New light curve of massive star binary system HD 152590

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Abstract:
We present a new light curve of the eclipsing binary system HD 152590. It was obtained by differential photometry from a series of images in filters B, V, R and I from the Johnson & Morgan system. The observations were made with the 0.6 m Helen Sawyer Hogg (HSH) telescope, located on the Burek hill, that belongs to Complejo Astronómico El Leoncito (CASLEO) in Argentina. The comparison of our light curve with that obtained from the photometric data of the All Sky Automated Survey (ASAS) yields new hints on the existence of apsidal motion in this system.

1 - Introduction

Massive stars ($M > 8M_{\odot}$ at the time they enters the ZAMS - Zinnecker & Yorke, 2007) play a key role among the astrophysical objects that dictate the evolution of the universe as we know it. They are usually found in binary systems much more frequently than stars of lower mass (Barbá et al., 2017; Sana, 2017).
Futhermore, eclipsing binaries are the most direct approach to determine fundamental stellar astrophysical quantities such as mass, radius, and temperature.
On this work our target was the massive binary system HD 152590 (V1297 Sco, V= 8.444 $\alpha_{J2000} = 16^h\ 56^m\ 05.215^s$ $\delta_{J2000} = -40^o\ 20'\ 57.576''$) that also is an eclipsing binary.
Through the years different authors have obtained orbital solutions for the systems using diverse methods:

- 1982 – Gieseking discovered the binarity of HD 152590 using radial velocity curves
- 2004 - Otero & Claus (hereafter, OC) were the first to obtain a light curve with photometric data from the All Sky Automated Survey (ASAS, Pojmanski, 1997).
- 2016 - Ferrero using high resolution spectroscopy taken at CASLEO and from the OWN Survey (high resolution spectroscopic monitoring of Galactic O- and WN-type stars of the Southern hemisphere - Gamen et al., 2007; Barbá et al., 2017) reported the probable existence of apsidal motion (also known as orbital precession) in this system.

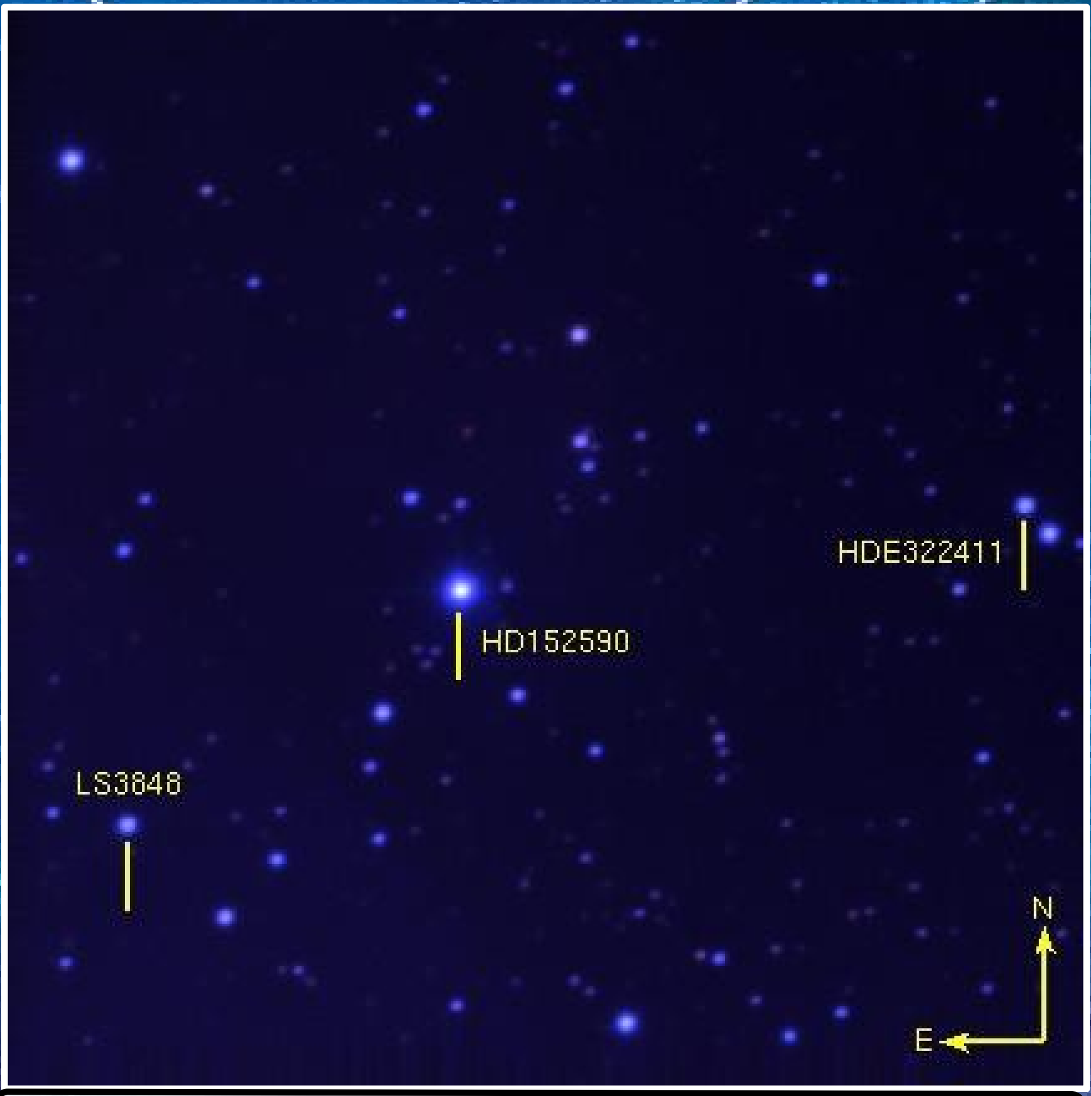

Figure 1 - RGB image of HD 152590 field averaging all the images taken during 10 June night in B, V and R filters. Comparison star LS 3848 and control star HD 322411 are also indicated.

Our goal:
Obtain a new orbital solution using photometry and spectroscopy as well. To accomplish this and considering the uncertainties in the ASAS observations (tipically ~ 0.043 mag) we realized that we should focus to obtain a better photometry (error lower than 0.01 mag).
Additionally, the possible existence of apsidal motion indicates that it is convenient to obtain a light curve in a short time span.

2- Observations

We obtained images of HD 152590 using filters B, V, R and I from the Johnson & Morgan system (Fig. 1). The observations were made on the nights from 10 to 16 june of 2018 making use of Helen Sawyer Hogg (HSH) telescope (f/15, FOV of 9.2 × 9.2 arcmin^2 and plate scale of 0.54 arcsec pix^{-1} - Pereyra et al., 2018) belonging to CASLEO.
The primary eclipse was observed in the nights of June 10 and 14, and the secondary eclipse on June 12 and 16.
During each night we observed with the four filters B, V, R, I, following the sequence BBB VVV RRR III BBB... From that observation shift we obtained a total of 1797 images. The exposure times in each filter were chosen in such a way that the maximum intensity in our images were approximately 30 000 counts. In this way we prevent the saturation of the CCD (approx 60 000 counts).
Exposure times for each filter and average seeing values are presented in Table 1.
According to our measurements, it seems that the seeing during our observations was better than usual for that site (3 arcsec). In our observations we measured a typical value of 2.4 arcsec, with a minimum value of 1.4 arcsec in filter R and I during the night of June 16.

3 - Photometry

The images were processed using the standard procedure with iraf . To get an optimal signal-to-noise ratio we work with an aperture radius of 7 pix. To subtract the emission of the sky, we took a ring of 14 pix internal radius and a width of 10 pix. The criterion of choice was to use a radius that was twice the opening one.
The differential photometry was performed using LS 3848 as a comparison star and HD 322411 as a control star (Fig. 1). These stars fulfilled the condition of being bright and having a constant brightness. In this analysis we found that the brightness of the two comparison stars are constant, at least within a range of 0.0097 magnitudes in the V filter (Fig. 2).

Table 1 – Observation parameters divided by night and filters.

Night	B				V				R				I			
	n	t_m	t_M	S	n	t_m	t_M	S	n	t_m	t_M	S	n	t_m	t_M	S
10	76	30	45	3.5	75	20	40	3.4	75	10	20	3.2	75	15	25	3.1
11	26	20	40	3.0	26	20	40	2.8	27	10	15	2.7	27	10	15	2.6
12	45	45	45	3.1	48	25	40	3.0	45	20	20	2.8	45	15	30	2.6
13	12	40	40	2.8	12	30	40	2.9	12	15	15	2.7	12	20	20	2.6
14	124	40	45	2.9	128	25	40	2.8	126	15	25	2.6	128	15	20	2.4
15	12	45	45	2.4	12	40	40	1.9	12	20	20	1.8	12	25	25	1.6
16	129	10	40	1.5	141	5	20	1.5	141	3	10	1.4	139	3	10	1.4

n: Number of observations; t_m : Minimum exposure time [s]; t_M : Maximum exposure time [s]
S: Average FWHM [”].

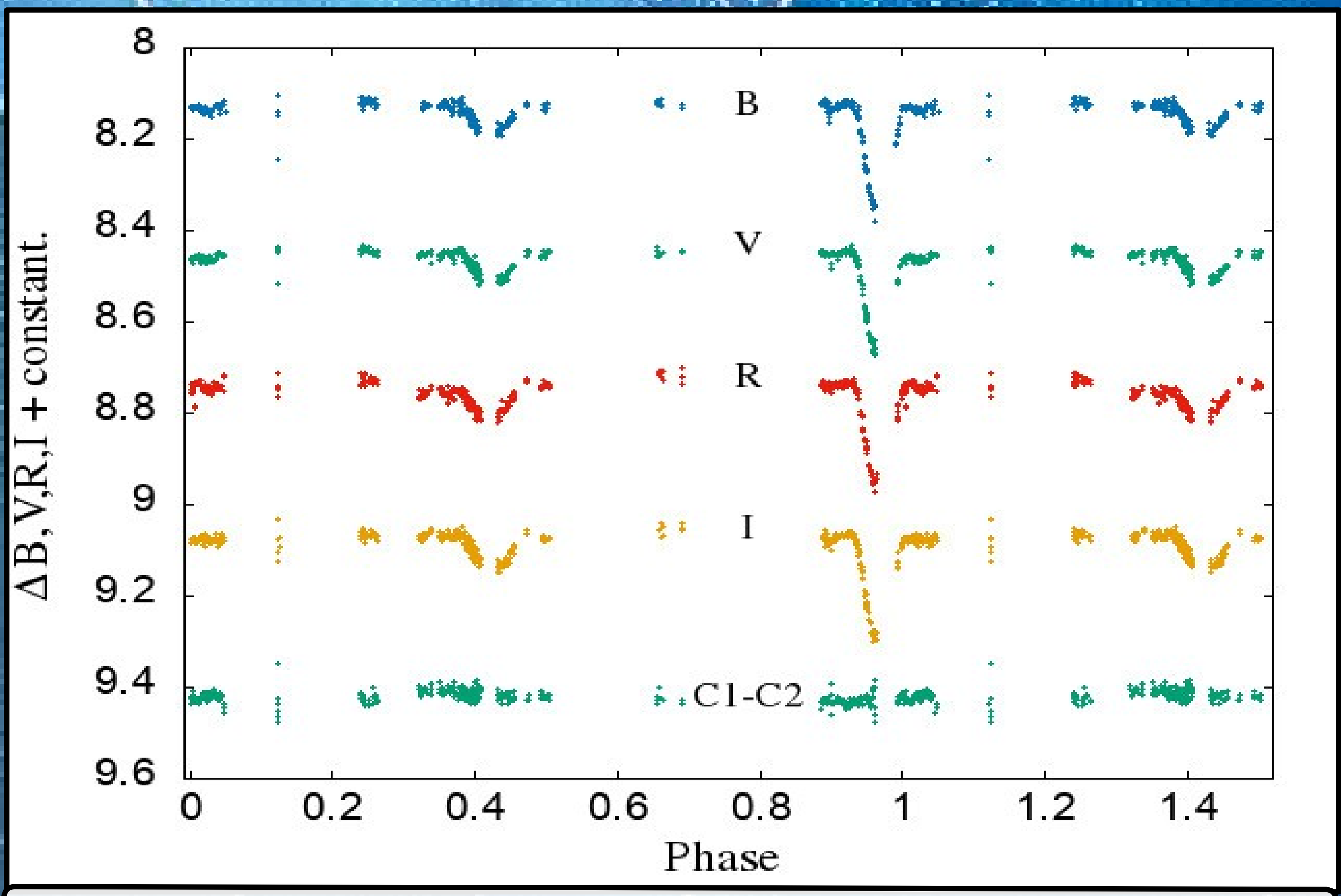

Figure 2 – Differential photometry of HD 152590. In each filter a different constant was added to make its visualization easier. C1-C2 represents the difference between the comparison star and the control star in the V filter.

4 - Light curve analysis and discussion

From the photometric measurements we obtained the system light curves for the different filters (Fig. 2). There we observed light curves with the characteristic profile of an eclipsing binary of the Algol type. We could also conclude the following:

- When we compare our observations with those of ASAS used by OC (Fig.3), we see the effect of the difference in the error estimated by ASAS in their measurements (0.043 mag) and the error in our measurements $\delta(\Delta V)$~0.005mag in V filter.
- The two measurements of the depths of the eclipses agree with each other.
- Our observations do not coincide exactly in phase with those of ASAS. They seem as if they were displaced, but the amount of displacement is greater around the secondary minimum.

The phase displacements could be explained in indifferent ways. Could be an error on the ephemeris parameters or a shift in the barycenter of the binary system due to the presence of a third body (Hilditch, 2001, Ch. 4). In this case we lean in favor of the idea proposed by Ferrero (2016) about apsidal motion as an explanation of this phenomenon.
On future works we will complement the analysis of the light curve with spectroscopic data. This way we aspire to achieve a complete orbital solution and to prove or reject the existence of apsidal motion in the system.

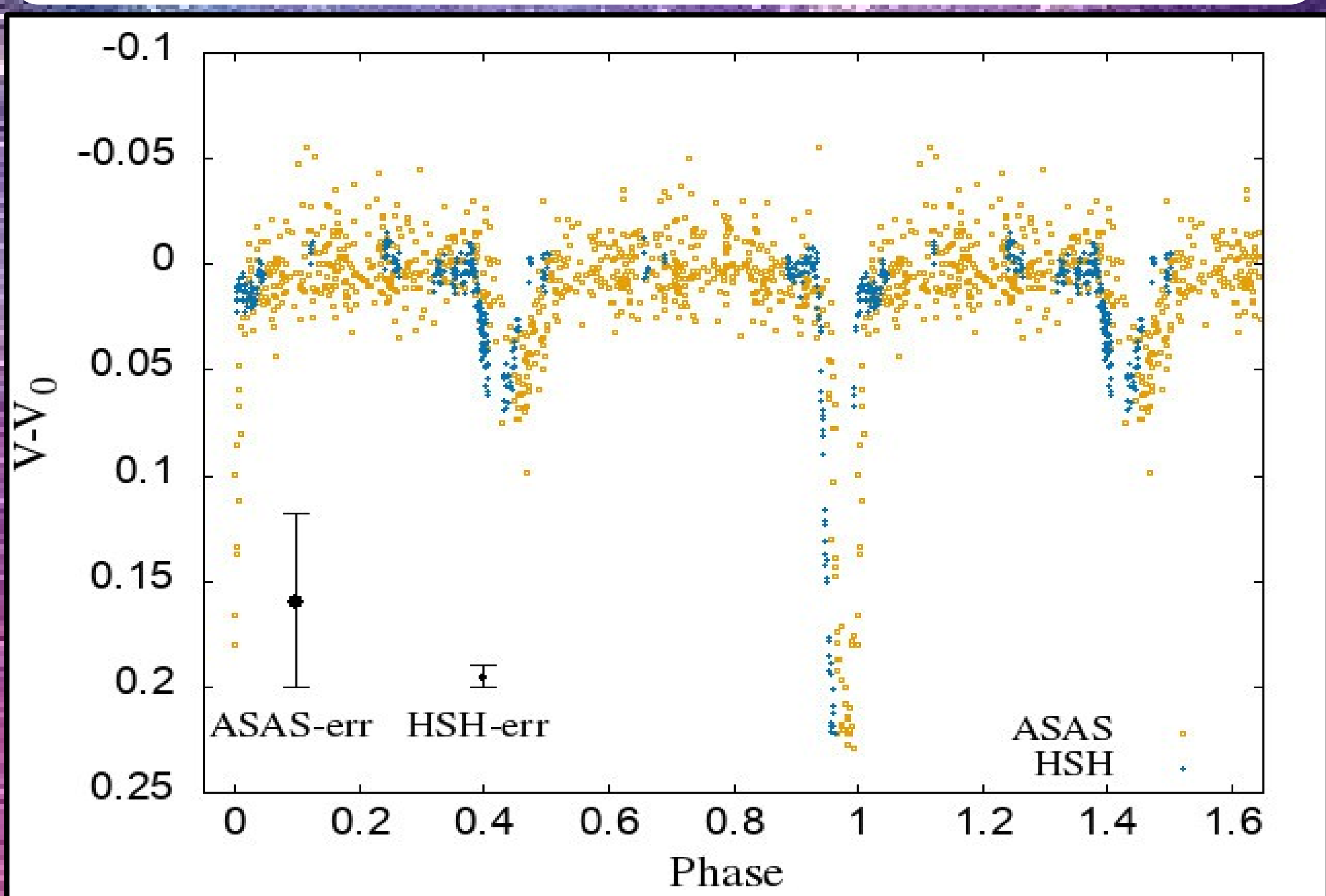

Figure 3 – ASAS light curve in dark yellow and ours in blue. The data error bars corresponds to the typical error in ASAS according to the survey tables and HSH data.

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