A Comparison of the HADS(B) Variables VZ Cnc and VY Equ

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1. INTRODUCTION

High Amplitude Delta Scuti (B) stars typically pulsate in two frequencies, for example first and second overtone. The ratio of those frequencies lie around 0.8.

Two stars of this class were observed in 2021 and 2022 using a small telescope in combination with a DSLR camera (90 mm F5.6 / Canon D450 and D600). TESS has also observed both stars: VZ Cnc already in 5 campaigns (2019-2021), VY Equ in one (August 2022). This allows to compare my observations with literature and TESS data. The focus is to investigate similarities as well as differences in the pulsation properties of the two stars.

2. BRIGHTNESS and AMPLITUDES

Tab. 1 shows the brightness range for both stars. TESS is using a filter between 600 and 1000nm, therefore the absolute values are smaller than the TG (transformed to V) data from DSLR photometry. The pulsation amplitudes decrease with wavelength for those pulsators and the TESS amplitudes are about 50-70% of those in the visible range. The maximal amplitude for VZ Cnc is about twice as big as for VY Equ.

	VSX	Kolb	TESS
VZ Cnc	7.18 - 7.91	7.19. – 7.88	7.03 - 7.48
VY Equ	10.21 - 10.51	10.11 - 10.49	9.87 - 10.07

Tab 1: V and Tess Magnitudes (mag)

3. LIGHTCURVES

Normal delta Scuti stars with one pulsation frequency show the typical pattern of steep increases followed by slower decreases, similar to Cepheids. Maxima and minima of the brightness appear at the same phase cycle by cycle; typically phase zero defines the maximum.

Pulsators with more than one significant frequency show more complicated light curves with significant amplitude and period modulation: The time differences between maxima do not exactly match the main period (inverse of major frequency). This is visible in Fig 1. The main period of 0.1783 days is modulated by the second frequency. The "beat" (v2-v1) generates an additional periodicity. The amplitudes vary very significantly, , one out of four is typically low, shoulders may appear.

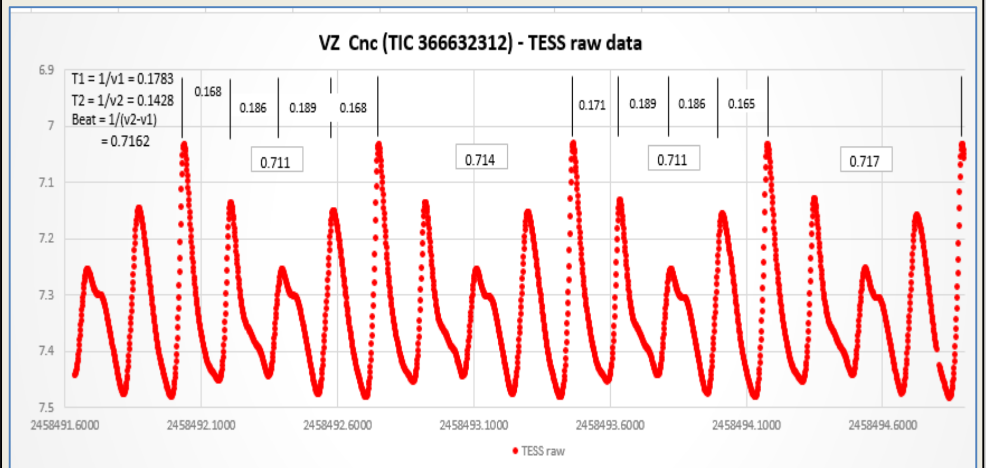

Fig.1: VZ CnC TESS lightcurve with major periods and beat

4. AMATEUR OBSERVATIONS vs. TESS

As I did not observe VZ Cnc same time as TESS did, I used the TESS measurements to build a Fourier model and interpolated to my observation dates. Fig. 2 shows three measurements. For the middle one I included data from the red DSLR channel to show that indeed the amplitude is smaller compared to the green (V) band, similar to TESS data.

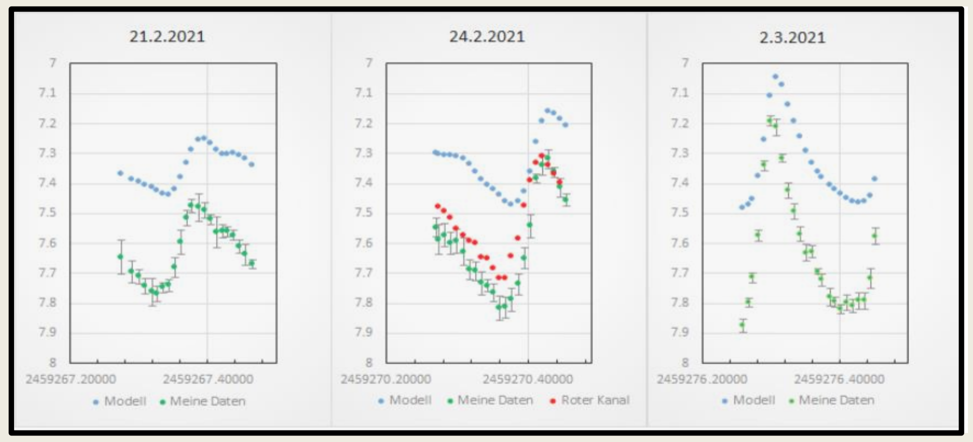

Fig.2: VZ Cnc: TESS light curve and my data

5. UNUSUAL LIGHTCURVES FOR VY EQU

The VY Equ light curves look different to VZ Cnc: The increases are not really steeper than the decreases and for one out of 4 consecutive cycles the brightness varies only very little with time. A plateau like feature replaces the expected maximum appears and it seems that the pulsation is "standing still". Fig. 3 shows the typical pattern of two "normal", one "unusual", and again a "normal" cycle.

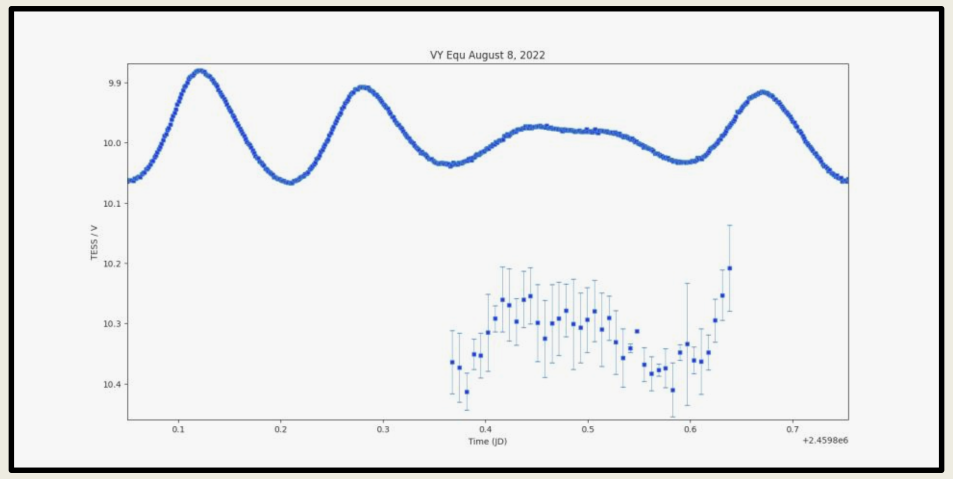

Fig.3: VY Equ: TESS lightcurve and my observations

The second part of this poster will try to analyze these observations by transformation of the light curves (brightness) into frequencies of pulsations

6. FREQUENCY ANALYIS

The standard method to extract pulsation frequencies from lightcurves is the fourier analysis. I used the program VStar from the AAVSO for both my measurements as well as the TESS data. I observed 10-20 cycles each star, often only partially covering the cycle time, in total several hundred data points for each star. Therefore the resulting power spectra of the Fourier analysis show significantly more alias peaks and noise, but with a technique called *pre-whitening* it was still possible to identify the two major frequencies.

The TESS dataset includes >16,000 data points per observation cycle, taken every 120 seconds. Therefore the power spectra show very clear peaks for both the two main frequencies as well as many combinations of them, in particular the harmonics 2v, 3v,… and the „beat" v2- v1. Fig. 4 shows the power spectrum of VZ Cnc identifying all peaks above the noise. No third independent frequency is visible.

The left axis shows the semi-amplitude which identifies the amount that the frequencies contribute to tthe overall variation of the brightness. F1 and harmonics are clearly the major contributors.

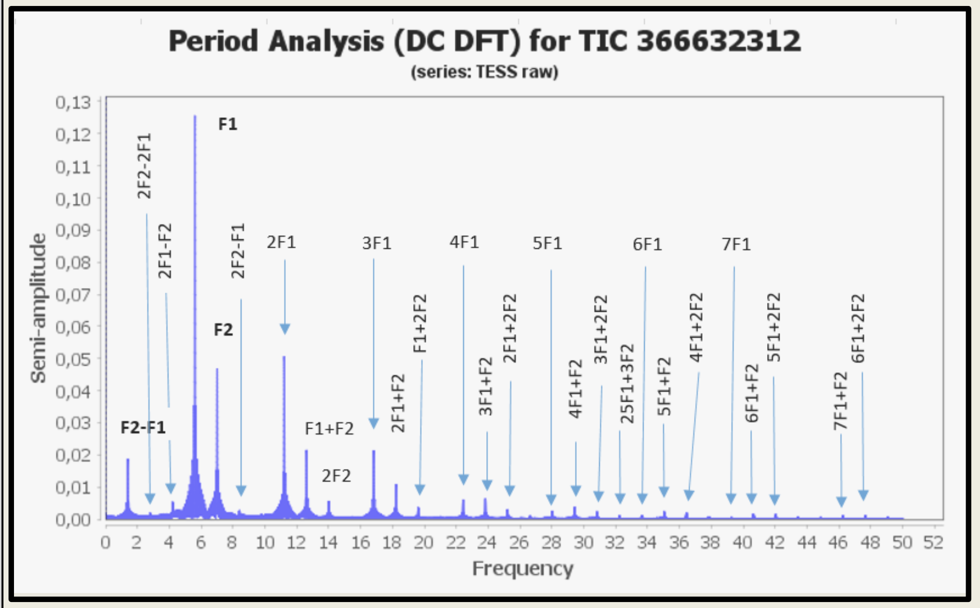

Fig.4: VZ Cnc: Power spectrum with semi-amplitudes

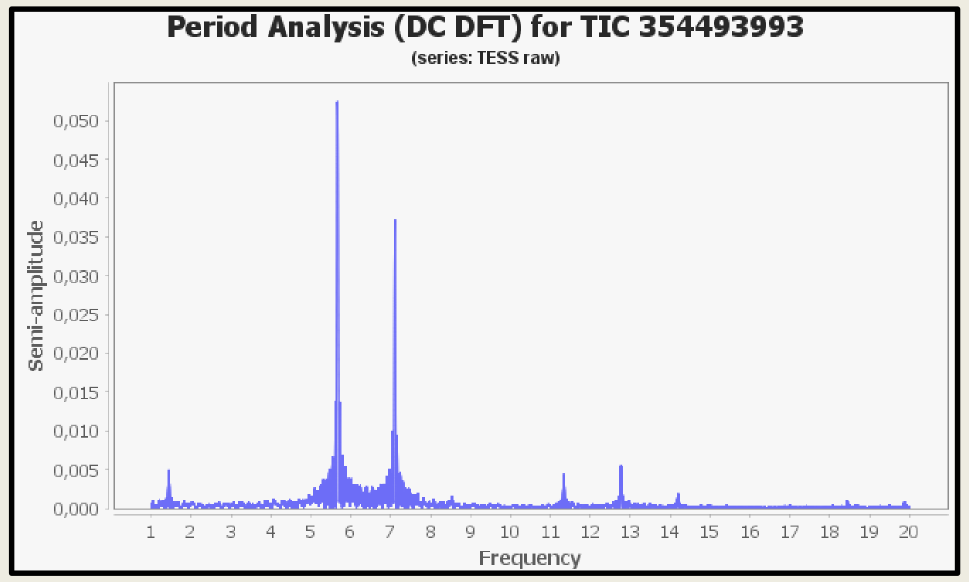

Fig.5: VY Equ: Power spectrum with Semi-Amplitudes

7. WHY IS VY EQU DIFFERENT TO VZ CNC

Looking at the same Fourier analysis of VY Equ it is clearly visible that the harmonics of v1 and other combination frequencies are much smaller, but v2 is much more pronounced vs v1 in comparison to VZ Cnc. As the lightcurve is a superposition of the frequencies, VY Equ shows a more complicates and less regular lightcurve than VZ Cnc. Table 2 shows the Frequencies and semiamplitudes for both stars. The periods are very similar between the two stars, but the ratio of the semiamplitudes is approx. 2.5 for VZ Cnc but only 1.3 for VY Equ!

		P1	P2	SA F1	SA F2
VZ Cnc	Fu	0.17836	0.14280		
	Cox	0.17836	0.14281		
	Kolb	0.17835	0.14279	0.180	0.060
	TESS	0.17836	0.14280	0.126	0.051
VY Equ	Khruslov	0.17644	0.14078	0.071	0.055
	Kolb	0.17644	0.14078	0.090	0.070
	TESS	0.17644	0.14079	0.052	0.037

Tab 2: Periods in days (1/F) and semiamplitudes (mag)

8. CONCLUSION

The calculated frequencies / periods from my limited number of observations match very well previous literature and TESS data.

The unusual lightcurves for some cycles of VY Equ originate from a pronounced excitation of v2 . It would be very interesting to understand the underlying differences in the stellar parameters that drive the increased contribution from the second overtone of the pulsation.

9. ACKNOWLEDGEMENTS AND REFERENCES

This paper includes data collected by the TESS mission. Funding for the TESS mission is provided by the NASA's Science Mission Directorate. (https://heasarc.gsfc.nasa.gov/docs/tess/)

VStar: https://www.aavso.org/vstar

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