PHOTOELECTRIC MINIMA OF ECLIPSING BINARY STARS - I

Observed by: The AAVSO Photoelectric Group
Report prepared by: DAVID R. SKILLMAN
9514 48th Avenue
College Park, MD 20740

Abstract

Twenty-four heliocentric times of minimum light are presented for twelve stars. All measurements were made with photoelectric equipment during the interval 1974-1977.

* * * * *

Table 1 presents the first set of results by AAVSO observers in their efforts to obtain measurements of times of minima through the use of photoelectric techniques. This table gives the time of minimum as determined by the tracing paper method and with heliocentric corrections added. It gives the estimated error of the time of minimum caused by scatter or limited numbers of data points. The O-C and 'cycle' values are given for the linear elements given in the 1969 General Catalog of Variable Stars.

The figures show the data used for determining the times of minima. These plots are presented so that future users of this data can judge its quality and so that all readers can get an idea of the results that can be achieved through photoelectric work. The vertical scale on all plots is in tenths of a magnitude per tick mark. The horizontal axis is one hour per tick mark except where noted.

Some possible sources of systematic error have not been accounted for due to insufficient information. No corrections have been made for differential extinction, and times reported by observers are assumed accurate. Heliocentric corrections have been included, and thanks go to A. Mallama for those calculations.

That these results were obtained at all is a credit to the ingenuity and resourcefulness of the amateur observers. Some minima were obtained with borrowed professional equipment and telescopes, but most were gathered with home-built photometers on moderate aperture reflectors. The variables observed ranged from fourth to eleventh magnitude at their brightest, and their periods ranged from seven hours to three and a half days. More than half the minima observed were less than one magnitude deep.

It is interesting to note that the above summation shows that the efforts of the photoelectric observers neatly complements the work of the visual observers. The photoelectric observers are restricted to the brighter stars, but can measure shallow minima, while the visual observers are restricted to deeper minima, but can observe much fainter stars. Visual observers can also work in poorer skies, and do several stars during the same night.

Although the collection of these minima is impressive, it is important that the present observers increase their skill so that our work will increase in quality. To show that there is room for improvement, the following analysis was performed. As each time of minimum was determined by the tracing paper method, a maximum positive and negative offset error was subjectively determined. The sum of the absolute value of these errors, divided by the star's period, gives a measure of the resolution, or quality, of the observation. High quality photometry should provide resolutions on the order of 0.001 or 0.002 of the period. Good visual work provides resolutions of 0.005 to 0.010 of the period. Only seven of the twenty-four minima meet the first criterion. Fully half the minima have resolution equal to or worse than a good visual observer. Thus it pays to observe as carefully as possible, keeping accurate time, using clear skies, and being sure that the star is within the useful range of brightness. Many sets of photoelectric data submitted to the AAVSO are weakened in value because of various flaws. In order to avoid observers' wasting their valuable time at the telescope, the following considerations are suggested.

At the telescope:

1) Keep accurate time. Time signals can usually be picked up without elaborate radio equipment. Some have the time available from the phone company, and it is usually of good accuracy. Try to time the observation to within 10 seconds if the star has a short period. Always check your time after the evening's work so drifts can be eliminated.
2) The comparison star. The absolute magnitude of the variable is not important in the determination of the time of minimum. The magnitude difference between comparison and variable plays little role in evaluating the time of minimum. What is important is an accurate measure of the changes of the variable with respect to the comparison star. This implies that the comparison star must be bright enough to be easily measured by your equipment, and that the time between comparison star measurements is kept short enough that the residual noise on the comparison star is approximately 0.01 m. A source of systematic error is introduced if the comparison star has an appreciable angular separation from the variable. This error arises from uncorrected differential extinction and has the effect of shifting the time of minimum. Try to pick a comparison star less than one degree away from the variable, and in general, the closer the better. Color is relatively unimportant for comparison star considerations when timing minima because we are not interested in magnitudes or transformations. Remember, however, that red stars have a much larger chance of intrinsic variability, and should always be used with a check star for insurance.
3) The quality of the sky. If there is haze or thin clouds your data are almost guaranteed to be unusable. The value of photoelectric observations comes almost entirely from the accuracy of the measurement. A visual observer can view both variable and comparison simultaneously and thus work in conditions too noisy for photoelectric measures. It is good for all photoelectric observers to be able to make visual observations so that stars are not missed because of poor skies or balky equipment.
4) The check star. It is good practice to use a check star. For long period variables or slow eclipsers a check star is a must. If up-legs and down-legs taken at different times are to be combined, a check star must be used to prove that the comparison star was constant. Again, the check star should be nearby and bright enough to measure accurately.

On your report to the AAVSO:

1) Identify the variable, primary or secondary minimum, the observer(s), the telescope, the U.T. date pair, the filter, the phototube, the approximate zenith distance at start and end of observing, and the sky and instrumental conditions.

2) Identify the comparison star by either its coordinates, a copy of the chart with the stars marked, or by a simple accurate sketch (with north and east marked, and with scale given). Give your best estimate of the magnitude of the comparison star.

3) A list of data points with associated U.T. times should be included. The data points should be differential magnitudes,

$$\Delta m = -2.5 \log_{10} ([\text{var-sky}]/[\text{comp-sky}])$$

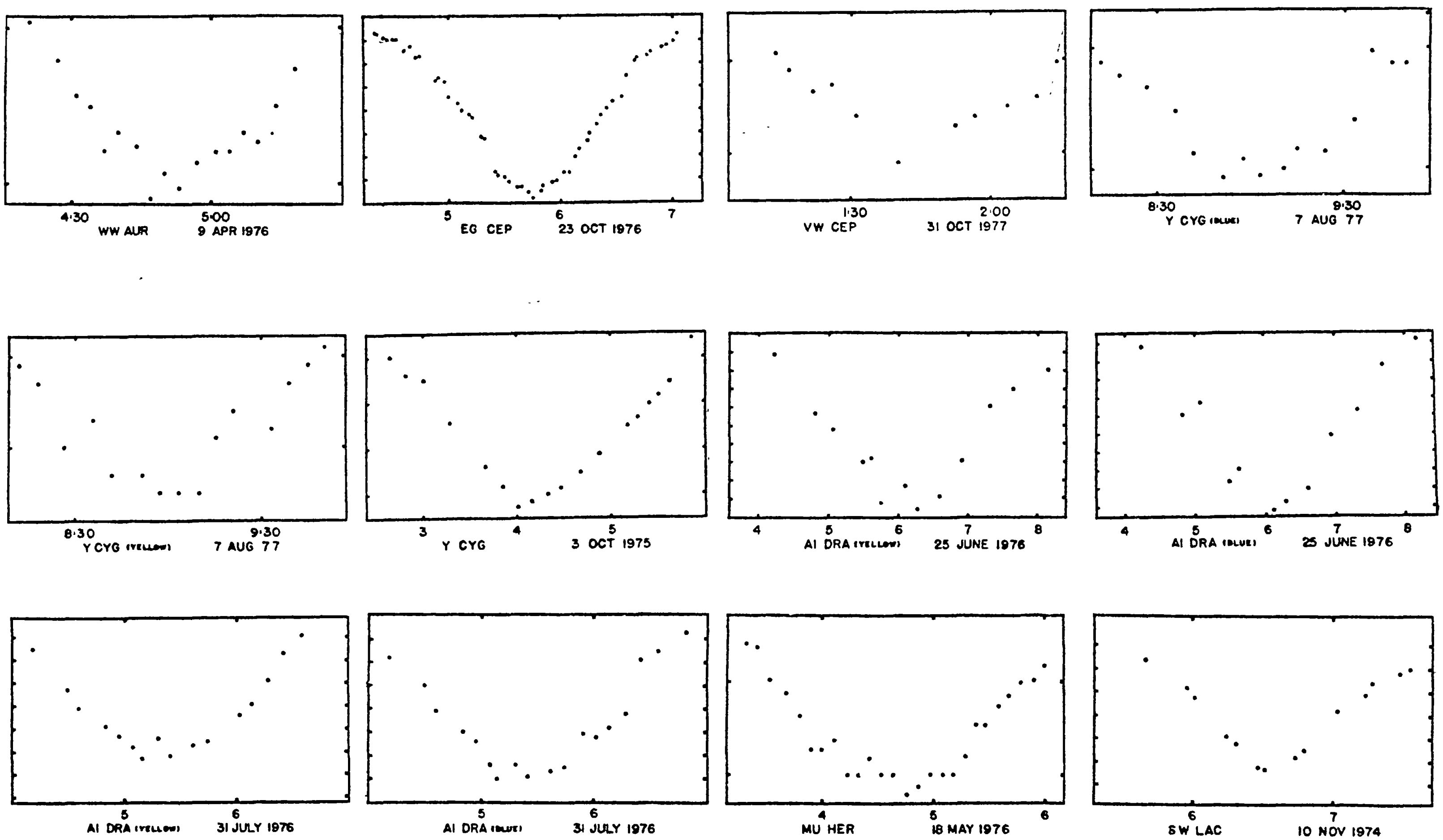
4) A graph of Δm vs. U.T. should be included, and the vertical scale should be chosen to give approximately 45° slope to the eclipse legs.

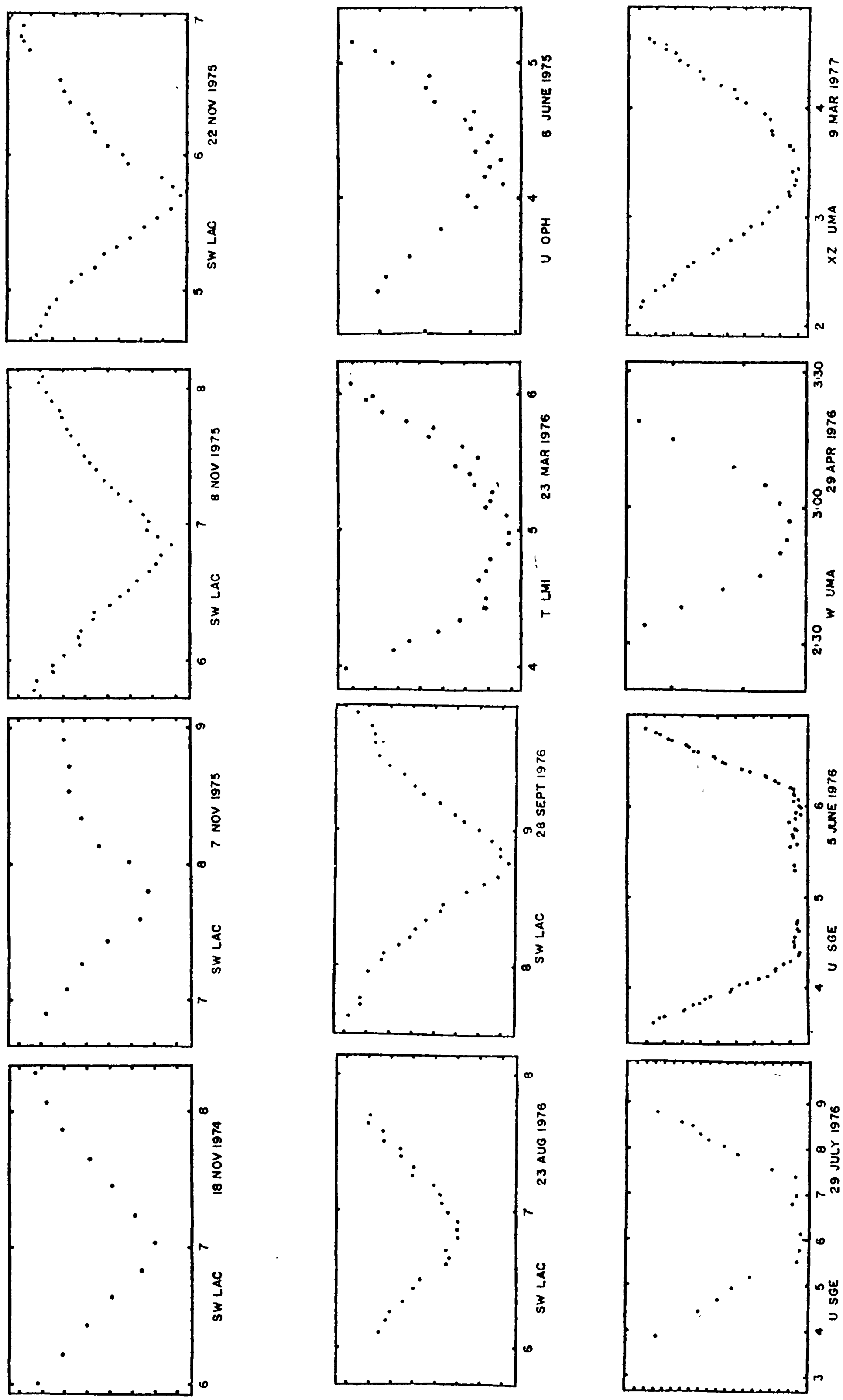
It is encouraging to see more amateurs attempting photo-electric work. Anyone interested in this method should contact Howard Landis through the AAVSO.

TABLE 1

Star	J.D. hel. 2440000+	error +/- (millidays)	O-C (days)	cycle	aperture (cm)	filter	no. of points	
WW Aur	2877.7027	+1.5/-1.5	0.0003	3933.5	25	v	17	Renner
EG Cep	3074.7416	+2.0/-1.5	0.0178	29645	30	v	52	Skillman
VW Cep	3447.5751	+2.0/-4.0	-0.0911	36949.5	30	v	11	Skillman
Y Cyg	3362.8773	+3.0/-5.0	-0.0429	11290	20	v	15	Tucker
Y Cyg	3362.8801	+5.0/-5.0	-0.0401	11290	20	B	15	Tucker
Y Cyg	2688.6798	+3.0/-4.0	-0.0655	11065	25	none	17	Renner
AI Dra	2954.7568	+7.5/-7.5	0.0018	3251	40	v	12	Sharpe+Smith
AI Dra	2954.7568	+4.0/-6.0	0.0018	3251	40	B	12	Sharpe+Smith
AI Dra	2990.7232	+2.0/-2.0	0.0038	3281	40	v	16	Smith+Jewell
AI Dra	2990.7250	+4.0/-5.0	0.0056	3281	40	B	18	Smith+Jewell
μ Her	2916.6986	+4.0/-5.0	-0.0016	18082	25	v	26	Renner
SW Lac	2361.7776	+3.0/-2.0	-0.0672	14932.5	20	v	14	Kalish
SW Lac	2369.7962	+1.5/-2.0	-0.0668	14957.5	20	v	12	Kalish
SW Lac	2723.8271	+1.5/-2.0	-0.1198	16061.5	20	-	12	Kalish
SW Lac	2724.7881	+2.0/-1.5	-0.1210	16064.5	20	-	38	Kalish
SW Lac	2738.7390	+1.5/-1.5	-0.1217	16108	20	-	30	Kalish
SW Lac	3013.7899	+1.5/-2.0	-0.0952	16965.5	20	none	24	Kalish
SW Lac	3049.8707	+1.0/-1.5	-0.0963	17078	20	-	32	Kalish
T LMi	2860.6695	+3.0/-4.0	-0.0956	6293	90	v	28	Skillman
U Oph	2579.6820	+3.0/-3.0	-0.0074	20449	25	none	22	Renner
U Sge	2988.7709	+3.5/-3.5	0.0096	4105	40	v	20	Sharpe
U Sge	2934.7210	+1.5/-1.5	0.0079	4089	30	v	68	Skillman
W UMa	2897.6219	+0.5/-0.5	-0.1119	12303.5	25	none	12	Renner
XZ UMa	3211.6481	+1.5/-1.5	-0.0704	13766	90	v	40	Skillman

Figures. Light curves during eclipses are plotted with relative magnitude, Δm, in $0^{m}.1$ steps and Universal Time in hours.




SW LAC 22 NOV 1975
SW LAC 8 NOV 1975
SW LAC 7 NOV 1975
SW LAC 18 NOV 1974
U OPH 6 JUNE 1975
T LMI 23 MAR 1976
SW LAC 28 SEPT 1976
SW LAC 23 AUG 1976
XZ UMA 9 MAR 1977
W UMA 29 APR 1976
U SGE 5 JUNE 1976
U SGE 29 JULY 1976