

# CESEB: A REPORT ON LATEST RESULTS

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**ABSTRACT.** Central-East-South European Binary star study group - CESEB - is an international research team focused on the study of binary stars through combined spectral and photometric observations that can be made using the Bulgarian NAO 2m telescope and several smaller telescopes located at various places in the Central East South European region. This paper is a report on our activities and results.

**Key words:** Stars: binaries: eclipsing - stars: binaries: spectroscopic - stars: radial velocity curve - stars: individual: HS Her, EP And

## 1. Introduction

Several eclipsing binary systems have been selected for combined spectral and photometric observations using the Bulgarian NAO 2m telescope and several smaller telescopes located at various places in the Central-East-South European (hereafter CESE) region. A pilot study were started in 2001, about radial velocity and light curve variations of the active W UMa system LS Del, which has been presented in 2005 (Hegeds et al., 2006). After that, the continuous photometry and simultaneous spectroscopy has been started for the selected list of targets. The present paper is a temporary status report of our international working group.

## 2. CESEB Spectroscopy

Spectroscopic observations in the frame of CESEB collaboration have been made at National Astronomical Observatory Rozhen, Bulgaria, in the period from 2002 to 2007, with the 2-m Ritchey-Chretien telescope and the Coude horizontal spectrograph, with wave-

length range of approximately 200 Å centered on two areas of interest: around Na I D1/D2 (5889.95/5895.92 Å) lines, and around Mg II (4481.15 Å) line.

Data reduction for all the observations has been done at Astronomical Observatory of Belgrade, Serbia, using standard IRAF packages for CCD reduction; images were bias and flatfield corrected, cleaned from cosmic rays, and wavelength calibrated using reference spectra of a ThAr lamp. The extracted spectra were continuum-normalized, and image headers were supplemented by the calculated corrections for radial velocity of Earth's motion. The reduction process was carefully standardized in the hope of future automatization.

So far radial velocities have been measured from Doppler shifts of spectral lines; this method is suitable for single-lined binaries and systems with relatively few lines in the selected spectral regions, but fails, for instance, in the case of V994 Her (which is a suspected hierarchical 4-body system) although this object has the best phase coverage, or in the case of RX Her which, on the other side, proved to have too few prominent lines. However, preparations are underway to measure radial velocities of all objects using the more advanced cross-correlation and spectral disentangling techniques.

In the following section we present the preliminary results of radial velocity measurements for HS Her.

### 2.1. HS Her

HS Herculis is a bright ( $m_v = 8.61$ ) detached binary system with a blue giant primary (Sp. B6III + A4); it has been a target of many photometric measurements due to its apsidal motion and a suspected third body in the system (Wolf & al. 2002). However, the only previous spectroscopic measurements were made by Cesco & Sahade (1945).

We have obtained a single-lined radial velocity curve

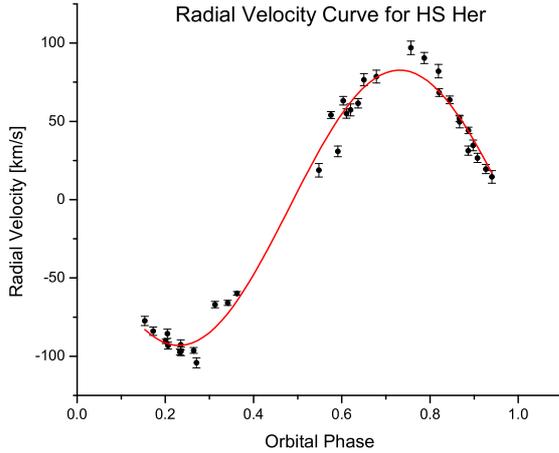


Figure 1: Radial velocity curve for HS Her.

for HS Her (Figure 1) from 35 observations. We used lines of neutral helium and ionized magnesium (He I at 5875.62, 4387.93 and 4471.48 Å and Mg II at 4481.23 Å) to calculate Doppler shifts of observed spectra, in which we measured the central wavelengths by fitting Gaussians to the lines.

Fitting the radial velocity curve to the data was done using PHOEBE (Prsa & Zwitter 2005), a modelling facility based on Wilson-Devinney code. The free parameters of the fit were the system's semi-major axis, center of mass radial velocity, mass ratio, eccentricity, and the argument of periastron, while we fixed the values of period to  $P = 1.63743125$  days (from Wolf & al. 2002) and the inclination to  $i = 88^\circ.5$  (Martynov et al. 1988). The results are given in Table 2.

Table 1: Results of radial velocity curve fitting for HS Her.

Parameter	Value
$K_1 [\frac{km}{s}]$	$90 \pm 5$
$S.m.a [R_\odot]$	$7 \pm 1$
$\gamma [\frac{km}{s}]$	$-7 \pm 2$
$\omega [deg]$	$25 \pm 20$
$q = \frac{m_2}{m_1}$	$0.6 \pm 0.2$
$e$	$0.08 \pm 0.03$

### 3. CESEB Photometry

We made numerous BVR measurements of the target systems of CESEB cooperation during 2001-2007 at the Baja Observatory, using the Apogee

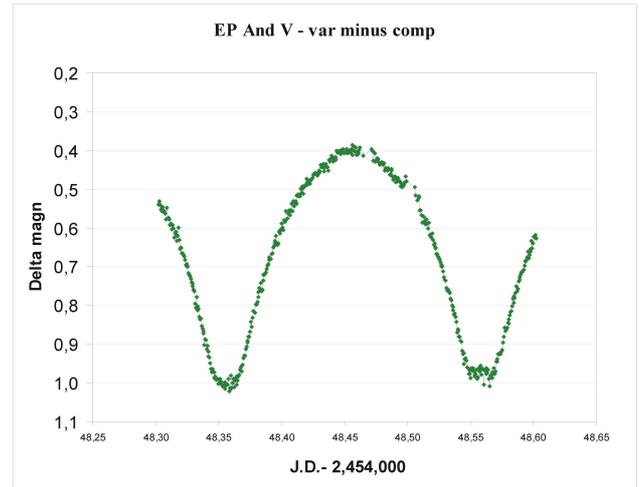


Figure 2: Figure 2. The sample photometric data from BART-1

AP7 CCD of the 50 cm f/8.4 RC telescope, and V measurements using the new 4k2 Apogee Alta U16 CCD on the brand-new 50cm f/6 MC robotic telescope. Large part of these data are mainly served as exact timing of one or both minima of the target systems for having good phases for construction of the RV curves. Some complete light curves were also obtained, good enough for light curve analysis - see e.g. Figure 2. The analysis of these data sets are under way.

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