

# V363 Cas, a double mode pulsating star?

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## Abstract

In October and November 2011 light curve measurements were performed on V363 Cas, a variable star in the constellation Cassiopeia, classified as being an RR Lyrae type.

These measurements were combined with ESA OMC satellite data because of ESA's Explore the High-Energy universe competition.

Measurements in the visual part of the spectrum were performed by students of the Emmauscollege in Rotterdam together with their physics teacher using a Celestron C11 with SXV-H9 CCD camera.

The measurements shows, from the combined datasets, a main period of 0,546578 +/- 0,000010 days with an amplitude of 0,19667 magnitudes for V363 Cas. The analysis of the light curve shows that V363 simultaneously oscillates in its fundamental and first overtone. The period ratio  $P_{10}=P_1/P_0$  could be an indication that the classification as an RR Lyrae star may be wrong. According to Buchler and Szabó [1] this ratio is a strong indication for a star with two pulsating periods being of the short period Cepheid type.

Further analysis of the star in the spectral bands and further light curve measurements are encouraged to be performed in order to get more insight in the physical behaviour of this intriguing star.

## Introduction

V363 Cas is a variable star classified by Paczyński [2] and the GCVS as an RR Lyrae type. RR Lyrae variables sometimes show irregularities in their light curves, also known as the Blazhko effect of double modes. Hajdu et al. [3] showed in 2009 that V363 shows a double mode behaviour and proposed to classify this star as a short period Cepheid instead of a RR Lyrae variable because of the star pulsating in both the fundamental and first overtone simultaneously. Using OMC data in combination with our own measurements of this star we want to see if we can positively identify this star as being a short period Cepheid, and therefore reclassify it.

In order to be able to tell if the star is an RR Lyrae or short period Cepheid the periods of the fundamental and first overtone and their ratio have to be determined. Buchler and Szabó [1] showed that a ratio of  $>0.74$  is an indicator of a beat Cepheid with a period of approximately 0.5 days.

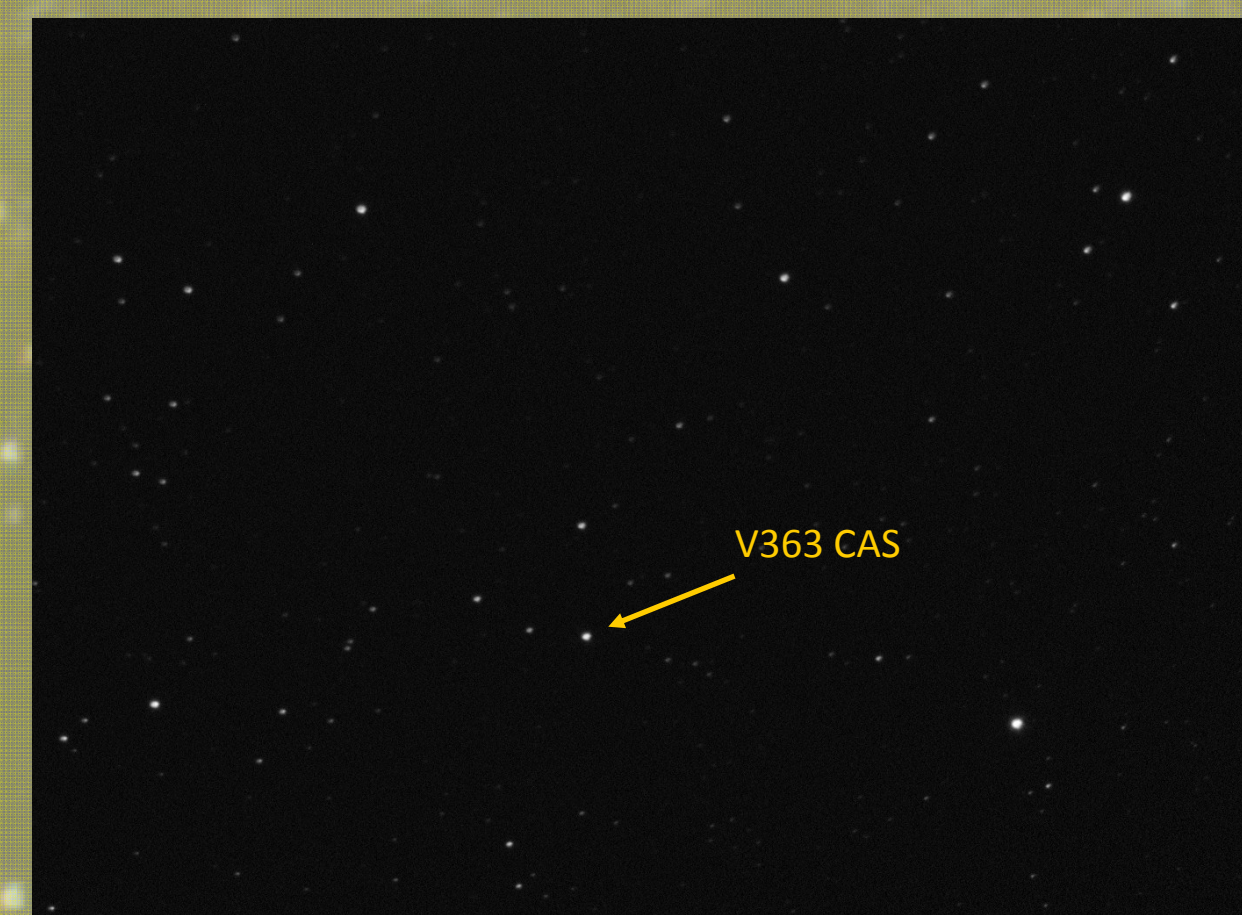


Figure 1: Overview of the field of view used during imaging (images obtained during measurements)

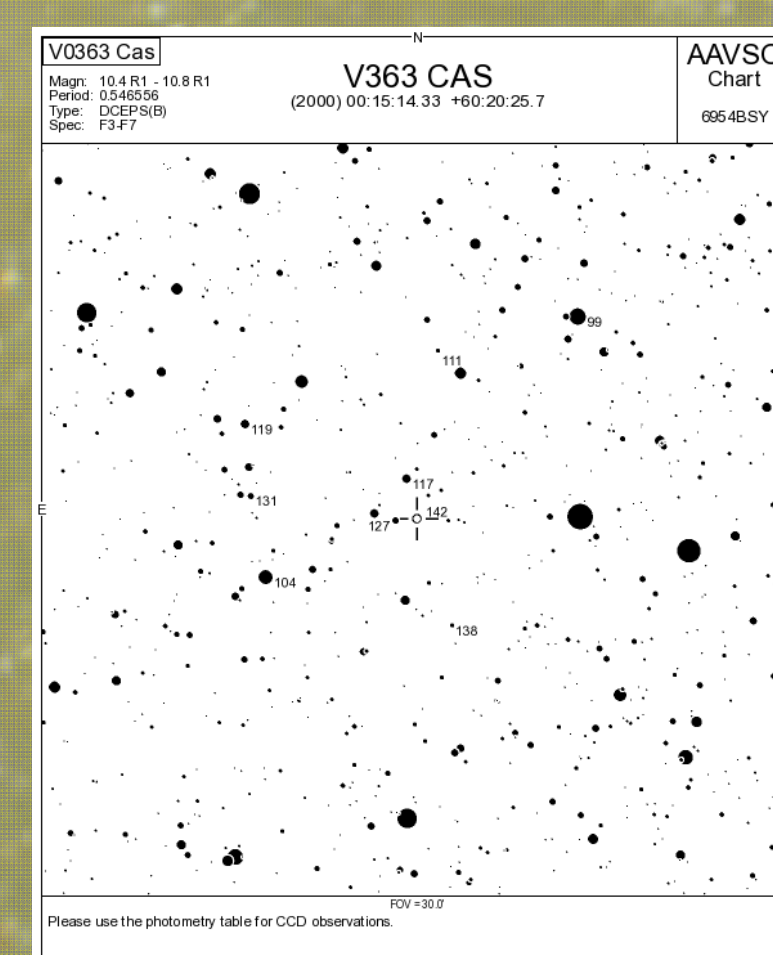


Figure 2: AAVSO finder chart for V363 Cas

## Equipment and data overview

Data of V363 Cas has been obtained during several nights in October 2011 using a Celestron C11 in combination with an SXV-H9 CCD camera and a Baader V-filter.

During the sessions the setup was running in automatic guiding mode obtaining images at 30s intervals.

During the observations darks, flats and darkflats were made directly after the measurements. Following the necessary meridian-flips around 00.00 UTC new flats were made for the second measurements series.

Flat frames were made using a LED-panel directly after stopping the imaging procedure.

Date	Number of images		Exposure	Conditions
	Before meridian-flip	After meridian-flip		
21/10/2011	19	62	30s/2.5 min interval	Very good seeing, dry, clear night, temperature just above freezing, moderate-high light pollution
23/10/2011	51	79	30s/2.5 min interval	Good seeing, dry, clear night, strong winds
24/10/2011	37		30s/2.5 min interval	Good seeing, dry, clear night, strong winds, gusting, at 22.00 clouds came in
26/10/2011	69	52	30s/2.5 min interval	Average seeing, haze in the start of the evening, after that more clear
27/11/2011	356		30s/30s interval	Clear night, good seeing,

Table 1: Overview of obtained data

## Procedure/method

Image capture was performed by using Nebulosity 2.0. Data was saved as raw fits files. Together with every set of raw lights also 10 darks, 20 flats and 10 darkflats were captured. When a meridian-flip was performed a new set of darks, flats and darkflats were obtained.

Image processing was performed using MaximDL 5. After image correction the images were stacked in batches of 3 minutes to reduce signal noise and strengthen the measurements. After stacking the images were analysed using the photometry module of MaximDL 5.

Reference stars kindly provided by the AAVSO were used as fixed magnitude stars while V363 was measured relative to these reference stars. A data file was created containing Julian dates and magnitude estimates and errors.

The data was corrected to heliocentric time and the ESA OMC data was referenced from barytime to heliocentric Julian dates.

Then our dataset was combined with the ESA OMC dataset. Peranso 2.0 was used to obtain estimates for the periods of the oscillations of V363 Cas.

In Peranso the CLEANest procedure was used to obtain the period of the fundamental. After that the fundamental was removed from the data, the residuals were used to obtain the period and magnitude of the first overtone.

The same procedure was followed using only the OMC and only our own data in order to compare the results with our added dataset.

## Results

From the stacked image sets periods were derived for the fundamental ( $p_0$ ) and first overtone ( $p_1$ ) of V363 Cas. The magnitude of the oscillation was simultaneously estimated together with the period.

	Multi-Period analysis of V363 Cas							
	Period (days)				Amplitude			
	$p_0$		$p_1$		$p_0$		$p_1$	
OMC Data	0,546574	+/- 0,000014	0,439886	-	0,20079	+/- 0,00190	0,02152	-
Own data	0,547100	+/- 0,000071	0,447750	-	0,19483	+/- 0,00250	0,03759	-
OMC + Own	0,546578	+/- 0,000010	0,438221	-	0,19667	+/- 0,00182	0,02220	
Hajdu et al.	0,546556	-	0,438243	-	0,1980	+/- 0,0011	0,0196	+/- 0,0012

Table 2: Estimated periods and magnitudes of fundamental and first overtone of V363 Cas

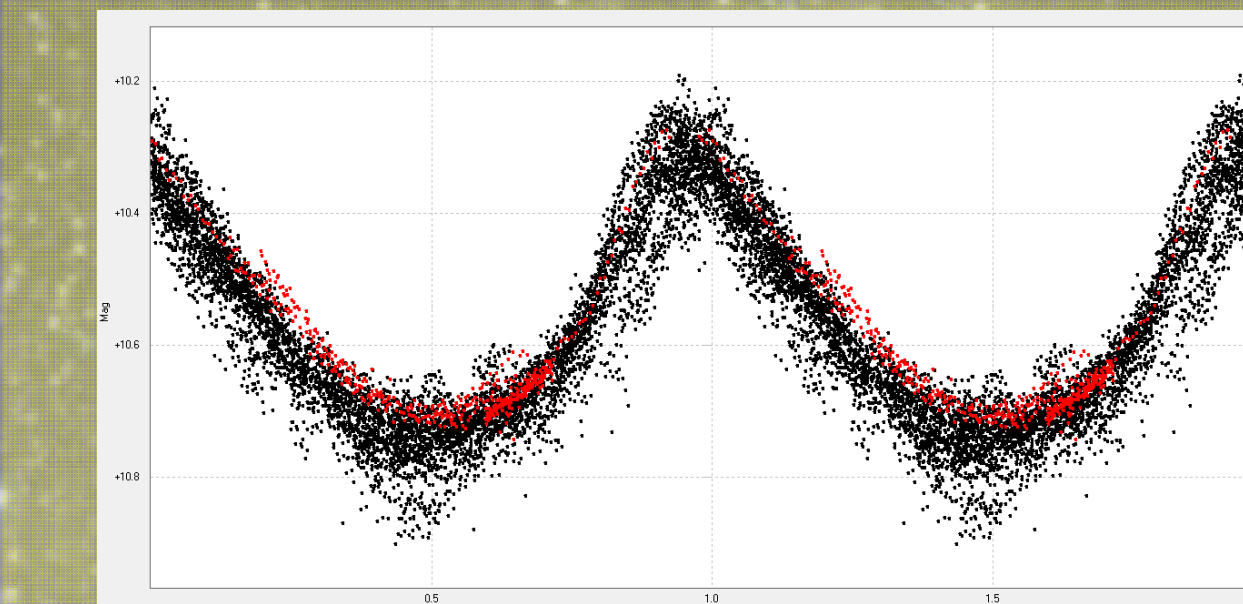


Figure 3: Phaseplot of the fundamental of V363 Cas, with in black the OMC data data

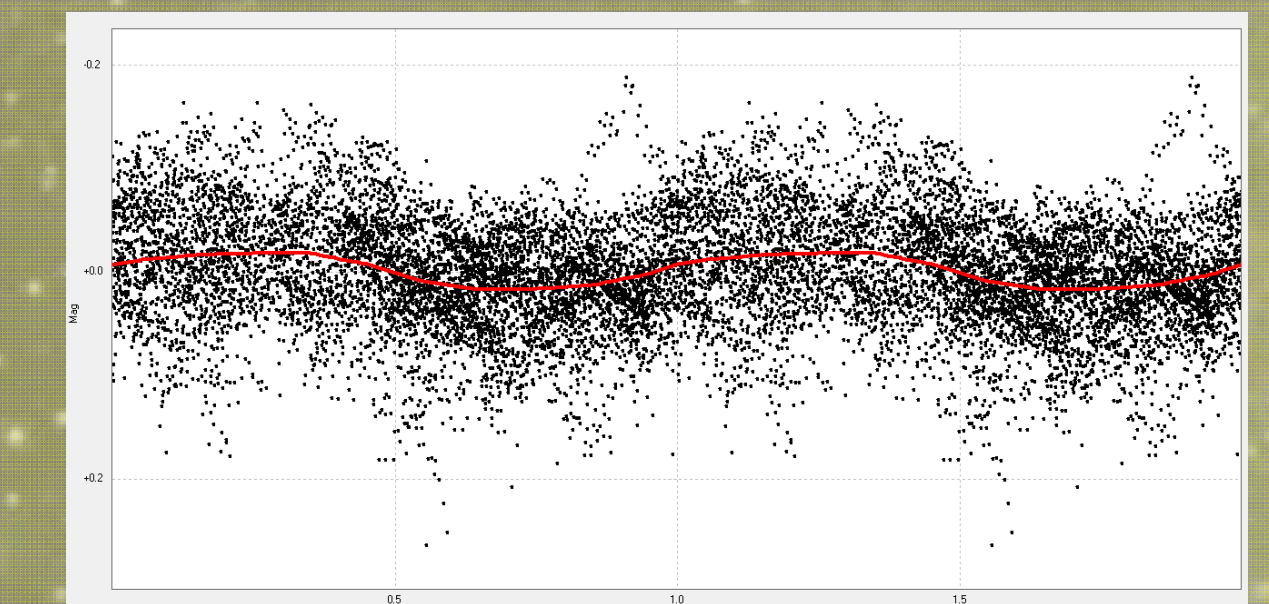


Figure 4: Phaseplot of the first overtone of V363 Cas. In red the best fit of red our the oscillation is shown.

## Conclusion and discussion

The obtained estimate of the period of the fundamental of our dataset closely matches the period obtained from the OMC and from the combined datasets. When looking at the first overtone the period and magnitude estimated is much less accurate for our dataset, but that is understandable because of the small period that the data covers. When combining the OMC and our own datasets the overtone becomes much more pronounced and a good estimate is possible. The ratio of the periods of the fundamental and first overtone is 0.82 in our own dataset and 0.80 in the combined dataset. This is an indication that V363 Cas is indeed not a RR Lyrae type of star, but should rather be classified as a short period Cepheid.

Further investigation of this star by spectral analysis and prolonged observations of the variability is recommended to clear this issue.

## References/Acknowledgements

- [1] J.R. Buchler and R. Szábo, Beat cepheids as probes of stellar and galactic metallicity, The astrophysical journal. Vol. 660, pages 723-731, 2007.
- [2] G. Hajdu, J. Jurcsik, Á. Sódor, Three new galactic double mode pulsating stars, Commissions 27 and 42 of the IAU information bulletin on variable stars, number 5882, 2009.
- [3] Paczyński, B. Three-Colour Photometry of RR Lyrae Stars. III.

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