THE ACCURACY OF VISUALLY DETERMINED TIMES OF PRIMARY MINIMA OF β LYRAE-TYPE AND W URSAE MAJORIS - TYPE VARIABLES

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INTRODUCTION

This paper is the sequel to the author's paper (Mallama 1974), hereafter referred to as Paper I, which evaluated the accuracy of visually timed minima of Algol-type variables. The present paper considers β Lyrae-type and W Ursae Majoris-type variables together because the shapes of their light curves in primary eclipse are similar, both being quasi-sinusoidal, and therefore it is permissible to use parameters defined in the same way when considering the accuracy of their visually timed minima. The purpose of this study is twofold: to aid the observer in selecting variables having light curves which lend themselves to accurate determination of times of minima, and to enable the person investigating period changes to estimate the standard deviation of the available visual times of minima.

METHODS

In order to evaluate the accuracy of the visually observed times of minima the author collected and analyzed O-C values for 11 β Lyr and 13 W UMa-type variables. The values were taken from AAVSO data supplied by Baldwin (1974) and from Bulletins 1 through 14 of the B.B.S.A.G. To prevent complications that could arise from O-C changes that are noticeable on a time scale of years, observations were analyzed in intervals which were kept as small as possible, always less than 400 days. The accuracy of the O-C values for a star is computed from the standard deviation (SD), which is given by

$$SD = \sqrt{\frac{\sum_{i=1}^{N} [(O-C)_i - (\overline{O-C})]^2}{N - 1}} \qquad (1)$$

where N is the number of O-C values analyzed, and $\overline{O-C}$ is the arithmetic average of the O-C values. For each variable star the five columns of Table I list the name of the variable, the type, the period (P), the number of O-C values analyzed (N), and the standard deviation (SD). The unit of measurement for the SD values is 0.001 day.

RESULTS

Table I shows that SD values for the 24 stars differ from one another by as much as a factor of seven. Paper I demonstrated that two parameters can be cited to account for the wide range of SD values among Algol-type variables. The parameters are 1) the visual amplitude (A) of the light variation for each star, and 2) the average rate of light change in magnitudes per hour ($\Delta m/hr$) during the eclipse. These can be applied to the β Lyr-type and W UMa-type variables, too; the appropriate definition of the second parameter in this case is

$$\Delta m/hr = A / 6P \quad , \qquad (2)$$

where A = amplitude in magnitudes, and P = period in days. Hence, the values of these parameters are easily computed for any variable for which A and P are contained in the General Catalog of Variable Stars (GCVS).

Figure 1 shows SD as a smoothed function of A and $\Delta m/hr$ for all 24 stars of both types. The figure shows that the visual observer should select variables with rapid brightness changes and/or with large light amplitudes to insure high accuracy in timing minima.

For a person studying period changes, Figure 1 will give an estimate of the reliability of a single visual time of minimum for any W UMa-type or β Lyr-type variable of known A and P. The results of this study (and those of Paper I) are based on O-C values for minima which typically involved about 10 individual brightness estimates each. Hence a minimum with significantly fewer or more brightness estimates (say, 5 and 20 respectively) should be accorded an estimated SD of correspondingly lesser or greater accuracy.

CONVERTING PHOTOGRAPHIC AMPLITUDES TO VISUAL

Visual observers selecting program stars by using data in the GCVS along with the guidelines suggested in this paper or in Paper I, will frequently find that photographic rather than visual amplitudes are listed. In many cases the photographic amplitude is approximately equal to the visual amplitude, especially for W UMa-type variables; but in some β Lyr-type and in many Algol-type variables there is a substantial difference.

This difference arises because at primary minimum a hotter star is being eclipsed by a cooler star. Since the usual photographic plate is most sensitive to the blue part of the spectrum, it records a larger brightness decrease for primary eclipse than does the eye.

Table II gives approximate conversions for observers wishing to correct photographic amplitudes to visual. These are average values derived from a sample of eclipsing variables for which both photographic and visual amplitudes are known.

REFERENCES

Baldwin, M. E. 1974, private communication.
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Kukarkin, B. V. et al. 1969, General Catalog of Variable Stars, Moscow.
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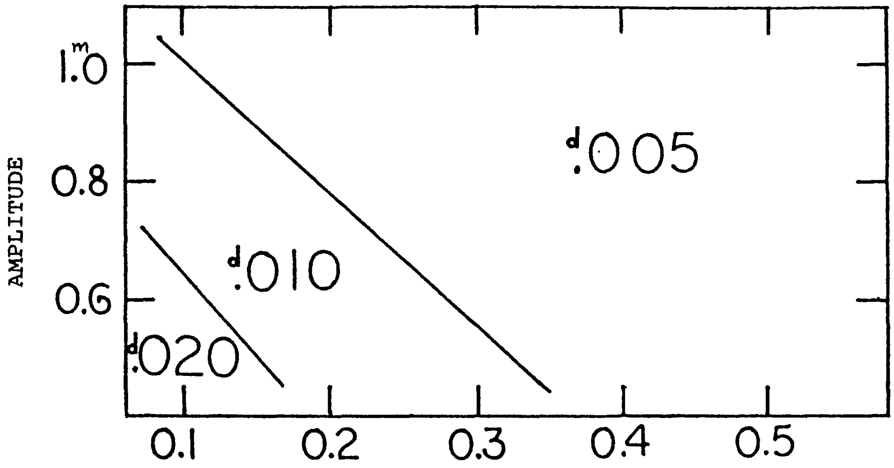

Figure 1. Smoothed plot of standard deviation as a function of amplitude and average magnitude change per hour during primary eclipse for β Lyrae-type and W Ursae Majoris-type variables.

TABLE I

DATA FOR VARIABLES ANALYZED

Variable	Type	P	N	SD*	A	Δm/hr
AB And	W UMa	$.^d332$	19	6.1	$0.^m9$	.45
OO Aql	W UMa	.507	22	6.2	0.8	.26
AD Boo	β Lyr	1.034	10	22.6	0.5	.12
VW Cep	W UMa	.278	10	8.9	0.4	.24
GK Cep	β Lyr	.936	5	19.7	0.6	.11
TW Cet	W UMa	.317	11	4.2	0.8	.42
VY Cet	W UMa	.315	12	4.9	0.6	.32
RW Com	W UMa	.237	12	3.9	0.6	.42
W Crv	β Lyr	.388	5	9.8	0.6	.26
KR Cyg	β Lyr	.845	8	7.5	0.6	.12
V548 Cyg	β Lyr	1.805	10	14.1	0.6	.06
RU Eri	β Lyr	.632	12	10.8	0.8	.21
YY Eri	W UMa	.321	11	5.1	0.7	.36
GW Gem	β Lyr	.659	5	3.5	1.1	.35
SW Lac	W UMa	.321	16	5.8	1.0	.52
TZ Lyr	β Lyr	.529	5	2.9	0.9	.28
V1010 Oph	β Lyr	.661	15	6.5	0.7	.18
ER Ori	W UMa	.423	14	6.9	0.7	.28
U Peg	W UMa	.375	8	4.4	0.6	.27
UV Psc	β Lyr	.861	.0	4.4	0.9	.17
UZ Pup	β Lyr	.795	7	6.7	0.9	.19
W UMa	W UMa	.334	6	5.6	0.8	.40
AH Vir	W UMa	.407	14	7.3	0.7	.29

*the unit is 0.001 day.

TABLE II

APPROXIMATE CONVERSIONS FOR CORRECTING PHOTOGRAPHIC AMPLITUDES TO VISUAL

Photographic amplitude	Visual amplitude
$0.^m5$	$0.^m5$
1.0	0.9
2.0	1.6
3.0	2.1