THE PHOTOELECTRIC ELEMENTS OF AS CAMELOPARDALIS

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Abstract. Improved geometrical elements of the system AS Cam have been obtained and the colour of the system has been discussed. The absolute dimensions have also been obtained on the basis of the spectroscopic elements given by Hilditch (1972). Both components are found to lie fairly on the Main Sequence. The system is a detached one.

1. Introduction

The eclipsing binary AS Cam (=BD+69°325=HD 35311=BV 268) was discovered and studied by Strohmeier (1959, 1963). On the basis of photographic observations, Strohmeier and Knigge announced the system to be apparently of Algol type with a period of $1^d.715490$ (Koch *et al.*, 1963). Hilditch (1969), on the basis of his photoelectric observations, announced the period of the system to be $3^d.4309714$, which is almost double the previously assigned period. Recently, Hilditch (1972) has also derived the photoelectric light elements. The star was also observed photoelectrically by us with the 38-cm reflector of Uttar Pradesh State Observatory, a total of 18 nights of observations having been secured during the period December 1969–February 1971. Our findings in respect of this system differ from those of Hilditch in the following respects:

(i) our observations do not show the possibility of the presence of a third body with consequently brighter values for the light of the secondary component;

(ii) we do not find any significant asymmetry in the ascending and the descending branches of the secondary minimum (see Figures 2a, b, c);

(iii) we do not find any specific lowering or increase in the brightness at some of the phases. Also, Hilditch's observations have been reported on the instrumental system, while ours are being reported on standard *U*, *B*, *V* system. For these reasons, these results are being published.

2. The Observations

The light of the star was fed to an unrefrigerated 1P21 photomultiplier and the photocurrent recorded using standard DC techniques. The conventional *U*, *B*, *V* filters of the Johnson and Morgan system (1953) were used.

The particulars of the stars are given in Table I. The range of the nightly standard deviations for the comparison star in *U*, *B*, and *V* filters are $0^m.010$ to $0^m.025$, $0^m.011$ to $0^m.019$ and $0^m.009$ to $0^m.022$, respectively, with means as given in the last column of

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TABLE I

Particulars of the stars

Star	α_{1900}	δ_{1900}	M_v	S_p	Average standard deviation of an individual observation in U, B and V filters
Variable star AS Cam = BD+69°325 = HD 35311	$05^h18^m.8$	+69°25′	$8^m.2$	A0	–
Comparison star BD+69° 317 = HD 34463	$05^h12^m.5$	+69°28′	$8^m.0$	A5	$\pm 0^m.019$ (U) $\pm 0^m.009$ (B) $\pm 0^m.011$ (V)

Table I. The data were reduced to the standard system from observations of twenty-four standard stars taken from the list of Johnson and Morgan (1953). A total of 447 observations in U, 458 in B and 456 in V have been obtained and discussed.

3. Epoch and Period

On the basis of the epoch of primary minimum = JD 2440204.5137 given by Hilditch (1969) and our observations, the period of the system does not appear to be significantly different from that given by Hilditch. We have, therefore, adopted the period of $3^d.4309714$ given by him.

During the course of our observations three primary and three secondary minima were observed. The epochs, determined by the graphical method, to an accuracy of $0^d.001$ are listed below:

Observed minima of AS Cam

Primary minima, JD(Hel)	Secondary minima, JD(Hel)
(1) 2 440 911.297	(1) 2 440 957.393
(2) 2 440 959.327	(2) 2 440 988.276
(3) 2 440 990.202	(3) 2 440 995.138

4. General Discussion of the Light Curves

The primary minimum has depths of $0^m.735$ in U, $0^m.655$ in B and $0^m.620$ in V filters respectively while the secondary minimum has depths of $0^m.335$ in U, $0^m.395$ in B and $0^m.395$ in V filters. The light curves in U, B and V filters are given in Figure 1.

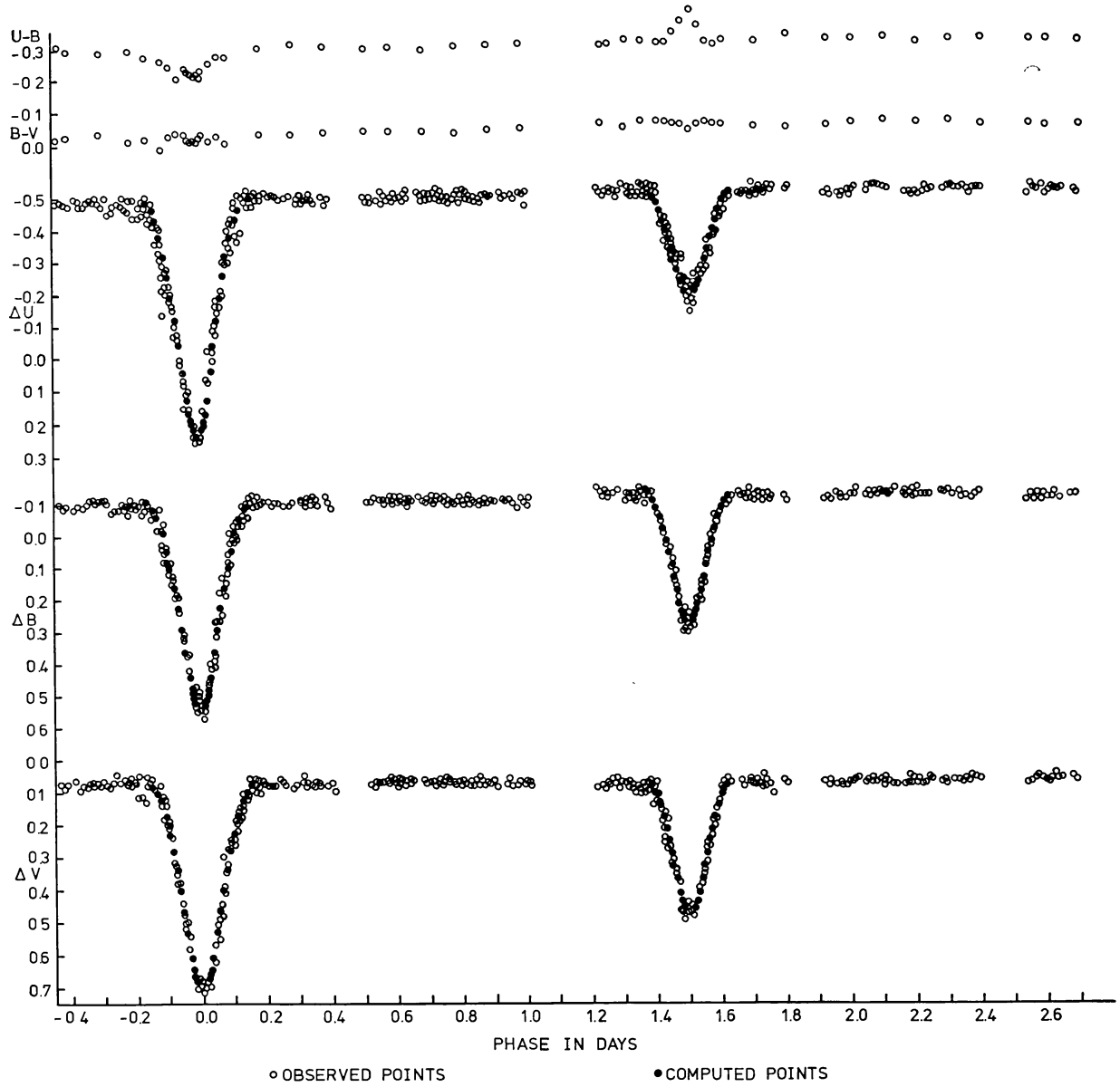

Fig. 1. Light and colour curves of AS Cam.

Following Irwin (1960), in order to decide definitely on the nature of the primary eclipse, we have compared the computed values of τL_g, the light lost at internal tangency, with the observed ones. We find that the light at internal tangency differs by 0.019, 0.014 and 0.001 in U, B and V filters respectively (accuracy ± 0.005 in terms of the intensity). We conclude that the primary eclipse is an annular one and the secondary is an occultation (total). Plots of the secondary minimum in U, B and V filters also show totality.

5. Determination of Elements

The elements have been determined with the help of Merrill's tables (1950) of the

ψ-function, the procedure described by Russell and Merrill (1952) having been followed. The solution has been derived on the basis of darkened discs and the value of the limb darkening coefficient is chosen as $x=0.4$ for both the eclipses. The value of $k=0.75\pm0.01$ was arrived at after trials for computation of elements because the theoretical light curves computed on that basis agree well with the observations. The value of $k=0.75$ was given by assuming $1-\lambda_p=0.475$, 0.440 and 0.425 and $1-\lambda_s=$ 0.245, 0.295 and 0.295 (in terms of the intensity outside the eclipse as unity) for U, B and V light curves respectively. The solution of the two minima did not require any rectification of the light curve.

The primary minimum has the χ-values of 0.318, 0.310 and 0.323 in U, B and V filters, while the secondary minimum has the χ-values of 0.347, 0.347 and 0.337 in these respective filters.

These values indicate that $\chi^{sec}>\chi^{pr}$, confirming that the secondary eclipse is an occultation while the primary eclipse is a transit one. The nomographic solution for these χ-values indicates that none of the eclipses is partial. The mean duration of total-

TABLE II

Elements of AS Cam

Element	U filter	B filter	V filter	Mean of the U, B and V filters
$1-\lambda_1$	0.475	0.440	0.425	
$1-\lambda_2$	0.245	0.295	0.295	
$4\tau L_g$	0.456	0.426	0.426	
L_1	0.755	0.705	0.705	
L_2	0.245	0.295	0.295	
$\frac{J_1}{J_2}$	1.938	1.492	1.441	1.622
i	87°.7	87°.6	87°.7	87°.7
r_1	0.159	0.164	0.162	0.162
r_2	0.119	0.123	0.122	0.121
θ_e(pr)	16°.1	16°.6	16°.4	16°.4
θ_e(sec)	13°.0	12°.7	12°.5	12°.7
θ_i(pr)	1°.7	1°.9	1°.9	1°.8
θ_i(sec)	1°.7	1°.2	1°.9	1°.6
d_1	0P.0894	0P.0922	0P.0911	0P.0909
d_2	0P.0722	0P.0706	0P.0695	0P.0708
ω	231°.6	231°.6	231°.6	231°.6
e	0.144	0.163	0.165	0.157

$x=0.4$ (assumed)
$P=3^d.430\ 971\ 4$ (Hilditch)
Duration of totality $=0^d.03$ (correct to the second decimal place)
$k=0.75$
$p_0=-1.0$
$\alpha_0^{oc}=1.0$
$\alpha_c^{tr}=1.0227$

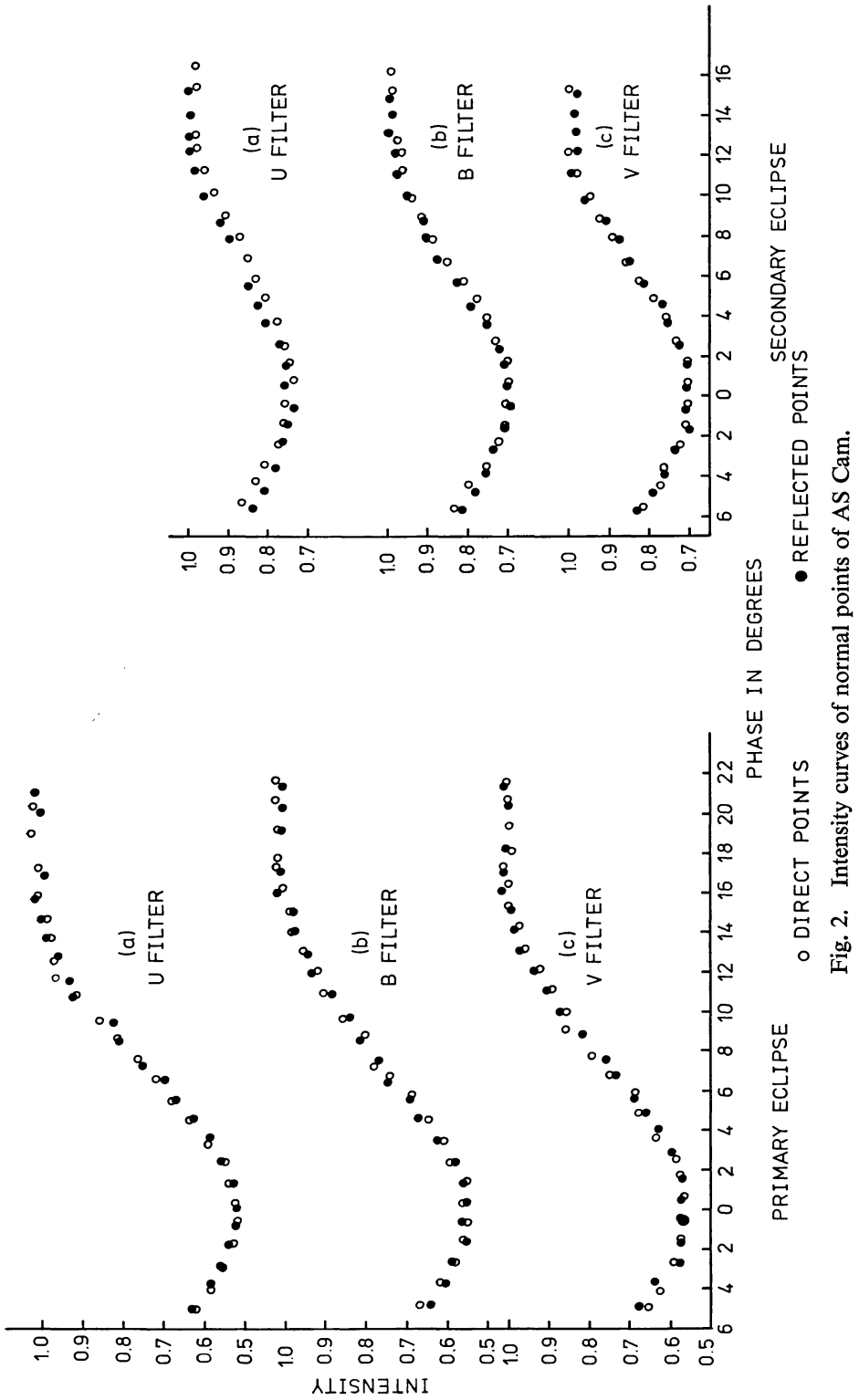

Fig. 2. Intensity curves of normal points of AS Cam.

ity for U, B and V filters of the primary minimum is $0^d.034$ (49^m), while that for the secondary minimum is 0.030 (43^m).

Our observations show that the secondary minimum falls at phase $+1^d.4994$ or $0^p.43702$. The system belongs to the third category of eccentric orbits (Binnendijk, 1960), where $i=90°$ in which the orientation of the major axis is in some general direction. One should then find both a phase shift and unequal durations of the minima.

TABLE III

Absolute dimensions of AS Cam

Elements	Primary	Secondary
A ($R_\odot$)	17.7	17.7
m ($\odot$)	3.3	2.5
R ($\odot$)	2.86	2.14
ϱ ($\odot$)	0.15	0.28
T_e K (assumed)	12300	11400
M (bol)	$-0^m.88$	$+0^m.18$
M (vis)	$+0^m.04$	$+0^m.86$

The elements of the system are given in Table II, wherein the subscripts 1 and 2 refer to primary and the secondary component respectively. Next, using the spectroscopic elements given by Hilditch (1972), the absolute dimensions of the system have been determined, and are listed in Table III. The computed points determined from the relation,

$$\sin^2 \theta = A + B\psi,$$

where θ is the phase and A, B are constants derived from the individual light curves in U, B and V filters and have been plotted in Figure 1 as filled circles.

6. Colour and Luminosity Classification

The average colours of the comparison star, come out to be $B-V=+0^m.147$ and $U-B=+0^m.093$. These values indicate that the comparison star belongs to spectral class A5V (Arp, 1958), which agrees with the HD classification of the star. The colour of the system has been determined by taking differences of magnitudes at maxima from Figure 1 and to these differences, i.e. $\Delta(B-V)$ and $\Delta(U-B)$, the colours of the comparison star have been added to get the colours ($B-V$ and $U-B$) of the system. The colour of the secondary component has been determined by first finding its intensity in each filter (i.e. intensity at maximum minus intensity at the tip of the secondary minimum with the help of Figure 1), and then converting these intensities into respective magnitudes, the differences of which give the colour of the other component. The colour curves are shown in Figure 1, the sharp peak at mid-secondary minimum indicates the excess of $U-B$.

The following table summarizes the results:

	$B-V$	$U-B$	Spectral type
System	$-0^m.04$	$-0^m.29$	–
Primary component	$-0^m.04$	$-0^m.35$	B8.5V
Secondary component	$+0^m.29$	$-0^m.08$	–

The B–V and U–B values, covering the whole cycle, have been calculated and are plotted in Figure 1.

The spectral class of the secondary component is defined by considering its U–B value, which indicates that it belongs to spectral class B9.5. The classes assigned for the primary and the secondary components are thus in fair agreement with the photometric results of Hilditch (1972).

On plotting the quantities concerned on the (log m, log R) diagram (Kopal, 1955), we find that both components lie fairly on the Main Sequence. Also, when the values of bolometric magnitudes are plotted on the spectrum-luminosity diagram, following the data listed by Arp (1958), both components again appear to lie on the Main Sequence.

The values of Roche constants are derived and are given below:

$C_0 = 3.99$ (read from table, Kopal, 1959, p. 136).
$C_1 = 8.09$ $C_2 = 8.61$

Since $C_1 > C_0$ and $C_2 > C_0$, the system is a detached one.

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