A MAGYAR TUDOMÁNYOS AKADÉMIA CSILLAGVIZSGÁLÓ INTÉZETÉNEK KÖZLEMÉNYEI

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PHOTOELECTRIC OBSERVATIONS OF THE 1955—56 ECLIPSE OF ZETA AURIGAE

by
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Since the discovery of ζ Aurigae as an eclipsing binary in 1932, the principal eclipse is a standard object for photoelectric photometry. Three periods being approximately equal to eight years, the eclipses regularly occur on the same season of the year, one being in December—January, one in August—September, and one in April—May, but only the winter eclipses are favourably placed in zenith distances and are completely observable. After having observed the (unfavourable) 1950 eclipse [1] I planned a thorough two colour photoelectric investigation of the winter eclipse in 1955—56. Unfortunately, atmospheric conditions were unusually bad during the whole season and I succeeded only in observing the *partial phase at egress* on Jan. 16—17.

The instrument used was the 24-inch reflecting telescope equipped with a 1P21-type R. C. A. multiplier phototube. As a rule, no amplification of the photocurrent was used. The filters were Schott BG12 (blue) and Schott GG11 (yellow). Comparison star was η Aurigae.

The choice of η Aurigae as comparison star is somewhat problematic and needs some apology. There is a great magnitude difference in blue light between ζ and η Aurigae and, in addition, the star η is a suspected variable (See e. g. *Kron*'s article [2].) Nevertheless, the question of occasional light variations of η Aurigae is not yet settled and the observations of *Brück* and *Green* in 1939 [3] and those of *Detre* and *Herczeg* in 1950 [1] are in good agreement with measurements based on the use of other comparison stars. On the other hand, increasing difficulties in the calculation of atmospheric extinction can be mostly avoided by the relative proximity of η and ζ Aurigae.

Unfavourable weather conditions prevented observations before the eclipse and during the ingress partial phase. Further, it was not possible to get more than one single set of measures during totality. Owing to the well-known intrinsic variations of the K-type component, it seemed necessary to determine the amplitude of the eclipse independently, by fixing the isophotic wave length of the instrument. This I made on the base of the „Göttinger Spektralphotometrie" of *Kienle, Strassl* and *Wempe* [4]. Using their data I got by intercomparing of α, β and γ Ursae Majoris for the isophotic wave length

in blue light: 4340 Å,

in yellow light: 5520 Å,

and without filter: 5140 Å, a surprisingly great wave length as compared with that of the older RCA931A multiplier tube used in 1950.* The above values give for the photometric amplitude of the eclipse

in blue light $0{,}69^m$

in yellow light $0{,}14^m$, in good agreement with the amplitude actually observed.

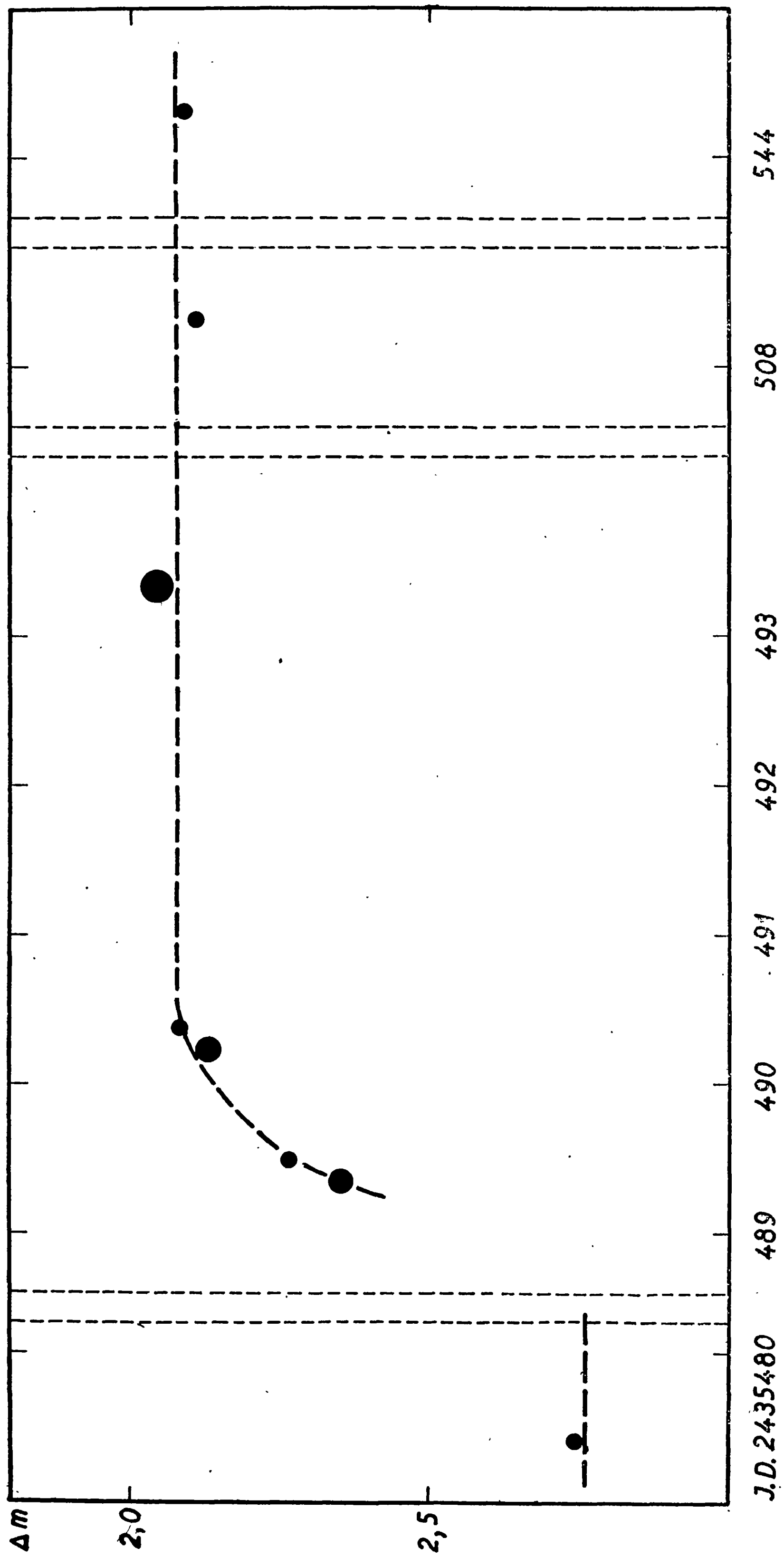
The observations are tabulated below, the columns are self-explanatory. One observation means the arithmetical mean of eight successive galvanometer readings, covering a time interval of about five minutes. Probable errors of normal points, derived from 2—4 three observations are of the order of $\pm$ $0{,}008^m$.

Obs. Number.	J. D (heliocentric)	Number* of Obs.	$\Delta m = m_\zeta - m_\eta$		Atmospheric condition
			blue	yellow	
1	2435479,402	1		0,744	good
2	479,410	1	2,744		,,
3	489,347	2	2,355		,,
4	489,359	2		0,642	,,
5	489,483	1	2,267		fair
6	489,487	1		0,623	,,
7	490,235	2	2,128		,,
8	490,238	2		0,634	,,
9	490,366	1		0,586	,,
10	490,370	2	2,081		,,
11	493,325	2		0,579	moderate ; Moon
12	493,336	5	2,043		,, ,,
13	508,320	1	2,106		good
14	508,323	1		0,622	,,
15	2435544,314	1	2,088		poor

The approximate character of light variation in *blue* light is illustrated by the accompanying figure. The graph is simply an interpolating curve drawn through the normal points and cannot be interpreted as a light curve in the proper sense of the word. The broken line indicates the „theoretical" amplitude corresponding to the isophotic wave length.

These rather scanty observations of the 1956 eclipse hardly give us the right to discuss finer details of the light variation. It is, however, possible to compare this particular result with photometric data of the earlier eclipses. Instead of barely comparing the present observations with the various predictions I give a brief survey of all the well-observed eclipses in order to get revised photometric elements for the system.

* We note that in our paper on the 1950 eclipse [1] the isophotic wave length is erroneously printed as 4800 Å instead of the correct value 4880 Å.


Δm
2,0
2,5
J.D. 2435480
489
490
491
492
493
508
544

The critical point is undoubtedly the length of the partial phase, i. e. the value $\frac{1}{2}$ (D—d), with the familiar notation. The various solutions give values differing considerably, from about 0,8 day to about 1,5 day. This question is closely connected with the physical nature of the eclipses in this remarkable binary system and cannot be solved on the basis of photometric observations alone. Therefore in the following discussion *I adopted 1,3 day* for the duration of the partial phase. This means — broadly speaking — the acception of a concept of a gradual dimming of the light of the B-type component instead of a sharp „cut-off".

As it is evident from even a superficial inspection of the published light curves, the exact date of contacts is highly ill-defined, due to the departure from a linear decrease (increase) of light. Moreover, the shape of the light-curve is dependent on the colour-sensitivity of the instrument used. But linear decrease (increase) holds well in the central part of descending (ascending) branch of the light-curve.

I based therefore the following discussion not on the dates of the contacts, but on the „middle" points of the descending (ascending) branch, where the fractional loss of light is 0,5 (1,0 being the total amplitude). Excluding ultraviolet observations there is no reason to suppose that this date is perceptibly dependent on the isophotic wave-length.

In the case of the well-observed eclipses in 1934, 1939 and 1947—48 the determination of these points on the light curve and independently of the epoch of mid-eclipse involves no difficulties. For the eclipses in 1937, 1950 and 1955—56 we have no complete light-curves, but only isolated points during partial phase. I used these single observations assuming a linear light-variation the rate of which is defined by the adopted duration of the partial phase and getting the above mentioned „middle" points simply by extrapolation. Departure from linear light variation just after the first contact, before second contact etc. makes it necessary to consider a somewhat steeper elevation of the light-curve; I had taken 4,17 per cent pro hour instead of the 3,21 per cent pro hour, corresponding to the duration of 1,3 day (see e. g. *Wellmann*'s light-curve [5]). In most cases the difference thus involved is not significant, being of the order of one and a half hour only.

I have considered all photoelectrically observed eclipses and the „basic" eclipse in 1934. The discussion is based on the following data, „egress" and „ingress" meaning always points where the loss of light is 50 per cent.

1934: *ingress, egress, mid-eclipse* (*Wellmann*'s light-curve [5])

1937: *ingress*, (*Schneller*'s photoelectric observation on Apr. 21. secured at very great zenith-distance [6]).

1939—40: *ingress* (*Kopal*'s composite light-curve [7]), *mid-eclipse* (based essentially on *Kron*'s measurements [2]).

1947—48: *ingress, egress* from *Pettit*'s observations [8], *mid-eclipse* adopted as the mean of data due to *Pettit, Wood* [9] and *Kron* [10], the latter being a little discordant.

1950: *ingress, egress* (extrapolated from the observations of *Detre* and *Herczeg* [1] and of *Beer* and *Ovenden* [11], respectively).

1956: *egress*, based on Budapest observations of this year.

As it turned out, all these observations can be represented with reasonable accuracy by taking a period of 972,176 days. The corresponding (O—C)-values are tabulated below (given in the decimals of a day).

	1934	1937	1939—40	1947—48	1950	1955—56
Ingress	0,0[1]	—0,23[2]	—0,12	+0,05(5)	+0,08	
Mid-eclipse	0,0[1]		—0,01	—0,03[3]		
Egress	0,0[1]			—0,03	0,0	—0,02(5)

There are indications that the diameter of the K-type component was really overnormal at the 1939—40 eclipse, while it was perhaps slightly below the normal in 1947—48, but the difference must be on the very limit of detectability by the aid of photometric methods.

After having accepted 972,176 days for the period, it is possible to compare also different eclipses in order to derive values for D and d. Disregarding the unfavourable eclipse in 1937, giving the weight $\frac{1}{2}$ to the data of the possibly „abnormal" eclipse in 1939—40 and giving the weight 2 to values derived *from one and the same eclipse* (and therefore not affected by a possible uncertainty in the period), we get finally the following set of photometric elements, very similar to those of *Christie* :

Period: $P = 972^{d}_{,}176$

Epoch of minimum light: J. D. 2432553,61 (for the 1947—48 eclipse)

Duration of eclipse: $D = 39^{d}_{,}50$

Duration of totality: $d = 36^{d}_{,}90$

$$\frac{1}{2}\ (D—d) = 1^{d}_{,}3 \text{ (adopted!)}$$

This system of elements is based on all the available photoelectric data since 1937 and on the very carefully observed eclipse in 1934.

I am greatly indebted to *Dr. L. Detre*, Director of the observatory, for his continuous help and taking interest in my work and also to *Mr. Zs. Bányai* and *Mr. M. Lovas* for their very effective coöperation in making the observations.

[1] L. Detre, T. Herczeg, Budapest Mitt Nr. 29. [2] G. E. Kron, P. A. S. P. *52.* 124, 1940. [3] H. A. Bruck—H. E. Green, L'Astronomie *54,* 38, 1940. [4] H. Kienle, H. Strassl, I. Wempe, Z. f. Ap. *16,* 201, 1938. [5] P. Wellmann, Veröff. Berlin Babelsberg, Bd XII. Heft 4. [6] P. Guthnick, H. Schneller, O. Hachenberg, A. N. *262,* 429, 1937, [7] Z. Kopal, Ap. J. *103,* 310, 1946. [8] E. Pettit, P. A. S. P. *60,* 102, 1948. [9] F. B.. Wood, A. J. *56,* 53, 1951. [10] See [11] data of the article in J. R. A. S. Canada, Vol. *43.* [11] A. Beer, M. W. Ovenden, Ap. J. *113,* 439, 1951.

[1] By assumption.
[2] Very uncertain value.
[3] Taking only the concordant values of *Pettit* resp. *Wood,* the (O—C) is + 0,02

A SHORT NOTE ON 32 CYGNI

by

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This ζ Aurigae-type system was observed photometrically in Budapest during its eclipse in 1952—53. Instrument and photoelectric equipment were the same as in the case of the 1950 eclipse of ζ Aurigae. Comparison star was 31 Cygni. The observations on Dec. 23. and 24. fall on the phase of totality; at the date of the later measurements in January the eclipse was over.

The only published observations are those of Wood and Lewis (A. J. *59.* 119, 1954.), indicating a decrease of light in ultraviolet corresponding to the beginning of ingress. In blue and yellow light neither the Flower Observatory measurements nor the Budapest observations show any trace of the usual light-curve for eclipsing binaries. Photometric data are indicating an irregular or semi-irregular light variation of about $0\overset{m}{,}25$ in yellow light, slightly resembling on a sinusoidal cycle of about two-month length. Beyond doubt the unusually great zenith distance seriously reduces the observational accuracy but there is no reason to attribute the uncertain character of light variation to errors of observation. Variations in blue and yellow light are ranning closely parallel (except the single evening on Dec. 24.).

The eclipse-amplitude in blue and yellow light is obviously very small and is completely masked by erratic fluctuations of the late giant component.

For the sake of completeness I give here the table of observational data:

Obs. Number	J. D. (heliocentric)	Number of Obs.	Δm (blue)	Δm (yellow)	Atm. conditions
1	2434370,23	2	—	0,300	moderate; Moon
2	370,24	1	0,627	—	poor; Moon
3	371,20	1	0,615	—	moderate; Moon
4	371,21	2	—	0,179	moderate; Moon
5	392,21	1	—	0,211	good
6	392,21	1	0,504	—	„
7	393,23	1	—	0,268	moderate
8	393,24	1	0,599	—	„
9	398,22	1	—	0,255	good
10	398,23	2	0,584	—	„

The writer is much indebted to *Mr. J. Elter*, workshop manager of the observatory for his kind help in making the observations, for over his official working-hours.

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