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First period investigation and light-curve study of the eclipsing contact binary V776 Cas

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HIGHLIGHTS

- Photometry study of the eclipsing binary system V776 Cas.
- First the orbital period of the system is studied.
- New ephemeris system is obtained.
- The mass transfer rate of the system and one of two factors presence of third body or Applegate effect.

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ABSTRACT

CCD photometry of the eclipsing binary system V776 Cas was carried out through Johnson-Cousins UBVR filters in Dr. Mojtahedi observatory of Birjand University during August and September 2014. The physical and geometrical parameters of the system were obtained by analyzing the light curves. Radial velocity data were used to determine the absolute parameters. Five new times of minimum light were found. The O-C diagram was plotted relying on these times and the previously reported times of minimum. New ephemeris of the system, the rate of orbital period variations and the mass transfer rate of the system were derived from the O-C diagram analysis. A periodic variation of about 8 years was found from the O-C diagram analysis. At first light-time effect was considered. Although the results confirmed the probability of the presence of third body, Applegate mechanism was checked as the reason for this periodic variation and this mechanism is also in agreement with the observations.

1. Introduction

V776 Cas was discovered by the Hipparcos Astrometry Satellite as an eclipsing binary in 1991 (ESA, 1997). The spectral type of the system was assigned as F0 and an amplitude of 0.147 ranging from 8.943 to 9.090 in V band was derived, and also almost equal depth of primary and secondary eclipses (ESA, 1997). The parallax measured by Hipparcos is 4.86 mas, for a distance of 205.8 pc. V776 Cas is the brighter member of the visual binary ADS1485. The separation of its companion is 5.38″ and its magnitude is 11 .164 ± 0.046. The first light curve of the V776 Cas was derived by Gomez-Forrelland and Garcia-Melendo (1999). Photometry and light curve analysis of the system were carried out by Elmash (2004); Kyu-Dong and Chun-Hwey (2005) and Zola (2005). The first spectroscopic observations of the system was presented by Rucinski (2001). These authors pointed out that the spectral type of the system is F2 V, and this mass ratio, q = 0.130 ± 0.004, is very small.

2. Observations and data reduction

Photometry of V776 Cas was carried out through Johnson–Cousins UBVR filters at Dr.Mojtahedi observatory belonging to the University of Birjand (longitude:59°26′22.56″, latitude:32°38′28.32″) during August and September 2014. The photometric observations were obtained with a 14-inch Schmidt-Cassegrain Telescope and an SBIG ST-7 CCD camera attached to the telescope. Maxim DL software (George, 1993) was used for the photometry and as an interface for connecting the CCD to the computer. Exposure time was 4 seconds. The ephemeris reported by Tanrverdi (2003) was used for calculating the orbital phase which is as follows:

$$HJD(MinI) = 2456221.047339 + 0.440413E \quad (1)$$

The stars TYC 4314-1746-1 and TYC 4314-961-1were used as comparison star and check star, respectively. Table 1 shows the

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Table 1
Position and magnitude of the variable, comparison and check stars.

star	RA	Dec	magnitude
V776 Cas	$01h53m233.43s$	$+70^{\circ}02'33.443''$	9.16
comparison	$01h52m27.72s$	$+70^{\circ}09'54.24''$	9.96
check	$01h52m32.22s$	$+70^{\circ}04'01.70''$	11.1

position and magnitude of these stars. IRIS software was used for the data processing and reduction(Buil, 2005).

3. Light-curve analysis

The PHOEBE 0.31 version (Prsa and Zwitter, 2005) was used in the light curve analysis. A fixed value of the temperature T_1 was assumed from the spectral type given by Rucinski (2001). The radial velocities reported by Rucinski (2001) were also used in the light curve analysis. Physical and geometrical quantities of eclipsing binary V776 Cas are shown in Table 2. Fig. 1 shows the fit of synthetic light curves to the observed data in U, V, B and R filters. Fig. 2 shows the view of the system at orbital phase 0.25, obtained with the parameters estimated from the observations. Fig. 3 shows the radial velocity curves fitted by PHOEBE with Rucinski's data(Rucinski, 2001). The temperature of the components must be corrected due to convective envelope in the stars. The temperatures were corrected by Hilditch (2001) and other absolute parameters are shown in Table 3.

4. Orbital period study

During the photometry of the system, several primary and secondary eclipses were covered. These minima times are shown in Table 4. The O-C diagram versus epoch was plotted for these times and the reported minima times from the Lichtenknecker Database of the BAV and the ephemeris reported by Tanrverdi (2003). This diagram is shown in Fig. 4. Then a quadratic function

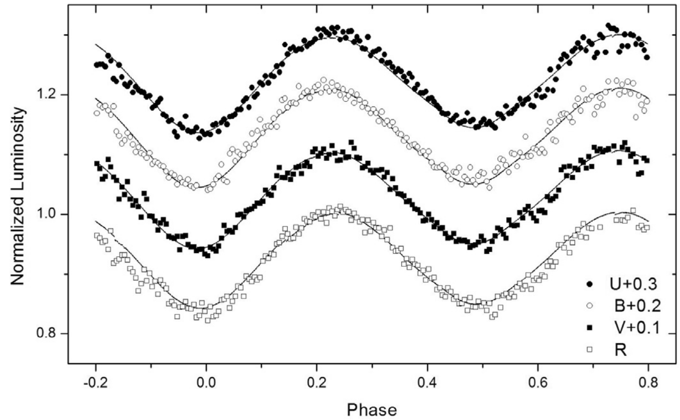

Fig. 1. Fit of synthetic light curves to observed data in UVBR filters.

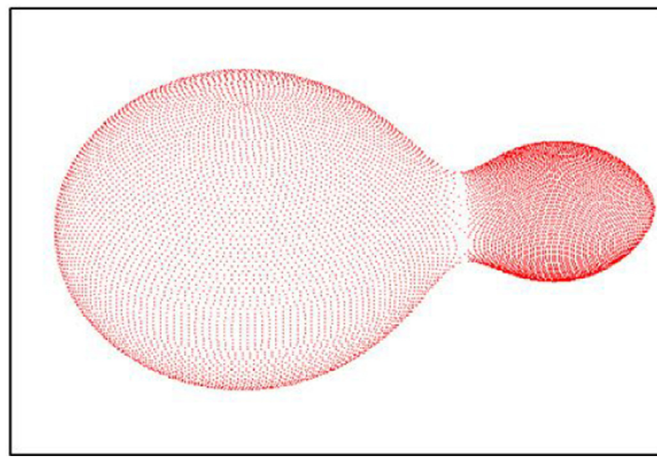

Fig. 2. Geometric configuration of V776 Cas.

Table 2
The obtained results of light curve analysis in this paper and the others' works.

	This paper					others' works		
parameter	R filter	V filter	B filter	U filter	RVBU	Elmash (2004)	Kyu-Dong and Chun-Hwey (2005)	Zola (2005)
$\Sigma(O-C)^2$	0.0280	0.0230	0.0278	0.026	-	-	-	-
i (deg)	54.6 ± 0.4	54.2 ± 0.3	54.6 ± 0.4	54.8 ± 0.3	54.5 ± 0.3	53.8	53.584 ± 0.134	52.5 ± 0.9
$q=\frac{m_2}{m_1}$	0.146 ± 0.001	0.142 ± 0.001	0.142 ± 0.001	0.143 ± 0.001	0.143 ± 0.001	0.13	0.145 ± 0.001	0.138
$T_1(^oK)$	7050	7050	7050	7050	7050	6890	7047	6700
$T_2(^oK)$	6880	6899	6929	6923	6907	6602	7004 ± 39	6725 ± 90
$\Omega_1=\Omega_2$	2.00127 ± 0.0036	2.00268 ± 0.0034	2.0223 ± 0.0040	2.0194 ± 0.0036	2.0114 ± 0.0040	2.0127	2.0127 ± 0.0019	2.001 ± 0.008
Ω_{in}	2.092079	2.0833362	2.081272	2.083403	2.08502	-	-	-
Ω_{out}	1.997783	1.991048	1.989432	1.991080	1.992335	-	-	-
$f_{over}[\%]$	96	87	64	69	79	41	82	77
$\frac{L_1}{L_1+L_2}$	0.838	0.845	0.851	0.851	0.845	0.875	0.822	0.817
x_1, x_2	0.591	0.688	0.787	0.792	-	-	-	-
y_1, y_2	0.294	0.291	0.282	0.327	-	-	-	-
$X_1, X_2(bol)$	0.642	0.642	0.642	0.642	0.642	-	-	-
$Y_1, Y_2(bol)$	0.253	0.253	0.253	0.253	0.253	-	-	-
$A_1=A_2$	0.5	0.5	0.5	0.5	0.5			
$Logg_1(cgs)$	4.17	4.17	4.17	4.17	4.17	4.18	0.417	
$Logg_2(cgs)$	4.01	4.01	4.01	4.01	4.01	4.06	0.401	
M^1_{bol}	2.67	2.68	2.71	2.70	-	-	-	-
M^2_{bol}	4.42	4.48	4.54	4.52	-	-	-	-
$r_1(pole)$	0.53404	0.53265	0.52725	0.52882	0.53069	-	-	-
$r_1(back)$	0.62706	0.62323	0.61231	0.61444	0.61926	-	-	-
$r_1(side)$	0.59853	0.59601	0.58723	0.58885	0.59264	-	-	-
$r_2(pole)$	0.24231	0.23725	0.22957	0.23160	0.23522	-	-	-
$r_2(back)$	0.36309	0.33407	0.30091	0.30741	0.32637	-	-	-
$r_2(side)$	0.25703	0.25097	0.24160	0.24398	0.24839	-	-	-

Note: $\Sigma(O-C)^2$=final sum of squares of residuals between observed and synthetic light curves, i (deg)=orbital inclination, q=mass ratio of the components, $T_{1,2}(^oK)$=temperature of the components, $\Omega_{1,2}$=dimensionless surface potential of the components, $\Omega_{in,out}$=dimensionless surface potentials of the inner and outer critical surfaces, respectively, $f_{over}[\%]$=filling factor, $L_{1,2}$=luminosity of the components, $x_{1,2}$, $y_{1,2}$ = logarithmic nonlinear limb-darkening coefficients of the components (Van Hamme 1993), $A_{1,2}$= albedos, Log g(cgs)=logarithm (base 10) of the system components effective gravity, $M^{1,2}_{bol}$=absolute bolometric magnitudes, $r_{1,2}(pole)$=polar radius, $r_{1,2}(back)$=back radius, $r_{1,2}(side)$=side radius.