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AN IMPROVED EPHEMERIS FOR BETA LYRAE

As Beta Lyrae is presently under intense study using both ground based equipment and space facilities, there is a need for more reliable phases in the binary orbit. It is the aim of this note to warn observers that the currently accepted cubic ephemeris formula by Wood and Forbes (1) is already more than 9 hours off and to supply an improved (quadratic) ephemeris giving reasonable representation of the minimum epochs observed during the last 25-30 years.

In the table we assembled all available photoelectrically determined times of primary minimum since 1944. In the column of O-C values, the heading (Herczeg) stays for the proposed formula:

$$\text{Min.I} = \text{JD}2439108.12 + 12^{d}.93266E + 0.458 \times 10^{-5}E^2.$$

Fig. 1

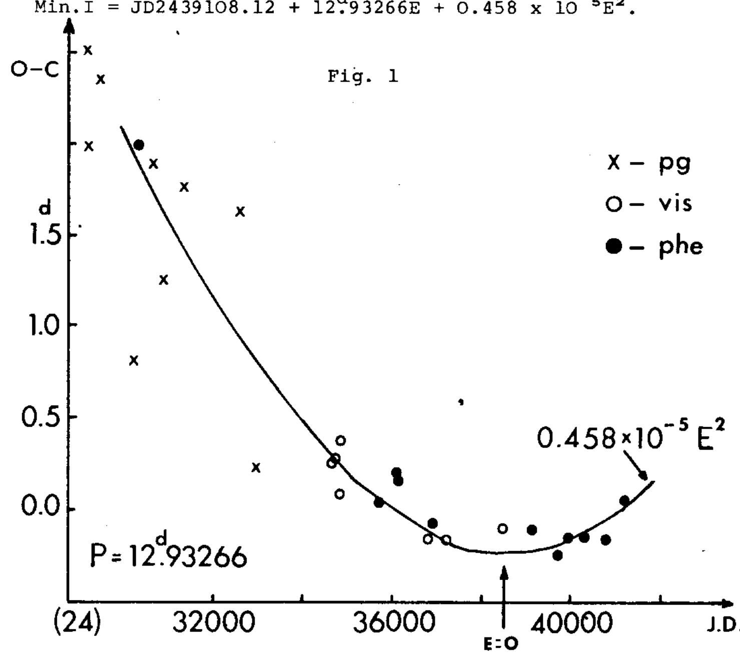


Fig. 1 shows these observations, plotted against a linear formula and supplemented, in order to fill the rather serious gaps, by a few visual minima determined by Gaposchkin (11),by the Berliner Arbeitsgemeinschaft (12), further a number of photographically derived epochs also published by Gaposchkin. Plates of photographic patrol seem to be ill-suited for the photometry of such a bright variable but careful visual epoch determinations compare surprisingly well with photoelectric results.

The following comments may be of interest.

1. It was impossible to derive a minimum epoch from Belton and Woolf's six-color photometry in 1961 (13). Moreover,a plot of the individual observations reveals how strongly asymmetric the light curve was at the time of observations (more precisely, on JD2437491): the actual minimum of light has not been reached before phase 0.03. This is a quite characteristic, recurrent disturbance, a drop of brightness immediately following zero phase, resulting in a "wedge-shaped" bottom of the light curve; see for instance Fig. 1 in Larsson-Leander's report of the 1959 campaign (4).

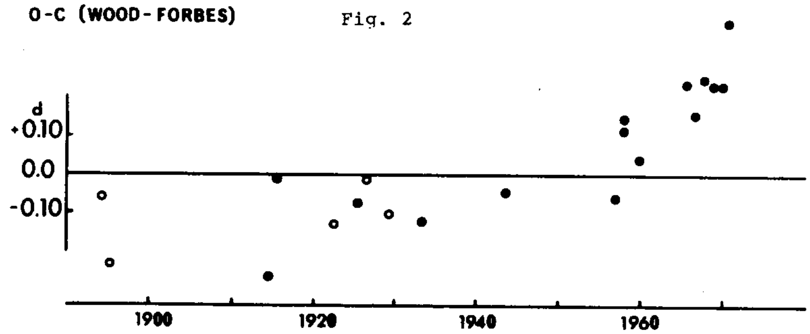
2. Minimum epochs of the same campaign all show markedly positive residuals. Our Fig. 1 indicates, however, that these O-C values are either due to a short-term period change or, possibly, to the above mentioned distortions of the light curve. It is worth mentioning that a comparison between Stebbins' observations in 1915 and those of Guthnick in 1916 discloses almost exactly the same temporary phase shift.

3. Under these circumstances the scatter in Fig. 1 and 2 may not entirely be due to errors of observation or reduction. Times of minimum light referred to under (7) through (10) are not given in the original publications: they are normal epochs derived by the present author, using simple graphical construction. Since some of these series of measurements show difficult, asymmetric light curves, the 3-decimal accuracy of the timing is probably not granted.

As to the basic period variation exhibited in Fig.1, it deserves some further comment.

Recent failures of the Wood-Forbes ephemeris formula correspond almost entirely to an unexpected and unusual increase of the binary period. In Fig. 2, the residuals of photoelectrically determined epochs are shown against Wood and Forbes (dots) together with a few

O-C (WOOD-FORBES) Fig. 2



visual timings by Pannekoek, Menze, Danjon, Parenago and McLaughlin, based mainly on longer series of observations (circles). The O-C values are systematically negative but, apart from the scatter, nearly constant indicating a correct representation of the period changes between about 1890 and 1960. In this case, as in the case of Prager's earlier formula (14) too, this is equivalent to an approximately linear increase of the period, for several decades, since the cubic term has a small coefficient. Thus the contribution to the O-C values of the E^3 term in the Wood-Forbes formula remains less than $0^d.01$ from its zero epoch in 1950 up to 1969. The sudden increase of the residuals after 1960 can only be explained by a substantial change in the rate of the lengthening of the period: for the time interval 1950-1966, Wood and Forbes predicted an increase of the period of $0^d.00315$ while the actual increase turned out to be close to $0^d.004$.

This is a novel feature in the period changes exhibited by Beta Lyrae, for earlier evidence strongly suggests that $dP/dE > 0$, yet $d^2P/dE^2 \leq 0$ throughout. It is an obvious challenge to the "asymptotic" representation, using exponential terms, as put forward recently (15). Further observations may indicate whether this abrupt change in the pattern of period variations could be related to reports of an increased spectroscopic "activity" in the system.

A more complete discussion of the period of Beta Lyrae is in progress. I am much obliged to Dr. Douglas Hall (Dyer Obs., Nashville) for sending lists of unpublished observations and to Dr. Kwan-Yu Chen (U. of Florida, Gainesville) for supplying information from the files of the Card Catalogue of Eclipsing Variables.

TABLE

Beta Lyrae, photoelectric minima 1944-72

Min. I (hel.)	O-C (Wood-Forbes)	(Herczeg)	Obs.	Ref.
JD2431337.30	-0.05	+0.05(5)	Guthnick	(2)
36379.472	-0.049	0.00	Wood, Walker	(3)
793.47	+0.12	+0.15	IAU campaign,	(4)
806.405	+0.124	+0.15	1959	(4)
819.36	+0.15	+0.18		(4)
37478.72	+0.05	+0.04	Engelkeimer	(5)
39677.24:	+0.24:	+0.07:	Herczeg	(6)
40142.713	+0.157	-0.05	Lovell, Hall	(7)
479.04	+0.24(5)	+0.01	Herczeg	(6)
724.751	+0.239	-0.02	Lovell, Hall	(8)
41086.860	+0.235	-0.06	Landis et al.	(9)
JD2441539.661	+0.388	+0.04	Landis et al.	(10)

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