MID-CYCLE OBSERVATIONS OF CR BOO AND ESTIMATION OF THE SYSTEM PARAMETERS

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Introduction

We present simultaneous observations (with Rozhen and Vidoevica telescopes) of the AM CVn star CR Boo in UBV bands. The data are obtained in two nights in July 2019, when the V band brightness was in the range 16.1 - 17.0 mag.

- In both nights, variability with a period of 25±1 minutes and amplitude of about 0.2 magnitudes is visible. These brightness variations are most likely indications of "humps".
- During our observational time, they appear with the period similar to the CR Boo orbital period. Possible reason of their origin is the phase rotation of the bright spot, placed in the contact point of the infalling matter and the outer disc edge.
- We estimated some of the parameters of the binary system, on the base of the observational data.

Object details

- CR Boo is a member of the AM CVn stars group.
- The AM CVn stars are short period (5 - 65 minutes) binary stars, in which a white dwarf accretes helium-rich material from a low-mass donor star (Podsiadlowski et al. 2003, Solheim 2010). Often are classified as interacting binary white dwarfs or Double White Dwarfs binaries.
- CR Boo is discovered in 1986 by Palomar Green (Green et al. 1986) and catalogued as PG 1346+082. The first observations of Wood et al. (1987) show brightness and magnitude variability at outburst with amplitude: 13.0 - 18.0 V. The average orbital period of CR Boo is ~ 1471.3s ~ 24.5 min or 0.017 days (Provencal et al. 1997, Isogai et al. 2016).
- The binary period, photometry and spectroscopy of CR Boo define its components as: a white dwarf primary and a helium white dwarf secondary star (Kato et al. 2000, Isogai et al. 2016) .
- The masses of two components vary in ranges of: 0.7-1.1 for M1 and (0.044 - 0.09) for M2 (Solheim 2010, Roelofs et al. 2007b).
- CR Boo has one of the best observational behavior, exhibits large-scale amplitude variations in brightness. The star produces high outbursts frequency in a super-cycle of about ~ 46 days (Kato et al. 2000).

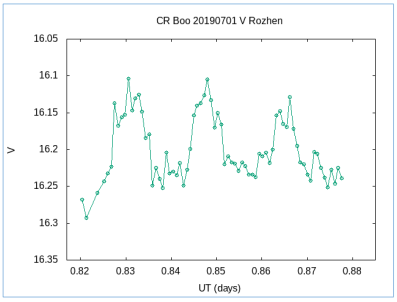

Figure 1. Light curves of CR Boo in V band on 2019 July 1. The star magnitude was 16.1–16.3 in V, with average amplitude variations - 0.2 and periodicity of ~ 21.6 min.

Table 1. System parameters:
M1 - mass of the primary star, **M2** – mass of the secondary star, **q** – mass ratio; **M = M1+M2**; **P** – orbital period; **τ** [days] - super-cycle period; ***i*** - inclination angle; **R1** – radius of the primary star; **R2**– radius of the secondary star ~ **RL** (Roche lobe radius); **a** – the orbital separation between the components.

M_1 [$M_\odot$]	M_2 [$M_\odot$]	q	M	P [min.]	τ [d]	*i* [deg]	R_1 [$R_\odot$]	R_2 [$R_\odot$]	a [$R_\odot$]
0.80	0.07	0.087	0.87	24.5	~ 46	30	0.012	0.052	0.266

Results

Observations

Two days in July 2019: 20190701, 20190705
Telescopes: 2.0 m telescope of the National Astronomical Observatory (NAO) Rozhen, Bulgaria + Vidoevica telescopes, Serbia.
Bands: UBV
mid-cycle: The time of our observations are between outbursts states, or probably before the high state, according to the super-cycle period of **~ 46 days** and comparing to other observations.

Humps

The observational data, see figures, shows small-amplitude variability in the luminosity (table 2), manifested in UBV bands.

- The period of these amplitude variations is very close to the orbital period of 24.5 min.
- Their behavior is recognized as a "humps" production.
- The average amplitude of the humps varies: 0.2 – 0.3 Mv.

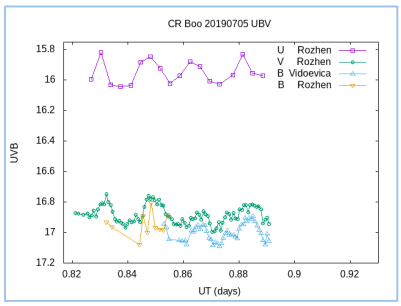

Figure 2. Light curves of CR Boo in UBV bands on 2019 July 5. The brightness decreases with 0.7 magnitudes in its maximum and minimum values in V, comparing to July 1 data (fig.1). The variability is again 0.1 – 0.2, with periodicity of 21.6–25.9 min.

Table 2. Mean values of luminosity L[L⊙], calculated for two days of observations, for each of the bands separately. Values in the cells - in order by: min/mean/max.

Date\ Band	V1	V2	U	B	B_Vid
20190705	0.0154 0.0171 0.0194		0.0372 0.0406 0.0461	0.0143 0.0161 0.0184	0.0138 0.0166 0.0196
20190701		0.0279 0.0318 0.0352			

Concluding remarks

- We presented the observations of AM CVn star CR Boo in UBV bands, made in 2 days of July 2019: 20190705 and 20190701
- On the base of these observations, we calculated the luminosity values for each band.
- The observed small-scale brightness variations in those two days are probably the "humps" productions.
- Since these humps are appearing during the quiescent state, we suggest that the most possible origin is the existence of the hot spot and its periodical visibility. That's why they are usually called an "orbital humps".

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