RESULTS OF PHOTOGRAPHIC OBSERVATIONS OF THREE ECLIPSING STARS CD AND, AT MON AND BW CAS

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ABSTRACT. Photometric elements for CD And, AT Mon and BW Cas are presented. The initial epochs for primary minima are 2444469.97(3), 2443598.1295(8) and 2445579.4812(2) respectively, with corresponding period values of 34.4425(7), 4.29405(12) and 2.52563(5) days. Brightness of comparison stars and moments of weakenings are determined. No period changes have been detected.

Key words: Stars: binary: eclipsing; stars: individual: CD And, BW Cas, AT Mon

1. Introduction

Binary system, in which the bright and massive star is a normal star at the Main Sequence and a faint component with low mass is a subgiant, relates to semi-detached systems, according to a Svechnikov classification (Svechnikov, 1986). The number of such systems is high, which shows long duration of this stage and does not allow these stars to evolve roughly and rapidly. Actually, semi-detached systems, unlike detached systems, show mass transfer rates of 10^{-7} - 10^{-9} solar masses per year rather than 10^{-5}. Mass transfer is realized by matter outflow from the low-mass subgiant, which fills it's Roche lobe, through its inner Lagrangian point L_1. Stellar wind is not typical for subgiants, however, because their masses are usually no less than 1.5 solar masses, they have convective envelope, they have noticeable magnetic stellar wind.

Main stars of the semi-detached systems usually have an earlier spectral class than F2 and the mass more than 1.3 solar masses. The companion star is situated in subgiant's region, and the deviation from initial Main Sequence increases with decreasing mass ratio. Companions of such systems usually have later spectral classes and high light excesses, which increase with decreasing mass ratio. At the same time, one can suggest that with the same masses of the main stars and different companion masses, the last ones are situated on the equal radius lines.

The object of study are 3 semi-detached systems: CD And, AT Mon, BW Cas. The stars had been studied using photographical plates obtained at 7-channel astrograph in the observational station of the Astronomical Observatory of the Odessa National University in Majaki. The plates takenk both in photographical (pg) and in photovisual (pv) spectral bands have been used. The brightness estimates were visual using the interpolation method by Nyiland - Blazhko. The brightness of comparison stars was determined by linking to the standards in NGC 752 (CD And), NGC 2323 (AT Mon) and NGC 654 (BW Cas) (Kazanasmas et al., 1982). A microphotometer MF-2 was used for binding. The brightness of the comparison stars is listed in Table 1. The coordinates of comparison stars are listed in Table 2. For the periodogram analysis, we have used the method described by Lafler and Kinman (1965) and realized among other algorithms in the set of computer programs by Andronov (1994). The moments of brightness weakenings with corresponding magnitudes are listed in Table 3.

2. CD And

First among considered stars is CD And. It was discovered by Wedel (1955). I made brightness changing estimations in photovisual (pv) band. 385 brightness estimations were obtained. An amplitude of brightness changes is within $8.^{\rm m}5$ - $9.^{\rm m}5$. In its maximal part the light curve has large scattering (to $0.^{\rm m}3$), which does not permit to conclude anything about a secondary minimum.

The search of period and its later accurate definition by method of differential correction was made for obtained data. New value of the zero epoch T_0 was also obtained. As a result, one can say that in the observational period brightness minima are well described by the elements:

$$Min = J.D.2444469.97 + 34.^{\rm d}4425 \cdot E.$$
$$\pm .03 \quad \pm .0007$$

Phase curve is built by using these elements (Fig.1).

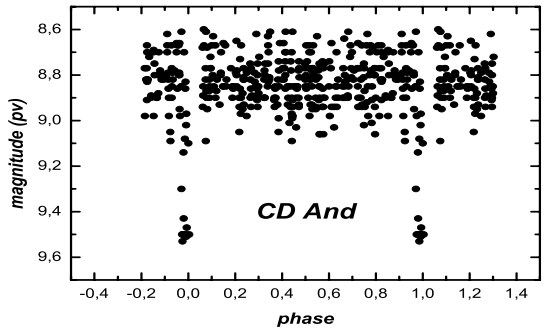

Figure 1: The phase curve of CD And.

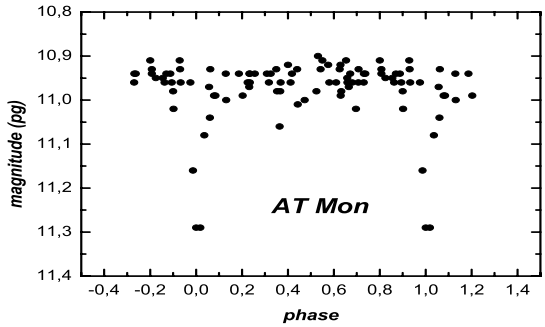

Figure 2: The phase curve of AT Mon.

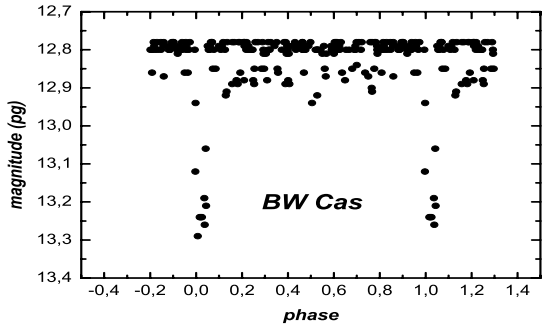

Figure 3: The phase curve of BW Cas.

Searches did not found any period changes.

In spite of relatively low quality of materials obtained on this star, one can say that its minimum has a flat part, and it means that we deal with the system in which full eclipses take place. For eclipse width, the value $D = 9$ was obtained (per cent of the orbital period).

Table 1: Magnitudes of the comparison stars

Star		a	b	c	d	e
CD And	pv	8.94	9.38	9.80	-	-
AT Mon	pg	10.59	11.21	11.60	-	-
BW Cas	pg	12.43	12.73	12.84	12.97	13.41

Table 2: Coordinates of comparison stars

	α_{2000}	δ_{2000}
	CD And	
a	$01^h\ 26^m\ 38^s.2$	$+44^\circ\ 32'\ 45''$
b	01 28 58.5	+44 15 44
c	01 25 22.2	+44 05 29
	AT Mon	
a	07 25 26.1	-07 33 41
b	07 26 13.2	-07 34 30
c	07 25 48.2	-07 36 03
	BW Cas	
a	01 39 21.5	+63 23 34
b	01 39 37.0	+63 26 51
c	01 39 17.2	+63 27 38
d	01 39 33.3	+63 28 00
e	01 39 51.2	+63 27 42

Table 3: Moments of weakenings (HJD 24.....) and corresponding brightness

CD And		CD And	
39055.4144	9.50	48629.2037	8.66
39743.5369	9.14	AT Mon	
39743.5640	9.30	41652.5258	11.29
41568.5081	8.70	41682.4476	11.16
41568.5310	8.66	41708.4231	11.08
41569.4939	9.50	45023.2773	11.29
41569.5168	9.50	47917.3599	10.96
43395.5151	9.50	BW Cas	
44875.4449	8.95	42331.4344	12.81
44875.4984	8.98	42801.2109	12.93
44876.4491	9.50	44109.5496	13.25
45565.5487	9.10	44114.5420	13.10
45943.5298	9.50	45589.5185	13.24
45943.5583	9.53	46324.5416	13.26
46357.4052	9.51	46708.4750	12.79
46702.4356	8.61	47097.4057	13.06
48182.4247	9.50	48183.4246	13.19
48182.4495	9.43	48539.4707	13.29
48217.3373	9.47		

3. AT Mon

AT Mon was first discovered as a variable by Meinunger (1964). It was studied by 168 plates taken in pg band. Brightness changes are within $10.^{m}9$ - $11.^{m}3$. The secondary minimum depth is no more than $0.^{m}05$.

Standard processing of number of the observations, which obtained elements was made:

$$Min = J.D.2443598.1295 + 4.^{d}29405 \cdot E.$$
$$\pm .0008 \quad \pm .00012$$

Phase curve was built (Fig.2).

One should suggest that this result does not fit to GCVS data. The phase curve analysis gives the value $D = 7$ which differs from GCVS twice. It is difficult to determine the parameter d (duration of the constant brightness in the main minimum). It may exist, but the width is no more than 3 per cent of the orbital period.

4. BW Cas

As a variable BW Cas was discovered by Belyavsky (1933). It was studied a lot by plates took at pg band. 184 brightness estimations were obtained. Brightness changes within $12.^{m}8$ - $13.^{m}3$ were detected.

The search of periods and zero time was made. Obtained results one can reduce to the formula:

$$Min = J.D.2445579.4812 + 2.^{d}52563 \cdot E.$$
$$\pm .0002 \quad \pm .00005$$

The phase curve was built by the result of calculations (Fig.3). The obtained period is two times higher than the value obtained by Deithelm (1997).

Unfortunately, obtained observations are render burdened with strong preference error. One can suppose that secondary minimum depth is about $0.^{m}1$. It is difficult to say anything about system structure, because the sharp minimum is observed and the curve is full of noise. One can try to determine the value D=10.

5. Conclusion

All done work is based on original observation made by Odessa collection of sky patrol plates. Improved values were obtained for all stars. More accurate parameters, such as the main minimum width, were improved or first obtained. Period searches were carried out, and such were not found. So, one can say that in all cases new values of photometrical elements, which can be used for models construction of these systems, were obtained.

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