THE 1972 ANOMALY OF XZ CYGNI

MARVIN E. BALDWIN
Andrews Air Force Base, Maryland

XZ Cygni (193056) is an RR Lyrae type variable with a marked Blazko effect. It has created a great deal of interest among observers during the past several years because of its unusually large and progressive change of period. In less than seven years its period has decreased by 9.3 seconds and its cumulative deviation from the elements listed in the 1969 General Catalog of Variable Stars now amounts to ten hours, only a little less than one full cycle (Fig. 1). Based upon the visual maxima timings plotted in Figure 1 the current elements are determined to be: Max = 2440981.328 + $0^{d}.466471$E. This represents an appreciable change of period from that reported earlier (Baldwin, in Mayall 1971).

Throughout these years of observation some variations in the light curve have been noted, both in the form and in the brightness reached at maximum. Nevertheless, the times of maxima, as measured by the Pogson method, have been fairly consistent; and until the summer of 1972 it appeared that each carefully timed maximum would fall neatly on the smooth O-C curve within the limits of visual observing error. At that time, however, observers began recording an unusual series of maxima that no longer fitted this pattern.

On the night of 10/11 August 1972 Bruce Small observed a maximum more than an hour earlier than predicted which attained a brightness of only 9.55 magnitude, about 0.6 magnitude below that normally reached. The validity of this unusual observation was confirmed by a report from Horace Smith who independently observed XZ Cygni on the same night (Fig. 2). Smith, however, continued his observations which revealed a second maximum much brighter than the first arriving about an hour later than predicted.

The ensuing flurry of observing activity resulted in the recording of many "nonstandard" maxima, some of which had double peaks and others which had pre-maxima humps indicative of the presence of another pulsation frequency in addition to the star's primary period of oscillation. All maxima exhibiting these anomalies began their rise toward maximum earlier than usual, and all such maxima were less bright than usual (Figures 3 & 4). Observations through the end of November indicated the continuation of these anomalies, but it should be noted that some of the maxima observed were "normal".

Variations in the form of the light curve during the previou years, although apparently not as pronounced as during 1972, suggest that this behaviour may be cyclic. Preliminary examination of seven normal maxima observed in 1972 and a few of the very brightest maxima since 1966 reveals some interesting facts in this connection.

The 1972 maxima which rose steeply from minimum reaching 8.9 magnitude or brighter at or very near the predicted time occurred at intervals of 53, 55, 55, 61, and 58 days. Application of the same criteria to all of the available maxima from 1966 onward did not result in such a clear-out pattern of regular intervals. So, another attempt was made, changing the criteria to eliminate possible marginal maxima by including only the very bright maxima. The revised criteria included only those maxima which attained an observed magnitude of 8.8 or brighter and rose steeply from minimum reaching maximum at or near the predicted time based on the O-C curve shown in Figure 1. The Julian Dates of these latter seven very bright maxima are listed here along with other applicable information.

J.D.	Interval Days	Interval Cycles	E*	Predicted	O-C
38882.88	---	---	0	38882.88	0.00
	119	2			
39001.84			2	38999.48	+ 2.36
	756	13			
39757.66			15	39757.38	+ 0.28
	710	12			
40467.72			27	40456.98	+10.74
	514	9			
40981.33			36	40981.68	- 0.35
	413	7			
41394.62			43	41389.78	+ 4.84
	170	3			
41564.41			46	41564.68	- 0.27

Cursory examination shows that the intervals between listed maxima are multiples of about 58 or 59 days in all cases. Based on this the number of cycles between bright maxima has been determined and is also entered. Using the first and last dates and the total number of cycles elapsed the period has been determined to be approximately 58.3 days or 124.9P. Using this period and JD 2438882.0 as the initial epoch, O-C residuals were computed and an O-C diagram constructed (Fig. 5).

A "best fit" straight line was fitted to the plotted points on this diagram with measurements made for appropriate corrections to the initial epoch and the period. This resulted in establishment of the following elements for this apparent cyclic effect: JD 2438883.9 + 58.316E.

Further examination was pursued by applying the reciprocal of this newly determined period to find the relative phase positions of all observed maxima. The first value to be considered for comparison to the phase position was magnitude at maximum and the second considered was the time the variable rose through magnitude 9.6 relative to the normal time of maximum. The results of both are charted in Figures 6a and 6b respectively. Both charts reveal a great deal of scatter and neither can be considered an optimum depiction of the cycle we have described, but both show very definite trends which warrant further investigation.

Not all maxima timed in 1972 have been included in the long term O-C diagram (Fig. 1). Because of the large O-C scatter among the "nonstandard" maxima the O-C curve is better defined if it is constructed using only the maxima that rise quickly from minimum to high maximum excluding all others. It should also be noted that the period of the cyclic effect is nearly equal to two lunar months. Because observers tend to do most of their variable star work during the new moon this results in the bunching of data at two points along the cycle during any given observing season. The effects of this are already evident in Figures 4 and 6. Our observing objectives for 1973 and future years include better distribution of the observations through the lunar month.

* Elapsed Cycles

It should be noted that these cyclic variations, although determined independently, are not an original discovery. The remarks section of the GCVS states that, according to Yowell, interference of two oscillations takes place with periods resulting in a beat frequency of 57.30 days. Although his period is one day shorter, his is undoubtedly the same phenomenon discussed here.

REFERENCES

Baldwin, M. E. 1968, "Program for Observing RR Lyrae Type Variables", AAVSO Abstracts, Spring 1968.

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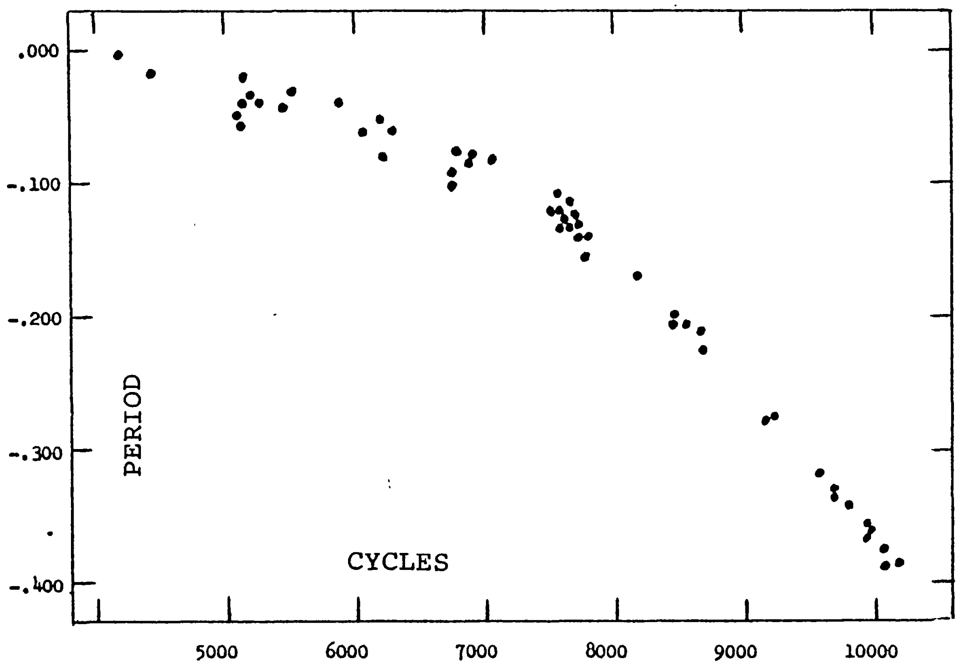

Figure 1. O-C esiduals for observed maxima of XZ Cygni.

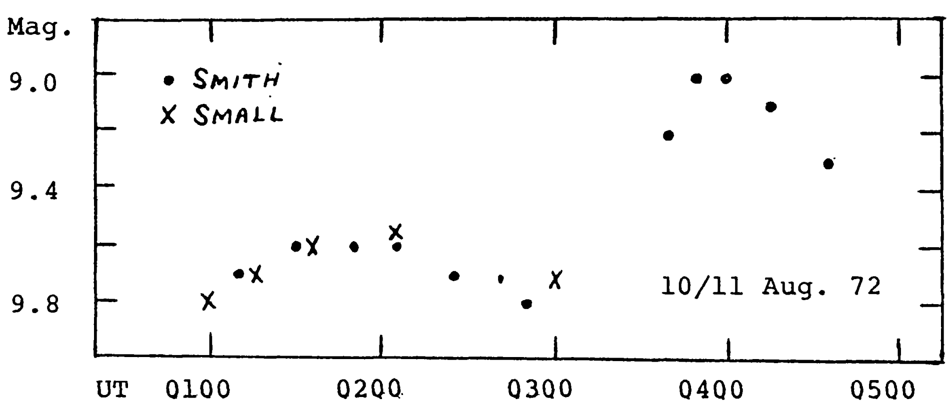

Figure 2. Maximum of XZ Cygni as reported by Small and Smith.

Figure 2 (preceding page) aptly illustrates the ability of two skilled observers to provide data that corroborates each others observations.

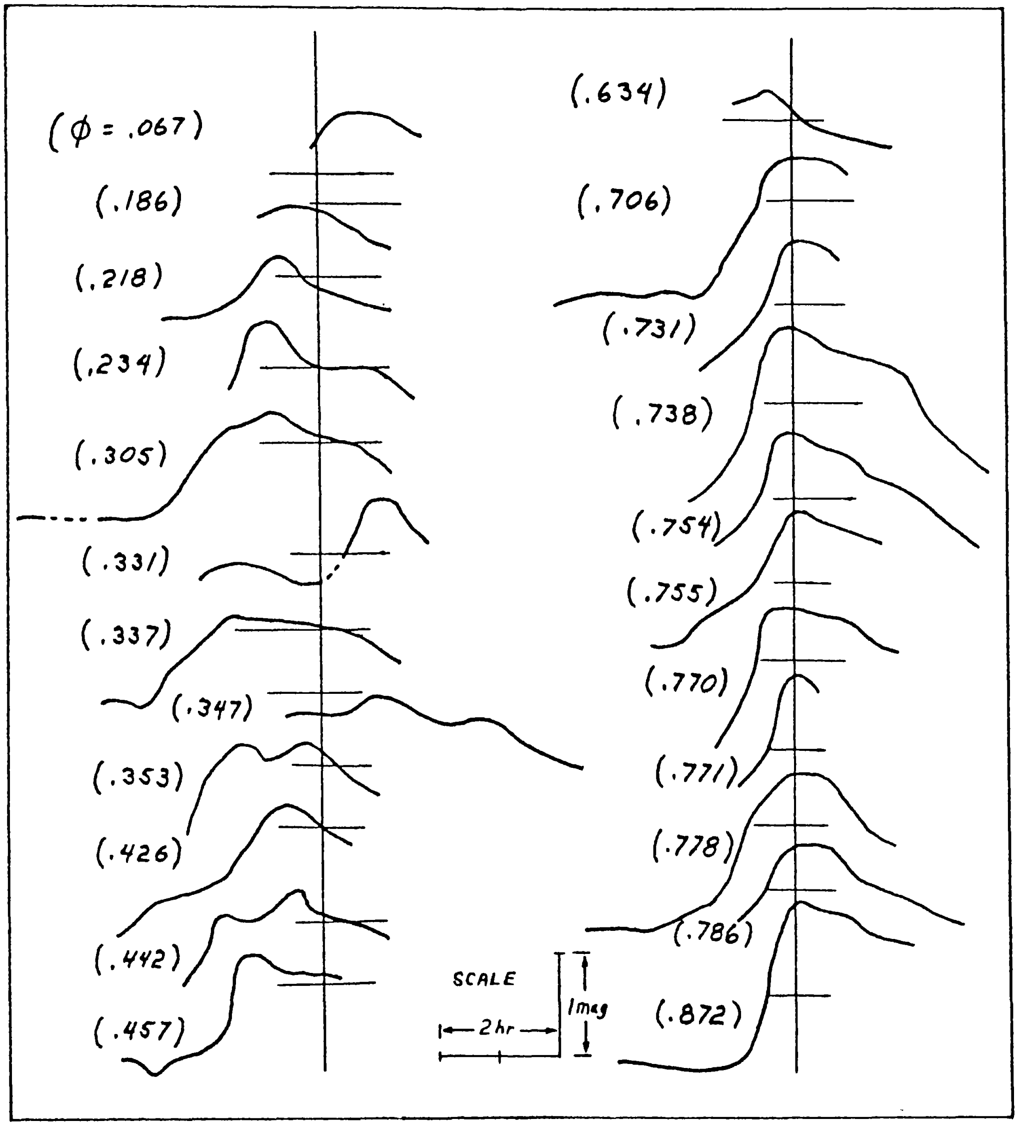

Figure 3. Shapes of light curves observed visually during 1972.

Twenty-three maxima of XZ Cygni observed during 1972 are shown. All maxima are shown in phase, with time of predicted maximum being represented by the vertical line intersecting the curves. The short horizontal line with each curve lies at 9.5 magnitude and provides a reference point for examining the height of the maximum. The phase position of each maximum relative to the 58 day cycle is also shown for comparison purposes. Note that a variety of light curve forms exist from about phase 0.2 to 0.5 but that a more typically RR Lyrae type curve is seen between phases 0.7 and 0.9.

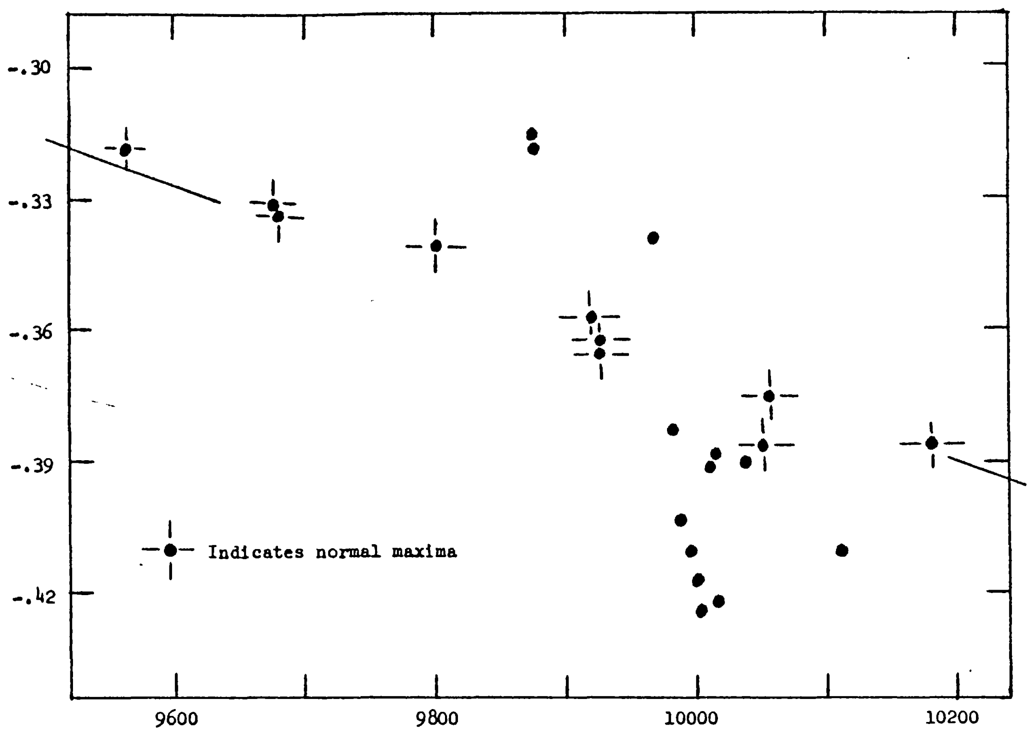

Figure 4. O-C diagram for Maxima observed during 1972.

The lines protruding into the diagram from the left and right are segments of the line representing the revised elements. Notice that all normal maxima fall very near this line.

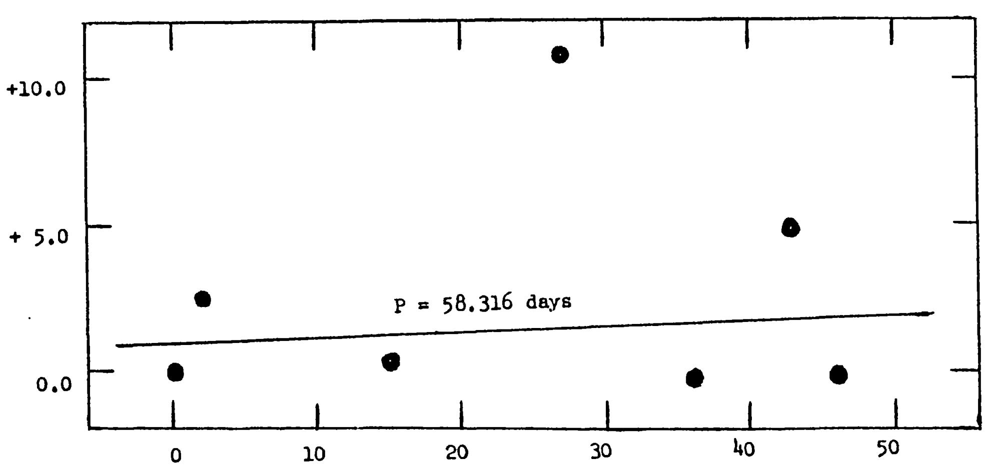

Figure 5. Seven very bright maxima from 1966-1972.

Number of cycles elapsed since the initial epoch are shown on the horizontal axis and deviation of the time of maximum from the zero phase position on the vertical axis. The elements used to establish this diagram are JD 2438882.88 + $58^{d}.30$E. The maximum at cycle 27 is weighted less than others in establishment of the refined elements represented by the "best fit" line.

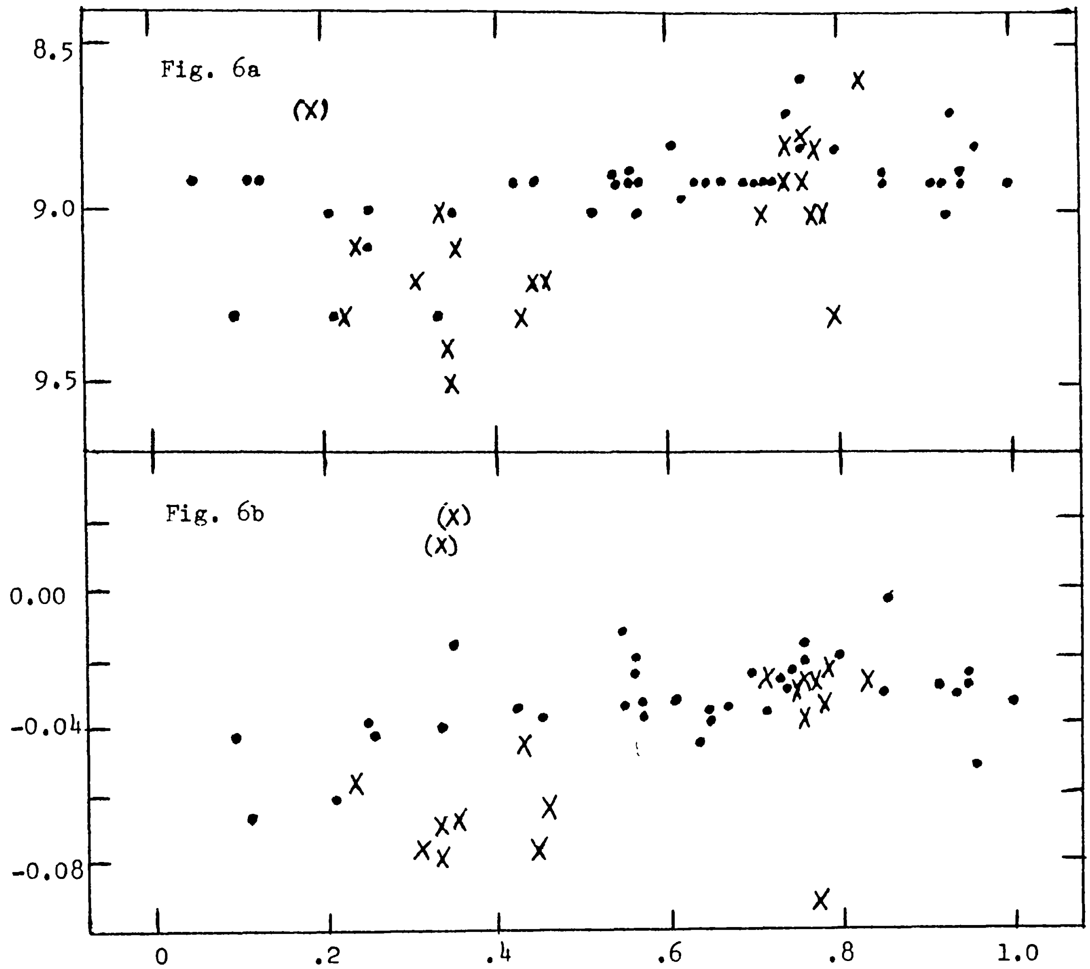

Figure 6.

Cyclic effects of variations in the XZ Cygni light curve. In both portions of this figure progress along the horizontal axis represents phase position relative to the $58^{d}.316$ cycle. X denotes a 1972 maximum and • denotes all others.

Figure 6a. Magnitude at maximum is compared to phase position. The dimmest maxima are concentrated near phase 0.4 and brighter maxima near 0.8. The maximum shown in parenthesis was poorly defined.

Figure 6b. Since many maxima were difficult or impossible to define, a point on the rising portion of the light curve was selected for a reference for the purpose of measuring the time the star reached this reference point relative to the time it was scheduled to reach maximum. The time star reaches 9.6 magnitude was selected as this reference point. Scheduled time of maximum is defined by the mean O-C curve (Fig. 1). The two maxima in parentheses represent the second peak of double-peaked maxima. An in-phase relationship with Figure 6a is evident.