Photometric study of the short-period eclipsing star ROTSE1 J171630.99+433832.1

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Abstract. We present Rozhen photometric observations of the short-period eclipsing star ROTSE1 J171630.99+433832.1. Its global parameters were determined by light curve solution. It revealed that the target is a W UMa system of A-subtype.

Key words: eclipsing stars, modeling

Introduction

The study of binary stars is important for the modern astronomy because they give a possibility for determination of the stellar global parameters and statistical relations between them, for determination of the stellar age and distance as well as for testing of the stellar evolution scenarios.

Probably one of every 150 stars in the Galaxy is a contact binary of W UMa type. But the structure and evolution of these systems remains unsolved problem in stellar astrophysics (Maceroni & Veer 1996) due to the bad statistics of such systems with known global parameters.

Most of the contact binaries consisting of solar-type components have orbital periods within the range $0^d.25 < P < 0^d.7$. Recently several hundreds binaries with shorter periods were discovered (see Norton et al. 2011; etc.).

The short-period binaries with non-degenerate components are important objects for the astrophysics, especially for our knowledge of the very late evolutional stages of the binaries connected with the processes of mass and angular momentum loss, merging or fusion of the stars, etc. However, most of the appropriate targets are too faint for detailed study.

The target ROTSE1 J171630.99+433832.1 (GSC 3085-916) is included in the list of eclipsing binaries of Akerlof et al. (2000) as variable of W UMa (EW) type with a period of $0^d.233502$. We carried out follow-up precise photometric observations of this target in order to obtain its global parameters.

Observations

The photometric observations of the star ROTSE1 J171630.99+433832.1 were performed on July 18, 2013 (total time 6 h 30 min) with the 50 cm/70 cm Schmidt telescope of the Rozhen National Astronomical Observatory (Bulgaria), using the CCD camera FLI PL 16803 (4096 × 4096 active pixels, 9 × 9 $\mu m/pixel$ size). The exposure times were 60 sec in I filter and 90 sec in V band. Additionally, several B images were also obtained. The average photometric precision per data point does not exceed $0^m.01$.

The data were reduced in a standard way using the software package *MaxIm DL 5* by dark subtraction and flat field division. The aperture photometry was made by the same software. For transition from instrumental system to standard photometric system we used five standard stars (Fig. 1). They were chosen by the criterion to be constant within 0.01 *mag*. Table 1 reveals their coordinates, magnitudes in V and color indices B-V and V-I according to the catalogs GSC 1.2, NOMAD and USNO-B1.

Table 1.

Star	GSC ID	RA [$h\ m\ s$]	DEC [$^{o}\ '\ ''$]	V [mag]	B-V	V-I
Var	3085-916	17 16 31.76	+43 38 17.9	12.70	1.33	1.99
C1	3085-551	17 16 47.64	+43 41 02.2	12.34	0.29	0.23
C2	3085-1468	17 16 04.78	+43 45 42.4	12.98	0.56	1.23
C3	3085-1383	17 16 52.58	+43 33 47.6	13.48	1.60	2.26
C4	3085-608	17 16 02.49	+43 39 58.4	11.76	1.77	1.64
C5	3085-903	17 16 16.40	+43 42 36.4	13.65	0.98	1.42

Note: The magnitudes of the target are at quadratures.

The periodogram analysis (by the software package *PerSea*) of our photometric data revealed the same period value as that determined by Akerlof et al. (2000) and HJD ($MinI$) = 2456492.292934.

The light amplitudes of our I and V curves are correspondingly $0^{m}.46$ and $0^{m}.55$ while the light variability of the target in the catalog of Akerlof et al. (2000) was only $0^{m}.15$. The reason for this discrepancy is the light contribution of close field object near GSC 3085-1091. The quality of the ROTSEI observations is not enough to separate the two stars. Our precise photometric observations gave a possibility to obtain the real light amplitude of the target.

The qualitative analysis of our light curves revealed: (a) the brightness of our target changes continuously that means the star is contact or overcontact binary system; (b) the depths of the two eclipse minima are close but not equal that means almost thermal contact; (c) the levels of the light maxima differ (O'Connell effect) by around $0^{m}.023$ in I color and by $0^{m}.031$ in V color.

Results of the light curve solution

It is known that the determination of the mass ratio by light-curve analysis q_{ph} is an ambiguous approach compared with that of the radial velocity solution q_{sp}. However, the fast rotation of the components of the short-period binaries is serious obstacle to obtain precise q_{sp} from measurement of their highly broadened and blended spectral lines (Dall & Schmidtobreick 2005). Tests have revealed that photometric mass ratios are more reliable than spectroscopic ones for totally eclipsing W UMa type stars and are sufficiently reliable for partially eclipsing systems (Maceroni & Veer 1996). Moreover, the light curve solutions of the W UMa type stars are much more sensitive to the geometrical parameters than those of detached systems. Because of the similarity of effective temperatures of their components, the eclipse depths depend strongly on geometrical parameters and the mass ratio q.

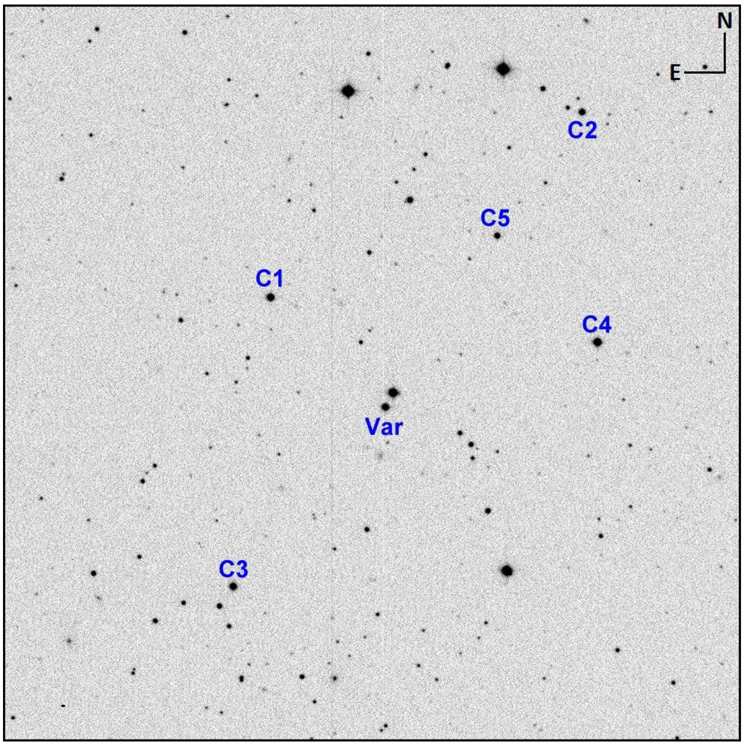

Fig. 1. The field of ROTSE1 J171630.99+433832.1

Taking into account these considerations we solved the Rozhen light curves of the target using the code *PHOEBE* (Prsa & Zwitter 2005) by the following procedure.

We determined the mean temperatures $T_m = 4200\ K$ of the binary by its out-of-eclipse color index $B-V = 1.33$ according to the relation of Sekiguchi & Fukugita (2000) adopting both components to be MS stars with normal metallicity and gravity. We searched for solution for fixed $T_1 = T_m$ (a good approximation for contact binaries with very close temperatures of the components) by varying the secondary temperature T_2, orbital inclination i, mass ratio q and relative stellar radii r_1 and r_2.

We adopted coefficients of gravity brightening $g_1 = g_2 = 0.32$ and reflection $A_1 = A_2 = 0.5$ appropriate for late stars while the limb-darkening coefficients for each stellar component and each color were taken from the tables of van Hamme (1993). In order to reproduce the O'Connell effect we added cool spots on the stellar surface and varied their parameters.

The best light curve solution (Fig. 2) corresponds to the following parameters: mass ratio $q = 0.85 \pm 0.01$; orbital inclination $i = 71.0 \pm 0.1^o$; relative stellar radii $r_1 = 0.42 \pm 0.01$, $r_2 = 0.38 \pm 0.01$; stellar temperatures $T_1 = 4200 \pm 10\ K$, $T_2 = 4000 \pm 10\ K$; spot parameters $\beta_1 = 45 \pm 10^o$, $\lambda_1 = 265 \pm 5^o$, α_1

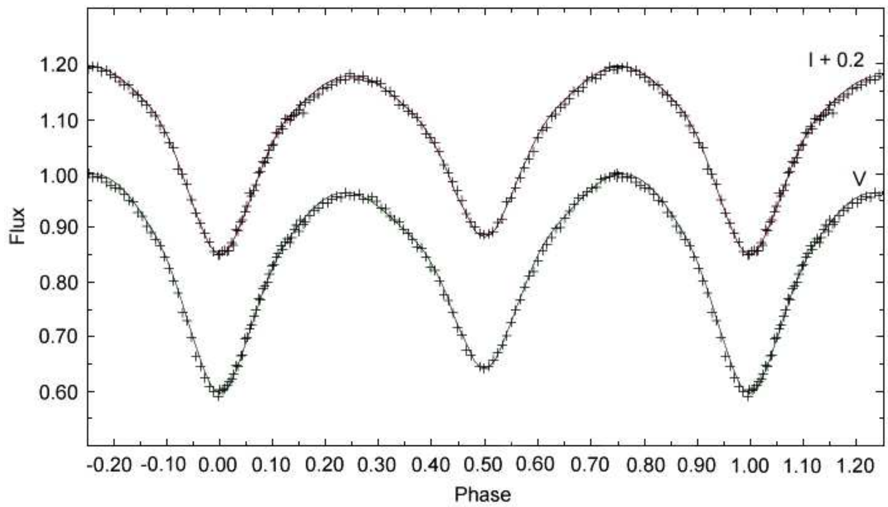

Fig. 2. The best light curve solution

$= 14 \pm 1^o$, $T_{sp}^1 = 3350 \pm 50\ K$, $\beta_2 = 50 \pm 10^o$, $\lambda_2 = 160 \pm 5^o$, $\alpha_2 = 11 \pm 1^o$, $T_{sp}^2 = 3750 \pm 50\ K$.

Our light curve solution reveals that the short-period eclipsing star ROTSE1 J171630.99+433832.1 is a W UMa system of A-subtype.

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