COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5954

Konkoly Observatory
Budapest
26 October 2010

HU ISSN 0374 – 0676

SPECTROSCOPY OF ECLIPSING BINARY DY LYNCIS THIRD COMPONENT DETECTED

SĘKALSKA, JUSTYNA[1]; DIMITROV, WOJCIECH[1]; FAGAS, MONIKA[1]; KRUSZEWSKI, ADRIAN[1]; PRZYBYSZEWSKA, ANNA[1]; KURZAWA, KRYSTIAN[1]; ŻYWUCKA, NATALIA[1]; ROŻEK, AGATA[1]; BORCZYK, WOJCIECH[1]; BARTCZAK, PRZEMYSŁAW[1]; BĄKOWSKA, KAROLINA[1]; HIRSCH, ROMAN[1]; KAMIŃSKI, KRZYSZTOF[1]; KWIATKOWSKI, TOMASZ[1]; SCHWARZENBERG-CZERNY, ALEKSANDER[1,2]

[1] Astronomical Observatory, Adam Mickiewicz University, Słoneczna 36, 60-186 Poznań, Poland

[2] Nicolaus Copernicus Astronomical Center, Bartycka 18, 00-716 Warsaw, Poland

The following paper[1] presents the results of spectroscopic observations of DY Lyncis (HD 65498). The object is listed in SIMBAD database as an eclipsing binary of Algol type with V magnitude of $9\overset{m}{.}67$, color index $(B-V) = 0\overset{m}{.}56$ and with equatorial coordinates $\mathrm{RA} = 08^{\mathrm{h}}00^{\mathrm{m}}46^{\mathrm{s}}, Dec = +42^{\circ}10'33''$. Eclipsing nature of HD 65498 was detected by SAVS (Semi-Automatic Variability Search described by Maciejewski et al., 2003). The light curve is typical of detached binaries and suggests similar components and partial eclipses with amplitude of 0.4 mag. According to Maciejewski et al. (2003) the orbital period of HD 65498 is 31.5 hours and the ephemeris is:

$$\begin{aligned}\text{Min. I} = \text{HJD } 2452704.48836 + 1\overset{d}{.}31324 \times E.\\ \pm 0.00054 \pm 0.00006\end{aligned} \qquad (1)$$

To determine the spectral type of the star spectroscopic observations were made. The obtained spectrum corresponds to F5V star (Maciejewski et al., 2003). There are also seven measurements of the times of minima (Gurol et al., 2007; Brat et al., 2008; Brat et al., 2009)

Our spectroscopic observations were made during 13 nights (between March 21 and April 13 in 2009). All data were collected at Borowiec station of the Poznań University Observatory. HD 65948 was observed spectroscopically with PST (Poznań Spectroscopic Telescope; Baranowski et al., 2009) equipped with 0.5m mirror and fiber-fed echelle spectrograph. The exposure time was 1800s and the spectra cover range from 4500 to 8250 Å. The thorium argon lamp provides calibration of the spectra with sigma RV of 100m/s. The spectrograph box is thermally stabilized on the level of 0.5 deg. Data reduction was performed with IRAF echelle package based script. For the RV measurement we have used IRAF FXCOR task. Cross correlation functions reveal three peaks (Figure 4). Two of them (low and broad) are connected with the eclipsing pair and the central one - with

[1]Based on PST spectroscopic and SAVS photometric data.
`http://www.astro.amu.edu.pl/PST/`
`http://www.astri.uni.torun.pl/~gm/SAVS`
Correspondence to: `dimitrov@amu.edu.pl`

the detected third component (the peak is high and narrow). Due to faster rotation (tidal effects) and possible higher $\sin i$ value, the eclipsing stars have wider peaks. The shape of the H_α (Figure 3) and H_β profile is also triple.

The light curve and radial velocities enable us to obtain Wilson-Devinney model of the system (Wilson & Devinney, 1971). We treat the third body as a third light. The third component can be dynamically connected with the eclipsing pair or be just in the same line of sight. Radial velocities of the third component are decreasing with time. This phenomenon can be explained by the mutual orbital motion. The time span of our spectra is about twenty days, they can be affected by the light-time effect.

Our spectroscopic data is shifted with respect to the ephemeris. In order to make a simultaneous solution we calculated a new ephemeris based on both photometric and spectroscopic observations:

$$\begin{array}{rl}\text{Min. I} = \text{HJD } 2452704.489 + & 1\overset{\text{d}}{.}313187 \times E. \\ \pm 0.001 \pm & 0.000003\end{array} \qquad (2)$$

Time span between spectroscopic and photometric data is about 6 years and the ephemeris has been probably affected by the light-time effect.

The eclipsing pair consists of two similar components with masses $1.02 M_\odot, 1.05 M_\odot$ and radii $1.28 R_\odot, 1.26 R_\odot$, respectively (Table 2). The components are slightly evolved. We have no direct information on the color index of the eclipsing pair. The temperature of the first component was obtained from evolutionary tracks, which were computed for the derived masses and radii. The temperature of the second component was fitted during the modelling. We found the third light to be 0.364 ± 0.016 (normalization $l_1 + l_2 + l_3 = 1$). The color index of the system ($B - V = 0.47 \pm 0.05$, Tycho) suggests that the third component is hotter than the eclipsing pair. The temperature must be higher than 6500 K due to the mixing of light of the three components (the eclipsing pair is cooler). We think that the mass of the third body must be higher than one solar mass. Further spectroscopic and photometric observations will enable us to measure the mutual orbit and the light-time effect, respectively.

The mass and radii of the eclipsing pair suggest that the system is quite old. Luminosities of the three stars are comparable but the temperature of the third component is significantly higher and inconsistent with stellar evolution theory. The existence of additional white dwarf component is a possible explanation of high $B - V$ index. The white dwarf is a source of a blue continuum light but it is not adding its lines to the triple lined spectrum of the object.

Table 1. Absolute radial velocity measurements from PST (template: *o* Aquilae).

HJD (+2454900)	RV1 (km/s)	RV2 (km/s)	RV3 (km/s)
12.319274	−103.9	145.7	58.0
12.474967	−54.6	91.6	58.3
12.504987	−37.2	95.7	59.3
16.330385	−81.7	121.4	56.6
16.356517	−70.6	111.0	57.2
16.383448	−61.0	120.0	58.4
24.527291	91.8	−14.4	55.4
24.569706	93.1	−45.8	55.6
25.413819	−110.1	155.3	55.6
25.440946	−114.6	157.3	55.5
35.327167	133.0	−100.7	52.3
35.353276	128.1	−93.4	51.9
35.379281	117.5	−79.4	52.5

Table 2. Preliminary solution for the eclipsing pair and formal errors outputted by the WD code.

parameter	component 1	component 2
i	$89\overset{\circ}{.}2 \pm 1\overset{\circ}{.}5$	
q	1.03 ± 0.13	
$a(R_\odot)$	6.42 ± 0.09	
$V_\gamma\ (km/s)$	23.2 ± 1.4	
Ω	6.07 ± 0.22	6.27 ± 0.62
l_V	0.330 ± 0.016	0.306 ± 0.016
$T(K)$	5400(fixed)	5340 ± 10
$M(M_\odot)$	1.017 ± 0.050	1.048 ± 0.050
$R(R_\odot)$	1.280 ± 0.054	1.260 ± 0.123

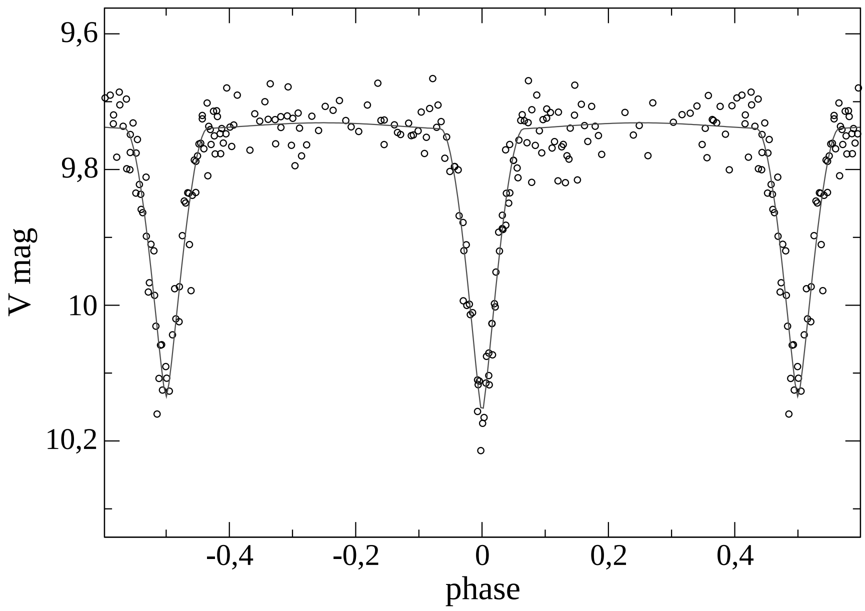

Figure 1. Light curve of HD 65498 from SAVS compared with the synthetic curve based on the derived model.

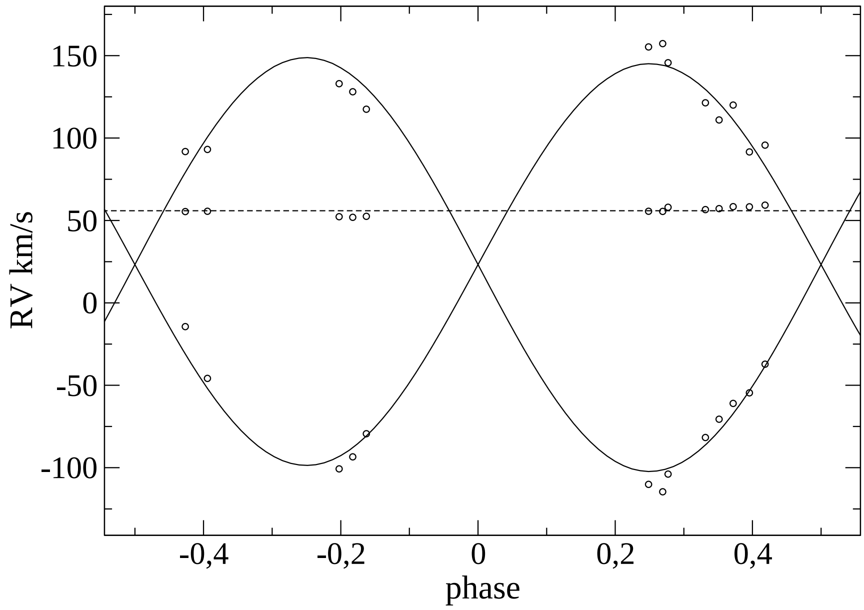

Figure 2. Absolute radial velocity curve for the three components of HD 65498. The solid line presents RV measurements for the eclipsing pair and the dashed line corresponds to the third component.

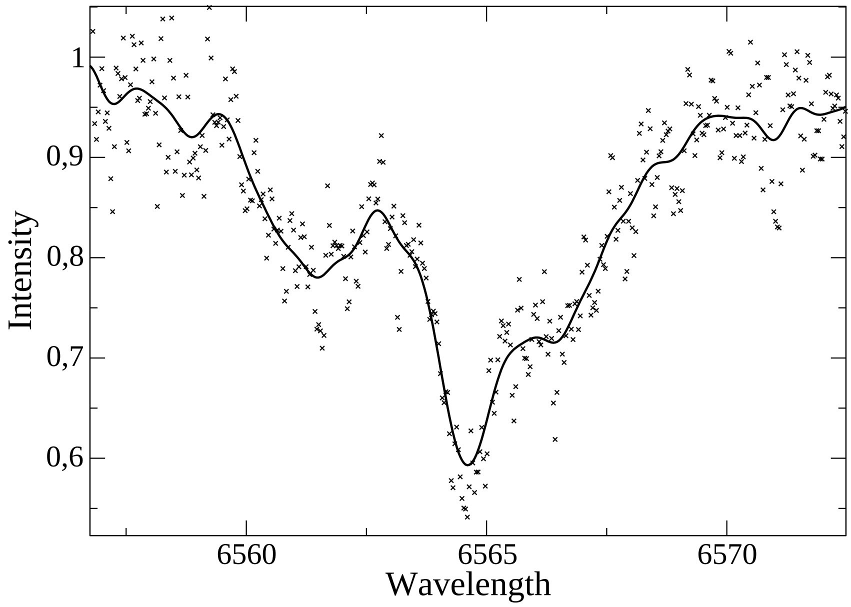

Figure 3. The H_α line profile (smoothed) is triple, we can see two shallow lines caused by the eclipsing pair and deep central line by the third component (x signs present the original not smoothed spectrum).

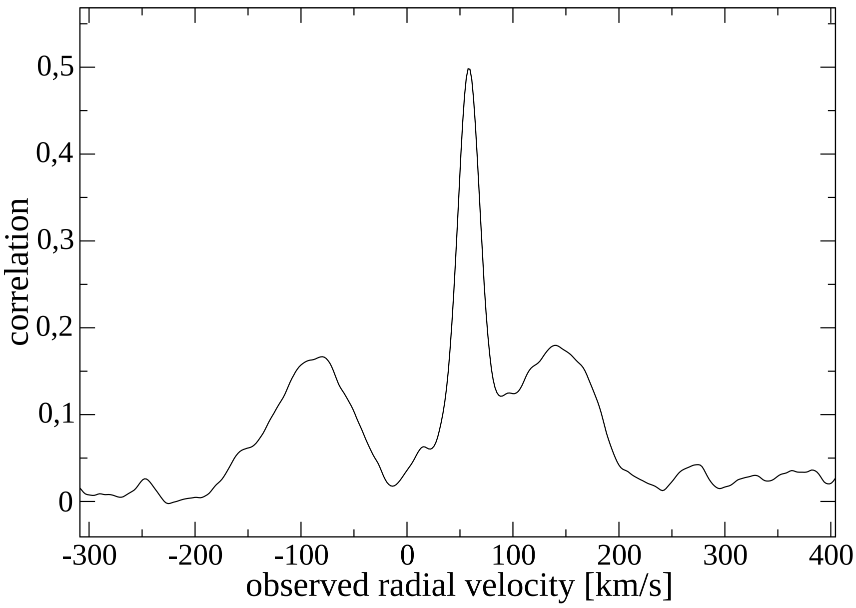

Figure 4. The cross correlation function for the same spectrum as in figure 3. We have the low and broad peaks of the eclipsing pair and the high and thin peak of the third component.

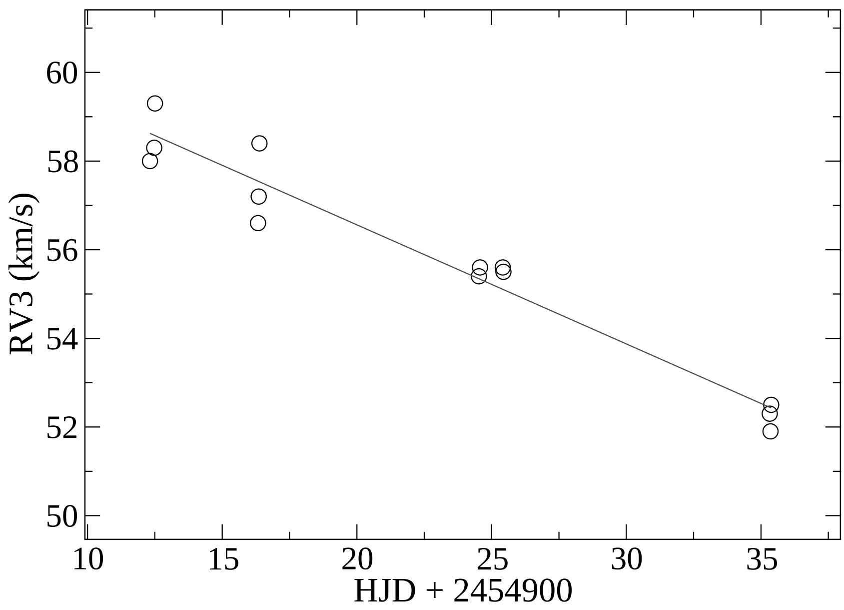

Figure 5. Radial velocity of the third component is decreasing with time (mutual orbit motion).

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