Optical Investigations of the Cataclysmic Variable Stars HP Lib and NY Lup

UNION COLLEGE

Christos Kakogiannis, Francis Wilkin

Union College

Abstract

A cataclysmic variable star system consists of two stars that are close enough for material transfer from one to the other through an accretion stream onto a circumstellar accretion disk. Variations are seen in the light due to rotation of the accretion hotspot, variations of the material flow rate, and the change of view angle due to orbital motion of the binary. We chose high priority targets from the Center for Backyard Astrophysics (CBA) [1], an amateur-professional collaboration, and observed them at the 0.6m telescope of El Sauce Observatory in Chile. We observed HP Lib on three nights in June and July and noted an overall brightening. We obtained photometry on NY Lup for three nights during a single week in July and detected substantial variation.

1. Introduction

Cataclysmic Variable star systems (CVs) are binary systems typically consisting of a white dwarf (WD) and a low-mass companion, either a later-than-G main sequence Star (MS), a subgiant, or a red giant [2]. Mass can be transferred from the companion onto the primary WD when one of the two stars has expanded beyond its Roche lobe. Mass accumulation on and/or around the primary WD can cause a bright outburst --a nova explosion-- from which the system can survive. The targets we analyzed are Intermediate Polars (IPs), a subtype of CVs, containing a magnetic WD, whose field-strength can perturb the accretion flow but cannot synchronize the WD rotational period with the binary orbital period [2].

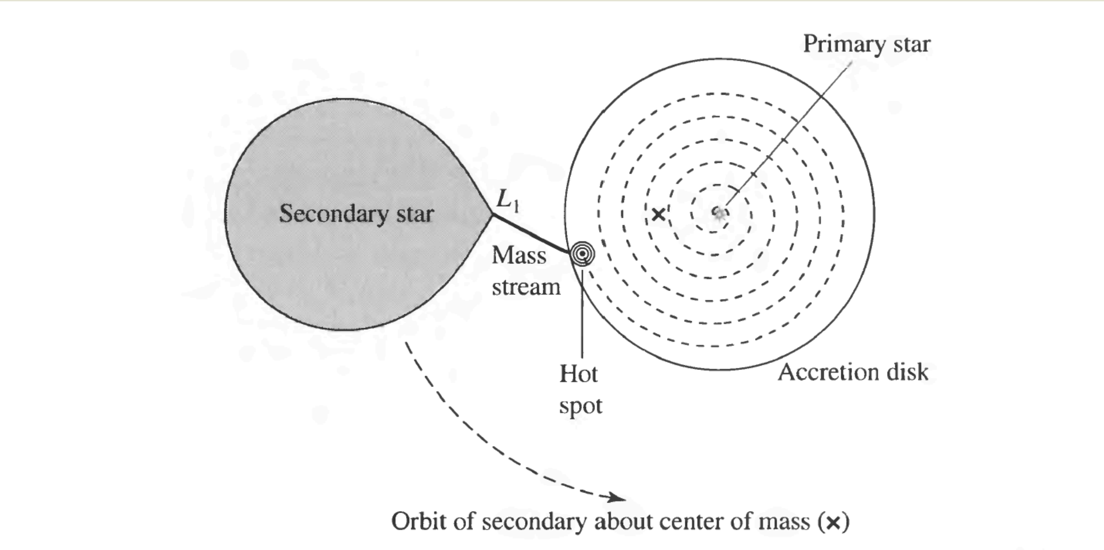

Fig. 1. *A CV star system model with an accreting WD, an accretion circumstellar disk, and an accretion stream in a semi-detached binary. [3]*

2. Observations & Telescopes

We chose to observe HP Lib as CBA needed more data on its long term variation. We also chose to study NY Lup, which had been recently neglected, hence the collaboration needed long timeseries to look for short term variations. We obtained telescope time for purchase from the Telescope Live network [4], which permitted our project to be conducted entirely remotely. Images were obtained from El Sauce Observatory in Chile, using a Planewave CKD24, 0.6m, f/6.5 reflector with an FLI PL9000 CCD camera. We used an Astrodon Luminance filter, which is the nearest possible to Clear, the CBA standard practice.

Table 1. *Source Parameters of the Target Systems.*

HP Lib			
Magnitude Range	**Right Ascension**	**Declination**	**Constellation**
V: 13.65 - 13.80	15h 35m	-14º 13’	Libra
NY Lup			
Magnitude Range	**Right Ascension**	**Declination**	**Constellation**
V: 14.50 - 14.78	15h 48m	-45º 28’	Lupus

Table 2. *Observing Circumstances.*

HP Lib			
Nights	**frames X exposure**	**Total Session time**	**Filter**
June 21, 2020	3 X 20s	0h 22min	L
July 18, 2020	5 X 60s	0h 17min	L
July 23, 2020	5 X 60s	0h 17min	L
NY Lup			
Nights	**frames X exposure**	**Total Session time**	**Filter**
July 19-20, 2020	130 X 45s	3h 20min	L
July 21, 2020	28 X 45s	0h 36min	L
July 24, 2020	23 X 45s	0h 30min	L

3. Photometry

We performed photometry with AstroImageJ [5], using 5 comparison stars for each target from the AAVSO finder charts and the Simbad database. We converted the relative fluxes to instrumental magnitudes according to Eq. 1.

$$L_{instr} = -2.5 \log_{10} F_{L,rel} \quad (1)$$

We used the transformation equation (Eq. 2) to convert the instrumental L mag into Clear (C) mag:

$$C = x \cdot L_{instr} + y \cdot (B - V)_{sim} + z \quad (2)$$

We decided not to use a color term, i.e. $y = 0$, since this is not standard for AAVSO. In order to find the coefficients x, z, we utilized a least squares model, minimizing the sum of the squared differences of the average C mag and the reported V mag for our comparisons:

$$S = \sum_{i=2}^{6} (C_{av,i} - V_{s,i})^2 \,, i = comp.index \quad (3)$$

We calculated the average C mag with Eq. 1 using the average L flux for each star.

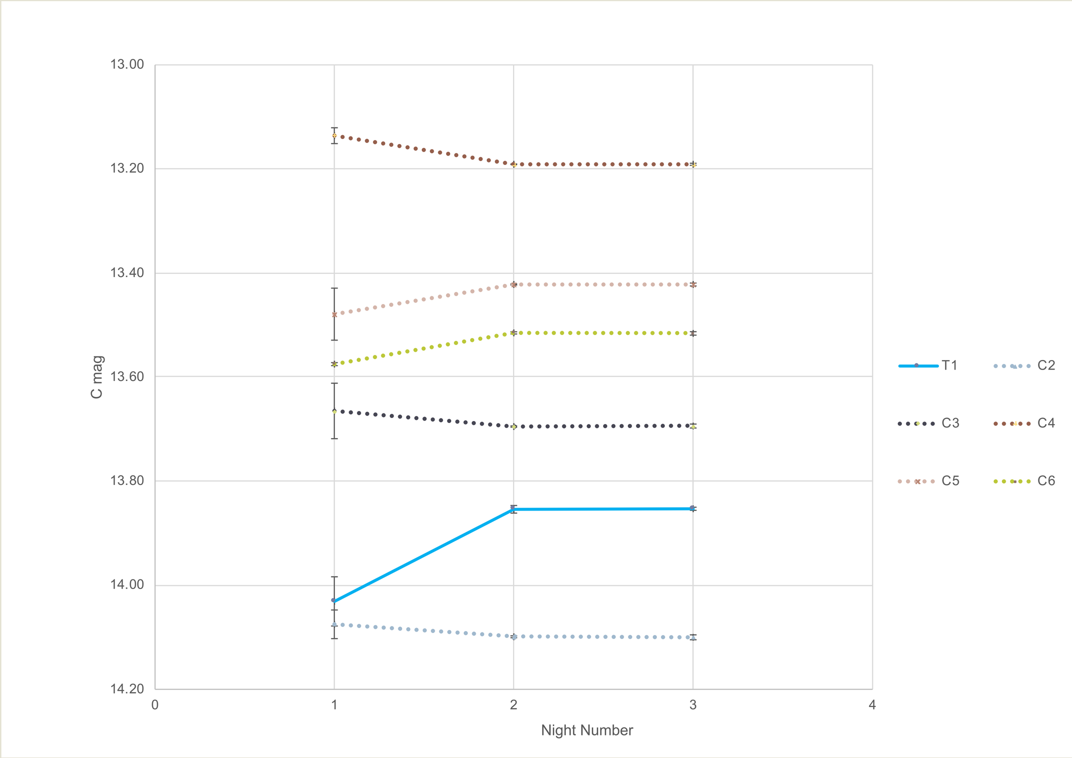

Fig. 2. *HP Lib photometry for June and July 2020. A brightening is seen between the first night (June 21) and the second night (July 18). Error bars represent internal errors only.*

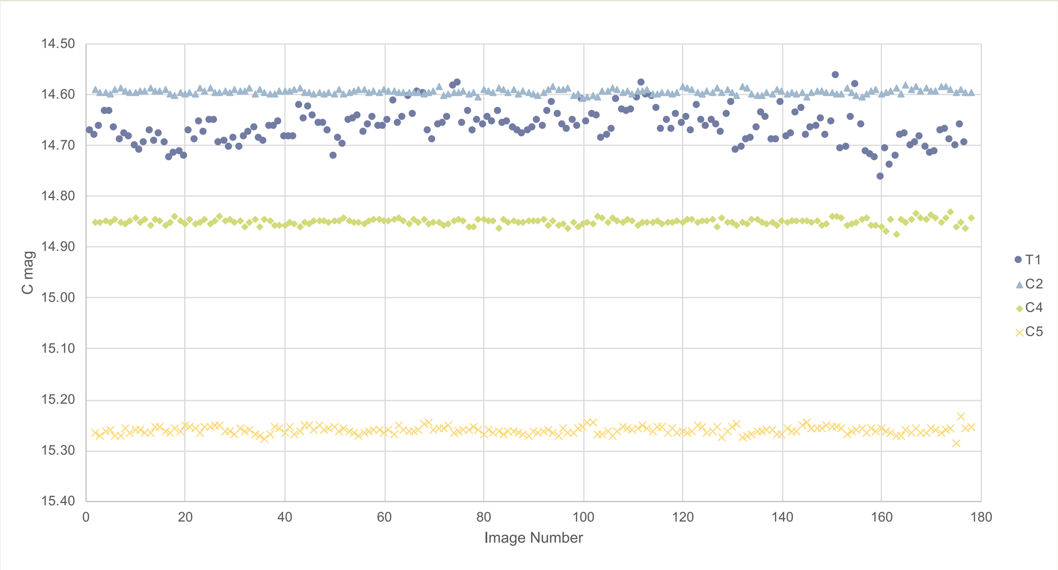

Fig. 3. *Preliminary Photometry for NY Lup. Images from three nights in July 2020 are included; night 2 starts at image 131, and night 3 stars at image 158. We continue to analyse the variations in NY Lup to determine whether a nearby bright star has affected the photometry.*

4. Future Prospects

Our results will be combined with those of other CBA observers and analyzed for variation on multiple timescales, allowing a detailed interpretation in terms of physical changes of these systems.

5. References

[1] CBA; https://cbastro.org/

[2] Littlefield, Colin et al. *“The Rise and Fall of the King: The Correlation Between FO Aquarii’s Low States and the White Dwarf’s Spin-Down.”* The Astrophysical Journal 896.2 (2020): 116. Crossref. Web.

[3] Carroll, Bradley, and Dale Ostlie. *An introduction to Modern Astrophysics.* 2nd ed., Pearson, 2007, p. 662.

[4] Telescope Live; https://telescope.live/

[5] Collins, Karen A. et al. “ASTROIMAGEJ: IMAGE PROCESSING AND PHOTOMETRIC EXTRACTION FOR ULTRA-PRECISE ASTRONOMICAL LIGHT CURVES.” The Astronomical Journal 153.2 (2017): 77. Crossref. Web.

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