1982JAVSO..11...17W

SPURIOUS PERIODS AND THE CASE OF EL COMAE BERENICES

JONATHAN WHEATLEY
Maria Mitchell Observatory
Nantucket, MA 02554

Abstract

An average period of 0.52285 day was calculated from 1978-81 observations of EL Comae Berenices. A 0.343 day period preferred by previous observers is rejected as spurious. EL Comae Berenices exhibits irregular light variations which prevent easy distinction between the two periods.

* * * * *

If regular intervals separate many of the observations of a periodic variable star, then several periods may fit the data equally well. Observers who are not acquainted with spurious periods may deduce an incorrect period from their observations.

Spurious periods are related to the true period by $1/P_{\text{spurious}} = 1/P_{\text{true}} \pm 1/T$, where T is the most common interval between observations. This interval might be the sidereal day (0.9972 day), the solar day (1.000 day), the lunar month (29.53 days), the tropical year (365.24 days), and so forth. In the case of EL Comae Berenices, the two periods are related by the one-day (solar) interval.

EL Comae Berenices is classified by Kukarkin *et al*. (1976) as an RR Lyrae variable of type RRab. It was photographed on 55 plates taken at the Maria Mitchell Observatory between 1978 and 1981. Magnitude estimates indicate that EL Comae Berenices varies in brightness between magnitudes 13.7 and 15.7. The observatory is not normally staffed during the winter months; thus most of the plates were taken in May, June, and July, when Coma Berenices sets early, permitting only one exposure to be made each night. This produced a one day periodicity in the observing times. A previous observer (Henry 1972) whose data was limited in the same way found that two periods, 0.343329 day and 0.523620 day, produced similar light curves.

Determining the period of a short period variable star is a time-consuming process when most of the observations are spaced several cycles apart. The method is described in detail in *JAAVSO* by Henry (1972). Briefly, the procedure involves finding a period that will produce a good light curve over a small time interval, and then refining it for larger and larger time spans until a good light curve is produced using all the data. At first, I concentrated on the one-half day alternative. After much effort, I found that the best light curve was produced by a period of 0.52285 day. To insure that another nearby period had not been overlooked, I searched near this value with the Maria Mitchell Observatory's period-search program based on the method of Lafler and Kinman (1965). The program tests periods within a specified range by computing a "criterion of merit," a measure of the scatter in the composite light curve. The 0.52285 day period had the best criterion of merit of any period in the range 0.50 - 0.56 day.

It is interesting to note that my value is related to the previous period by

$$1/0.52285 = 1/0.52362 + 1/358. \qquad (1)$$

The two periods differ by almost one cycle per year. My observations include some winter observations, whereas the previous data did not. The fact that both winter and summer observations fit the light curve indicates that the 0.52285 day period is better than its predecessor.

Once the half-day period was determined, I searched for a second alternative near one-third day. In order to find the best value of $\nu = 1/T$ to use in the spurious period equation, the window transform (Borkowski 1980) was used. This operation finds the constituent frequencies that contribute prominently to the sequence of observing times.

The window tranform produces $W(\nu)$, a number between zero and one for a specific frequency. Frequencies with the highest values of W contribute most to the spurious period effect. Table I displays the results of a computer program which found frequencies with high W-values in the 1978-81 data.

The one-day interval was used in the spurious period formula to obtain 0.343 day as another candidate for the period. I used the period search program to see if there was a good period in this region. A 0.34391 day period was found to have a light curve similar to the 0.52285 day period. The two values are related by

$$1/0.52285 = 1/0.34391 - 1/1.00491. \qquad (2)$$

I am not sure why a 1.00491 day periodicity appears in the data.

It is not at all obvious which period is spurious from the light curves, which are shown in Figure 1. If all of the observations were at 1.0049 day intervals, it would be impossible to distinguish between them. Fortunately this situation is not the case. It can be seen from Figure 2 that on the average, a spurious period will show greatest deviation from the mean light curve for observations that fall between the 1.0049 day intervals. The two curves coincide at the 1.0049 day intervals, so there will be less departure from the mean for observations made here. If one of the periods shows scattering that is dependent on the time of observation, then it is the spurious one.

I computed the mean light curve for each period and then found the difference between the observed magnitudes and the magnitudes predicted by the mean light curve, $(m_{obs} - m_{calc})$. The observations were then classified into groups according to the time of observation. For each group, I calculated the root-mean-square of $(m_{obs} - m_{calc})$. The results are shown in Figure 3. In the case of the 0.52285 day period, there is no correlation between $(m_{obs} - m_{calc})$ and the observing time, whereas the scatter in the 0.34391 day period is largest for observations made at times between the 1.0049 day intervals. The 0.34391 day period therefore has the characteristics of a spurious period.

One problem remains: the light curve for the selected period has more scatter in it than the uncertainty of 0.2 magnitude in the magnitudes would indicate. EL Com probably has a more complex light variation than can be described by a single period. Another irregular variation may be superimposed on this basic period. The poor time resolution of the 1978-81 observations makes it impossible to study what produces the scatter in the composite light curve.

This work was supervised by Dr. Emilia Belserene. Her advice and encouragement were invaluable. The National Science Foundation supported this research with grant number AST 80 05162 A01.

REFERENCES

Bloomfield, P. 1976, Fourier Analysis of Time Series: An Introduction, John Wiley and Sons, New York.

Borkowski, K. J. 1980, Acta Astron. 30, No. 4, 393.

Henry, D. J. 1972, Journ. Amer. Assoc. Var. Star Obs. 1, 29.

Kukarkin, B. V. et al. 1976, Third Supplement to the General Catalog of Variable Stars, Moscow.

Lafler, J. and Kinman, T. D. 1965, Astrophys. Journ. Suppl. 11, 216.

TABLE I

Contributions to Spurious Periods

$W(\nu)$	ν	T	Identification
0.87	1.00000	1.00000	solar day
0.83	1.00027	0.99729	sidereal day
0.67	0.99506	1.00497	?
0.67	0.00268	373	year
0.63	0.03403	29.4	synodic month
0.61	0.00507	197	half year

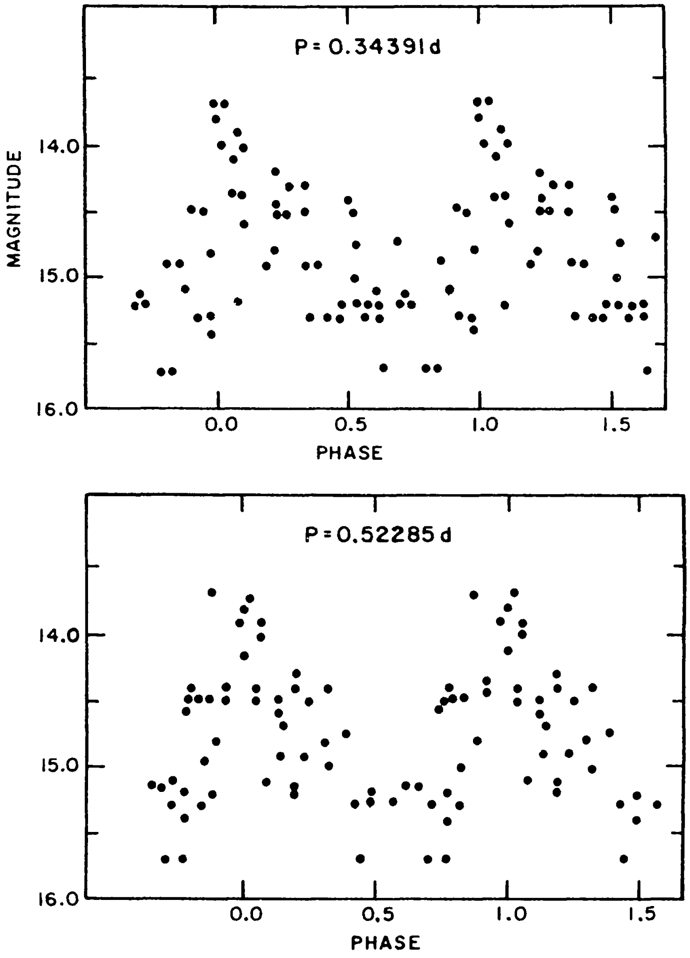

Figure 1. Composite light curves for the two possible periods of EL Comae Berenices.

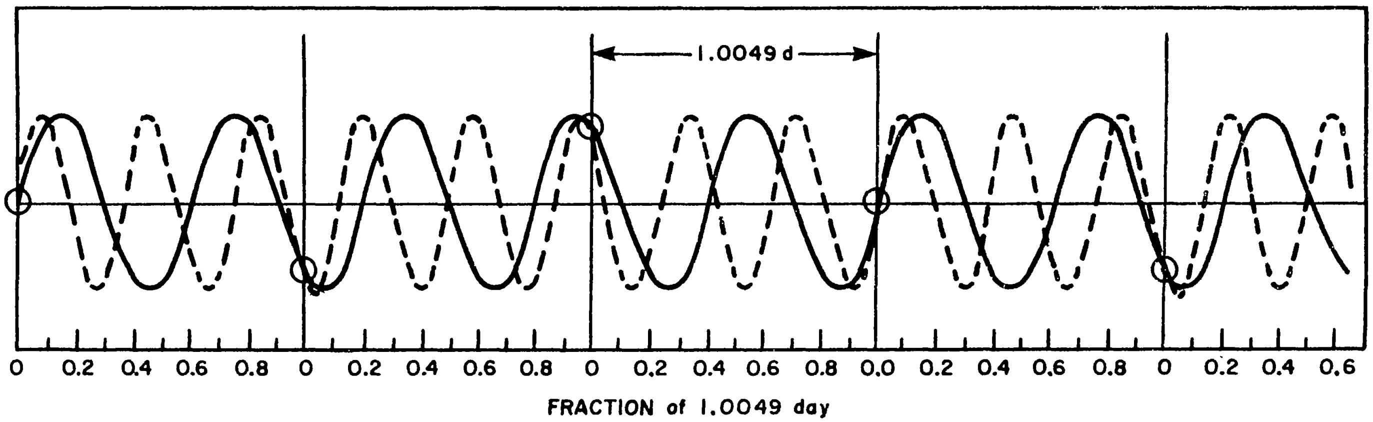

Figure 2. The dotted line represents a light variation with a 0.34 day period; the solid line represents a 0.52 day period. At 1.0049 day intervals the light curves coincide. At times between 1.0049 days there is, on the average, a large difference between the two.

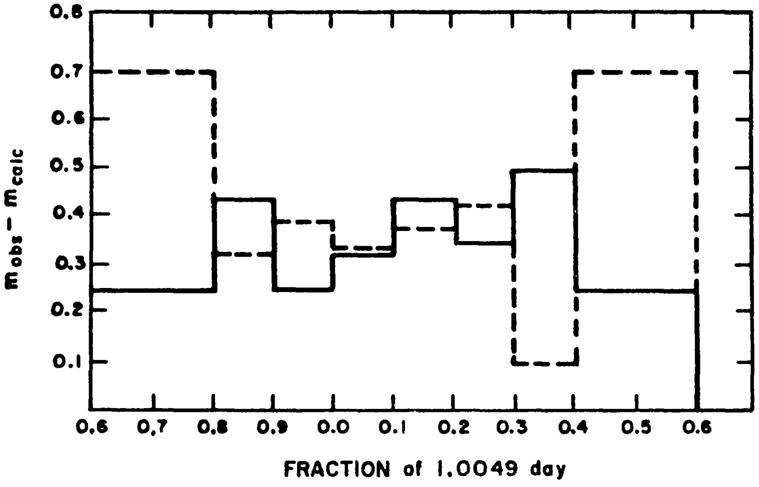

Figure 3. The average value of $(m_{obs}-m_{calc})$ is displayed for observations made at different times in the 1.0049 day interval. In the case of the spurious period (dashed line, P=0.34391 day), observations made between 0.4 and 0.8 show a much larger deviation from the mean light curve than observations made at other times. Observations in the 0.4 - 0.8 day interval fit the average light curve well in the case of the true period (solid line, P=0.52285 day).