10107/6

The British Astronomical Association

VARIABLE STAR SECTION

CIRCULAR 58

"LIGHT CURVE"

DECEMBER
1984

Head Office: Burlington House, Piccadilly, London W1V 0NL. Telephone 01-734 4145

VARIABLE STAR SECTION

CIRCULAR 58

CONTENTS

*****0*****

Printed in England by Castle Printers of Wittering,
Shore Road, East Wittering, West Sussex.

Changes of Officers and Addresses

Members are asked to note that Melvyn Taylor has now become Secretary for both Binocular and Telescopic Programmes. ALL observations should be sent to him at the usual six-monthly reporting intervals. This change comes into effect immediately.

Members are also reminded that both Guy Hurst and John Parkinson have moved - their new addresses are given inside the front cover.

Circulars

Members are reminded that with the problems of availability of material and Officers' work load, issues of these Circulars take place at irregular intervals, 3 or 4 times a year. At present, subscriptions cover 4 issues, rather than a calendar year.

Names and addresses have been transferred to a different computer file for the printing of labels. Some members may find that their code numbers have been altered. This is for internal organisational reasons, and has no other significance. (Another change may be necessary at a later date.) As previously, the number of future issues that a member will receive is given by the figure after the oblique stroke. If your subscription expires with this issue, please renew immediately, as the next Circular (59) will be published in about a month.

It has been decided that certain detailed observational results (unsuitable for publication in full in the *Journal*), will be printed in these Circulars. We begin this policy with the Eclipsing Binary Report given in this issue.

We remind members that contributions for these Circulars are always welcome, and thank those who have submitted material. The reproduction of light-curves poses considerable problems, which we hope to overcome. (We regret that one contribution from Ian Middlemist on some red variables has been delayed, pending the light-curves being redrawn.) Please discuss any diagrams or light-curves with Storm Dunlop before submission.

Computing and VSS Records

Considerable progress has been made with computerisation of VSS records and now all Main Programme observations are being entered in machine-readable form as they are received. This process is now being extended to Binocular Programme observations. We have adequate actual computional power, but would be grateful if any members with access to BBC microcomputers could help us in the task of entering estimates from report forms. Collation and analysis would be carried out centrally, of course. If anyone is able to help, please contact the Director. Even a small amount of assistance will be helpful. (We regret that as yet we cannot include other machines.)

1983 Observational Totals - Main Programme

Star totals for 1983

	No.	Ob'vers		No.	Ob'vers
R And	238	20	AB Dra	284	11
W And	211	17	U Gem	303	20
RW And	167	12	IR Gem	272	10
RX And	330	14	RU Her	110	11
DZ And	181	11	SS Her	139	13
R Aql	262	20	AC Her	383	18
UU Aql	37	7	AH Her	201	10
UW Aql	144	9	R Hya	76	9
V603 Aql	22	2	SU Lac	135	9
N'82 Aql	27	1	DK Lac	-	-
VY Aqr	51	6	X Leo	201	14
SS Aur	441	18	AY Lyr	245	12
U Boo	88	9	U Mon	339	20
V Boo	202	12	RS Oph	163	13
V Cam	139	8	U Ori	215	17
X Cam	226	13	CN Ori	182	13
Z Cam	403	14	CZ Ori	237	12
XX Cam	308	17	RU Peg	257	18
S Cas	155	14	S Per	233	17
T Cas	221	19	RS Per	321	20
UV Cas	396	13	TZ Per	402	14
γ Cas	361	13	UV Per	277	10
ρ Cas	272	11	BU Per	318	20
DM Cep	61	2	GK Per	177	9
o Cet	89	12	WZ Sge	148	9
R CrB	659	29	HS Sge	54	2
S CrB	266	17	R Sct	467	22
T CrB	308	19	Branchett's Obj.	27	3
V CrB	139	13	R Ser	135	16
W CrB	137	12	RV Tau	193	18
R Cyg	196	18	SU Tau	208	13
S Cyg	171	12	T UMa	293	15
V Cyg	237	14	SU UMa	309	13
W Cyg	394	21	SW UMa	271	11
SS Cyg	627	20	CH UMa	316	11
BC Cyg	163	13	V Vul	301	14
BI Cyg	176	14	PU Vul	269	12
CI Cyg	271	16	Honda's Obj. Cyg	-	-
χ Cyg	230	19	3C 273	81	6
HR Del	216	9	NGC 4151	159	5
T Dra	190	12	Markarian 421	43	2

Total 18 156

Observer Totals 1983

	Obs.		Obs.
D. Stott	2766	S. Hoste	183
M.J. Gainsford	1655	W. Worraker	183
R. Paterson	1309	R. Chambers	150
P. Wheeler	1039	T. Saville	129
J. Shanklin	886	H. Colquhoun	120
G. Poyner	860	J. Howarth	105
L. Brundle	818	P. Moore	98
A. Bueno	805	E. Collinson	96
J. Toone	706	* Photogrphic	95
C. Munford	669	R. Stuart	90
J. Ells	440	D. Cozen	78
S. Albrighton	411	R. Fraser	78
I. Middlemist	404	A. Markham	78
N.F.H. Knight	390	M. Hather	77
N. Kiernan	383	L. Baker	68
M. Nicholls	351	N. Bone	56
P. Withers	348	R. Middleton	46
R. Dryden	335	R. Godden	37
R. Pickard	328	H. Smith	33
M. Taylor	313	A. Kocsis	29
A. Tanti	303	G. Hirst	26
S. Lubbock	223	A. Kimber	26
G. Hurst	185	* 13 Observers	194
		Total	18 002

Binocular Chart Booklet

Preparation of the booklet containing all VSS binocular charts is at a an advanced stage. We expect it to be printed shortly and hope to be able to announce availability at some time in the New Year. Details will be given in the next Circular.

Determining Eclipsing Binary Minima from Visual Observations: A comparison of Algorithms - J.E. Isles

Introduction

A graphical method of determing the time of minimum from a series of visual estimates, the tracing-paper method (TPM), was used in past reports on the Eclipsing Binary Programme, the last of which dealt with observations made in 1975. The TPM was described in the *Journal* 92, 76 (1982 Feb.).

In VSSC 53 it was proposed to investigate the feasibility of determining times of minima by computer, rather than by this graphical method, before attempting to bring the reports up to date. This note reports the interesting results of that investigation.

In principle, the advantages of computerisation include:

1 greater objectivity, since different people using the same algorithm ought to get the same results from a given set of data;

2 improved precision, since graphical methods may not make full use of the data and also any manual process is prone to error; and

3 reduced effort.

Against these points it may be objected that:

1 in a manual procedure the analyst can more readily bring to bear his knowledge of the characteristics of the star, the observer, and the relative accuracy of the observations;

2 when the calculations are performed invisibly inside a computer, it is mch harder to see when the algorothm is performing incorrectly or there is a transcription error in the data; and

3 there is a temptation to spend long hours perfecting a computer program instead of producing results for publication.

thus the choice between manual and computer methods is not automatic.

In comparison with photoelectric measures, visual observations are characterised by lowere precision (internal standard errors of the order of 0.1 m) and fewer numbers. It is not practicable to multiply the observations indefinitely without the observer becoming biassed. Estimates are therefore usually made at intervals of 15 to 30 minutes. Thus, the reduction procedure needs to be robust and what may be a good method for handling photoelectric data may not perform so well on visual work.

Algorithms considered

Silvano Ghedini (Software for Photoelectric Astronomy, Richmond, Virginia, 1982) has published five BASIC computer programs for determining times on minima. Two of these (the 'Best Fit' method, and the 'Middle Line' method) allow the light curve to be asymmetric. These were not considered, because of the danger that errors in the observations will suggest a spurious asymmetry which will be duly modelled by the computer. Even though slight asymmetry may be truly present in the star's light-curve, a method which assumes symmetry is likely to be more robust for reducing visual estimates.

The three other algorithms are as follows.

1 The Kwee and van Woerden (KvW) method. From the original data, a series of magnitudes uniformly spaced in time is interpolated. A preliminary estimate T of the time of minimum defines a reflection axis. the mean square difference between the observation and the corresponding reflected magnitude (again, linearly interpolated), provides a measure of the lack

of fit. Starting from and initial value of T half way from the first to the last observation, the program iterates towards a value of T which minimises S(T).

2 The Polygonal Line method (Poly). Again given a preliminary time T (in this case, that of the faintest estimate - the first if there are ties), the program reflects the ascending branch of the curve onto the descending branch, calculates the length L(T) of a line joining each observation to the next in time, and iterates to a minimum of L(T). It seems somewhat irrational that the results can depend on what units are used for recording times, but apparently this makes little difference in practice.

3 The Sliding Integrations method (Slide). This will be easier to explain after the next method has been described.

After my *Journal* paper had appeared, Mr D.G. Hinds wrote to me suggesting a computer implementation of the tracing-paper method. Suppose we have a series of estimates from T1 to T2, bracketing the time of minimum T. If T>(T1 + T2)/2, then the area under the curve from 2T - T2 to T should equal the area from T to T2. If T<(T1 + T2)/2, then the areas to be compared are from T1 to T, and from T to 2T - T1. The star's magnitude is assumed to change linearly between observed points, in order to calculate these areas. In Mr Hind's implementation on a Spectrum computer, the operator would try successive values for T until a value were found for which the areas were essentially equal.

This method seemed to be unsophisticated in comparison with Ghedini's programs, but it was decided to give it fair trial along with the others. In my implementation on a Commodore 64, a binary chop method is used to find the best value for T; convergence is very fast. In what follows, this is referred to as the Hinds method.

Ghedini's Sliding Integrations method uses the same principle, but starts by producing a linearly interpolated series of magnitudes at uniform time intervals, and finds the minimum by fitting a regression line of differences between the two areas against a series of trial values for T.

These four algorithms were evaluated by reducing afresh 51 sets of observations of eclipsing binary minima in 1975. These had already been reduced by Peter Hornby using the tracing-paper method. Stars observed once only in the year were omitted, as only where two or more minima were observed can we use the scatter in the O-C values (the differences between observed times of minima, and the calculated times of minima according to catalogue elements) to estimate the standard errors of the results. (Within a single year, any variation in the O-C values due to changes in a system's period or light-curve is likely to be negligible in comparison with observation errors.) The magnitudes or grades (the latter divided by 10 to convert approximately to relative magnitudes) were input to the programs exactly as they had been reduced by Mr Hornby using the TPM.

Results

The Kwee and van Worden method failed to give a time of minimum in eight cases, where the number of observations was small (six or fewer), or the observations were very asymmetrically distributed about the apparent time of minimum. Many of the deduced times agreed closely with TPM, but quite a few were wild, differing by more than half an hour and looking implausible from inspection of the original data.

Results for the Polygonal Line method were very similar. It failed to give a time only for one minimum (for which KvW had succeeded). There were slightly fewer implausible results, but also fewer cases of very close agreement with TPM.

On further investigation it was found that both programs were frequently converging to a local minimum of the measures of disagreement S(T) and L(T). Modified versions were therefore developed which sought the absolute minimum of S(T) and L(T). The times produced by the modified KvW program (which incidentally cut out the initial linear interpolation stage) were still wildly inconsistent with the observations in many cases, particularly where they were few in number and asymmetrically distributed about mid-eclipse. The modified Poly program, however, now produced sensible results.

My implementation of Poly first scales the magnitudes so that their range is the same as the range in times. This arbitrarily tackles the problem of the results varying when the units of time are changed. The program then samples the function L(T) at successively finer intervals of T, and finally fits a parabola to the three points nearest its minimum to estimate the absolute bottom. It yielded a time in every case, agreeing with TPM within 0.002d in 30 cases out of 51. There were some larger discrepancies, up to 0.021d. These were examined and it was found that the Poly time seemed at least as plausible as the TPM time.

The Sliding Integrations method also produced a time for every set of estimates, but the majority were wild and were frequently well outside the observed time intervals - by about half a day in a few cases.

The Hinds method yielded a time in every case, agreeing with TPM within 0.002d in 33 cases. Again there were some larger discrepancies, up to 0.013 day. Again it was found that the Hinds time seemed at least as plausible as the TPM time.

Poly and Hinds agreed with one another within 0.002 day in 34 cases. In one case they differed by 0.015d, and in three more cases by 0.008 or 0.009d. Examination of the observations suggested that Poly times were perhaps more plausible, but there was not much to choose between them.

Close agreement between two methods, however, does not in itself prove their superiority. We should also look at how consistent the results are for a particular eclipsing binary at different minima. The estimated standard deviations of the timings given by the three methods, from the scatter among the O-C values for each star, are shown below. Standard errors have been calculated separately for the EW stars VW Cep and W UMa (21 timings), which are much more difficult than the other nine systems (30 timings) owing to their small amplitudes.

Estimated Standard Deviations:

Method	VW Cep, W UMa	Other systems
	d	d
TPM	0.015	0.008
Poly	0.018	0.008
Hinds	0.019	0.008

There is nothing to choose between these three methods, when we consider systems other than VW Cep and W UMa. It is possible that in interpreting the difficult observations of VW Cep and W UMa, Mr Hornby unconsciously brought them into closer agreement than they strictly warranted, and this may be why TPM shows a slightly smaller SD for them. It would require a very much larger sample of minima to determine the slight edge Poly shows over Hinds is real.

Ghedini's programs, incidentally, provide standard error estimates. For KvW and Slide, these are based on the scatter within the data, but for Poly the operator has to supply the standard error of magnitudes and times (which in this case were taken as 0.1m and 0.001d). The RMS values obtained were 0.011d for KvW, 0.017d for Poly, and 0.013d for Slide (which needed at least seven observations to produce a non-zero error estimate). While these average values appear to be of the right order of magnitude, the error estimates for VW Cep and W UMa did not differ significantly from those for other systems. It is concluded that these error estimates are not a reliable guide to the relative accuracy of individual estimates.

One can envisage circumstances where the Hinds method may fall down, e.g. where there is a long gap in the observations around minimum so that linear interpolation of magnitudes is inaccurate. Poly should still cope under these circumstances. It is therefore proposed that Poly should be used to reduce visual observations in future reports on the Eclipsing Binary Programme, but Hinds will be used as a check. It should now be possible to bring these reports up to date quickly. A copy of the reduction program will be communicated to the BAA Microcomputer Users' Group.

Photoelectric observations have recently constituted an increasing proportion of the results reported. For these, the KvW method is well established and the problem of wild values is likely to be much reduced given the higher precision of the data and the greater numbers of observations possible. However, and investigation of alternative methods of reduction will be worthwhile when sufficient photoelectric data have accumulated.

Notes from other publications

Information Bulletin on Variable Stars (IBVS) and
Monthly Notices of the RAS (MN)
(Note that from 1984 January MN are issued twice monthly! The references below are to date and page.)

Nova Aquilae 1982

Two recent papers report infrared photometry between 1982 Mar 5 and Oct 16, when visual observations (assembled from various sources including *The Astronomer*) showed the object declining from 12^m to 13^m, rising to a secondary max of 12^m, and finally fading to 16^m. Both papers note that heated dust was present from the first observation. Most likely a dust shell was already present before the outburst. (Williams and Longmore MN '84 Mar 1, 139 and Bode *et al.* MN '84 Apr 15, 897.)

AT Cancri

In IBVS 2362 (1983 June 30) and 2526 (1984 May 28) W. Götz reports observations of this object, which appears to be a cataclysmic type of variable. As yet only B magnitudes are available, the range being apparently between 12.5 and 16. It has shown typical cataclysmic outbursts, with rises of approximately 3.5 magnitudes in two days. IBVS 2362 gives a close-field chart with comparisons.

VW Cephei

IBVS 2516 (1984 May 4) - C. Cristescu and G. Oprescu report their photoelectric observations. Contrary to the results of Rovithis and Povithis-Livaniou (VSSC 57), they find better agreement with Kukarkin's ephemeris than with Kwee's! O-C values range between +0.0011 and +0.0076 (days) for the former and -0.1238 to -0.1301 for the latter.

CH Cygni

Speisman (MN '84, Jan 1, 77) reports UBV and Hα photometry from summer 1982. This shows flickering at all wavelengths with amplitude $\simeq$ 0.2 m in V and on time-scales of 2 - 100 minutes. Although there are series of 'regularly' spaced bursts, no periodic component is obvious. This type of flickering is characteristic of cataclysmic variables. On Aug 3 one rise of $0^m.18$ in V took place over only 7 minutes. The B-V colour index had become steadily bluer since the 1977 outburst, and according to the author the V-band radiation in 198 no longer originated from the M-type absorption spectrum, but primarily from the blue continuum, the presumed source of the flickering.

CI Cygni

T.A. Belyakina *et al.* (IBVS 2485, 1984 March) report observations of the 1982 eclipse of this star observed in UBVRI. Before eclipse the magnitude rose, reaching about 10.6 (V) on 244 5155.

The eclipse began about 244 5190 declining 1.2 in U, 0.9 in B, 0.4 in V and 0.1 in R by 244 5225, whereas the magnitude in I remaed constant. After phase 0.0 (about 244 52250) there was a further decline of 0.2 in B, 0.4 in V, 0.3 in R and 0.2 in I, U remaining constant. The rise then set in and eclipse ended about 244 5300. Duration of eclipse was comparable to that observed in 1980. The second decline is thought to have been caused by variation in the cool component, which is probably an irregular red giant.

HR Del (Nova Del 1967)

H.-M. Steinach and L. Kohoutek(IBVS 2367 1983 Jly 11), report 1981 and 1982 observations, finding periodic variations as had been previously noted in 1977-1980. Observations for 1982 July 27/28 and 28/29 were combined and searched for periods. Three possible periods were found, with the best fit being 0.21231 day - apparently close to periods ranging from 0.2159 - 0.2201 day found in earlier data. The brightness of the nova appears to be still declining very slightly, the differential magnitude between one comparison and the nova increasing by about 0.06 mag between 1981 and 1982.

AG Pegasi

R. Luthardt (IBVS 2495 (1984 March 22) has examined visual observations of this symbiotic star by the AFOEV in an attempt to determine which of the two published periods (827 days and 733 days) is most likely to be correct. The former (derived by Meinunger from plates taken by the Sonneberg Sky Patrol) also appeared to fit the radial velocity data - i.e the orbital period. The shorter period was established from AAVSO visual data by Slovak. Two additional minima were found and the analysis showed that the best fit was obtained by Meinunger's elements:

$$\text{Min} = 242\ 8250 + 827 \times E_1$$

until epoch 16. A period-change seems to have occurred about 244 3000, and epochs from 17 agree with:

$$\text{Min} = 244\ 2370 + 760 \times E_2.$$

Cataclysmic variables

X-ray observations in 1979-80 from the Einstein satellite are reported by Cordova and Mason (MN '84 Feb 15, 879) for 27 novae, recurrent novae, dwarf novae and nova-like objects. Of seven dwarf novae observed during optical outbursts, only U Gem exhibited enhanced ultrasoft X-ray emission in addition to weak, hard X-ray emission. A number of stars showed flickering on similar time-scales to optical flickering. Long observation of SU UMa and GK Per also revealed X-ray variability on time-scales of hours. Watson (IAUC 3850) reported X-ray pulses from GK Per with a period of 351 seconds, during an optical outburst in 1983 Aug; but pulses with this period were not detected in the Einstein data.

Review:

Advances in Photoelectric Photometry, Vol.1, Wolpert, R.C. and Genet, R.M. (eds). Fairborn Obs'y, 1247 Folk Road, Fairborn, Ohio 45324, USA, 1983. Pp iv + 237, pbk, $23.95 (about £18)

Following the emergence of the IAPPP as the premier body fostering photoelectric photometry (PEP) among amateurs, and the success of the book *Photoelectric Photometry of Variable Stars*, by Hall and Genet, comes this book emphasizing advances made at small observatories and in observations using small telescopes.

After a good introduction, which summarizes the book's contents, comes a chapter entitled 'The contribution of Small Telescopes', which analyzes the usefulness of telescopes of less than 40 cm aperture. This shows that very useful work can be undertaken with modest equipment. We then launch into the main part of the book, which falls into three broad sections: observations, equipment and observatories.

The opening chapter of the first section attempts to answer the question 'What Can You Do?', and concentrates on the types of star that can be observed (including the discovery of new variables - principally of small amplitude). The observation of micro-variables is then dealt with, demonstrating that observations better than 0.005 mag in accuracy can be achieved. The next two chapters deal with photometry of Be stars and the star ϵ Aur respectively, before the first section ends with a most interesting chapter entitled 'Photometry Among the Climatically Underprivileged'. This is based on results from the David Dunlap Observatory, Toronto, Canada, and demonstrates to anyone doubting the use of PEP away from mountain-top sites just how wrong they can be. It is also pointed out that large telescope complexes cannot afford the time to devote to long-term projects on brighter stars, and further that many of the smaller telescopes at these sites are being closed down because of financial cutbacks. So it is left to the smaller (often amateur) observatory to continue work on many stars where climate need not be a deterrent.

The second section of the book commences with a chapter by Norman Walker of the RGO at Herstmonceux on the design, construction and use of a 4-channel photometer using fibre optics. This is quite an advanced design, particularly for amateurs, but something to be aimed for, especially judging from the fact that spectacular results can be obtained, even through a diminution of 6 magnitudes of cloud! Chapter 9 describes the use of a micro-computer with a PEP system and list some useful BASIC programs. Next, the professionally built SSP-3 photometer, which uses a photodiode-type detector is described by the manufacturer, and then follows the details of a useful circuit for calibrating a D.C. amplifier. The final two chapters of this section deal with the full automation of telescopes for photoelectric work by controlling with a computer, not just the telescope, but also all the ancillary equipment.

The last section describes six individual (amateur) observatories equipped with PEP. Of special interest are chapter 17, which examines a completely portable (or perhaps more accurately, transportable) photoelectric observatory, and chapter 18 by Richard Miles, the foremost amateur exponent of PEP in this country, describing the evolution of his system in some detail.

The book has been produced in a rather small format, but is almost entirely free of typographical errors. (Volume II, which is due to be published later this year, will be produced in a larger format.)

Generally, an excellent book, which, whilst not containing the wealth of information found in *Photoelectric Photometry of Variab Stars*, does provide plenty of encouragement, and is recommended for anyone embarking on the PEP road.

Roger Pickard, Crayford Manor House Astronomical Society

Minima of Eclipsing Binaries: 1976-78 - John Isles

The Section's visual timings of minima of eclipsing binaries in the years 1976-78 are given in the accompanying table. The successive columns give:

1 Star name

2 Epoch, the number of cycles elapsed since the initial minimum given in the 1969 GCVS. For consistency with previous reports (1972: *BAAJ* 83, 452, 1973 Oct.; 1973-4: *BAAJ* 85, 443, 1975 Aug.; 1975: *BAAJ* 87, 79, 1976 Dec.), any revised elements appearing in Supplements to the GCVS are ignored. ".5" indicates a secondary minimum.

3 Heliocentric JD of minimum, derived using the computer programs described earlier. The time is followed by the symbol : in a few cases where discordance or long gaps in the estimates rendered the interpretation uncertain.

4 O - C value, the difference between the observed and calculated times of mid-eclipse, using the *linear* elements of the catalogue. For convenience in analysis, any extra polynomial or trigonometrical terms given in the Catalogue's remarks are ignored.

5 The number of estimates.

6 The observer, abbreviated as follows:

AG = S. Albrighton	KG = G.J. Kirby
BJ = B.J. Beesley	MY = A. Maudsley
BS = T. Brelstaff	NR = R.H. McNaught
DT = D. Stott	PJ = A.R. Pratt
EQ = J. Evans	PS = P.J. Swift
HO = A.J. Hollis	TY = M.D. Taylor
HU = D. Hufton	VB = J.S. Bullivant
IS = J.E. Isles	

Finally, an asterisk draws attention to a remark below.

It will be seen from an examination of the O – C values that, while the observations are fairly concordant in most cases, some of the timings appear to be erroneous. As it is not always clear which the latter are, particularly where only two or three timings have been reported for the system concerned, it has been thought best to list all the results as they stand. Comparison with timings in other years or with results published elsewhere should eventually resolve any doubts. It is empahsised that a timing has been marked as uncertain (:) only for the reasons given above, and not merely because the resultant timing looks odd, nor merely because the number of estimates on which it is based is small.

Future Circulars will report timings made in later years, and when these have been brought up to date a discussion will be prepared for the *Journal*. Observers are urged to send in as soon as possible any unreported observations.

Remarks

V822 Aql The period in the 1969 GCVS is wrong (see *BAAJ* 85, 447, 1975 Aug.), so the O – C is against the elements of the 1974 Supplement.

AC Boo Observations on nine nights between 3653 and 3670 have been folded onto a single cycle, and used to derive the times of the minima nearest the median date of the observations.

BV Dra No initial epoch is given in the 1969 GCVS, so the O – C is against the elements of the 1974 Supplement. Estimates made 3656-3670 were combined to derive the time of minimum.

S Equ The timing is derived from 3 estimates on the falling branch by HO on 3421, and 5 on the rising branch by BS on 3366.

β Lyr All the estimates in each calendar year have been folded onto a single cycle, and used to derive the times of the minima nearest to the median date of the observations. Observers in 1976 were BJ, BS, DT, MY and VB; and in 1977 BS and DT.

IQ Per No period is given in the 1969 GCVS, so the O – C is agains the elements of the 1974 Supplement.

W UMi The timing is derived from 7 estimates on the falling branch by TY on 3472, and 7 on the rising branch by BS on 3387.

The numbers of estimates given against certain minima include estimates made on other nights that were also used in deriving the times of minimum. These were as follows:

RZ Cas	3824	BS includes 3 estimates on 3875
GK Cep	3597	BS includes 3 estimates on 3596
GK Cep	3597	AG includes 5 estimates on 3511
U CrB	2967	BS includes 7 estimates on 2991
u Her	3670	IS includes 11 estimates on 3653-3664
V566 Oph	3737	BS includes 4 estimates on 3746
β Per	3763	BS includes 18 estimates on 3743-3769
U Sge	2907	BS includes 5 estimates on 2958
RS Vul	3769	BS includes 10 estimates on 3747-3760

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER	
BX AND	11241.5	3387.411	+0.022	9	BS	
	11453	3516.425	-0.003	12	BS	
	11825	3743.415	+0.023	7	BS	
	11853	3760.482	+0.007	8	BS	
V822 AQL	2489.5	2961.507	+0.110	8	BS	♦
	2496.5	2998.495	+0.033	6	TY	♦
	2559	3329.469	+0.064	6	BS	♦
TT AUR	16509	3244.395	+0.045	6	TY	
WW AUR	3933	2876.406	-0.034	4	BS	
	4185	3512.754	+0.009	9	BS	
	4186.5	3516.537	+0.005	9	BS	
	4199.5	3549.358	0.000	7	TY	
AR AUR	3957	3103.309	+0.023	5	TY	
	3957.5	3105.371:	+0.018:	9	TY	
	3972	3165.307	+0.001	7	PS	
	3974	3173.591	+0.016	11	BS	
	4047	3475.412	+0.007	9	NR	
	4061	3533.282:	-0.002:	7	TY	
	4076.5	3597.373	-0.004	10	BS	
CM AUR	3247	2819.329	+0.014	7	BS	
	3261.5	2837.407	+0.007	6	BS	
	3375.5	2979.555	-0.038	5	BS	
	3510	3147.343	-0.012	6	BS	
	3531	3173.531	-0.017	10	BS	
	3761	3460.388	-0.039	6	BS	
	3806	3516.539	-0.017	5	BS	
	3870	3596.354	-0.022	7	BS	
	3988	3743.536	-0.028	8	BS	
LY AUR	1129	3580.347	-0.069	5	TY	
	1190	3824.484:	-0.090	7	BS	
ZZ BOO	2533	3512.766	+0.015	9	BS	
AC BOO	16723	3658.354	+0.003	6	IS	♦
	16723.5	3658.516	-0.011	11	IS	♦
AW CAM	22546	3741.412	+0.028	4	BS	
	22589	3774.571	+0.019	10	BS	
UU CNC	83	3584.4:	-2.7:	6	TY	
RS CVN	3693	2967.473	-0.093	7	DT	
	3693	2967.497	-0.069	3	BS	
RZ CAS	4735	2803.486	+0.002	13	KG	
	4765	2839.354	+0.012	7	BS	
	4771	2846.516	+0.003	11	KG	
	4786	2864.445	+0.003	16	KG	
	4796	2876.395	0.000	5	BS	
	4822	2907.477	+0.007	6	BS	
	4858	2950.498	-0.001	8	BS	
	4863	2956.478	+0.002	8	KG	

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER	
RZ CAS	4868	2962.455	+0.003	7	BS	
	4909	3011.451	-0.007	12	KG	
	4909	3011.453	-0.004	7	TY	
	4934	3041.351	+0.013	5	BS	
	4940	3048.521	+0.011	9	TY	
	4975	3090.337	-0.007	7	AG	
	4975	3090.338	-0.006	25	EQ	
	4975	3090.341	-0.002	7	HU	
	4980	3096.316	-0.003	11	AG	
	4980	3096.320	+0.001	9	TY	
	4980	3096.321	+0.001	8	KG	
	4990	3108.279	+0.006	7	AG	
	4991	3109.461	-0.006	5	AG	
	4996	3115.441	-0.002	7	AG	
	5001	3121.425	+0.005	16	KG	
	5026	3151.294	-0.007	5	AG	
	5026	3151.296	-0.005	7	KG	
	5026	3151.300	-0.001	9	BS	
	5026	3151.304	+0.003	6	HO	
	5057	3188.358	+0.004	9	AG	
	5062	3194.334	+0.004	5	AG	
	5093	3231.368	-0.015	6	AG	
	5221	3384.373	-0.001	5	AG	
	5262	3433.384	+0.005	7	HO	
	5333	3518.231	-0.011	8	BS	
	5360	3550.515	+0.002	12	TY	
	5406	3605.495	0.000	10	NR	
	5529	3752.515	+0.004	7	NR	
	5559	3788.370	+0.002	6	PJ	
	5589	3824.212	-0.014	8	BS	*
TV CAS	12606	2967.484	-0.027	7	BS	
	12627	3005.583	+0.007	6	BS	
	12633	3016.443	-0.008	10	BS	
	12735	3201.332	-0.007	5	HO	
	12756	3239.386	-0.016	10	BS	
	12863	3433.341	-0.010	7	HO	
	12905	3509.456	-0.026	11	BS	
	13043	3759.593	-0.029	10	BS	
TW CAS	16758	3759.512	-0.016	16	BS	
	16765	3769.522	-0.003	18	BS	
	16767	3772.379	-0.004	11	BS	
DO CAS	14388	3777.428	-0.003	9	BS	
U CEP	1809	2801.447	+0.033	8	TY	
	1870	2953.529	+0.041	15	KG	
	1874	2963.493	+0.033	6	BS	
	1884	2988.444	+0.053	9	BS	
	1949	3150.473	+0.034	12	KG	
	1953	3160.443	+0.032	11	KG	
	1953	3160.444	+0.033	8	HO	
	2020	3327.493	+0.049	5	AG	
	2093	3509.488	+0.051	11	BS	
VW CEP	34649	2807.330	-0.066	7	BS	
	34692	2819.287	-0.077	6	BS	

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER
VW CEP	34703	2822.330	-0.095	4	BS
	34760.5	2838.354	-0.075	5	BS
	34764	2839.334	-0.068	6	BS
	34778.5	2843.359	-0.079	6	BS
	34872	2869.431	-0.030	6	BS
	34940.5	2888.467	-0.058	5	BS
	34944	2889.425	-0.075	11	KG
	35163.5	2950.497	-0.093	6	BS
	35188.5	2957.482	-0.067	4	BS
	35192	2958.478	-0.045	5	BS
	35203	2961.502	-0.083	6	DT
	35203	2961.520	-0.064	8	BS
	35206.5	2962.489	-0.070	6	BS
	35224.5	2967.481	-0.087	6	DT
	35224.5	2967.487	-0.081	6	BS
	35249.5	2974.451	-0.075	5	DT
	35274.5	2981.463	-0.021	5	BS
	35275	2981.562	-0.061	5	BS
	35289	2985.461	-0.058	7	DT
	35300	2988.515	-0.066	6	BS
	35310.5	2991.425	-0.078	4	BS
	35364.5	3006.455	-0.078	8	DT
	35368	3007.431	-0.075	5	DT
	35382.5	3011.434	-0.108	5	TY
	35382.5	3011.472	-0.070	5	DT
	35389.5	3013.414	-0.076	5	TY
	35389.5	3013.417	-0.074	7	BS
	35390	3013.563	-0.067	8	BS
	35393	3014.387	-0.078	6	DT
	35490	3041.419	-0.042	5	BS
	35515	3048.334	-0.085	7	BS
	35676.5	3093.301	-0.066	5	HU
	35687.5	3096.335:	-0.094:	7	TY
	35849	3141.310	-0.067	7	BS
	35849.5	3141.451	-0.066	6	BS
	35964	3173.313	-0.071	7	BS
	35964.5	3173.438	-0.085	7	BS
	35965	3173.575	-0.087	7	BS
	36065	3201.421	-0.073	5	DT
	36201.5	3239.415	-0.069	8	BS
	36209	3241.488	-0.084	6	TY
	36288	3263.456	-0.103	5	TY
	36288.5	3263.585	-0.113	3	TY
	36367	3285.469	-0.077	7	BS
	36845	3418.488	-0.094	8	HO
	36848	3419.349	-0.067	6	HO
	36866	3424.321	-0.106	6	HO
	36891	3431.305	-0.080	6	HO
	36909	3436.321:	-0.074:	7	HO
	36995	3460.262	-0.068	6	BS
	37128	3497.274	-0.072	7	BS
	37197	3516.480	-0.070	6	BS
	37488	3597.471	-0.069	6	BS
	38013	3743.578	-0.079	5	BS
	38070	3759.478:	-0.043:	10	BS
	38073.5	3760.456	-0.040	6	BS
	38177.5	3789.338:	-0.102:	8	IS

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER	
EI CEP	730.5	2985.460	+0.037	8	DT	
	733	3006.460	-0.061	11	DT	
	744	3099.354	0.000	7	TY	
	749	3141.470	-0.081	11	BS	
	801	3580.369	-0.028	8	TY	
	821.5	3753.420	+0.015	7	NR	
	824	3774.489	-0.014	15	BS	
EK CEP	967	3284.416	+0.020	4	TY	
GK CEP	4889	2802.581	-0.045	6	KG	
	5047	2950.497	-0.044	6	BS	
	5054.5	2957.506	-0.056	4	BS	
	5055.5	2958.501:	+0.003:	5	BS	
	5118.5	3017.522	+0.045	11	BS	
	5206	3099.359	-0.033	6	TY	
	5361	3244.481	-0.017	8	TY	
	5486	3361.450	-0.070	7	AG	
	5510.5	3384.403	-0.053	5	AG	
	5738	3597.386	-0.049	16	BS	*
	5738	3597.411	-0.024	9	AG	*
	5894	3743.435	-0.043	11	BS	
	5911	3759.354	-0.039	12	BS	
	5925	3772.448	-0.051	17	BS	
U CRB	7595	2967.422	-0.033	14	BS	*
Y CYG	11279.5	3331.522	+0.063	7	BS	
	11300.5	3394.413	+0.032	10	BS	
	11307.5	3415.392	+0.036	8	HO	
	11308.5	3418.411	+0.058	10	HO	
	11310.5	3424.363	+0.018	11	HO	
	11313.5	3433.363	+0.029	7	HO	
	11314.5	3436.353	+0.022	6	HO	
	11322.5	3460.320	+0.019	12	BS	
	11403	3701.492	-0.014	6	NR	
	11404	3704.495	-0.007	5	NR	
	11406	3710.478	-0.017	5	NR	
	11415	3737.435	-0.027	5	BS	
	11417	3743.438	-0.017	10	BS	
	11420	3752.431	-0.012	6	NR	
	11459	3869.289	-0.011	7	BS	
V477 CYG	4312	2966.481	-0.017	6	BS	
	4332	3013.416	-0.022	7	TY	
	4332	3013.431	-0.007	13	BS	
	4335	3020.469	-0.010	5	BS	
	4378	3121.375	-0.025	8	KG	
V1143 CYG	2338	3366.495:	+0.024:	12	BS	
V1425 CYG	2692	3772.355	-0.015	9	BS	
	2696	3777.374	-0.005	10	BS	
TW DRA	3189	2839.510	-0.050	10	BS	
	3251	3013.546	-0.041	15	BS	
	3308	3173.534	-0.044	16	BS	
	3459	3597.383	-0.032	11	BS	

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER	
AI DRA	3155	2839.686	+0.017	7	BS	
	3270	2977.538	+0.006	7	TY	
	3300	3013.510	+0.013	10	BS	
	3310	3025.473	-0.012	11	KG	
	3622	3399.518	+0.004	7	BS	
	3909	3743.575	0.000	8	BS	
	3933	3772.360	+0.014	8	BS	
BV DRA	9411.5	3657.444	+0.009	11	IS	*
S EQU	1452	2957.522	+0.001	4	BS	
	1461	2988.463	+0.017	9	BS	
	1571	3366.452:	+0.037:	8	2	*
Z HER	7479	2948.507	-0.001	4	BS	
	7486	2976.461	+0.004	5	TY	
	7489	2988.438	+0.001	9	BS	
	7489	2988.458	+0.022	5	TY	
	7495	3012.403	+0.010	5	TY	
	7496	3016.409	+0.023	6	TY	
	7504	3048.322:	-0.007:	7	BS	
RX HER	5468.5	2896.528	+0.007	4	TY	
	5514	2977.451	+0.004	9	TY	
	5961	3772.459	-0.009	8	BS	
	5970.5	3789.359	-0.005	8	IS	
TX HER	6292	3285.528	+0.002	6	TY	
	6443.5	3597.566	-0.022	10	TY	
u HER	18117	2988.478	-0.008	9	BS	
	18135	3025.403	-0.002	6	KG	
	18449.5	3670.432:	-0.021:	13	IS	*
AR LAC	8165	2817.339	+0.003	8	BS	
	8166	2819.336	+0.016	6	BS	
	8278	3041.454	+0.014	6	BS	
	8338	3160.422	-0.011	9	KG	
	8456	3394.471	+0.018	10	BS	
	8523	3527.326	-0.002	6	TY	
	8526	3533.292	+0.014	7	TY	
	8632	3743.508	+0.010	15	BS	
	8640	3759.380	+0.015	16	BS	
UV LEO	8003.5	3243.466	-0.046	5	BS	
	8005	3244.408	-0.004	8	TY	
	8010	3247.397	-0.016	9	BS	
	8565	3580.442:	-0.017:	8	TY	
	8593.5	3597.550	-0.012	13	BS	
BETA LYR	3438	3014.18	+45.47	78	5	*
	3438.5	3020.43	+45.26	60	5	*
	3465	3363.45	+46.22	48	2	*
	3465.5	3369.83	+46.15	44	2	*
U OPH	20604	2839.673	-0.005	6	BS	
	20877.5	3298.453	+0.021	5	BS	

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER	
U OPH	20889.5	3318.543	-0.017	6	BS	
	20896	3329.468	+0.005	6	BS	
V451 OPH	4003	2958.508	+0.044	5	BS	
	4013.5	2981.541	+0.012	10	BS	
	4201.5	3394.466	-0.023	7	BS	
V566 OPH	18538.5	2839.695	+0.021	6	BS	
	18809	2950.519	+0.037	7	BS	
	18826	2957.482	+0.036	4	BS	
	18828.5	2958.500	+0.030	5	BS	
	18836	2961.561	+0.019	8	BS	
	18848	2966.485	+0.027	6	BS	
	18850.5	2967.510	+0.028	7	BS	
	18875	2977.552	+0.034	9	TY	
	18880	2979.571	+0.005	6	BS	
	18909	2991.490	+0.044	5	BS	
	18970	3016.458	+0.024	8	BS	
	19048	3048.347	-0.039	8	BS	
	19527	3244.628	+0.024	7	TY	
	19658.5	3298.491	+0.019	5	BS	
	19739	3331.493	+0.045	7	BS	
	20730	3737.405	+0.003	9	BS	*
	20808	3769.374	+0.020	10	BS	
ER ORI	16555.5	3518.351	-0.047	7	BS	
AW PEG	1587	3401.515	+0.065	7	BS	
	1619	3741.426	+0.055	5	BS	
EE PEG	3196	3022.405	+0.046	8	BS	
DM PER	3567	2981.524	+0.026	10	BS	
	3582	3022.421	+0.007	8	BS	
	3758	3502.524	+0.030	8	BS	
	3857	3772.563	+0.024	17	BS	
IQ PER	1674	3141.351	+0.022	13	BS	*
	1822	3399.385	+0.008	9	BS	*
	1857	3460.407	+0.005	9	BS	*
	1887	3512.716	+0.007	8	BS	*
	1935	3596.399	-0.001	5	BS	*
	2036	3772.503	+0.002	11	BS	*
IZ PER	4767	3150.464	+0.024	13	KG	
	4937	3777.349	+0.006	10	BS	
BETA PER	1171	2837.311	-0.049	8	BS	
	1178	2857.352	-0.080	6	VB	
	1254	3075.281	-0.073	11	AG	
	1261	3095.333	-0.093	8	TY	
	1261	3095.339	-0.087	7	BS	
	1268	3115.415	-0.083	8	AG	
	1298	3201.440	-0.079	10	AG	
	1298	3201.445	-0.074	6	HO	
	1382	3442.279	-0.101	8	AG	
	1394	3476.706	-0.083	7	NR	
	1403	3502.516	-0.079	8	BS	

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER	
BETA PER	1404	3505.354	-0.109	8	NR	
	1405	3508.235:	-0.095:	9	TY	
	1427	3571.307	-0.105	10	TY	
	1494	3763.429	-0.099	23	BS	*
	1525	3852.312	-0.104	9	TY	
SZ PSC	1760	3095.360	-0.016	4	TY	
	1761	3099.388	+0.045	6	TY	
	1852	3460.345	+0.063	6	AG	
	1852	3460.358	+0.078	12	BS	
U SGE	4081	2907.634	+0.007	12	BS	*
	4112	3012.431	+0.005	5	TY	
	4225	3394.441	+0.006	7	BS	
CD TAU	4679	2866.359	-0.062	7	BS	
	4760.5	3146.338	-0.047	9	BS	
	4762	3151.476	-0.061	8	KG	
	4762	3151.479	-0.058	13	BS	
HU TAU	8526	3173.292	+0.019	12	BS	
	8724	3580.431	+0.011	8	TY	
	8816	3769.634	+0.034	16	BS	
W UMA	12063	2817.395	-0.097	5	BS	
	12123	2837.412	-0.099	4	BS	
	12276	2888.487	-0.072	4	BS	
	12462	2950.502	-0.115	7	BS	
	12483	2957.500	-0.124	4	BS	
	12486	2958.511	-0.114	5	BS	
	12495	2961.512	-0.116	7	BS	
	12498	2962.522	-0.106	7	BS	
	12513	2967.526	-0.107	5	BS	
	12650.5	3013.404	-0.105	7	BS	
	12651	3013.567	-0.109	8	BS	
	13028.5	3139.518	-0.110	5	BS	
	13034	3141.341	-0.122	8	BS	
	13064	3151.366	-0.106	6	BS	
	13130	3173.379	-0.113	10	BS	
	13130.5	3173.550	-0.110	9	BS	
	13328	3239.442	-0.112	7	BS	
	13337	3242.438	-0.119	4	BS	
	13343	3244.433	-0.126	4	TY	
	13352	3247.444	-0.119	5	BS	
	13466	3285.487	-0.111	7	BS	
	14101	3497.343	-0.120	7	BS	
	14116.5	3502.525	-0.111	6	BS	
	14137	3509.358	-0.117	6	BS	
	14158	3516.361	-0.121	7	BS	
	14350	3580.399	-0.143	7	TY	
	14398	3596.450	-0.107	7	BS	
	14401	3597.444	-0.113	7	BS	
	14839	3743.569	-0.126	6	BS	
	14887	3759.580	-0.130	7	BS	
	14905	3765.585	-0.131	7	BS	
	14926	3772.581	-0.142	8	BS	
TX UMA	1409	3509.422	+0.003	9	BS	

STAR	EPOCH	HELIO JD 244...	O - C	No	OBSERVER	
W UMI	5887	3472.386	-0.087	14	2	*
	5914	3518.366	-0.041	9	BS	
Z VUL	7101	2888.564	+0.017	5	BS	
	7461	3772.335	+0.015	10	BS	
RS VUL	2268	2963.544	-0.054	8	BS	
	2448	3769.591:	+0.014:	24	BS	*

CHANGES OF ADDRESS

A. Markham - 33 Church Drive, Leven, Hull, East Yorks.
HU17 5LH

Col. J.E.S. Singh - Nehru Planetarium, Teen Murti House,
New Delhi - 11011, INDIA

P.B. Withers - 4 Cranborne Gardens, Millers Dale,
Chandler's Ford, Eastleigh, Hants. SO5 1TA

NEW MEMBERS

R. Dudley, Wayside, Flexton, York YO6 7RN

G. Johnson, 14 Heathfield Avenue, Cattisfield, Fareham,
Hants. PO15 5QA

R. Lewis, 15 Ivy Dale, Lisvare, Cardiff CF4 5RT

T. Robinson, 3 Roylance Drive, Middlewich, Cheshire CW10 9

SECTION OFFICERS:

Director	D.R.B. Saw, 'Upanova', 18 Dollicott, Haddenham, Aylesbury, Bucks. HP17 8JG Tel: Haddenham (0844) 292065
Assistant Director	S.R. Dunlop, 140 Stocks Lane, East Wittering, nr Chichester, West Sussex PO20 8NT Tel: Bracklesham Bay (0243) 670354

Programme Secetaries:

Secretary	M.D. Taylor, 17 Cross Lane, Wakefield, West Yorkshire WF2 8DA Tel: Wakefield (0924) 374651
Assistant Secretary Telescopic	G.A.V. Coady, 15 Cedar Close, Market Deeping, Peterborough PE6 8BD Tel: Market Deeping (0778) 345396
Assistant Secretary Binocular	J. Toone, 2 Hilton Crescent, Boothstown, Worsley, Manchester M28 4FY Tel: 061 702 8619
Eclipsing Binary Secretary	J.E. Isles, Flat 5, 21 Bishops Bridge Road, London W2 6BA Tel: 01 724 2803
Nova/Supernova Search Secretary	G.M Hurst, 16 Westminster Close, Kempshott Rise, Basingstoke, Hants. RG22 4PP Tel: Basingstoke (0256) 471074
Chart Secretary	J. Parkinson, 229 Scar Lane, Golcar, Huddersfield, West Yorkshire

CIRCULARS

Charges: (4 issues)	U.K. & Eire - £2 for Circulars and light-curves Other countries - £3

Payments (made out to the BAA) and material for inclusion should be sent to Storm Dunlop.

CHARTS

Charges: Main programme - SAE plus 20p per star (4 charts)
All other programmes - SAE plus 5p per star (1 sheet)