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SPECTROSCOPIC ANALYSIS OF THE R CANIS MAJORIS BINARY SYSTEM

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ABSTRACT

R Canis Majoris is a bright, short-period ($1^d.1359$) Algol-type eclipsing binary. For a long time, it was considered to be a low-mass binary star with $M_1 = 1.1M_\odot$ and $M_2 = 0.17M_\odot$ primary and secondary components, respectively (Tomkin, 1985). Glazunova, Yushchenko & Mkrtichian (2009) found new masses for the primary and secondary components of M_1=1.81$M_\odot$ and M_2=0.23$M_\odot$, respectively and resolved a long-standing problem with the low masses of components for this binary. Budding and Butland (2011) confirmed the results of Glazunova, Yushchenko & Mkrtichian and obtained improved orbits and masses. New spectroscopic observations of R CMa were done during 8 nights on December 2012 with the 2.4-meter telescope of the Thai National Observatory (TNO) and fibre-fed medium resolution echelle spectrograph. We obtained new, accurate orbital radial velocities of the two components of this binary system. Results of these investigations and the new orbital parameters are presented.

Key words: spectroscopic: eclipsing binaries: close binaries

1. INTRODUCTION

R Canis Majoris (R CMa, HD 57167, HIP 35487, HR 2788, TYC 5965-2336-1) is a bright (B = 6.05, V = 5.71) eclipsing semi-detached Algol-type binary system, with F0V and G81V spectral classes for the primary and secondary components, respectively. The variability of R CMa was discovered by Sawyer (1887). Wood (1946) improved the orbital period to the value of 1.1359 days and first made the conclusion that the star is too bright for its estimated mass of $0.9M_\odot$.

The R CMa system was related by Kopal (1956) to a definite sub-class of low-mass Algol stars with overluminous components. The masses $M_1 = 1.1M_\odot$ and $M_2 = 0.17M_\odot$ redeterminated by Tomkin (1985) for the primary and the secondary components, respectively, underpinned this hypothesis for a long time.

The important breakthrough in understanding the R CMa system was made by Glazunova et al. (2009), who, based on a high resolution spectra of R CMa obtained from the 2.7-m telescope of the McDonald observatory definitely show that all previous estimations of the mass of the primary component of R CMa were underestimated. They found new accurate masses of the primary and secondary components of M_1=1.81 $M_\odot$ and M_2=0.23 $M_\odot$, respectively. Recent high-resolution spectroscopic investigation of R CMa by Budding & Butland (2011) confirmed the masses of components found by Glazunova et al.(2009). Their improved accurate parameters are: M_1=1.67±0.08$M_\odot$, M_2=0.22±0.07$M_\odot$; R_1=1.78±0.03$R_\odot$, R_2=1.22±0.07$R_\odot$, L_1=8.2±0.2$L_\odot$, L_2=0.49±0.01$L_\odot$. A new astrometric analysis show the existence of a third body with M_3=0.8±0.1$M_\odot$, R_3=0.83±0.07$R_\odot$, and L_3=0.4±0.1$L_\odot$

The purpose of our work was to obtain new high time-resolution radial velocities of the primary and the secondary components of R CMa, to measure the Rossiter effect and to find new orbital parameters based on the new radial velocity curve.

2. OBSERVATIONS AND DATA REDUCTION

Spectroscopic observations of R Canis Majoris binary system were obtained by commercial fibre-fed medium resolution echelle-spectrograph eShel attached to the 2.4-meter Ritchey-Chretien Telescope located at the Thai National Observatory. Observations were made on eight nights in December 2012. Exposure times of 300 seconds were used. The G8.5V star τ Cet was used as a radial velocity standard.

The spectra of R CMa and τ Cet were reduced and wavelength calibrated using the DECH software (www.gazinur.com). Each spectrum was corrected for instrument shifts using telluric lines. For the normalization of spectra we used the synthetic spectrum of R CMa calculated with SYNTHV software (Tsymbal, 1996). Finally, barycentric correction was applied to each spectrum.

Table 1
PARAMETERS OF R CMA

Parameters	Value
T_0 [HJD]	245 2501.134 751±0.019 577
P [days]	1.135 954
γ [kms^{-1}]	-38.4065±0.3202
a [$R_\odot$]	5.8440±0.0228
q [$=m_2/m_1$]	0.1150±0.0017
i [°]	79.0277±0.5146
ω [°]	6.2832
$T_{1,2}$	7300 ; 4353
$X, Y_{1,2}$	0.6443,0.2589 ; 0.6477,0.2430
$M_{1,2}$ [$M_\odot$]	1.8327 ; 0.2058
$R_{1,2}$ [$R_\odot$]	1.5844 ; 1.3895
$Log_{g1,2}$ [cgs]	4.3012 ; 3.4657

3. LSD ANALYSIS AND RV DETERMINATION

High time-resolution spectra were used to construct the least square decomposition (LSD) profile using a list of selected spectral lines. For the calculation of LSD profile, we used the wavelength region from 500 to 650 nm and the atomic spectral line database VALD.

Figure 1 shows the orbital RVs for the primary and secondary components (crosses) and orbital fits (solid line with dots).

The amplitude of the Rossiter effect was found to be ±11 km/s. The mean radial velocity of the standard τ Cet was found to be 16.68±1 km/s (see figure2).

4. RADIAL VELOCITY ANALYSIS

For the radial velocity curve of the primary and secondary components, we used the Wilson-Devinney synthesis method using the PHOEBE program (Prsa et al. 2011) to compute the orbital solutions for R CMa. The initial parameters from Budding & Butland (2011) were used.

The orbital parameters are presented in Table 1.

5. CONCLUSIONS

We present the new high time-resolution spectroscopic observations of R CMa. For the first time for R CMa, we obtained repeated observations of the Rossiter effect, well resolved in time. The new orbital radial velocities for both components of R Canis Majoris were obtained and new improved accurate orbital and binary parameters were determined. The masses of the components of R CMa are to within ±0.025$M_\odot$ of the ones found by Glazunova et al. (2009). More detailed results of investigations of R CMa will be submitted to refereed astrophysical journals.

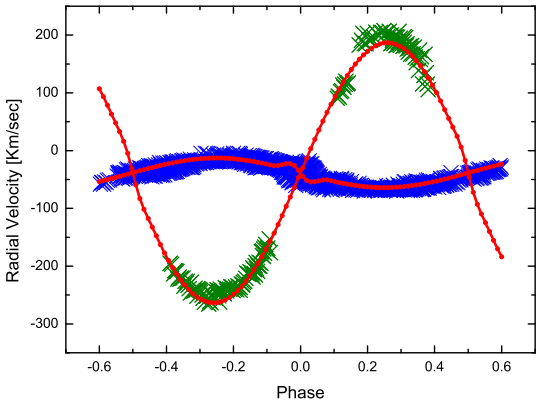

Figure 1. Orbital radial velocity curves of the two components of the R CMa binary. Solid lines are PHOEBE fits to the orbit.

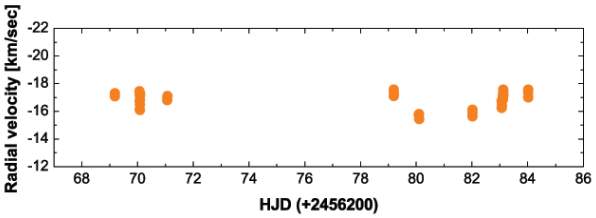

Figure 2. Radial velocity of the standard velocity star τ Cet.

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