and JD 2444118.784 ± 0.026 which, it may be noted, are not very different from those suggested without considering the 1983 point. The new period, then, is actually only a slight refinement of the old one; the new epoch, however, is more recent and more closely fits the observations than the previous epoch had. I tentatively conclude, therefore, that these elements can be accepted as improved values for the period and epoch of V1510 Cyg.

To find the range of photographic magnitudes through which V1510 Cyg varies, comparison magnitudes were determined using an unpublished sequence of stars in Cygnus whose photoelectric magnitudes had been determined by Arlo Landolt, and applying the fly-spanker technique described by Stock and Williams (1962) and Nygard (1973). Figure 2 is the finder chart for V1510 Cyg and shows this sequence. The resulting photographic magnitudes of the comparison stars are listed in Table III. According to this calibration, V1510 Cyg is estimated to vary from about magnitude 13.9 to 16.0, which is different from the previously published estimates of magnitude 14.0 to 14.8 (Hoffleit 1975).

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TABLE I

Summary of O-C Data for V1510 Cyg

JD	Year(s)	O-C (phase)	Est. Error
2425050	1926-1928	0.040	0.013
2426250	1930	0.046	0.020
2426520	1931	0.036	0.011
2426960	1932	0.026	0.013
2427270	1933	0.048	0.011
2427700	1934	0.070	0.012
2428010	1935	0.042	0.015
2428380	1936	0.055	0.010
2428750	1937	0.055	0.011
2429130	1938	0.039	0.012
2429490	1939	0.043	0.015
2429850	1940	0.055	0.015
2431200	1942-1946	0.056	0.015
2432470	1947	0.031	0.023
2432950	1948-1949	0.030	0.018
2433660	1950-1951	0.041	0.014
2434410	1952-1953	0.061	0.017
2435750	1954-1959	0.036	0.021
2438310	1960-1966	0.012	0.013
2439880	1967-1968	0.016	0.011
2440430	1969	-0.013	0.014
2440800	1970	0.015	0.019
2441160	1971	-0.014	0.020
2441550	1972	0.032	0.030
2441900	1973	0.014	0.017
2442260	1974	0.005	0.010
2442620	1975	0.011	0.017
2442990	1976	-0.010	0.015
2443350	1977	0.017	0.023
2443730	1978	0.000	0.016
2444100	1979	0.022	0.026
2444460	1980	0.021	0.021
2444800	1981	0.036	0.020
2445150	1982	0.048	0.030
2445540	1983	0.010	0.021

TABLE II

Phase Shift Predictions for 1983 for V1510 Cyg

Line or Curve	Predicted Phase Shift for JD 2445540 (ϕ)	Implied New Period (Days)	Implied New Epoch (Julian Date)
Line through all points	0.0024	0.5811462	2444118.783
Line through last 14 pts.	0.0277	0.5811493	2444118.790
Line through last 15 pts.	0.0185	0.5811480	2444118.789
Parabola through last 15 pts.	0.0462	0.581152	2444118.791
Actual phase shift:	0.010	Estimated range: -0.012 to 0.029	

TABLE III

Comparison Star Sequence for V1510 Cyg

Star	Photographic Magnitudes
a	13.7
b	14.5
c	15.1
d	15.6
e	15.9

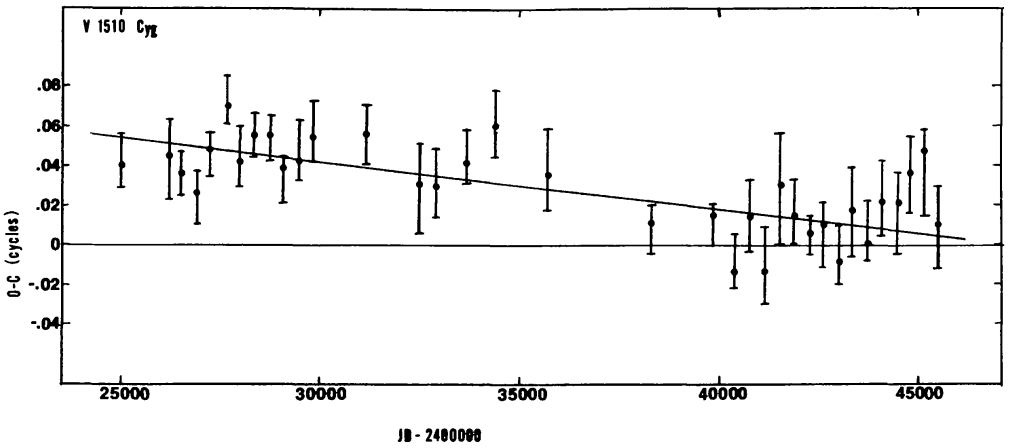

Figure 1. O-C diagram for V1510 Cygni. Some of the points represent several years of data combined because of scarcity of data. See Table I.

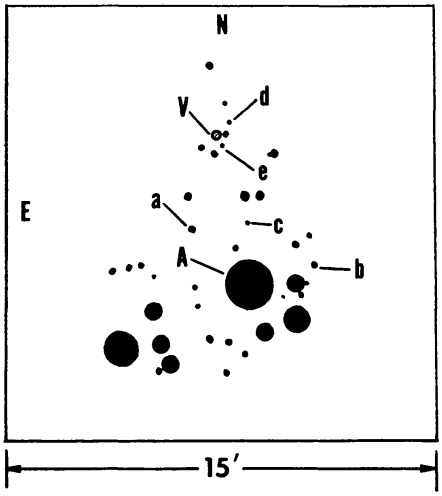

Figure 2. Finder chart for V1510 Cygni, $19^h\ 56^m\ 35^s$ $+43^o\ 25'.3$ (1900). Star A is SAO 49062. The other labeled stars are comparison stars. See Table III for their magnitudes.