COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS
Number 3207

Konkoly Observatory
Budapest
24 June 1988
HU ISSN 0374-0676

BLUE LIGHT CURVE OF VW Cep SYSTEM

VW Cep is one of the most frequently observed eclipsing systems. It is the brighter member of a visual binary (Hershey 1975) and has a light curve of W UMa type (subtype W). Variability of the period and shape of the light curve (Kwee 1966, Karimie 1983) is a reason of great interest in this system. By analyzing differences between the depths (heights) of two minima (maxima) Karimie obtained two different periods of changes for Δm_{min} and Δm_{max}. For Δm_{min} the suspected period is about 828 days while for Δm_{max} Karimie obtained a period of about 44 years. These data suggests that the changes of minima are connected with short time-scale changes of the system such as asynchronously moving spots or clouds, while the changes of maxima might be connected with longer time-scale changes, such as orbital motion of the eclipsing system around the third component (Hershey 1975, gives that orbital period as P≈30.5 years). Notice that the period of changes for Δm_{max} as estimated by Karimie is approximately four times greater than the "period" of changes of the orbital period of the system (Karimie 1983, gives 1931, 1941, 1961, 1971 as times when the orbital period changed abruptly). On the other hand, Hershey (1975) gives that the minimal separation between the eclipsing system and the third component took place at T=1966.48. It means that the sudden period changes occurred at the position of the third component around the eclipsing system about $\pm 90^{\circ}$ from the periastron.

The degree of contact is the most important thing in the investigation of physical status of VW Cep. Observations suggest that this parameter is not fixed, but changes on a time scale of a few years from detached to contact configuration (Lucy 1973, Rucinski 1973, Anderson et al. 1980, Leung 1980, Linnell 1980).

All the above mentioned peculiarities have encouraged us to make observations of the star.

Our observations include 171 measurements with b filter obtained on 5 nights between 16 March, and 5 May 1986. They were made at the Astronomical

Observatory of the Jagiellonian University in Cracow using the 35 cm Maksutov-type telescope with Russian photomultiplier FEU 92 and a blue Schott filter. The constancy of the primary comparison star BD+75°0889 was checked against the star BD+75°0884. It was constant within ±0.03 of a magnitude. The observations were corrected for atmospheric extinction using the mean coefficients for Cracow and reduced to the B magnitude of the Johnson-Morgan system.

The observations allowed to determine five moments of minima. The calculation of these moments was made by parabolic fitting to observational data. The errors δ_{JDhel} were calculated in the following way: for each observed magnitude m_i the "theoretical" (from fitted polynomial) time coordinate t_i was calculated, then the sum of squares $D=\sum_{i=1}^{N}\left[t_i - (JDhel)_i\right]^2$ was formed and δ_{JDhel} obtained from the formula: $\delta_{JDhel}=\left[\frac{D}{N^2}\right]^{1/2}$.

Adding to our results moments of minima obtained at our observatory by M. Banaczkowski (to be published) in the years 1985-1986 we obtained new elements of VW Cep assuming a constant period :

$$JDhel(Min)=2446467.4000 + 0\overset{d}{.}2783094\ E$$
$$\pm.0005 \qquad \pm.0000024$$

All the minima mentioned above and the corresponding O-C values are given in Table I.

Figure 1 presents all observations (comparison minus variable) as a function of the phase computed from elements given above. Unfortunately, not all parts of the light curve are covered with observation due to a bad weather that concerns mainly the max I.

The heights of both maxima (see Figure 1) show insignificant differences (but the small number of points within max I should be kept in mind). So, at the time of our observations (March-May 1986) the light curve of VW Cep was asymmetric, but the maxima were of similar heights. The asymmetry of the light curve manifests itself in an easily visible difference of slopes of ascending and descending branches of both minima and in a shift of secondary minimum (see also Karimie 1983 and Kwee 1966).

The normal points obtained by averaging measurements over 0.02 phase intervals were used for simulations of the light curve by the well known Wilson-Devinney program LC (Woodward and Wilson 1983).

For the bolometric albedo a and gravity darkening exponent g we have adopted the theoretical values for a convective envelope (Lucy 1973,

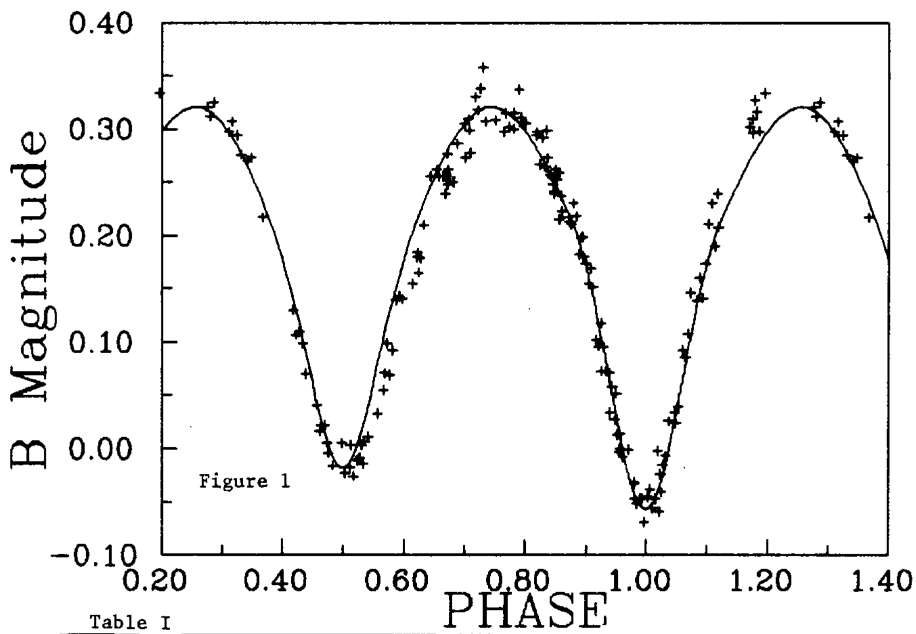

Figure 1

Table I

No	JDhel(Min) 24....	E	δ_{JDhel}	O-C	Filter
1	46373.3316	-338.0	0.0004	0.0002	V
2	46373.4712	-337.5	0.0001	0.0007	V
3	46378.4807	-319.5	0.0002	0.0006	V
4	46466.2828	-4.0	0.0005	-0.0039	V
5	46466.4262	-3.5	0.0001	0.0003	V
6	46467.2625	-0.5	0.0004	0.0017	V
7	46467.3995	0.0	0.0004	-0.0005	V
8	46506.6432	141.0	0.0005	0.0015	B
9	46508.3089	147.0	0.0003	-0.0026	B
10	46509.4247	151.0	0.0003	0.0000	B
11	46550.4754	298.5	0.0007	0.0000	B
12	46555.4869	316.5	0.0003	0.0020	B

(1-7) Banaczkowski (to be published)

(8-12) authors

Table II

i	q	f	T_1	T_2	x	a	g	l_1	l_2	l_3
67	0.41	0.03	5370	5280	0.83	0.5	0.08	0.314	0.644	0.042

Rucinski 1974). The coefficient of the limb darkening x for $T_{eff} \approx 5400$ K we adopted from Al Naimiy (1977). The brightness of the third light l_3 was taken into account following Linnell (1986). A value of mass ratio q we adopted according to Binnendijk (1967). The parameters fitted in our simulations were: inclination i, temperatures of both components T_1, T_2, the degree of contact. We started from semidetached systems (mode 4 and 5 of LV program) and fitting procedure always resulted in a contact configuration (mode 3). Fitting for a contact configuration showed a rather marginal contact, with degree of contact $f \approx 0.03$.

The temperature difference ΔT should be of order $\Delta T \approx 100$ K to fit depths of both minima and inclination is equal approximately to 67°. Table II lists the parameters given by our present best fit. The fit is plotted in Figure 1 as a solid line.

It may be interesting to find relationships between changes of the shape of the light curve, orbital period, motion around the third component and configuration status of the system. Such investigations may enable us to decide which model of the system is an adequate one, consistent with observations. Although VW Cep is a frequently observed object, the spectroscopic data are not sufficient to determine the fundamental physical and geometrical parameters well enough. More regular spectroscopic, astrometric and photometric observations of the system are needed.

Acknowledgement. We are grateful to S. Zola for calling our attention to that star and for his valuable discussion.

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