NATIONAL ASTROPHYSICS AND SPACE SCIENCES
Accreting Compact Binaries (ACB)
Department of Astronomy
Makofane Comfort(MKFMAN002)
Project
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1 Introduction

Polars (AM Her) are a type of close binary system with very short orbital periods. They consist of a white dwarf (primary) and a red dwarf (secondary). The red dwarf fills its Roche lobe and loses material through the inner Lagrangian point (L1). This material enters the primary's Roche lobe and as the results it's so close that is pulled toward the white dwarf through gravitational overflow. The white dwarf's strong magnetic field causes the two stars to rotate in sync with their orbit (synchronous rotation). The material flows in a ballistic path at first (as in normal CVs), but then hits a point where magnetic pressure dominates, it's redirected onto the white dwarf's magnetic poles where is forced to flow along the magnetic field lines directly onto the white dwarf's surface, often forming bright accretion spots (see, figure 1)

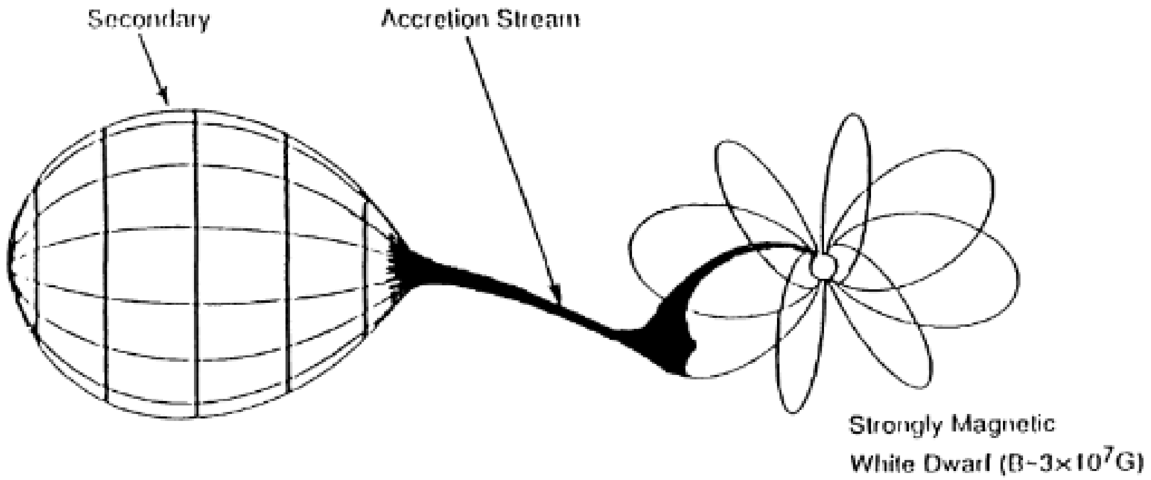

Figure 1: Schematic representation of a polar system. Material from the secondary star is transferred towards the magnetic white dwarf, where it is redirected by the strong magnetic field lines and guided along them to accrete onto the magnetic poles of the white dwarf.

CTCV J1928-5001 was first recognized in the Calán-Tololo survey using both its spectrum and light curve, which is identified as AM her system candidate [1]. AM Her system (a strongly magnetic cataclysmic variable, aka a polar). Stephen B. Potter et al, conducted follow-up study on the system using high time-resolved photometry which have confirmed its CV characteristics showing periodic brightness changes every $\sim$ 101 minutes along with brief but deep eclipses, confirming a close binary geometry. The light curve shows two bright humps phase and faint phase of the orbit. The ingress and egress of each eclipse happen very quickly, within 2 to 3 seconds, which allows the eclipses to be timed with high precision. By analyzing the exact shape of the eclipse the key binary system parameters such as inclination, mass ratio, white dwarf mass were estimated. Stephen B. Potter et al. further applied Stokes imaging to polarimetric data, revealing two accretion regions on the white dwarf. By combining this with eclipse analysis and particle trajectory modeling, they constrained key binary parameters.

In this work we use period04 to study the the light-curves of the CTCV J1928-5001 system using the data observed on the 5th and 9th of June 2013.

2 Observations

Observations of CTCV J1928-5001 used in this work were made on 5th and 9th June 2013, with no observations on the intervening days. The data collected on these dates are shown in Figure 2, along with the combined dataset.

3 Analysis

3.1 Fourier Analysis

A Fourier Transform is a mathematical tool that transforms a signal from its time-based representation into a frequency-based one, making it possible to examine the various frequency components contained within the signal [2]. The astronomical software (period04) used in this work has fourier transform mode to calculate the spin frequency of the white dwarf in the CVs. Figure 4 shows the dominant frequency calculated. Figure 3 show the orbital phase corresponding the calculated frequency.

3.2 Analyzing Figures

In Figure 2, the top panel shows the light curve of CTVJ1828 observed on 5 June 2013, the middle panel displays the light curve from 9 June 2013, and the bottom panel presents the combined light curve from both observations. The spin frequency of the White's dwarf is 15.03 cycles/day, rounded down to two decimal place (see, figure *4*). Figure 2 top and middle panel show repeating features. The light curves clearly shows sharp, periodic dips in brightness, where the flux drops dramatically, which can be interpreted as the obscuration of the accretion hot-spot by the accretion stream and subsequent eclipse by the donor star. Rapid increases in brightness followed by steep declines in polars' light curves can correspond to accretion stream impacts or flares at the magnetic poles. In top panel, sharp, periodic decreases in brightness due to the secondary star eclipsing the accretion regions on the magnetic white dwarf. These deep eclipses are indicative of high-inclination systems[3].

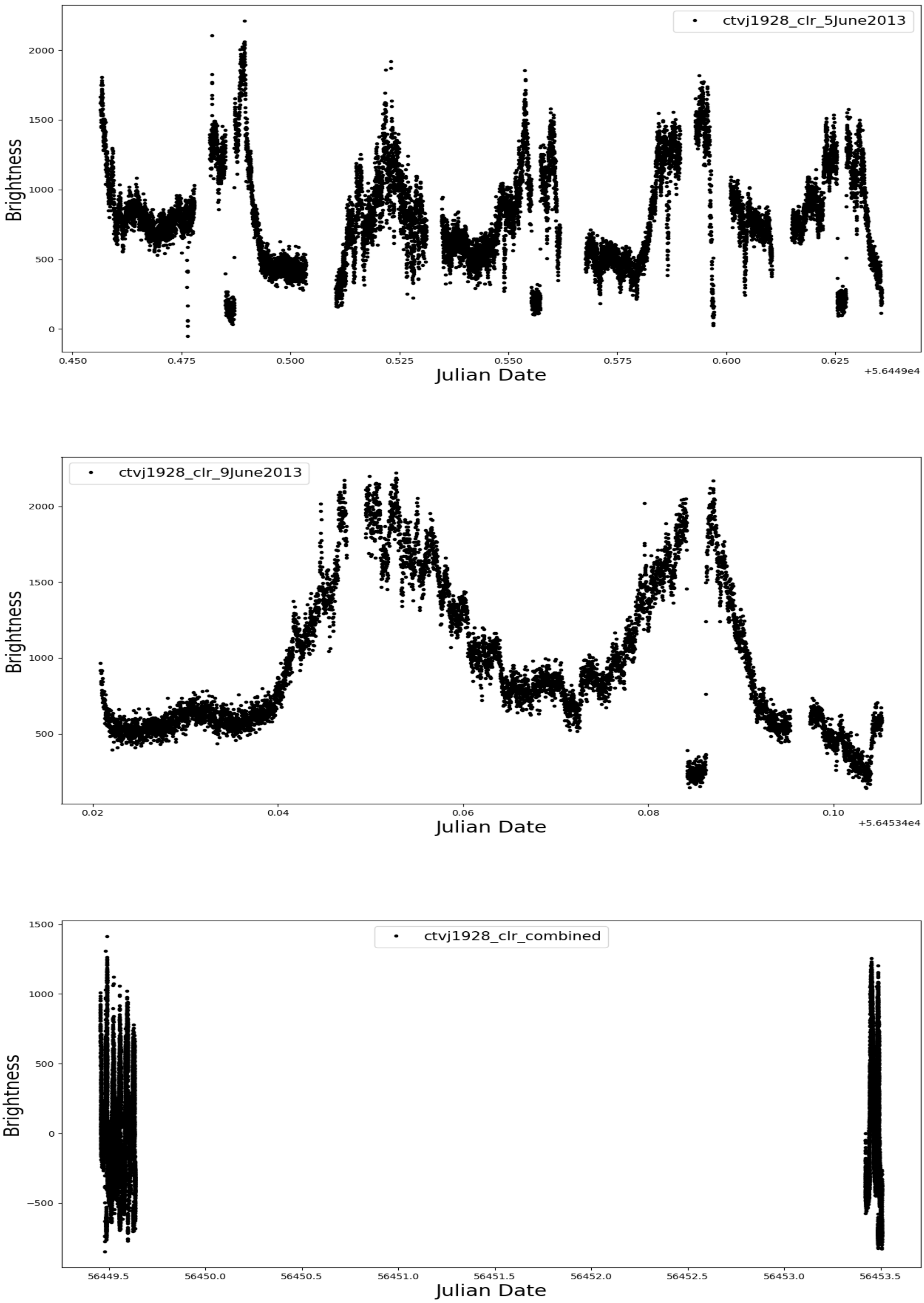

Figure 2: Images from 5 June 2013 (top), 9 June 2013 (middle), and combined image (bottom).

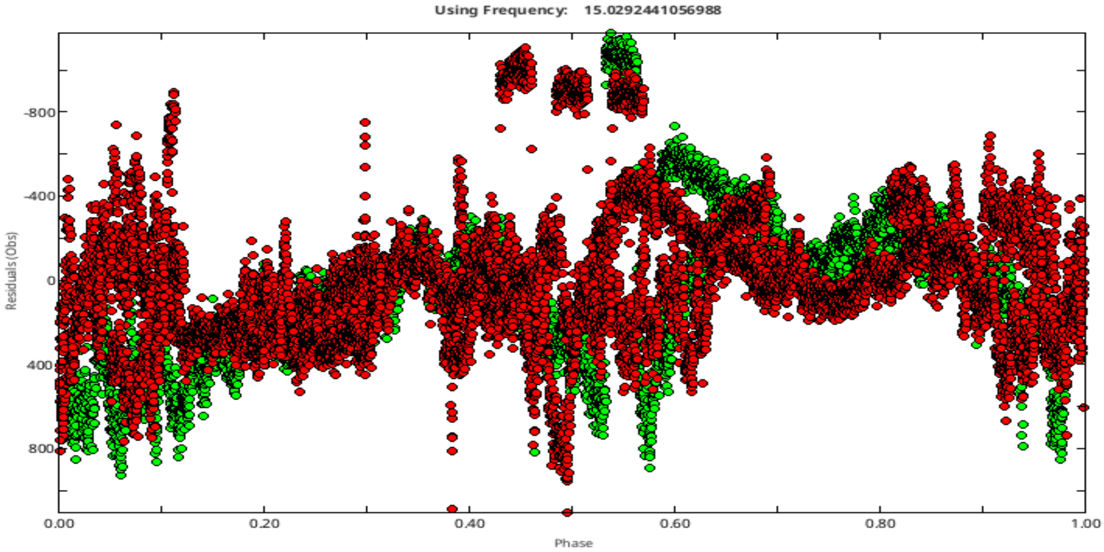

Figure 3

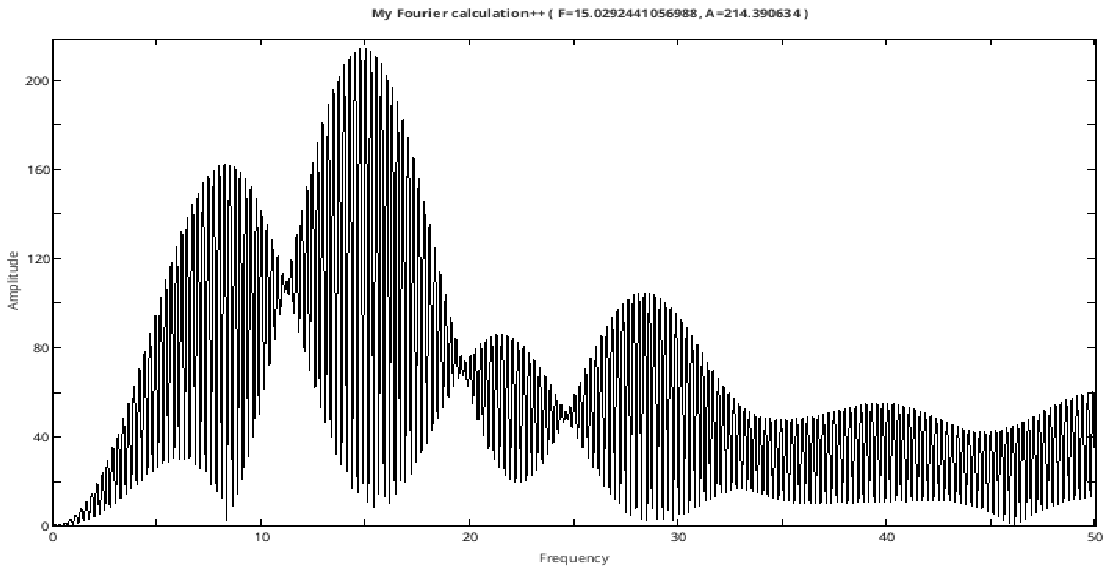

Figure 4

3.3 Computations

The spin frequency corresponding to the orbital phase of the system, figure 3 is 15,03 cycles/day. The corresponding spin period is calculated as follows:

$$
\begin{aligned}
P_{\text{spin}} &= \frac{1}{F} \\
&= \frac{1}{15.03} \times \text{days} \times 60\,\text{minutes} \\
&= 95.8\,\text{minutes}
\end{aligned}
$$

4 Discussion and Conclusion

In the literature [1], white's-dwarf in the system CTCV J1928-5001 reported to have strong magnetic field strength of approximately 20 G, hence polar(AM Herculis systems).

In this work, spin frequency of the light-curve of CTCV J1928-5001 is found to be 15.03 cycles per day. The corresponding orbital period is 95.8 minutes. In the study by Stehen B. Potter and others [1], CTCV J1928-5001 is classified as a polar, and their observations revealed that both photometric and polarimetric data are modulated on a period of approximately 101 minutes, which corresponds to the system's orbital period. This modulation indicates that the white dwarf's spin period is synchronized with the orbital period which defines characteristic of polars. The slight discrepancy between the 15.03 cycles per day mentioned in this work and the 14.26 cycles per day reported in the study may be due to differences in measurement techniques or data interpretation (*as you can see, orbital phase is not properly aligned 3*). In figure 2 top and middle panel shows an evidence of an eclipsing polar[3]. Therefore the light-curves of CTCV J1928-5001 system studied in this work suggest that CTCV J1928-5001 an eclipsing polar which is sipported by the literature.

References

[1] Stephen B. Potter, Thomas Augusteijn, and Claus Tappert. Photopolarimetric observations of the new eclipsing polar ctcv j1928 — 5001. *Monthly Notices of the Royal Astronomical Society*, 364(2):565–572, 12 2005. ISSN 0035-8711. doi: 10.1111/j.1365-2966.2005.09569.x. URL https://doi.org/10.1111/j.1365-2966.2005.09569.x.

[2] R. U Reddy. On fast fourier transform. *SpringerNature*, 3:79–88, November 1998. doi: 10.1007/BF02841425. URL https://doi.org/10.1007/BF02841425.

[3] H Breytenbach, D A H Buckley, P Hakala, J R Thorstensen, A Y Kniazev, M Motsoaledi, P A Woudt, S B Potter, V Lipunov, E Gorbovskoy, P Balanutsa, and N Tyurina. Discovery, observations, and modelling of a new eclipsing polar: Master otj061451.70–272535.5. *Monthly Notices of the Royal Astronomical Society*, 484(3):3831–3845, January 2019. ISSN 1365-2966. doi: 10.1093/mnras/stz056. URL http://dx.doi.org/10.1093/mnras/stz056.