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THE FIRST LIGHT CURVE ANALYSIS OF HD 162905

TAŞ, G.; EVREN, S.

Ege University Observatory, 35100 Bornova - Izmir - Turkey
e-mails: gunay.tas@ege.edu.tr, serdar.evren@ege.edu.tr

Wils and Dvorak (2003) were reported ten short period eclipsing binaries discovered on the images from Stardial system. HD 162905 is one of these eclipsing systems. Its spectral type was given as K0 in different catalogues like SAO and HD. According to the TYCHO catalog (ESA 1997), HD 162905 has a colour index of $0\overset{m}{.}587$, which it corresponds to the spectral type G0 (Gray 1992). Wils and Dvorak (2003) reported that HD 162905 is a W UMa type eclipsing binary, and they determined the light elements of this system as follows,

$$HJD\ (\mathrm{Min\ I}) = 24\ 52369.95 + 0\overset{d}{.}42651 \times E. \qquad (1)$$

The poorly studied system HD 162905 is observed during the total of 9 nights in the years 2003 and 2005 using Johnson B, V and R filters with high-speed three-channel photometer attached to 48 cm Cassegrain type telescope of Ege University Observatory. HD 162776 and HD 162775 are chosen as the comparison and the check stars, respectively. Following traditional reduction procedure, we obtained differential magnitudes, in the sense variable minus comparison, and corrected for atmospheric extinction. The extinction coefficients were calculated for each filter using the observed magnitudes of the comparison star. The times were also reduced to the Sun's center. The nightly mean standard errors were $0\overset{m}{.}009$, $0\overset{m}{.}008$ and $0\overset{m}{.}007$ in B, V, and R filters, respectively. It is also observed the standard stars BD $-00°3356$ ($V = 10\overset{m}{.}353$, $B - V = 0\overset{m}{.}609$) and BD $-00°3353$ ($V = 9\overset{m}{.}332$, $B - V = 1\overset{m}{.}462$) from the list of Landolt (1992) during the observing run. The standard magnitudes of the stars obtained from observations were listed in Table 1. These values contain the effect of the interstellar reddening. In Table 2, we presented the depths of the light minima for B, V, and R colours. As can be seen from Table 2 the depths for both minima are nearly same for each colour, and they become shallower at longer wavelengths. The continuous light change throughout whole phases implying the proximity of both components in all colours, the reddening of the colours during the minima, and the similarity of the depths of the minima reflects the characteristics of W UMa type binaries. The light curves obtained in the years 2003 and 2005 do not show O'Connell effect, and there is no difference in the brightness level of the light curves during the observing years.

During the observing season, we observed one time of mid-primary and one time of mid-secondary minimum during the 2005 observation season (in B, V, and R filters) and listed in Table 3. The times of minima obtained in the year 2003 were published by Taş et al. (2004). A linear ephemeris (Eq. 1) was applied to obtain differences between the observed and the computed times. To correct the light elements, we applied the linear least-squares method to $O-C$ (I) values of the primary and the secondary minima using equal weights for each. We determined the new light elements as follows, and we used to calculate the orbital phases,

Table 1: The standard magnitudes for the stars of observing program.

Star	HD	V	$B-V$	$V-R$
Comparison	162776	$9^{\mathrm{m}}_{.}423$ (±5)	$0^{\mathrm{m}}_{.}487$ (±7)	$0^{\mathrm{m}}_{.}315$ (±3)
Check	162775	$7^{\mathrm{m}}_{.}510$ (±2)	$1^{\mathrm{m}}_{.}362$ (±4)	$0^{\mathrm{m}}_{.}715$ (±3)

Table 2: The depths of the minima for HD 162905.

Filter	MIN I	MIN II
B (mag)	0.170	0.165
V (mag)	0.163	0.151
R (mag)	0.159	0.147

Table 3: New times of the light minima of HD 162905.

HJD (24 00000 +)	E	$O-C$ (I) (days)	$O-C$ (II) (days)	Filter	Type
53558.4221 (±5)	−16.5	−0.0004	0.0010	B,V,R	II
53565.4591 (±5)	0.0	−0.0008	0.0006	B,V,R	I

Table 4: The synthetic light curve parameters for HD 162905.

Parameter	The solution results
$x_{1B}=x_{2B}$	0.789
$x_{1V}=x_{2V}$	0.684
$x_{1R}=x_{2R}$	0.582
g_1 , g_2	0.32, 0.32
A_1 , A_2	0.500, 0.500
i (°)	54.22 (20)
T_1, T_2 (K)	5720 (fixed), 5636 (17)
$\Omega_1=\Omega_2$	3.022 (7)
q (m_2/m_1)	0.55 (fixed)
$L_1/(L_1+L_2)$	0.661 (57)(B), 0.655 (43)(V), 0.652 (35)(R)
r_1, r_2 (pole)	0.398 (1), 0.299 (1)
r_1, r_2 (point)	0.498 (5), 0.377 (6)
r_1, r_2 (side)	0.421 (2), 0.311 (2)
r_1, r_2 (back)	0.446 (2), 0.339 (2)

$$HJD\ (\mathrm{Min\ I}) = 24\ 53565.4585\ (\pm 21) + 0^{\mathrm{d}}_{.}426511\ (\pm 1) \times E. \qquad (2)$$

We used all averaged observing points obtained in each filter during two years for the light curve analysis, after we normalized to the light maximum, namely with the flux at phase 0.25. B, V, and R light curves consisting of the normal points obtained in the years 2003 and 2005 were solved simultaneously by using the latest version of Wilson - Devinney code (Wilson and Van Hamme 2003). Starting with the assumption that the system is detached (Mode 2), the differential corrections always converged to a Mode 3 solution (contact mode). Since there is no spectroscopic classification of the components and neither primary nor secondary minimum is not total eclipse, we assumed that the temperature for Star 1 (T1) is 5720 K, determined from the colour index of $B-V = 0\overset{m}{.}648$ at phase 0.25 using Tables of Flower (1996), and we fixed it during the analyse. We started to solve the light curve using different values for the mass ratio of the system. Then, we obtained the light curve solutions for the specific values of the mass ratio between 0.1 and 2.0. However, all fits in the range of q obtained between 0.4 and 0.8 give similar residuals, the resulting sum of square of residuals of the converged solutions for each value of q indicates that the fitting is the best for $q = 0.55$, and thus, the other adopted parameter was q during the light curve analysis. In final solution we also adjusted l_3. Although the results of the Wilson-Devinney code always gives the positive luminosity value of the third light, its error from solution is fairly large respect to the contribution to the total light, and therefore, we decided to omit it from analyse.

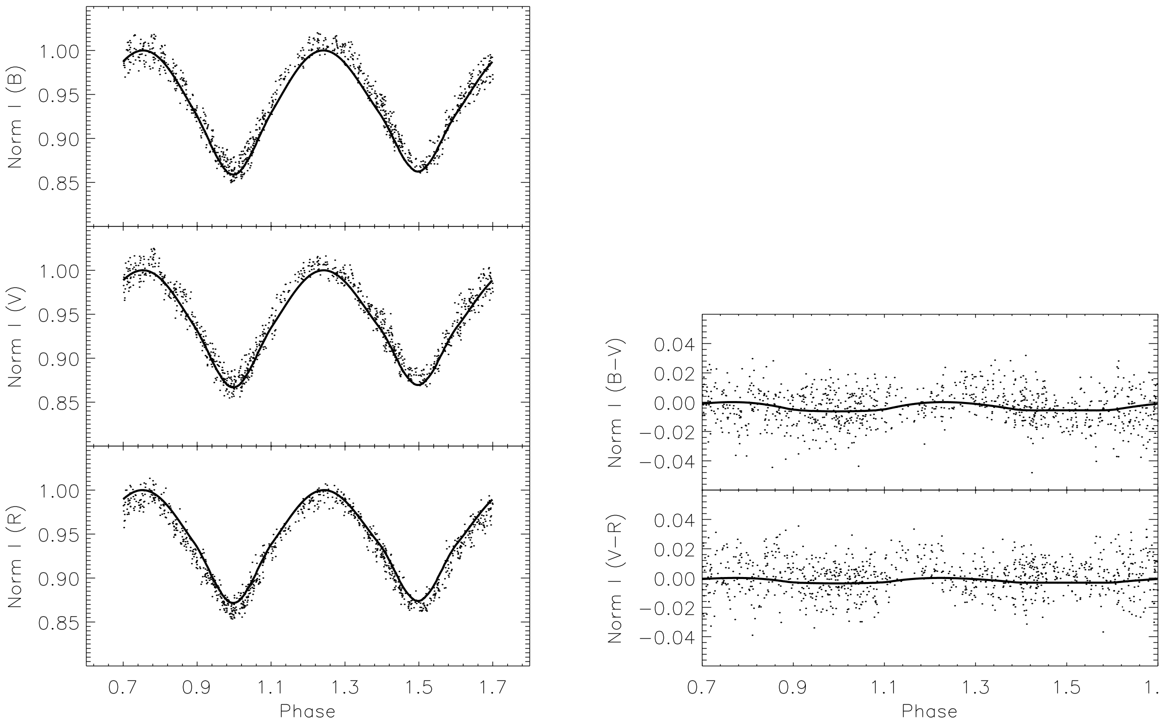

Figure 1. The comparison of the observed and synthetic light curves in the filters B, V and R, normalized to unity at phase 0.25, top to bottom, respectively, are shown in the left panel. In the right panel, the normalized colour curves of the system are compared with calculated synthetic ones.

The final results of the light curve analyse are presented in Table 4. The computed light and colour curves are compared with the observations in Fig. 1. The parameters of our solution indicate that the hotter component is larger and massive star, while the cooler component is smaller and less massive one. This indicate that HD 162905 is an A-subtype W UMa system according to the classification of Binnendijk (1970). Although it is an eclipsing binary exhibiting an EW-type light curve according to our observations, the results of the photometric solution reveal that HD 162905 is both components are almost filling their Roche lobes. Therefore, the system should be at the out of contact phase of the thermal - relaxation oscillation of W UMa type stars like BL Eri (Yamasaki et al. 1988) and TW CrB (Zhang and Zhang 2003).

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