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The Peculiarities of the Shortest-Period Eclipsing Binary Star GSC 2314-0530*

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Abstract. The main results from the investigation of the newly discovered eclipsing binary GSC 2314-0530 are presented. Its period of P=0.192636 days is the shortest orbital period of a binary with non-degenerate components. Our "champion" is interesting also by its low-mass, fast-rotating dMe components. Their high activity is revealed by the strong Hα emission, cool spots covering 3.5 % of the primary' surface and observed several flares. We found a star at a distance 61 arcsec from the binary that has the same proper motion as GSC 2314-0530. The color indices as well as the low-dispersion spectra of the distant companion (called by us the *Twin*) show that its spectral type is later than dM5. The existence of the *Twin* explains the exclusive small angular momentum of GSC 2314-0530.

1 Introduction

Applying a multiparametric method for searching for variable stars in large datasets to the Northern Sky Variability Survey (NSVS) many new eclipsing stars were discovered (Dimitrov 2009). One of them was GSC 2314-0530 (NSVS 6550671). Initially it attracted our interest by its short orbital period because until 2010 there were only 3 binaries with non-degenerate components and periods below the cut-off limit of 0.22 days (Rucinski 2007).

After that we established that the components of GSC 2314-0530 were dM stars and our interest increased. The M dwarfs are the most numerous stars in our Galaxy but they are poorly investigated due to the selection effect (they are faint and small stars). As a result the empirical relations mass-luminosity and mass-radius are determined by few low-mass stars and this deficiency hinder the development of the models for the cool dense atmospheres of the M dwarfs. Re-

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cently these stars became especially interesting as appropriate targets for planet searches due to the relative larger transit depths.

We undertook intensive photometric and spectral observations of GSC 2314-0530 in order to determine its global parameters and to add new information for the dM stars as well as for the short-period binaries. The investigation of GSC 2314-0530 (Dimitrov & Kjurkchieva 2010, further Paper I) was found to be one of the most significant achievements of the Bulgarian astronomy in 2010 (Annual report of Bulgarian Academy of Science, 2010).

This paper presents shortly the peculiarities of GSC 2314-0530.

2 The Main Results from the Investigation of GSC 2314-0530

The photometric and spectral observations of GSC 2314-0530 during 2009-2011 allowed us to infer several important results exhibiting its peculiarities.

(1) The Fourier analysis of all our photometric data in VRI bands led to the period value of 0.1926359 d. It is considerably below the cut-off limit and reveals that GSC 2314-0530 is the shortest-period binary with non-degenerate components (Paper I).

(2) The spectra of GSC 2314-0530 show wide emission Hα lines implying high rotational velocities as well as absorption TiO bands at 6569 A and 6651 A (Figure 1). These spectral features suggest a dMe classification of its components.

(3) The solution of the radial velocity curves (Figure 2) of the stellar components of GSC 2314-0530 corresponds to values: radial velocity amplitudes K_1=109.7 km/s and K_2=211.3 km/s; mass ratio q=0.519; binary separation $a \sin i$=1.22 R$\odot$ (Paper I).

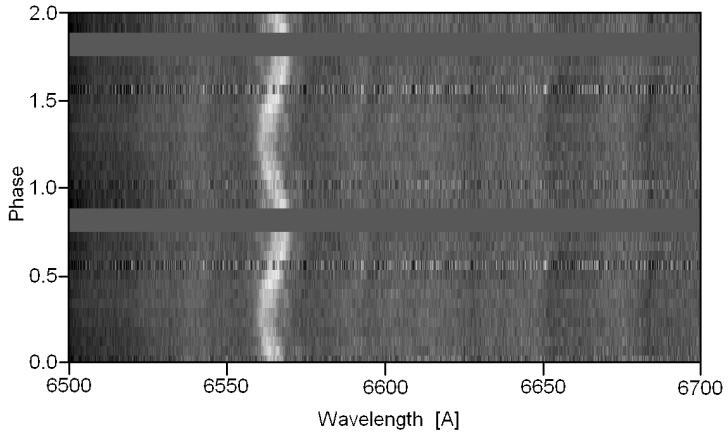

Figure 1. The orbital variability of the spectra of GSC 2314-0530

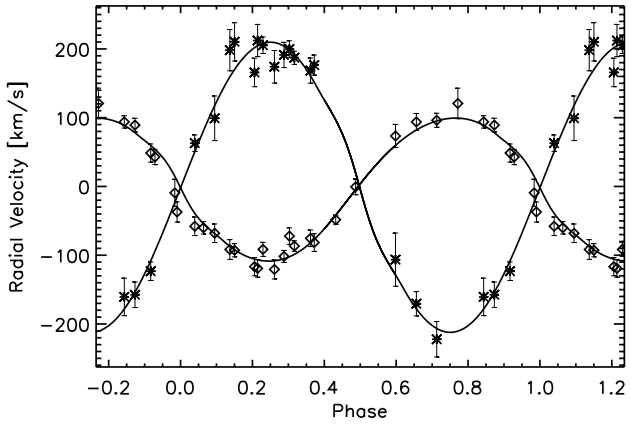

Figure 2. Radial velocities of the two components of GSC 2314-0530 and their fits

(4) By simultaneous light curve solution of our VRI folded curves (Figure 3) we inferred the following parameters of the target: orbital inclination i=72.5^0; temperatures T_1=3735 K and T_2=3106 K; potentials Ω_1=2.944 and Ω_2=3.545. In order to reproduce the distortions of the light curves as well as their O'Connell effect (the light maxima are not equal) we have to assume the presence of two cool spots on the primary component as well as a third light which contribution is different for the different colors. We considered the last supposition as artificial step to compensate the peculiar energy distribution of the dM stars that appear especially faint in the V band probably to the big TiO absorption as well as to the big contribution of the spots. The synthetic VRI light curves are shown in Figure 3 as gray lines while Figure 4 reveals the 3D configuration of the binary.

(5) Using the results from both the light curve solution and the radial-velocity curve solution we determined the global parameters of GSC 2314-0530 (Paper I): binary separation a=1.28 R$\odot$; distance d=59 pc; masses M_1=0.51 M$\odot$ and M_2=0.26 M$\odot$; radii R_1=0.55 R$\odot$ and R_2=0.29 R$\odot$; luminosities L_1= 0.053 L$\odot$ and L_2=0.007 L$\odot$; surface gravities $\log g_1$=4.68 and $\log g_2$=4.95; bolometric absolute magnitudes $M_{bol}(1)$=7.91^m and $M_{bol}(2)$=10.11^m.

(6) The equatorial velocities of the stelar components $V_{rot}(2)$=145 km/s and $V_{rot}(2)$=69 km/s correspond to quite fast rotators. The large rotational velocities and the low temperatures are important requirements for the stellar activity. They are satisfied for the components of GSC 2314-0530 which high activity is manifested by: (a) the strong Hα emission (with mean *EW*=5 A); (b) the presence of cool spots covering 3.5 $\%$ of the primary surface; (c) the observed 6 optical flares resembling those of UV Ceti stars (Paper I); (d) the registered X-ray emission (the target is identified as ROSAT X-ray source 1RXS J022050.7+332049) and X-flares (Fuhrmeister *et al*. 2003).

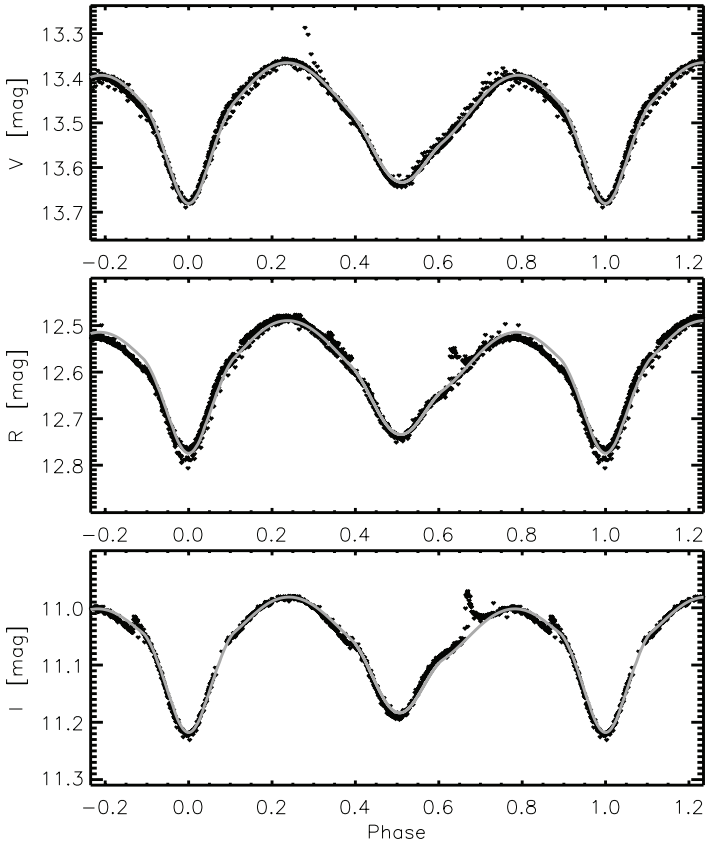

Figure 3. The folded V, R, I light curves of GSC2314-0530 and their fits

The coincidence of 3 of the observed 6 flares with the phase of maximum visibility of the larger spot implies that the spots and the flares are appearances of long-lived active area on the primary star. Moreover, there was an anti-correlation between the Hα emission and the total light of GSC 2314-0530 that is typical for the chromospheric active stars of types RS CVn and BY Dra.

(7) The orbital angular momentum $\log J_{rel}$= -1.01 of GSC 2314-0530 is considerably smaller than those of the RS CVn binaries and detached systems which have $\log J_{rel} \geq +0.08$. It is smaller even than those of the contact systems which have $\log J_{\rm rel} \geq -0.5$. The orbital angular momentum of GSC 2314-0530 turned out bigger only than those of the shortest-period CVs of SU UMa type. The small orbital angular momentum of our target implies past episode of angular momentum loss during the binary evolution and/or existence of companion (Pribulla & Rucinski 2006).

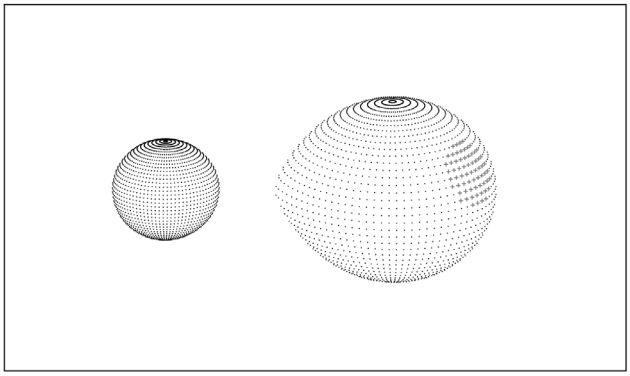

Figure 4. 3D model of GSC 2314-0530 at phase 0.75

(8) We found a weak star (USNO-B1 1233-0046425) on the observed field (Figure 5) that has the same proper motion as our target star GSC 2314-0530 (according to the catalogue NOMAD). We called it the *Twin*. The angular distance between them of 61 arcsec corresponds to a linear separation around 3500 AU (for distance of 59 pc). We supposed that the *Twin* and the binary GSC 2314-0530 form wide visual binary.

The color indices of the *Twin* revealed that it is redder than the GSC 2314-0530 components (Paper I). The last conclusion was confirmed by the low-dispersion

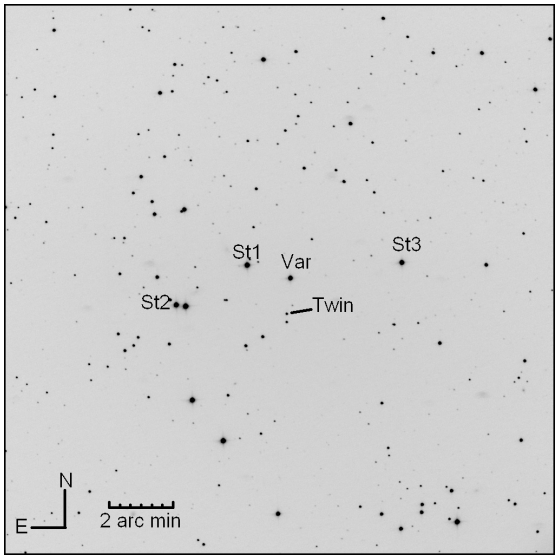

Figure 5. The observed field around GSC 2314-0530

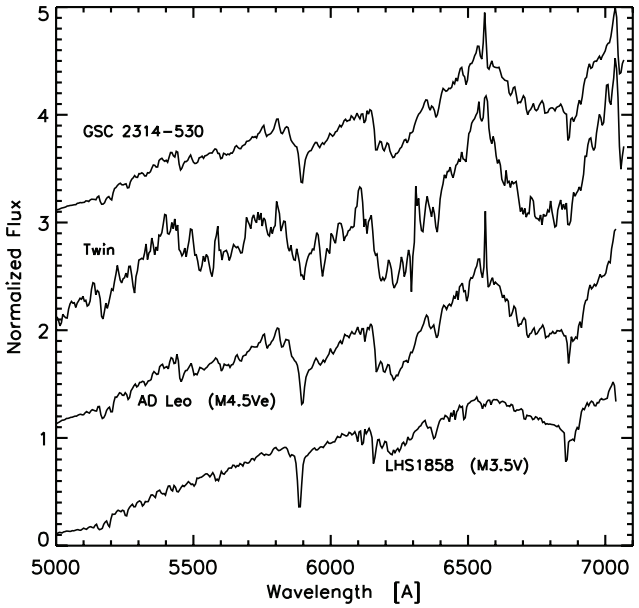

Figure 6. The low-dispersion spectra of GSC 2314-0530 (top), the *Twin* (middle) and two M-type standard stars (bottom)

spectra covering the range 5000-7000 A both of GSC 2314-0530 and the *Twin* obtained in March 2011 (Figure 6). These spectra correspond to middle M-type stars. The spectrum of the *Twin* reveals that it is cooler than the components of GSC 2314-0530 and that the *Twin* is also a source of Hα emission.

3 Conclusion

Our study of the newly discovered shortest-period eclipsing binary with non-degenerate components GSC 2314-0530:

(i) adds new empirical data for the ultra-short period binaries;

(ii) adds information to the poor statistic of the low-mass dM stars;

(iii) contributes to a better understanding of the late stage of binary evolution;

(iv) confirms the role of the companions for the explanation of the small angular momenta of the short-period binaries.

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